MECHANIC DIESEL

NSQF LEVEL - 4

2nd Semester

TRADE THEORY

SECTOR: Automobile

Directorate General of Training

DIRECTORATE GENERAL OF TRAINING
MINISTRY OF SKILL DEVELOPMENT & ENTREPRENEURSHIP
GOVERNMENT OF INDIA

NATIONAL INSTRUCTIONAL
MEDIA INSTITUTE, CHENNAI

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FOREWORD

The Government of India has set an ambitious target of imparting skills to 30 crores people, one out of every four Indians, by 2020 to help them secure jobs as part of the National Skills Development Policy. Industrial Training Institutes (ITIs) play a vital role in this process especially in terms of providing skilled manpower. Keeping this in mind, and for providing the current industry relevant skill training to Trainees, ITI syllabus has been recently updated with the help of Mentor Councils comprising various stakeholders viz. Industries, Entrepreneurs, Academicians and representatives from ITIs.

The National Instructional Media Institute (NIMI), Chennai, has now come up with instructional material to suit the revised curriculum for **Mechanic Diesel, 2nd Semester Trade Theory NSQF Level - 4 in Automobile Sector under Semester Pattern.** The NSQF Level - 4 will help the trainees to get an international equivalency standard where their skill proficiency and competency will be duly recognized across the globe and this will also increase the scope of recognition of prior learning. NSQF Level - 4 trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF Level - 4 the trainers and trainees of ITIs, and all stakeholders will derive maximum benefits from these Instructional Media Packages IMPs and that NIMI's effort will go a long way in improving the quality of Vocational training in the country.

The Executive Director & Staff of NIMI and members of Media Development Committee deserve appreciation for their contribution in bringing out this publication.

Jai Hind

RAJESH AGGARWAL
Director General/ Addl.Secretary
Ministry of Skill Development & Entrepreneurship,
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New Delhi - 110 001

PREFACE

The National Instructional Media Institute (NIMI) was established in 1986 at Chennai by then Directorate General of Employment and Training (D.G.E & T), Ministry of Labour and Employment, (now under Directorate General of Training, Ministry of Skill Development and Entrepreneurship) Government of India, with technical assistance from the Govt. of Federal Republic of Germany. The prime objective of this Institute is to develop and provide instructional materials for various trades as per the prescribed syllabus under the Craftsman and Apprenticeship Training Schemes.

The instructional materials are created keeping in mind, the main objective of Vocational Training under NCVT/NAC in India, which is to help an individual to master skills to do a job. The instructional materials are generated in the form of Instructional Media Packages (IMPs). An IMP consists of Theory book, Practical book, Test and Assignment book, Instructor Guide, Audio Visual Aid (Wall charts and Transparencies) and other support materials.

The trade practical book consists of series of exercises to be completed by the trainees in the workshop. These exercises are designed to ensure that all the skills in the prescribed syllabus are covered. The trade theory book provides related theoretical knowledge required to enable the trainee to do a job. The test and assignments will enable the instructor to give assignments for the evaluation of the performance of a trainee. The wall charts and video clips are unique, as they not only help the instructor to effectively present a topic but also help him to assess the trainee's understanding. The instructor guide enables the instructor to plan his schedule of instruction, plan the raw material requirements, day to day lessons and demonstrations.

IMPs also deals with the complex skills required to be developed for effective team work. Necessary care has also been taken to include important skill areas of allied trades as prescribed in the syllabus.

The availability of a complete Instructional Media Package in an institute helps both the trainer and management to impart effective training.

The IMPs are the outcome of collective efforts of the staff members of NIMI and the members of the Media Development Committees specially drawn from Public and Private sector industries, various training institutes under the Directorate General of Training (DGT), Government and Private ITIs.

NIMI would like to take this opportunity to convey sincere thanks to the Directors of Employment & Training of various State Governments, Training Departments of Industries both in the Public and Private sectors, Officers of DGT and DGT field institutes, proof readers, individual media developers and coordinators, but for whose active support NIMI would not have been able to bring out this materials.

R. P. DHINGRA
EXECUTIVE DIRECTOR

Chennai - 600 032

ACKNOWLEDGEMENT

National Instructional Media Institute (NIMI) sincerely acknowledges with thanks for the co-operation and contribution extended by the following Media Developers and their sponsoring organisation to bring out this IMP **(Trade Theory)** for the trade of **Mechanic Diesel** under the **Automobile** Sector for ITIs.

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NIMI records its appreciation of the Data Entry, CAD, DTP Operators for their excellent and devoted services in the process of development of this Instructional Material.

NIMI also acknowledges with thanks, the invaluable efforts rendered by all other staff who have contributed for the development of this Instructional Material.

NIMI is grateful to all others who have directly or indirectly helped in developing this IMP.

INTRODUCTION

TRADE THEORY

The manual of trade theory consists of theoretical information for the Second Semester course of the Mechanic Diesel Trade. The contents are sequenced according to the practical exercise contained in the manual on Trade practical. Attempt has been made to relate the theortical aspects with the skill covered in each exercise to the extent possible. This co-relation is maintained to help the trainees to develop the perceptional capabilities for performing the skills.

The Trade theory has to be taught and learnt along with the corresponding exercise contained in the manual on trade practical. The indicating about the corresponding practical exercise are given in every sheet of this manual.

It will be preferable to teach/learn the trade theory connected to each exercise atleast one class before performing the related skills in the shop floor. The trade theory is to be treated as an integrated part of each exercise.

Module 1	Diesel engine over view		50 Hrs
Module 2	Diesel engine components		175 Hrs
Module 3	Cooling & lubricating system		75 Hrs
Module 4	Intake and exhaust system		25 Hrs
Module 5	Diesel fuel system		75 Hrs
Module 6	Marine & stationary engine		25 Hrs
Module 7	Emission control system		25 Hrs
Module 8	Charging and Starting system		25 Hrs
Module 9	Trouble shooting		50 Hrs
		Total	525 Hrs

The material is not the purpose of self learning and should be considered as supplementary to class room instruction

TRADE PRACTICAL

The trade practical manual is intented to be used in workshop . It consists of a series of practical exercises to be completed by the trainees during the Second Semester course of the Mechanic Diesel trade supplemented and supported by instructions/ informations to assist in performing the exercises. These exercises are designed to ensure that all the skills in compliance with NSQF LEVEL - 4

The manual is divided into Nine modules. The distribution of time for the practical in the Eight modules are given below.

The skill training in the shop floor is planned through a series of practical exercises centred around some practical project. However, there are few instances where the individual exercise does not form a part of project.

While developing the practical manual a sincere effort was made to prepare each exercise which will be easy to understand and carry out even by below average trainee. However the development team accept that there is a scope for further improvement. NIMI, looks forward to the suggestions from the experienced training faculty for improving the manual.

CONTENTS

LEARNING / ASSESSABLE OUTCOME

On completion of this book you shall be able to

- **Understand basics of engine types construction, working.**
- **Dismantle & assemble of Diesel Engine from vehicle (LMV/HMV) along with other accessories (torqueing methods, handling parts.)**
- **Overhaul, service and testing Diesel Engine, its parts and check functionality.**
- **Trace, Test & Repair cooling and Lubrication System of engine (types of coolants and oils relevant to the engines).**
- **Trace & Test Intake and Exhaust system of engine. (cleaning egr valves, exhaust inlet valves, ports and manifolds)**
- **Service Diesel Fuel System and check proper functionality (calibration of mechanical and electronic pumps, checking injectors, filters)**
- **Plan & overhaul the stationary engine and Governor and check functionality.**
- **Monitor emission of vehicle and execute different operation to obtain optimum pollution as per emission norms.**
- **Carryout overhauling of Alternator and Starter Motor.**
- **Diagnose & rectify the defects in LMV/HMV to ensure functionality of vehicle**
- **Checking the condition of hoses, mounts, radiators and fans.**
- **Electronic control diagnostics of CR engines.**

SYLLABUS FOR MECHANIC DIESEL TRADE

SECONED SEMESTER **Duration: 06 Months**

Week No.	LearningOutcome Reference	Professional Skills (Trade Practical) with Indicative hrs.	Professional Knowledge (Trade Practical)
27-28	Dismantle & assemble of Diesel Engine from vehicle (LMV/HMV) along with other accessories.	62. Identify the different parts of IC Engine(10 hrs) 63. Identify the different parts in a diesel engine of LMV/ HMV (10 hrs) 64. Perform practice on starting and stopping of diesel engines. Observe and report the reading of Tachometer, Odometer, temp and Fuel gauge under ideal and on load condition. (10 hrs)	**Introduction to Engine:** - Description of internal & external combustion engines, Classification of IC engines, Principle & working of 2&4-stroke diesel engine (Compression ignition Engine (C.I)), - Principle of Spark Ignition Engine(SI), differentiate between 2-stroke and 4 stroke, C.I engine and S.I Engine, - Main Parts of IC Engine - Direct injection and indirect injection, Technical terms used in engine, Engine specification. - Study of various gauges/ instrument on a dash board of a vehicle- Speedometer, Tachometer, Odometer and Fuel gauge, and Indicators such as gearshift position, Seat belt warning light, Parking-brake-engagement warning light and an Enginemalfunction light. - Different type of starting and stopping method of Diesel Engine - Procedure for dismantling of diesel engine from a vehicle.
20-30	Overhaul & service Diesel Engine, its parts and check functionality.	65. Practice on dismantling Diesel engine of LMV/HMV as per procedure. (20 hrs) 66. Perform Overhauling of cylinder head assembly, Use of service manual for clearance and other parameters,(10 hrs) 67. Perform practice on removing rocker arm assembly manifolds. (07 hrs) 68. Perform practice on removing the valves and its parts from the cylinder head, cleaning. (07 hrs) 69. Inspection of cylinder head and manifold surfaces for warping, cracks and flatness. Checking valve seats & valve guide – Replacing the valve if necessary. (07 hrs)	**Diesel Engine Components:** - Description and Constructional feature of Cylinder head, Importance of Cylinder head design, - Type of Diesel combustion chambers, - Effect on size of Intake & exhaust passages, Head gaskets. - Importance of Turbulence Valves & Valve Actuating Mechanism - - Description and Function of Engine Valves, different types, materials, - Type of valve operating mechanism, Importance of Valve seats, Valve seats inserts in cylinder heads,

		70. Check leaks of valve seats for leakage – Dismantle rocker shaft assembly -clean & check rocker shaft-and levers, for wear and cracks and reassemble. (07 hrs) 71. Check valve springs, tappets, push rods, tappet screws and valve stem cap. Reassembling valve parts in sequence, refit cylinder head and manifold & rocker arm assembly, adjustable valve clearances, starting engine after adjustments. (12 hrs)	- importance of Valve rotation, Valve stem oil seals, size of Intake valves, Valve trains, Valve-timing diagram, concept of Variable valve timing. - Description of Camshafts & drives , - Description of Overhead camshaft (SOHC and DOHC), importance of Cam lobes, Timing belts & chains, Timing belts & tensioners.
31	-do-	72. Perform Overhauling piston and connecting rod assembly. Use of service manual for clearance and other parameters (05 hrs) 73. Perform Practice on removing oil sump and oil pump – clean the sump. 74. Perform removing the big end bearing, connecting rod with the piston. (05 hrs) 75. Perform removing the piston rings; Dismantle the piston and connecting rod. Check the side clearance of piston rings in the piston groove & lands for wear. Check piston skirt and crown for damage and scuffing, clean oil holes. (05 hrs) 76. Measure -the piston ring close gap in the cylinder, clearance between the piston and the liner, clearance between crank pin and the connecting rod big end bearing. (05 hrs) 77. Check connecting rod for bend and twist. Assemble the piston and connecting rod assembly. (05 hrs)	- Description & functions of different types of **pistons,** piston rings and piston pins and materials. - Used recommended clearances for the rings and its necessity precautions while fitting rings, common troubles and remedy. - Compression ratio. - Description & function of connecting rod, - importance of big- end split obliquely - Materials used for connecting rods big end & main bearings. Shells piston pins and locking methods of piston pins.
32	-do-	78. Perform Overhauling of crankshaft, Use of service manual for clearance and other parameters (05 hrs) 79. Perform removing damper pulley, timing gear/timing chain, flywheel, main bearing caps, bearing shells and crankshaft from engine(05 hrs) 80. Inspect oil retainer and thrust surfaces for wear. (05 hrs) 81. Measure crank shaft journal for wear, taper and ovality. (05 hrs)	- Description and function of Crank shaft, camshaft, - Engine bearings- classification and location – materials used & composition of bearing materials- Shell bearing and their advantages- special bearings material for diesel engine - Application bearing failure & its causes-care & maintenance. - Crank-shaft balancing, firing order of the engine.

		82. Demonstrate crankshaft for fillet radii, bend & twist. (05 hrs)	
33	-do-	83. Inspect flywheel and mounting flanges, spigot and bearing.(05 hrs) 84. Check vibration damper for defect. (02 hrs) 85. Perform removing cam shaft from engine block, Check for bend & twist of camshaft. Inspection of cam lobe, camshaft journals and bearings and measure cam lobe lift. (07 hrs) 86. Fixing bearing inserts in cylinder block & cap check nip and spread clearance & oil holes & locating lugs fix crank shaft on block-torque bolts - check end play remove shaft - check seating, repeat similarly for connecting rod and Check seating and refit. (11 hrs)	- Description and function of the **fly wheel** and vibration damper. - Crank case & oil pump, gears timing mark, Chain sprockets, chain tensioner etc. - Function of clutch & coupling units attached to flywheel.
34	-do-	87. Perform cleaning and checking of cylinder blocks. (04 hrs) 88. Surface for any crack, flatness measure cylinder bore for taper & ovality, clean oil gallery passage and oil pipe line. (05 hrs) 89. Perform bore - descale water passages and examine. (05 hrs) 90. Removing cylinder liners from scrap cylinder block. (04 hrs) 91. Perform practice in measuring and refitting new liners as per maker's recommendations precautions while fitting new liners. (07 hrs)	- Description of **Cylinder block,** - Cylinder block construction, - Different type of Cylinder sleeves (liner).
35	-do-	92. Perform reassembling all parts of engine in correct sequence and torque all bolts and nuts as per workshop manual of the engine. (12 hrs) 93. Perform testing cylinder compression, Check idle speed. (08 hrs) 94. Perform removing & replacing a cam belt, and adjusting an engine drive belt, replacing an engine drive belt. (05 hrs)	- **Engine assembly** procedure with aid of special tools and gauges used for engine assembling. - Introduction to Gas Turbine, Comparison of single and two stage turbine engine, - Different between gas turbine and Diesel Engine.
36-38	Trace, Test & Repair Cooling and Lubrication System of engine.	95. Perform practice on checking &top up coolant, draining & refilling coolant, checking / replacing a coolant hose. (10 hrs) 96. Perform test cooling system pressure. (05 hrs) 97. Execute on removing & replacing radiator/ thermostat check the radiator pressure cap. (10 hrs) 98. Test of thermostat. (5 hrs) 99. Perform cleaning & reverse flushing. (10 hrs)	Need for Cooling systems - Heat transfer method, Boiling point & pressure, - Centrifugal force, - Vehicle coolant properties and recommended change of interval, - Different type of cooling systems,

		100.Perform overhauling water pump and refitting. (10 hrs) 101.Perform checking engine oil, draining engine oil, replacing oil filter, & refilling engine oil (10 hrs) 102. Execute overhauling of oil pump, oil coolers, air cleaners and air filters and adjust oil pressure relief valves, repairs to oil flow pipe lines and unions if necessary. (15 hrs)	**Basiccoolingsystem components** - Radiator, Coolant hoses, - - Water pump, - Cooling system thermostat, Cooling fans, - Temperature indicators, - Radiator pressure cap, Recovery system, Thermoswitch. **Need for lubrication system,** - Functions of oil, Viscosity and its grade as per SAE , - Oil additives, Synthetic oils, The lubrication system, **Splash system,** - Pressure system - Corrosion/noise reduction in the lubrication system. - Lubrication system components - Description and function of Sump, Oil collection pan, Oil tank, Pickup tube, - different type of Oil pump & Oil filters Oil pressure relief valve, Spurt holes & galleries, Oil indicators, Oil cooler.
39	Trace & Test Intake and Exhaust system of engine.	103. Execute dismantling air compressor and exhauster and cleaning all parts - measuring wear in the cylinder, reassembling all parts and fitting them in the engine. (6 hrs) 104. Execute dismantling & assembling of turbocharger, check for axial clearance as per service manual. (05 hrs) 105.Examine exhaust system for rubber mounting for damage, deterioration and out of position; for leakage, loose connection, dent and damage; (05 hrs) 106. Perform practice on exhaust manifold removal and installation, practice on Catalytic converter removal and installation. (05 hrs) 107.Check Exhaust system for rubber mounting for damage, deterioration and out of position; for leakage, loose connection, dent and damage. (04 hrs)	**Intake & exhaust systems**– - Description of Diesel induction & Exhaust systems. Description & function of air compressor, exhauster, Supercharger, Intercoolers, turbo charger, variable turbo charger mechanism. **Intake system components-** - Description and function of Air cleaners, Different type air cleaner, Description of Intake manifolds and material, **Exhaustsystem components-** - Description and function of Exhaust manifold, Exhaustpipe, Extractors, Mufflers-Reactive, absorptive, Combination of Catalyticconverters, Flexible connections, Ceramic coatings, Back-pressure, - Electronic mufflers.

40-42	Service Diesel Fuel System and check proper functionality.	108. Perform work on removing &cleaning fuel tanks, checking leaks in the fuel lines. (10 hrs) 109. Perform soldering & repairing pipe lines and Unions, brazing nipples to high pressure line studying the fuel feed system in diesel engines, draining of water separators. (10 hrs) 110.Execute overhauling of Feed Pumps (Mechanical & Electrical). (10 hrs) 111.Perform bleeding of air from the fuel lines, servicing primary & secondary filters. (10 hrs) 112. Execute removing a fuel injection pump from an engine-refit the pump to the engine re- set timing - fill lubricating-oil start and adjust slow speed of the engine. (15 hrs) 113.Execute overhauling of injectors and testing of injector. (10 hrs) 114. General maintenance of Fuel Injection Pumps (FIP). (10 hrs)	**Fuel Feed System in IC Engine(Petrol & Diesel)** - Gravity feed system, Forced feed system, main parts, Fuel Pumps- Mechanical & Electrical Feed Pumps. - Knowledge about function, working & types of Carburettor. **Diesel Fuel Systems** - Description and function of Diesel fuel injection, fuel characteristics, concept of Quiet diesel technology &Clean diesel technology. **Diesel fuel system components** - Description and function of Diesel tanks & lines, Diesel fuel filters, water separator, Lift pump, Plunger pump, Priming pump, - Inline injection pump, Distributor-type injection pump, Diesel injectors, Glow plugs, Cummins & Detroit Diesel injection. **Electronic Diesel control-** - Electronic Diesel control systems, Common Rail Diesel Injection (CRDI) system, hydraulically actuated electronically controlled unit injector (HEUI) diesel injection system. Sensors, actuators and ECU (Electronic Control Unit) used in Diesel Engines.
43	Plan & overhaul the stationary engine and Governor and check functionality.	115. Execute Start engine adjust idling speed and damping device in pneumatic governor and venture control unit checking. (06 hrs) 116. Verify performance of engine with off load adjusting timings. Start engine- adjusting idle speed of the engine fitted with mechanical governor checking- high speed operation of the engine. (07 hrs) 117. Check performance for missing cylinder by isolating defective injectors and test- dismantle and replace defective parts and reassemble and refit back to the engine. (12 hrs)	**Marine & Stationary Engine:- Types,** - double acting engines, opposed piston engines, starting systems, cooling systems, lubricating systems, supplying fuel oil, hydraulic coupling, - Reduction gear drive, electromagnetic coupling, - Electrical drive, generators and motors, supercharging.

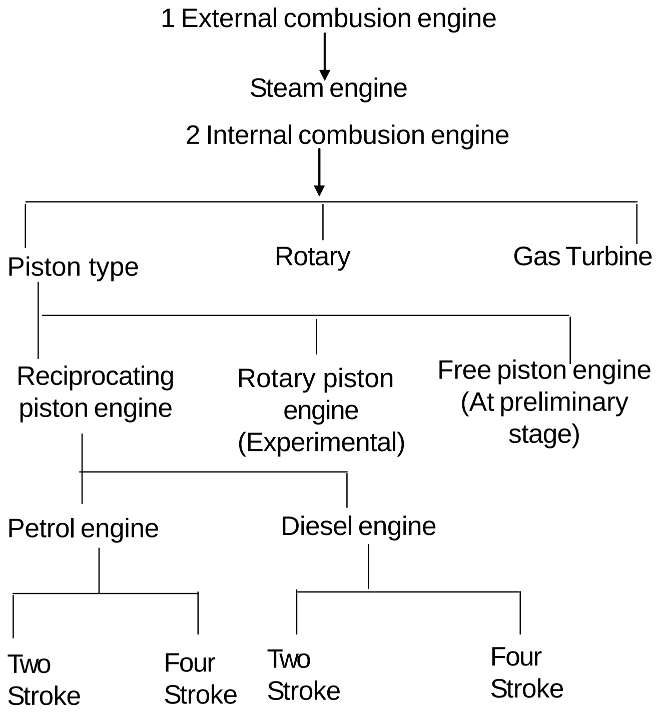
44	21.. Monitor emission of vehicle and execute different operation to obtain optimum pollution as per emission norms.	118. Monitor emissions procedures by use of Engine gas analyser or Diesel smoke meter. (10 hrs) 119.Checking & cleaning a Positive crank case ventilation (PCV) valve. Obtaining & interpreting scan tool data. Inspection of EVAP canister purges system by use of scan Tool. (10 hrs) 120. EGR /SCR Valve Remove and installation for inspection. (05 hrs)	**Emission Control:- Vehicle emissions** - Standards- Euro and Bharat II, III, IV, V Sources of emission, Combustion, Combustion chamber design. **Types of emissions:** - Characteristics and Effect of Hydrocarbons, Hydrocarbons in exhaust gases, Oxides of nitrogen, Particulates, Carbon monoxide, Carbon dioxide, Sulphur content in fuels Description of Evaporation emission control, Catalytic conversion, Closed loop, Crankcase emission control, - Exhaust gas recirculation (EGR) valve, controlling air-fuel ratios, Charcoal storage devices, Diesel particulate filter (DPF). Selective Catalytic, Reduction (SCR), EGR VS SCR
45	Carryout overhauling of Alternator and Starter Motor	121. Perform removing alternator from vehicle dismantling, cleaning checking for defects, assembling and testing for motoring action of alternator & fitting to vehicles. (15 hrs) 122. Practice on removing starter motor Vehicle and overhauling the starter motor, testing of starter motor (10 hrs)	Basic Knowledge about DC Generator & AC Generator. - Constructional details of Alternator - Description of charging circuit operation of alternators, regulator unit, ignition warning lamp- troubles and remedy in charging system. - Description of starter motor circuit, - Constructional details of starter motor solenoid switches, common troubles and remedy in starter circuit.
46-47	23. Diagnose & rectify the defects in LMV/HMV to ensure functionality of vehicle.	123. Execute troubleshooting in LMV/ HMV for Engine Not starting – Mechanical & Electrical causes, High fuel consumption, Engine overheating, Low Power Generation, Excessive oil consumption, Low/High Engine Oil Pressure, Engine Noise. (50 hrs)	**Troubleshooting :** Causes and remedy for - Engine Not starting Mechanical & Electrical causes, - High fuel consumption, Engine overheating, - Low Power Generation, - Excessive oil consumption, - Low/High Engine Oil Pressure, Engine Noise.

49-50	In-plant training / Project work Projects viz. a. Overhauling of Pressure Lubrication system b. Maintenance of cooling system. c. Overhauling of FIP. d. Cleaning & Testing of Injectors. e. Overhauling of Alternator f. Overhauling of Starter Motor g. Study on Diagnosis Tool/Scanner Tool for ECU of CRDI engine
51	Revision
52	Examination

Internal and external combustion engine

Objectives : At the end of this lesson you shall be able to
- **type of heat engine**
- **state the internal and external combusion engine**
- **difference between an internal and external combusion engine.**

Types of heat engines



As indicated above, modern automobile engines are:

With regard to their construction and operation:

i Piston type

ii Rotary

iii Turbine

Internal combustion engine

Internal combustion engine means, that combustion takes place inside the cylinder, this definition including the two stroke and four stroke engine, spark ignition and compression ignition engine, wrankle, austine and jet engines are also i.e engine.

External combustion engine

External combustion engine is that type of engine in which combustion takes place outside the engine cylinder. ex: steam engine.

Difference between internal and external combustion engine

Sl.No	Internal combustion engine	External combustion engine
1	Occupies less space.	Occupies more space.
2	Lighter in weight.	Heavier in weight.
3	High speed engine.	Slow speed engine.
4	Combustion of fuel takes palce inside the engine.	Combustion of fuel takes palce inside the engine.
5	Fuels used in when engine is not running.	Soild or liquid fuels used to form steam.
6	No loss of fuel when engine is not running.	Fuel has to burn even when the engine is not running for small halts.
7	Could be started or stopped at will.	Cannot be started unless steam is prepared which takes much time.
8	Temperature produced inside the cylinder is too high.	Works at comparatively low temperature.
9	Cooling arrangement necessary.	No cooling of the cylinders required. Rather it is steam jacketed.
10	Single acting.	Mostly double acting.
11	Exhause gas temperature as high as 300°C.	The temperature of exhaust steam is quite low.
12	Thermal efficiency of diesel engine up to 40%.	Thermal efficiency up to 24% as that of petrol engine.
13	No needs boiler, furnace or condenser.	Boilder, furnace and condenser are must.

Classification of engine

Objective: At the end of this lesson you shall be able to
- **state the classification of engines.**

Engines are classified according to the following factors.

Number of cylinders

Single cylinder

Multi cylinder

Arrangements of cylinders

In-line engine (Fig 1)

`V' shape engine (Fig 2)

Opposed engine (Fig 3)

Horizontal engine

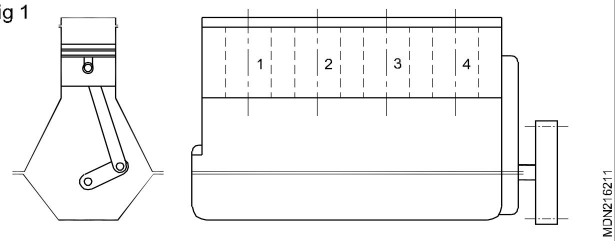
Radial engine (Fig 4)

Vertical engine

Types of engines as per cylinder arrangement

In-line engines

Fig 1

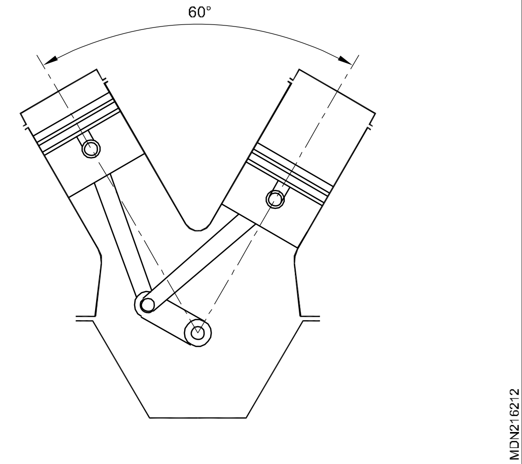


In this type, the cylinders are arranged in one line. The length of the crankshaft is longer than that of the other types of engines, and hence a limited number of cylinders are used. Better balancing and more uniform torque is obtained in this type.

V engines

In this type, the cylinders are arranged in V shape at an angle, of usually 60°. This engine is more economical and compact. For multi-cylinder engines, the length of the crankshaft is much shorter than that of the in- line engine. In this type, the engine height is also lower than it is in the in-line engine.

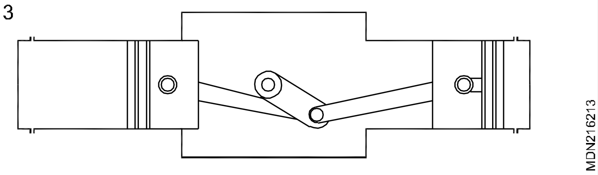
Fig 2



Opposed engines

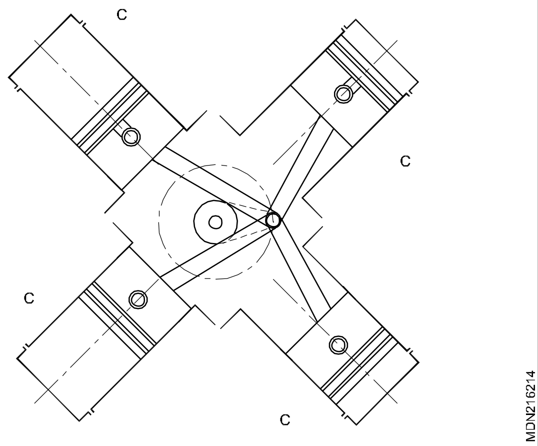
In this type the cylinders are arranged horizontally opposite to each other. This provides better mechanical balance. This type of engine can run smoothly even at a much higher speed. It also gives higher output. The length of the engine is too much, and therefore engine has to be placed in the transverse direction in the vehicle.

Fig 3



Radial engines

Fig 4



In this type, the cylinders are arranged radially. This type of engine is shorter, lighter and more rigid. Since it is rigid, a higher engine speed is possible and a higher combustion pressure can be obtained. This leads to high fuel efficiency. The radial type engines are used mostly in aeroplanes.

Types of engine as per number of cylinders

Single cylinder engines

An engine which has only one cylinder is called a single cylinder engine. Since it is a single cylinder engine it cannot develop more power. It is normally used only in two wheelers like scooters and motor cycles.

Multi cylinder engines

These engines have more than one cylinder. Two-cylinder engines are usually used in tractors. Three or four cylinder engines are used in cars, jeeps and other vehicles. In heavy vehicles six-cylinder engines are used. A greater number of cylinders gives smoother engine operation.

Types of fuel used

Petrol

Diesel

Types of valve arrangements

`I' head engine

`F' head engine

`L' head engine

`H' head engine

`T' head engine

Application of engine

Constant speed engine

Variable speed engine

Cooling system

Air cooled engine

Water cooled engine

Strokes of engine

Four-stroke engine

Two-stroke engine

Rotary engine

Function of Diesel engine

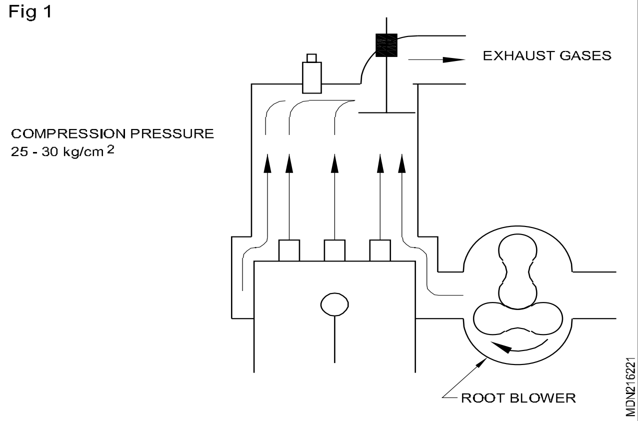
Objectives : At the end of this lesson you shall be able to
- **describe the function of a two-stroke diesel engine**
- **describe the function of a four-stroke diesel engine.**

Two strke diesel engine:

To produce power in a two stroke engine the following operation take place in the sequence given.

First stroke: Piston at BDC the scavenging port and outlet valve open (Fig 1). A root blower sucks in pure air and presses it through the scavenging port into the cylinder. The tangential layout of the scavenging port brings the air into a turbulent motion. The cylinder is completely flushed out in the direct current and filled with fresh air. The exhaust gases flow out towards the outlet valve.

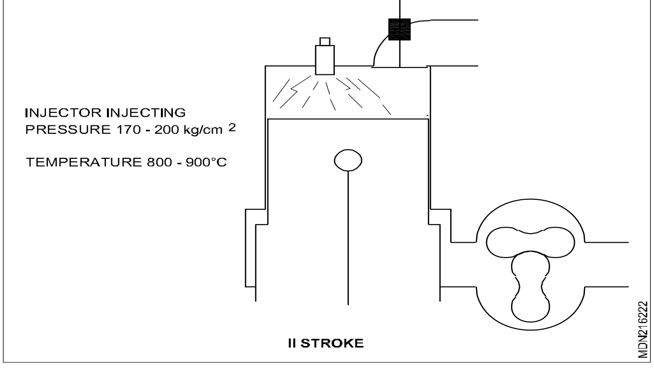
Fig 1



As the piston moves up from BDC the scavenging port and outlet valve closed. The piston compresses the fresh air to the compression chamber. The air temperature increases intensively.

Second stroke: Piston at TDC (Fig 2) scavenging port and outlet valve closed. The fuel is directly injected into the cylinder with the help of a fuel injection pump and an injector fitted in the cylinder head. The fuel gets vaporised into an ignitable fuel air mixture by the hot air. After attaining the ignition temperature the mixture gets automatically ignited and burns. The heat increases the pressure in the combustion chamber. The gases get expanded and push the piston to the bottom dead centre.

Fig 2



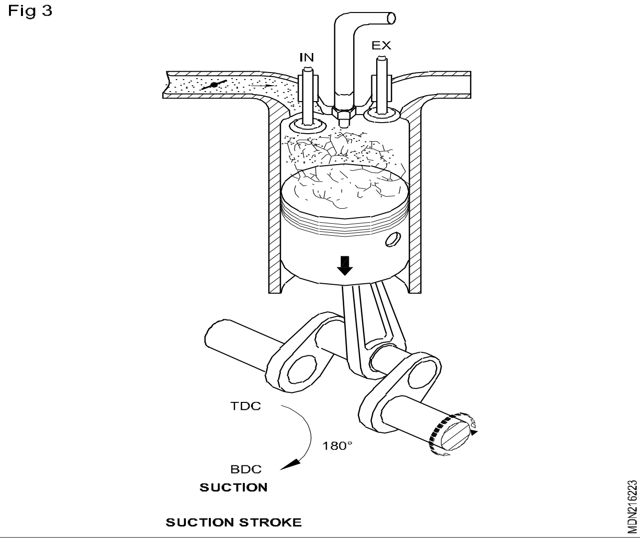
Four-stroke engine

To produce power in a four-stroke engine the following operations take place in the sequence given.

Suction stroke

The piston moves from TDC to BDC (Fig 3). A vacuum is created inside the cylinder. The inlet valve opens while the exhaust valve remains closed. The charge (air/air-fuel mixture) enters the cylinder.

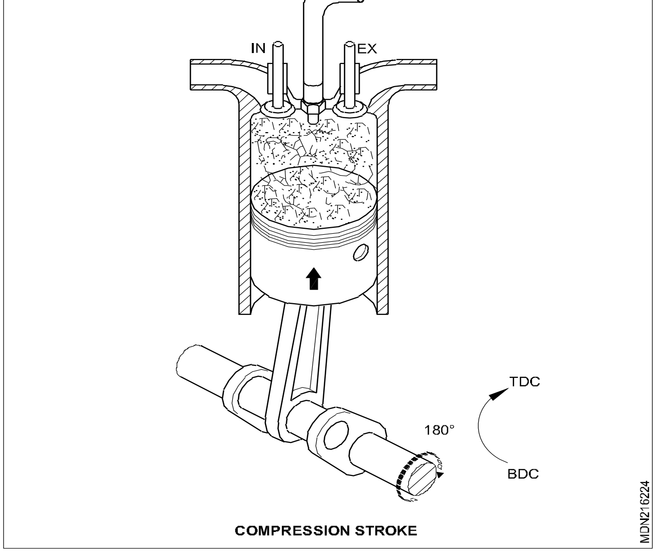
Fig 3



Compression stroke

The inlet valve closes. The exhaust valve remains closed. The piston moves from BDC to TDC (Fig 4). The charge (air/air-fuel mixture) is compressed.The pressure and temperature rise.

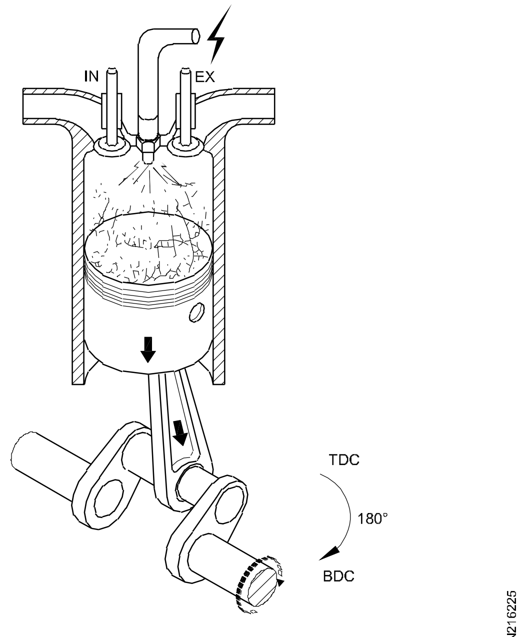
Fig 4



Power stroke

At the end of compression stroke diesel fuel is injected into the hot compressed air in the combusion chamber; result in instances burning of diesel with an explosion the gas expand for is the piston down and power is produced and pressure develops inside the cylinder. The gas expands and the piston is forced down from TDC to BDC (Fig 5). Both the valves remain closed. Power is supplied to the flywheel.

Fig 5



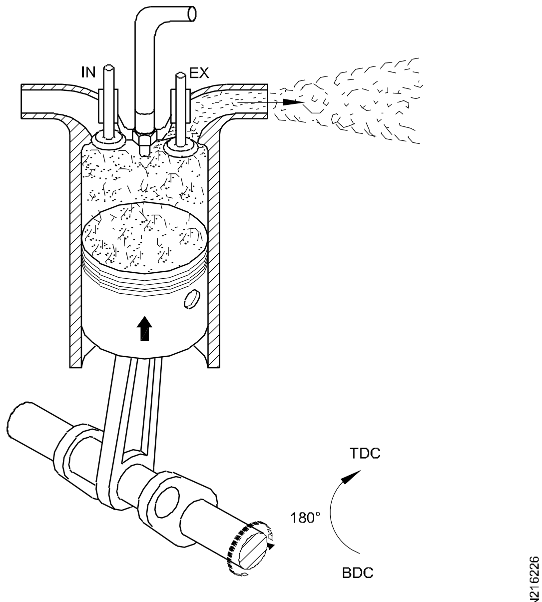
POWER STROKE

Exhaust stroke

The inlet valve remains in the closed position. The exhaust valve opens, the piston moves from BDC to TDC (Fig 6) due to the energy stored in the flywheel. The burnt gases inside the cylinder go out through the exhaust valves. At the end of the stroke the exhaust valve closes.

The cycle of suction, compression power and exhaust are repeated. In this type of engines one power stroke is obtained in two revolutions of the crankshaft.

Fig 6



EXHAUST STROKE

Function of spark ignition

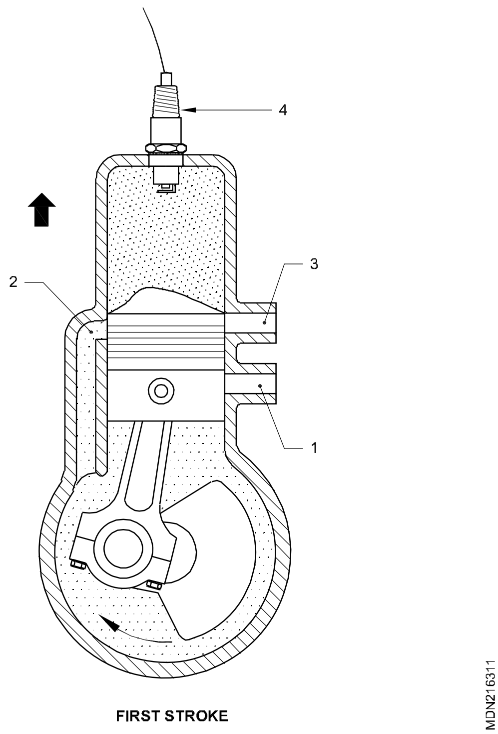
Objectives : At the end of this lesson you shall be able to
- **describe the function of a two-stroke engine**
- **describe the function of a four-stroke engine**
- **differentiate between a four-stroke and a two-stroke engine**
- **explain an OTTO cycle**
- **explain a diesel cycle.**

Two-Stroke spark ignition engines

To produce power in two stroke engine the following operations take place in the sequence given.

First stroke (Suction and compression)

Fig 1



FIRST STROKE

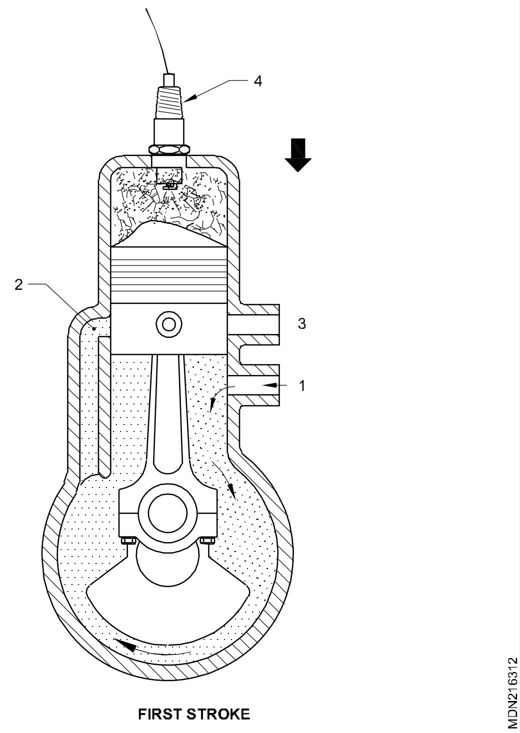
As the piston moves up from BDC,(Fig 1) it closes the inlet port (1), the exhaust port (3) and the transfer port (2). Further upward movement of the piston results in compressing the mixture in the cylinder and opening of the inlet port (1). The upward motion of the piston creates a partial vacuum inside the crank-case below the piston, and the air/fuel mixture is drawn into the crank-case through the inlet port (I). The exhaust and transfer ports remain closed during the operation of the upward stroke and the charge which reached above the piston during the previous stroke is compressed.

At the end of this stroke the mixture is ignited by an electric spark (4). This causes the pressure to rise.

Second stroke (power and exhaust)

The piston is forced downward from the TDC (Fig 2). During this stroke the exhaust port opens and burnt gases escape into the atmosphere.

Fig 2



FIRST STROKE

Further downward movement of the piston opens the transfer port and allows the partially compressed mixture, received during the previous stroke, to reach the combustion chamber from the crankcase.

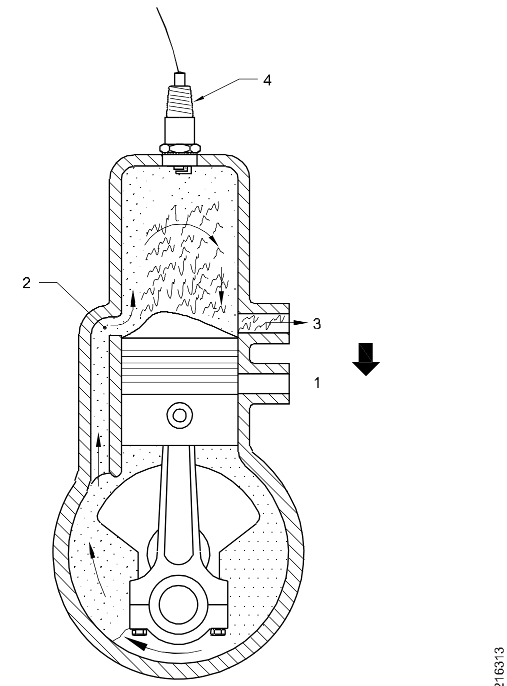
The piston head has a special shape. It deflects a fresh change of fuel mixture up into the cylinder. The mixture flows down and pushes the burnt gas out. Through the exhaust port. This process is called scavenging. Once the flywheel has completed one revolution, the cycle is repeated. In this engine one power stroke is obtained in each revolution of the crankshaft.

Spark ignition (Fig 3)

In a spark ignition (SI) engine, petrol is used as fuel. During the suction stroke the air and fuel mixture is sucked into the cylinder. The quantity of the mixture is metered by the carburettor according to the load and speed. The ratio of air/fuel mixture is also metered by the carburettor. During the compression stroke, this air/fuel mixture is ignited by the spark and the mixture is burnt. It raises the pressure of the gas above the piston. The piston is forced down and this power is supplied to the flywheel. During the exhaust stroke burnt gases escape through the exhaust port/valve.

In this type of engine the compression ratio is low.

Fig 3



SECOND STROKE

Four-stroke spark ignition engine

To produce power in a four-stroke engine the following operations take place in the sequence given.

Suction stroke

The piston moves from TDC to BDC (Fig 4). A vacuum is created inside the cylinder. The inlet valve opens while the exhaust valve remains closed. The charge (air/air-fuel mixture) enters the cylinder.

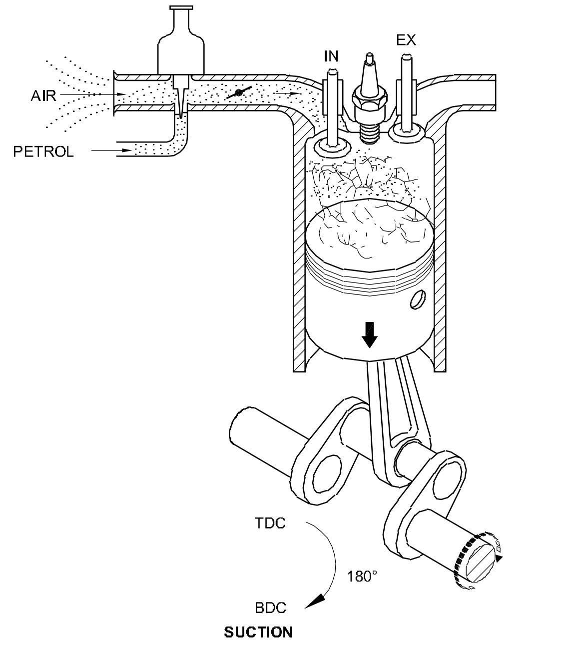
Compression stroke

The inlet valve closes. The exhaust valve remains closed. The piston moves from BDC to TDC (Fig 5). The charge (air/air-fuel mixture) is compressed. The pressure and temperature rise.

Power stroke

The charge is ignited and pressure develops inside the cylinder. The gas expands and the piston is forced down from TDC to BDC (Fig 6). Both the valves remain closed. Power is supplied to the flywheel.

Fig 4



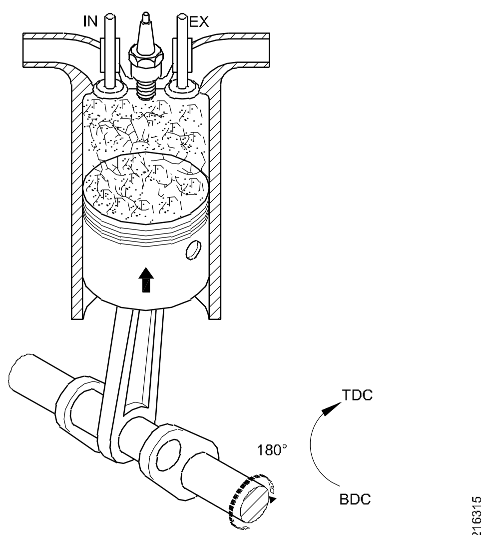
SUCTION STROKE

Exhaust stroke

The inlet valve remains in the closed position. The exhaust valve opens, the piston moves from BDC to TDC (Fig 7) due to the energy stored in the flywheel. The burnt gases inside the cylinder go out through the exhaust valves. At the end of the stroke the exhaust valve closes.

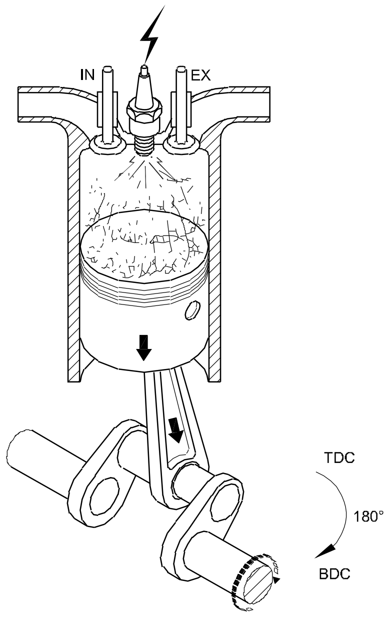
The cycle of suction, compression power and exhaust are repeated. In this type of engines one power stroke is obtained in two revolutions of the crankshaft.

Fig 5



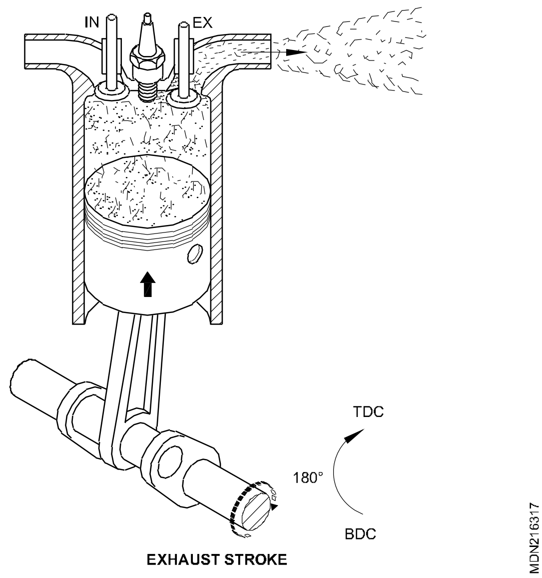
COMPRESSION STROKE

Fig 6



POWER STROKE

Fig 7



EXHAUST STROKE

Comparison between four-stroke engine and two-stroke engine

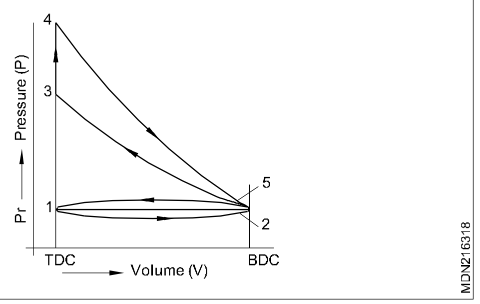
Four-stroke engine	Two-stroke engine
Four operations (suction, compression, power and exhaust) take place in the four strokes of the piston.	The four operations take place in two strokes of the piston.
It gives one power stroke in the four strokes, i.e in two revolutions of the crankshaft. As such three strokes are idle strokes.	The power stroke takes place in every two strokes i.e. one power stroke for one revolution of the crankshaft.
Due to more idle strokes and non-uniform load on the crankshaft, a heavier flywheel is required.	The engine has more uniform load as every time the piston comes down it is the power stroke. As such a lighter flywheel is used.
The engine has more parts such as valves and its operating mechanism. Therefore, the engine is heavier.	The engine has no valves and valve-operating mechanism therefore it is lighter in weight.
The engine is costlier as it has more parts.	The engine is less expensive as it has a lesser number of parts.
The engine efficiency is more as the charge gets completely burnt out. Consequently the fuel efficiency is more.	The engine efficiency is less. A portion of the chargescapes through the exhaust port, and because of this, the fuel efficiency is less.

Comparison between S.I and C.I. Engine

SI engine	CI engine
Petrol is used as fuel.	Diesel is used as fuel.
During the suction stroke air and fuel mixture is sucked in.	During the suction stroke air alone is sucked in.
Compression ratio is low. (Max. 10:1)	Compression ratio is high. (Max. 24:1)
Compression pressure is low. (90 to 150 PSI)	Compression pressure is high. (400 to 550 PSI)
Compression temperature is low.	Compression temperature is high.
It operates under constant volume cycle (otto cycle).	It operates under constant pressure cycle (diesel cycle).
Fuel is ignited by means of an electric spark.	Fuel is ignited due to the heat of the highly compressed air. Combustion takes place at constant pressure.
A carburettor is used to atomize, vaporize and meter the correct amount of fuel according to the requirement.	Fuel injection pumps and atomizers are used to inject metered quantities of fuel at high pressure according to the requirement.
Less vibration, and hence, smooth running.	More vibration, and hence, rough running and more noisy.
Engine weight is less.	Engine weight is more.
It emits carbon monoxide. (CO)	It emits carbon dioxide. (CO_2)

Otto Cycle

Fig 8



1 - 2 - Suction
2 - 3 - Compression
3 - 4 - Heat addition
4 - 5 - Power
5 - 2 - 1 - Exhaust

In otto cycle engine,(Fig 8) combustion takes place at constant volume.

Suction takes place at a pressure below atmospheric pressure when piston moves from TDC to BDC. (1-2)

Compression takes place when piston moves from BDC to TDC. (2-3)

Fuel mixture is ignited by introducing a spark at constant volume. (3-4)

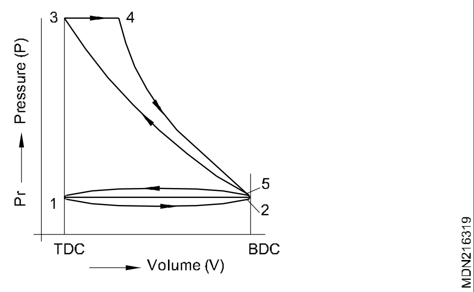
The gas expands during the power stroke (4-5), reducing both pressure and temperature.

Heat is rejected at constant volume. (5-2)

Burnt gases exhaust when piston moves from BDC to TDC. (2-1)

Diesel Cycle

Fig 9



1 - 2 - Suction
2 - 3 - Compression
3 - 4 - Heat addition
4 - 5 - Power

Suction takes place at (Fig 9) pressure below atmospheric pressure when piston moves from TDC to BDC. (1-2)

Compression takes place when piston moves BDC to TDC. (2-3) (Both the valves closed).

Fuel is sprayed at high pressure and ignited by hot compressed air (3-4), and this process takes place at constant pressure.

Fuel ignites, pressure of burnt gas increases, gas expands and piston is forced from TDC to BDC. (4-5)

Heat is rejected at constant volume. (5-2)

Burnt gases exhaust when piston moves from BDC to TDC. (2-1)

Main parts of Internal Combustion engine

Objectives : At the end of this lesson you shall be able to
- **location of an engine parts fitting.**

Internal combustion engine parts

Internal combustion engine's function is accomated with the different types of components and it is connected in outer JPG & inside of the engine.

Name of the components (Fig 1, 2 & 3)

1 Air compressor
2 F.I.P
3 Injector
4 Air cleaner
5 High pressure fuel
6 Fly wheel
7 Oil filter
8 Fuel filter
9 Fan belt
10 Alternator
11 Self starter
12 Water pump
13 Cam shaft
14 Inlet manifold
15 Exhaust manifold
16 Valve door (cover)
17 Rocker assembly
18 Push rod
19 Tappets
20 Cylinder head
21 Piston
22 Turning chain
23 Oil sump
24 Strainer
25 Fly wheel housing
26 Dip stick
27 Connecting rod
28 Crank shaft
29 Remove the timing gear and chain (22). (Notedown timing marks.)
30 Remove the cam shaft
31 Remove the oil sump (23)
32 Disconnect the oil pipes from the oil pump.
33 Remove the oil pump and strainer (24)
34 Remove the oil filter
35 Remove the connecting rod caps. (Note down Nos. on the caps)
36 Remove the piston (21) and connecting rod (27) from engine. (Note down the marks/Nos. on the piston)
37 Remove the main bearing caps. (Note down them No. on the caps)

Fig 1

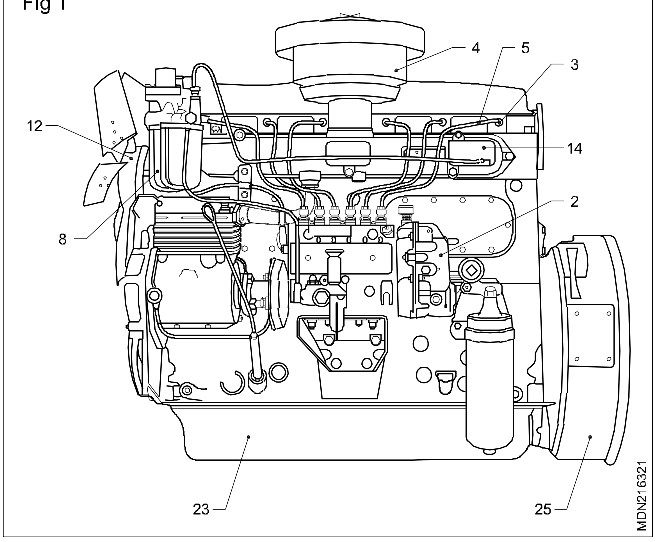


Fig 2

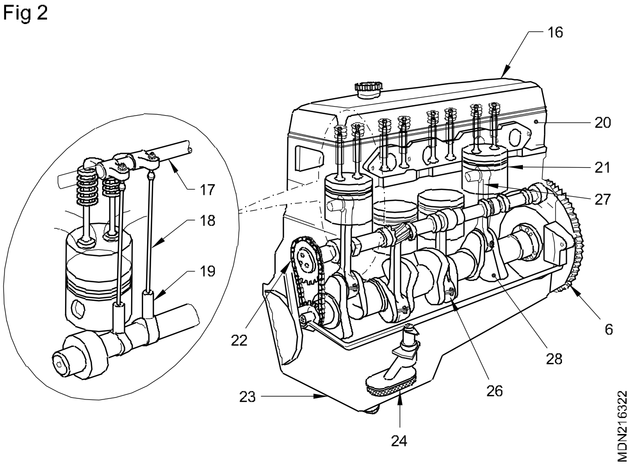
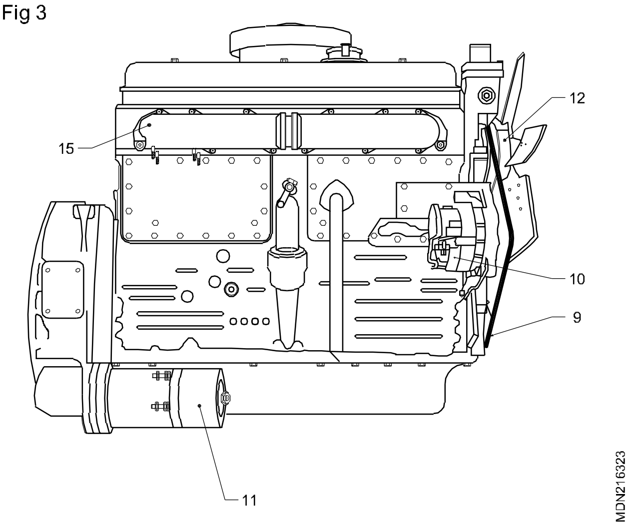


Fig 3



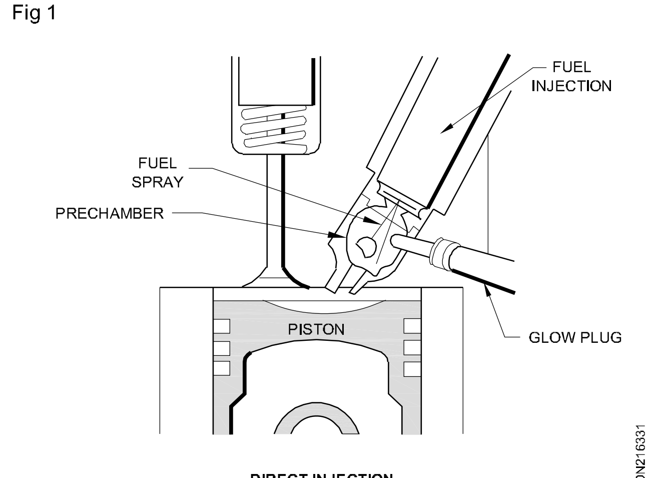
Direct and indirect fuel injection system

Objectives : At the end of this lesson you shall be able to
- **state the function of direct fuel injection**
- **state the function of indirect fuel injection.**

Direct Fuel Injection Works (Fig 1)

Gasoline engines work by sucking a mixture of gasoline and air into a cylinder, compressing it with a piston, and igniting it with a spark. The resulting explosion drives the piston downwards, producing power. Traditional indirect fuel injection systems pre-mix the gasoline and air in a chamber just outside the cylinder called the intake manifold. In a direct injection system, the air and gasoline are not pre-mixed. Rather, air comes in via the intake manifold, while the gasoline is injected directly into the cylinder.

Fig 1



DIRECT INJECTION

Advantages of Direct Fuel Injection

Combined with ultra-precise computer management, direct injection allows more accurate control over fuel metering, which is the amount of fuel injected and injection timing, the exact point when the fuel is introduced into the cylinder. The location of the injector also allows for a more optimal spray pattern that breaks the gasoline up into smaller droplets. The result is a more complete combustion - in other words, more of the gasoline is burned, which translates to more power and less pollution from each drop of gasoline.

Disadvantages of Direct Fuel Injection

The primary disadvantages of direct injection engines are complexity and cost. Direct injection systems are more expensive to build because their components must be more rugged. They handle fuel at significantly higher pressures than indirect injection systems and the injectors themselves must be able to withstand the heat and pressure of combustion inside the cylinder.

Indirect injection (Fig 2)

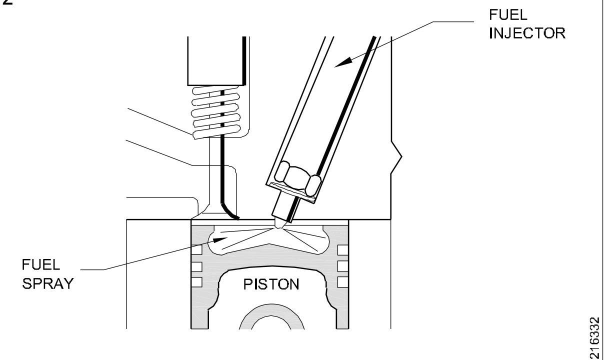
Indirect injection in an internal combustion engine is fuel injection where fuel is not directly injected into the combustion chamber. In the last decade, gasoline engines equipped with indirect injection systems, wherein a fuel injector delivers the fuel at some point before the intake valve, have mostly fallen out of favor to direct injection. However, certain manufacturers such as Volkswagen and Toyota have developed a 'dual injection' system, combining direct injectors with port (indirect) injectors, combining the benefits of both types of fuel injection. Direct injection allows the fuel to be precisely metered into the combustion chamber under high pressure which can lead to greater power, fuel efficiency. The issue with direct injection is that it typically leads to greater amounts of particulate matter and with the fuel no longer contacting the intake valves, carbon can accumulate on the intake valves over time.

Adding indirect injection keeps fuel spraying on the intake valves, reducing or eliminating the carbon accumulation on intake valves and in low load conditions, indirect injection allows for better fuel-air mixing. This system is mainly used in higher cost models due to the added expense and complexity.

Port injection refers to the spraying of the fuel onto the back of the intake port, which speeds up its evaporation.

An indirect injection diesel engine delivers fuel into a chamber off the combustion chamber, called a prechamber, where combustion begins and then spreads into the main combustion chamber. The prechamber is carefully designed to ensure adequate mixing of the atomized fuel with the compression-heated air.

Fig 2



INDIRECT INJECTION

Classification of indirect combustion chambers

- 3.1Swirl chamber
- 3.2Precombustion chamber
- 3.3Air cell chamber

Overview

The purpose of the divided combustion chamber is to speed up the combustion process, in order to increase the power output by increasing engine speed.[2] The addition of a prechamber, however, increases heat loss to the cooling system and thereby lowers engine efficiency. The engine requires glow plugs for starting. In an indirect injection system the air moves fast, mixing the fuel and air. This simplifies injector design and allows the use of smaller engines and less tightly toleranced designs which are simpler to manufacture and more reliable. Direct injection, by contrast, uses slow-moving air and fast-moving fuel; both the design and manufacture of the injectors is more difficult. The optimisation of the in-cylinder air flow is much more difficult than designing a prechamber. There is much more integration between the design of the injector and the engine.[3] It is for this reason that car diesel engines were almost all indirect injection until the ready availability of powerful CFD simulation systems made the adoption of direct injection practical.

Advantages of indirect injection combustion chambers

- Smaller diesels can be produced.
- The injection pressure required is low, so the injector is cheaper to produce.
- The injection direction is of less importance.
- Indirect injection is much simpler to design and manufacture; less injector development is required and the injection pressures are low (1500 psi/100 bar versus 5000 psi/345 bar and higher for direct injection)
- The lower stresses that indirect injection imposes on internal components mean that it is possible to produce petrol and indirect injection diesel versions of the same basic engine. At best such types differ only in the cylinder head and the need to fit a distributor and spark plugs in the petrol version whilst fitting an injection pump and injectors to the diesel. Examples include the BMC A-Series and B-Series engines and the Land Rover 2.25/2.5-litre 4-cylinder types. Such designs allow petrol and diesel versions of the same vehicle to be built with minimal design changes between them.
- Higher engine speeds can be reached, since burning continues in the prechamber.

Disadvantages

- Fuel efficiency is lower than with direct injection because of heat loss due to large exposed areas and pressure loss due to air motion through the throats. This is somewhat offset due to indirect injection having a much higher compression ratio and typically having no emissions equipment.
- Glow plugs are needed for a cold engine start on diesel engines.
- Because the heat and pressure of combustion is applied to one specific point on the piston as it exits the precombustion chamber or swirl chamber, such engines are less suited to high specific power outputs (such as turbocharging or tuning) than direct injection diesels. The increased temperature and pressure on one part of the piston crown causes uneven expansion which can lead to cracking, distortion or other damage due to improper use; use of " starting fluid" (ether) is not recommended in glow plug, indirect injection systems, because explosive knock can occur, causing engine damage.

Basic technical terms used in relation to engines

T.D.C. (Top dead centre)

It is the postion of the piston at the top of a cylinder, where the piston changes its direction of motion from the top to the bottom.

B.D.C. (Bottom dead centre)

It is the position of the piston at the bottom of the cylinder where the piston changes its direction of motion from the bottom to the top.

Stroke

The distance travelled by the piston from TDC to BDC or BDC to TDC.

Cycle

A set of operations performed in sequence by the motion of the piston in an engine to produce power.

Swept volume (VS)

Displacement volume of a piston.

Clearance volume (VC)

Volume of the space above the piston when it is at TDC.

Compression ratio (CR)

Ratio of compression volumes before the stroke and after.

$$CR = \frac{VS + VC}{VC}$$

where VS = Swept volume

VC = Clearance volume

VS+VC = Total volume at BDC.

Power

Power is the rate at which work is done in a specific time.

$$Power = \frac{(Force \times Distance\ moved)}{Time}$$

Horsepower (HP)

It is the measurement of power in SAE. One hp is the power required to lift a load of 33000 lbs, through one foot in one minute or 4500 kg through one meter in one minute (in metric system)

Thermal efficiency

It is the ratio of work output to the fuel energy burnt in the engine. This relationship is expressed in percentage.

Brake horsepower (BHP)

It is the power output of an engine, available at the flywheel,

$$BHP = \frac{2\pi NT}{4500}$$

where N is r.p.m of the crankshaft, and T is the torque produced.

Indicated horsepower (IHP)

It is the power developed in the engine cylinder.

$$IHP = \frac{PmLAN}{4500} \times K$$

Where Pm is the mean effective pressure in kg./cm².

L is length of stroke in metres

A is the area of the piston in cm²

N is the No. of power strokes per minute

K is the No. of cylinders.

Frictional horsepower

It is the horsepower lost in the engine due to friction.

FHP = IHP - BHP

Mechanical efficiency

It is the ratio of power delivered (BHP) and the power available in the engine (IHP). It is expressed in percentage

$$\text{Mechanical efficiency} = \ = \frac{BHP}{IHP} \times 100$$

Volumetric efficiency

It is the ratio between the air drawn in the cylinder during the suction stroke and the volume of the cylinder.

Throw

It is the distance between the centre of the crank pin to the centre of the main journal. The piston stroke is double the throw.

Firing order

The firing order is the sequence in which the power stroke takes place in each cylinder in a multi-cylinder engine.

Technical Specification of an engine

Engines are specified as per the following.

Type

Number of cylinders

Bore diameter

Stroke length

Capacity in cu.cm/cu.inch

Maximum engine output at specified r.p.m.

Maximum torque

Compression ratio

Firing order

Idling speed

Air cleaner (Type)

Oil filter (Type)

Fuel filter

Fuel injection pump

Weight of engine

Cooling system (type)

Type of fuel

Techincal specifications of vehicles

LPT - 1210 D

Specifications

Engine

Model	6692 D.I.
Number of cylinders	6
Bore	92 mm
Stroke	120mm
Capacity	4788 cc
Gross H.P. (S.A.E.)	125 at 2800 R.P.M.
Taxable H.P.	31.5
Maximum Torque	30 mkg at 2000 R.P.M
Compression Ratio	17 : 1
Compression pressure at 150-200 R.P.M.	Minimum 20 kg/cm^2
Fuel injection begins	23° before T.D.C.
Firing order	1-5-3-6-2-4
Opening pressure of the injection nozzles	200 + 10kg/cm^2 Newnozzels Min. 180 kg/cm^2 Used nozzels
Maximum variation permissible in injectionn: nozzle pressure	5 kg/cm^2
Inlect valve clearance	0.20 mm
Exhaust valve clearance	0.30 mm
Air cleaner	oil bath
Total bearing area per bearing	55 sq.cm
No.of main bearings	7
Fuel injection pump	MICO BOSCH
Weight (Dry)	382 kg

Capcity of cooling system	20 litres
Crankcase oil capacity	Maximum - 14 litres Minimum - 10 litres
Cooling water temperature	75°C - 95°C

Biasis

Raidator	Core frontal area..3500 sq.cm approx x551 (sq.in)
Clutch	Single plate dry friction type Diameter of clutch lining: Outside : 280 mm (11") Inside : 165 mm (61/2") Friction area (both sides) : 798 sq.cm approx (124 sq.in)
Transmission	No.of speeds: Forward 5 Reverse 1 Gear Ratio : 1st 7.37 :1 2nd 4.23 : 1 3rd 2.49 : 1 4th 1.56 : 1 5th 1 : 1 Reverse 7.15 : 1 Rear Axle ratio 7.48 - 1 : 6.8.57
Steering	Heavy duty re-circulating ball type steering with universal joint Gear Ration 34.2 :1 Steering wheel diameter 550 mm $\left(21\frac{5}{8}"\right)$
Brakes	Hand brake : Mehanically operated brake acting on rear wheel Foot brake : Hydraulic brakes on front and real wheels, assisted by single chamber air pressure booster. Brake drum diameter: Front : 408 mm (16") Rear : 408 mm (16") Total braking area Front : 1440 sq. cm approx (223 sq.in) Rear : 1440 sq. cm approx (223 sq.in)
Frame	Side member of channel section Depth max : 223 mm $\left(8\frac{3}{4}"\right)$ Width : 60 mm $\left(2\frac{3}{4}"\right)$ Thickness : 7 mm $\left(\frac{1}{4}"\right)$
Springs	No.of cross members : 8 Type : Semi-elliptical Composition of steel : silicon -manganese No.of leaves:

	Front	rear
Main	12	12
Auxillary	-	5

Leaf thickness

Main 11 mm $\left(\frac{3}{8}''\right)$ 13 mm $\left(\frac{1}{2}''\right)$

Auxillary —
Total thickness of spring with bottom plate:

132 mm $\left(5\frac{1}{6}''\right)$ 233 mm $\left(9\frac{3}{8}''\right)$

Width of spring leaf:

60 mm $\left(2\frac{3}{8}''\right)$ 80 mm $\left(3\frac{1}{6}''\right)$

Total weight of spring
50 kg. (123 lb) 123 kg. (271 lb)

Shock Absorbers Hydraulic telescopic type on fron and rear axles.

Wheels and tyres No.of wheels : Total 7 : Front 2, Rear 4, spare 1.
Rim size : 7.00 x 20
No.of Tyres : Toral 6 : Fron 2, Rear 4
Tyre size : 9.00 x 20 ... 12 ply EHD

Dimesions	LPT 1210D/36	LPT 1210D/42
Wheel base	3625	4225 mm
	$\left(142\frac{3}{4}''\right)$	$\left(166\frac{1}{4}''\right)$
Wheel track :		
Front	1925 mm	1925 mm
	$\left(75\frac{3}{4}''\right)$	$\left(75\frac{3}{4}''\right)$
Rear	1755 mm	1755 mm
	$\left(69\frac{1}{8}''\right)$	$\left(69\frac{1}{8}''\right)$

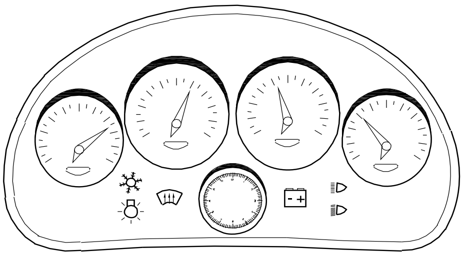
Dashboard gauges, meters and warnings lights

Objectives: At the end of this lesson you shall be able to
- **state different type of meters and their uses**
- **describe the purpose of each warning lights**
- **specify the purpose of each gauges.**

Odometer

An odometer (Fig 1) is an instrument that indicate distance travelled by a vehicle, such as motor cycle and motor vehicle automobile. The device may be electronic, mechanical, or a combination of both. It is also called as trip meter in case of short trips of every ride. The distance mentioned in the odometer generally in kms.

Fig 1



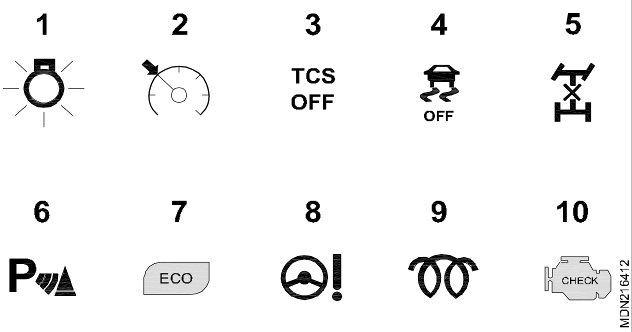
Speedometer

A speedometer or a speed meter is a gauge that measures and displays the instantaneous speed of a vehicle. The unit in which the display shown is in Km/hr. There are both analog and digital meters are available now a days.

Engine RPM meter

An engine rpm meter (Fig 2) is used to display the engine rotation in revolution per minute.

Fig 2



1 **Bulb indicator :** This shows you that you have a dead bulb. Not all cars have this, but it's a helpful warning.

2 **Cruise control indicator :** This indicator is used to display the accelerator opening level to maintain the set speed. This reminds you that cruise control is on.

3 **Traction control indicator :** This tells you the traction control is off. A blinking traction-control light indicates that the system is preventing wheel spin. In which case you should either; let off the gas a bit and drive a little slower; or let off the gas a bit and drive much slower.

4 **Stability control indicator :** This indicates that the stability control has been turned off. There's not much reason to turn it off on the road, and some cars can be dangerous in the wet without it. A blinking light indicates that the stability control system is actively preventing loss of control. If this happens, pay attention and stop trying to drive like an idiot.

5 **Centre differential lock (or 4Hi/Lo):** This indicates that the center differential on or car with part-time four-wheel drive has been engaged. We can't stress this enough; Part time all-wheel drive is not meant for on-road use, and running it on dry tarmac can cause "binding" and other problems. We've heard sob stories from dealerships where customers had to pay for costly repairs because the later didn't realize this.

6 **Proximity sensor indicator :** Some cars have proximity sensors all around instead of just the rear bumper. This helps you park your big, cumbersome vehicle in tight parking spots. It also makes for incessant buzzing as motorcyclists and pedestrians filter around you in traffic. Recognizing whether it's on or off can help prevent a nasty scrape.

7 **Econ indicator :** This can mean different things on different cars. Some cars use it to tell you that economy mode is engaged, which means that the accelerator and the transmission are in their most relaxed mode. On some cars with cylinder deactivation, this tells you that the system is turned on (typically when you're cruising or coasting), and half your cylinders are not burning gas at the moment. On other cars, this lights up when you are driving in an "economical" manner, and it can be used as a training tool for good, efficient driving. Other cars use color-changing dash lights for the same purpose. They're educational, helpful and rather cool.

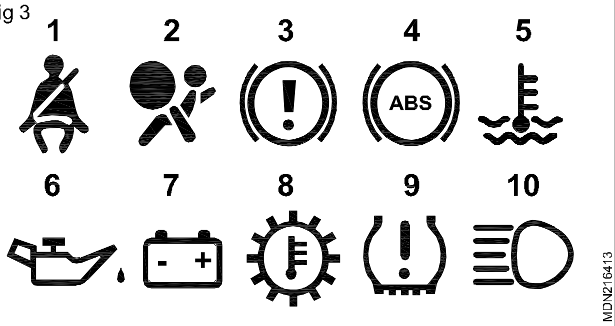
8 **Electric power steering indicator :** This indicates a fault in the EPS system. It could mean temporary overheating of the assist motor or a major fault in the system. Electric steering motors are usually compact, and violent sawing at the wheel can sometimes overtax them. This can happen when you're doing a 30-point turn in a tight garage, or when you're banging comes on a tight autocross. Best let things cool down and see if the problem goes away; otherwise, it's time for a checkup.

9 **Glow plug indicator :** Lacking spark plugs, diesels rely on pressure and heat to burn their fuel. As there's little heat in the motor when you first start it in the morning, glow plugs heat up the fuel coming out of the injectors to give the motor a better chance of starting. The light should turn on briefly after you switch the ignition to the 'on' position. Once it's off, the plugs are hot enough to start the car. A flashing light may indicate busted plugs, but some cars use the glow plug light as a catch-all indicator for problems ranging from bad injectors to exhaust gas recirculation valve issues. Get it checked as soon as possible.

10 **Check engine light :** We've saved the most crucial indicator for last. This is a confusing and often maddening-warning light. It can signal any number of issues or faults with the sensors and electronic equipment on the engine, some of which are serious, some of which are not. The most common cause is a busted exhaust oxygen sensor, which is bad for emissions but won't prevent your car from running. Other common causes include ignition coil and spark plug problems on gasoline cars, or an issue with any of the dozen-odd sensors that keep your engine happy. Even if you think it's nothing serious, don't ignore it. Have your car subjected to a diagnostic scan as soon as possible.

Mechanic motor vehicle/mechanic diesel

Fig 3



1 **Seatbelt indicator :** This one is easy. This indicates that the driver is not wearing the seatbelt. On newer vehicles, weight sensors in the seat tell the car if someone is sitting there, and warnings will appear for passengers, too. If the driver or passengers remain unbelted, a warning chime will sound. Don't ignore it. Studies show that seatbelt use reduces the chance of injury in a crash by 50%. Worse yet, being hit by an air bag with out your seat belt on can be fatal.

2 **Airbag indictor :** This signals a malfunction with the airbags or air bag sensor. This means that they may not go off in a crash. On some cars, there's also a passenger. Airbag off light that means the car has detected a small person in the front seat and has deactivated the front passenger airbag. This ensures that the (presumably short) front passenger doesn't suffocate or suffer a broken neck when the airbag goes off.

3 **Brake indicator :** This signals several things (Fig 3)

a Your parking brake is engaged, so disengage it;

b The parking brake sensor is out of alignment, so have it fixed;

c The brake fluid level is low

d The hydraulic pressure between the two braking circuits are mismatched. The last two are potentially dangerous, and could mean a possible fluid leak, as well as reduced or even completely absent braking performance.

Don't wait for the light to go off; check your fluid every morning before you go out, because sometimes the warning light comes on too late. Some newer cars also have a brake pad warning light that goes off if the pads need to be replaced.

4 **ABS indicator :** Some cars have a separate ABS light that signals a problem with the ABS system. If this goes off, that means that the Antilock Braking System has malfunctioned and the brakes may lock up under hard braking. Bring the car in for servicing immediately.

5 **Temperature warning :** Some older cars with temperature gauges merely have a red light, but many modern cars have this symbol. This indicates that your engine is overheating or is about to overheat. Best to pull over immediately to cool down, to avoid potentially expensive engine repair bills.

6 **Oil level/Pressure warning :** There's no genie in this lamp. Just the magic slippery stuff that keeps your engine lubricated. This typically signals your oil level is low by about two liters. No lasting damage should occur if you top off the oil the moment you see this warning. But if you ignore it, your motor could end up looking like a frying pen that's been left on the burner for a few hours. Not a pretty sight and a new engine is much more expensive than a new frying pan.

7 **Electrical system warning :** This one looks like a battery, which means battery problems. It could also mean alternator problems, so simply buying a new battery may not be enough. Thankfully, many shops can test the alternator's charging capacity when you go in for a battery replacement.

8 **Transmission warning light :** This comes in many different forms, and can indicate a malfunction with the transmission itself, the gearshift or transmission fluid overheating. You most often see this on trucks when you're hauling heavy loads, or in high performance cars with automatic transmission if you drive them a little too hard. Needless to say, pulling over to let the transmission cool down is a good idea.

9 **Tire pressure monitoring system :** This indicates either an issue with the TPMS itself or low pressure in one of your tires. Check immediately, Low pressure carry increased risk of blowout on the highway due to tire overheating.Not to mention the danger of hydroplaning in the rain, as wider tires slide over the water more easily than narrower ones.

10 **High beam indicator :** While not a warning light per se, this bright icon represents a big danger to other motorists, and is one of the most ignored indicators in the Philippines. Leaving your high beams on will blind other motorists and can lead to nasty accidents. Remember to turn them off when there's oncoming traffic or when driving behind another car.

You don't need to see the road 2km ahead when you can simply follow the other guy ahead of you.

You don't need to be a "car whisperer" to know something's wrong when your dashboard lights up like a Christmas tree. But knowing what these lights denote can mean the difference between a quick fix and a long walk home.

Gauges used in automobiles

Objectives: At the end of this lesson you shall be able to
- **explain the location of various gauges in a vehicle**
- **explain the purpose of a fuel gauge**
- **explain the working of a fuel gauge**
- **explain the purpose of a temperature gauge**
- **explain the working of a temperature gauge**
- **explain the purpose of an oil pressure gauge**
- **explain the working of an oil pressure gauge.**

The gauges indicate to the driver the working of the particular system to which they are connected. These gauges are located on the dashboard of the vehicle.

Some of the electrically operated gauges are the following.

- Fuel gauge (Balancing coil type)
- Temperature gauge (Balancing coil type)
- Oil pressure gauge (Balancing coil type)

Fuel gauge

Purpose

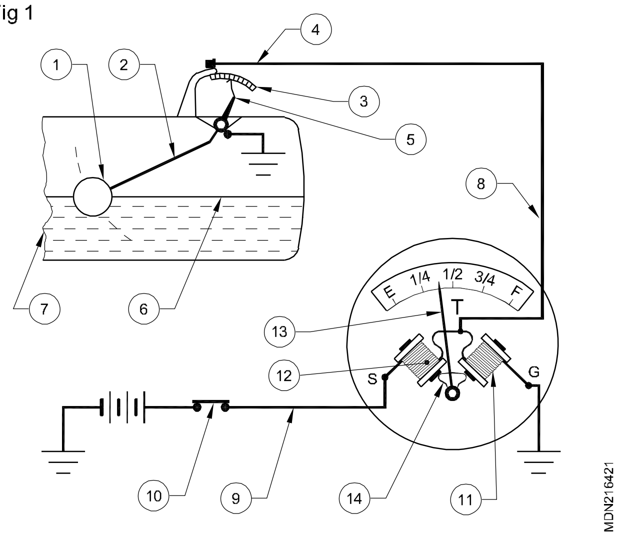
It is used to know the quantity of fuel available in the fuel tank.

Tank unit

It consists of a tank unit and the indicator unit (Fig 1). The two units are connected in series by a single wire to the battery through the Ignition switch. When the ignition switch is turned on, current passes through both the units.

The tank unit is fitted on the fuel tank and the indicator unit on the dashboard. The tank unit consists of a hinged arm with a float fitted at one end and a sliding contact at the other end and also a variable resistance. The sliding contact moves along the resistance. The float arm moves up and down as the level of fuel in the tank changes. The movement of the float arm changes the electrical resistance in the circuit.

Fig 1



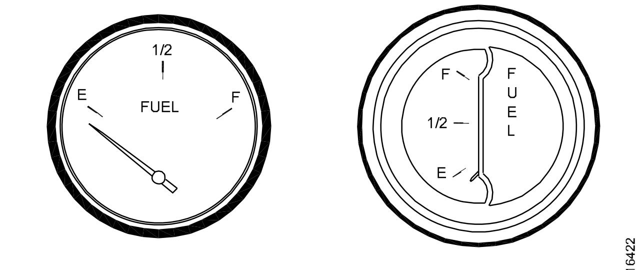
Gauge unit (Dash unit)

It is fitted on the panel board.

Two terminals (8) & (9) are connected to the tank unit's terminal (4) and ignition switch (10) respectively.

It consists of two coils (11) & (12) and a pointer (13) with the magnet (14) attached to it.

Fig 2



FUEL GAUGES

Working

When the ignition switch (10) (Fig 2) is on, current from the battery flows to the coils and a magnetic field is produced. When the tank (7) is full, the float (1) raises above and moves the sliding contact (5) to the high resistance position on the resistance coil (3). The current flowing through the coil (12) also flows through the coil (11). The magnetism of the coil (12) becomes weaker. The magnetism of the coil (11) thus becomes stronger and pulls the armature (14) and the pointer (13) to the full side of the dial. When the fuel level (6) comes down the float in the tank falls down and resistance also becomes less, thereby strengthening the magnetic field around coil (12) and forcing the armature and pointer towards the empty side of the dial.

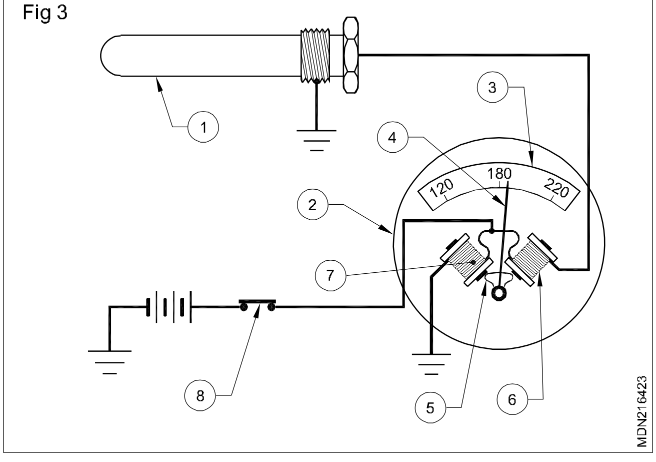
Temperature gauge

Purpose

It is used to know the temperature of water in the cooling system of engine at all times. It cautions the driver against overheating of the engine.

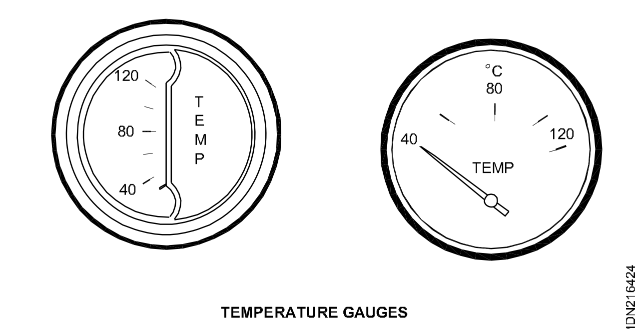
- It consists of an engine unit (1) immersed in the engine coolant in the cylinder head or cylinder block in the form of a pellet. (Fig 3)

Fig 3



- It is made of special material whose electrical resistance increases when temperature is lowered and it reduces when the temperature is increased.
- The resistance unit is provided with the dash unit (2) and it is fitted on the panel board.
- The dash unit consists of a dial (3) pointer (4), a magnet (5) and coil (6) and (7). (Fig 4)
- The two terminals of gauge are connected to the ignition switch (8) and the engine unit (1). The operating current is supplied from the battery through the ignition switch.

Fig 4



TEMPERATURE GAUGES

Working

When the coolant temperature rises, the engine unit becomes hot. When the engine unit temperature is high the resistance is less and more current passes to the right coil of the indicating units.

The difference in the strength of the magnetic field between the two coils increases and the armature and pointer move towards the right to indicate a high temperature.

When the engine coolant temperature falls down, the resistance becomes high. This results in less current flowing through the left coil, and the magnetic field becomes less and causes the armature and pointer to move towards the left to indicate lower temperature.

Oil pressure gauge

Purpose

This device is used to know the pressure of lubricating oil during the working of the engine and serves as a warning signal to the driver against any sudden failure of the lubrication system.

Types

- Bourdon tube type gauge (non-electric)
- Balancing coil type (electric)

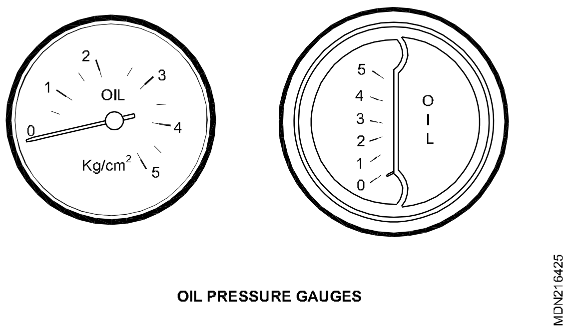
The Bourdon tube gauge is not widely used nowadays, as it has certain drawbacks i.e. the connecting tube leaks at joints.

In modern vehicles balancing coil type (electric) oil pressure gauges are used.

Working

It consists of two units (i.e) engine unit and the dash unit. (Figs 5 & 6)

Fig 5



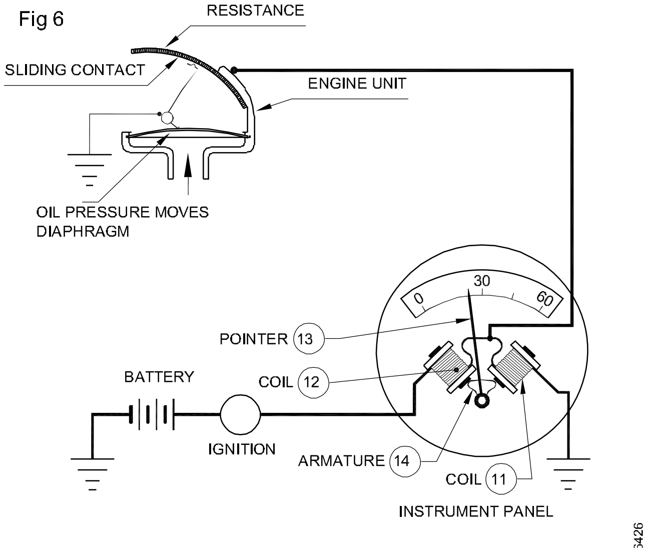
OIL PRESSURE GAUGES

The engine unit consists of a diaphragm, sliding contact, variable resistance.

The dash unit consists of two coils (11) & (12) and a pointer (13) with a magnet (14) attached to it. Both coils are connected in series with battery through ignition switch.

The increase in oil pressure pushes the diaphragm outward. This action results in increase in the resistance at the engine unit.

Fig 6



SCHEMATIC WIRING CIRCUIT OF A BALANCING -COIL OIL-PRESSURE INDICATING SYSTEM.

The right hand coil of the dash unit becomes magnetically stronger than the left hand coil.

Consequently the armature and the pointer swing towards the right side in indicate higher oil pressure.

Starting and stopping methods of engine

Objectives: At the end of this lesson you shall be able to
- **list out different ypes of engine cranking methods**
- **explain the different types of starting methods of diesel engine**
- **explain method of stopping the diesel engines.**

For starting the engine the following different methods are used.

1 Hand cranking

2 Electric Motor cranking

3 Hydraulic cranking motors

4 Compressed air cranking

5 Gasoline engine starting

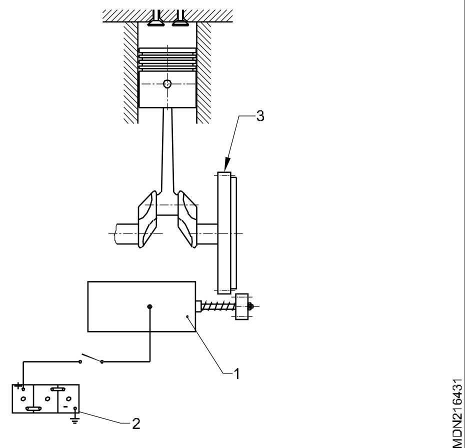
Hand cranking

Usually small diesel engines are being started using crank handle or rope.

Electric motor cranking

In this system a starter motor (1) is used to rotate flywheel (3) of the engine. A battery (2) is used to supply power to the starter motor. (Fig 1)

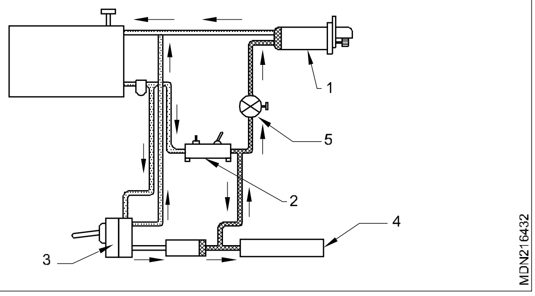
Fig 1



Hydraulic cranking motors

In this system hydraulic fluid under pressures passes through hydraulic starter motor (1) to rotate the engine flywheel. A hand pump (2) or an engine driven pump (3) is provided to create and develop pressure of fluid. This fluid under pressure accumulates in the accumulator (4). After pressing the starting lever, control valve (5) allows the hydraulic fluid under pressure to pass through the hydraulic starter motor. (Fig 2)

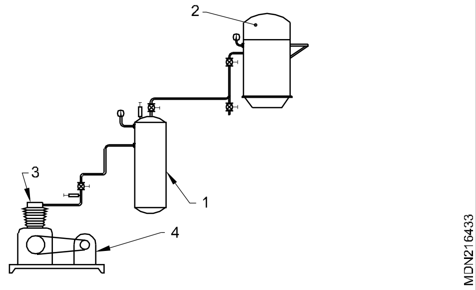
Fig 2



Compressed air cranking

In this method compressed air from the reservoir (1) is admitted through an automatic starting valve in the engine cylinder head when the piston is at the top dead centre at the beginning of the power stroke, at a pressure capable of cranking the engine (2). When the engine is turning fast enough, the injected fuel ignites and the engine runs on its own power, whereupon the air supply is cut off. An air compressor (3) is used to create air pressure. Air compressor (3) is driven by the engine or electric motor (4). (Fig 3)

Fig 3



Gasoline engine starting

This is used to start the heavy duty earth moving engines. Starting of the gasoline engine is done either by hand cranking or by an electric motor. The gasoline engine then cranks the heavy engine.

Generally diesel engines are stopped by cutting the fuel supply after reducing the engine speed to the minimum level.

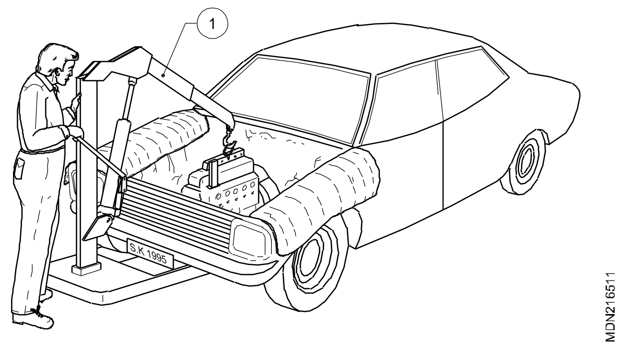
Procedure for dismantling of diesel engine from the vehicle

Objective: At the end of this lesson you shall be able to
- **remove the engine from the vehicle.**

Remove the engine from the vehicle

- Park the vehicle on a level surface.
- Choke all the four wheels with wooden blocks.
- Unscrew the bonnet mountings and remove it along with the grill.
- Disconnect the battery connections and take out the battery.
- Drain the radiator.
- Drain the engine oil.
- Remove the air cleaner.
- Remove the lower and upper hoses of the radiator.
- Remove the radiator mounting bolts/bracket bolts and remove the radiator without damaging the radiator core.
- Disconnect the wire connections of the starting motor, generator/alternator and heater plugs, oil pressure unit and other electrical connections to the dashboard instruments.
- Remove athe oil pipe to oil pressure gauge conenctions (if provided).
- Remove the exhaust pipe from the exhaust manifold. (The pipe hole to be covered by a cardboard to prevent foreign material getting into it.)
- Disconnect the fuel supply pipes at the feed pump, filter connectuons, fuel return lines to the tank.
- Disconnect the oil pressure and air pressure gauge connections.
- Disconnect the temperature gauge connections.
- Disconnect the accelerator connections.
- Remove the accelerator control shaft.
- Disconnect the engine stop connections.
- Remove the air compressor and its connections.
- Remove the clutch and gear linkages.
- Disconnect the propeller shaft at the gearbox end and support it at a convenient point on the chassis.
- Support the engine at the rear by wooden blocks.
- Disconnect gearbox mounting bolts and remove the gearbox with flywheel housing.
- Remove the dip stick.
- Fit a suitable engine lifting bracket.
- Align the left hook of the crane with engine lifting bracket.
- Support the engine at the front with wooden blocks.
- Remove the engine's mounting brackets and bolts and nuts.
- Attach the engine lifting bracket to the engine hoist (1).Fig 1

Fig 1



- Lift the engine slightly.
- Pull the engine forward until it comes out from the gearbox side.
- Lift the engine. Avoid oscillations and jerks. Ensure that the engine hoist does not shift/oscillate while removing it from the vehicle and does not hit the body of the vehicle or any accessories.
- Place it on a suitable workbench/engine stand. If placed on the floor, provide sufficient support below the front and rear brackets so that the engine does notmrest on the oil sump.

Description and constructional feature of cylinder head

Objectives: At the end of this lesson you shall be able to
- **state the constructional features of the cylinder head**
- **state the importance of cylinder head design.**

Cylinder head (Fig 1)

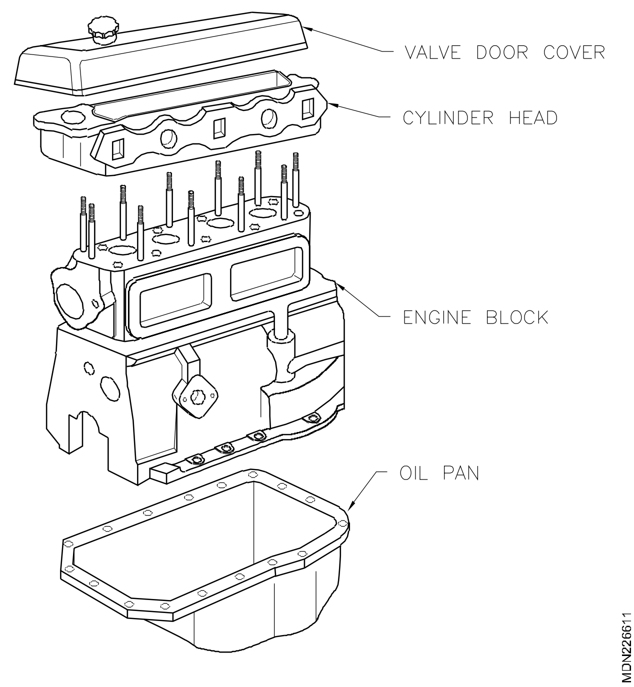
The cylinder head is made of a single casting. It is bolted on the top of the cylinder block. It has passages for oil and water circulation. It accommodates valves, spark plugs/ injectors (in the case of diesel engines) and heater plug. A combustion chamber is also provided in some cylinder heads. In the case of the overhead valve system, the cylinder head supports the rocker shaft assembly.

The lower surface of the cylinder head is machined to the specified accuracy and a gasket is used in between the cylinder head and cylinder block to avoid leakage.

The head also provided spaces for the passages that feed air, water fuel to the cylinder and that allow the exhaust to escape.

Material: Cast iron, aluminium alloy.

Fig 1



Types of cylinder heads

Four types of cylinder heads are used in an automobile engine as per the valve arrangements.

They are as follows.

In diesel engine fuel is injected into the combustion chamber against hight compressions pressure in the combusion chamber of the C.I. engine cyliner. The combusion depends upon the following factor.

- Fine atmization
- High temperature for quick ignitor
- High relative vabeity between air and fuel particles
- Good relative of air and fuel particles.

Atomization, prepearation and spreading of fuel depends on injection system, cylinder bore and stroke compression ratio and cooling system determine operating temperature miscing depends upon air intake system, injection pattern and combustion chamber design.

The design of combustion chamber plays an important part in the combustion process. In diesel engines, the following types of combustion chambers have been used.

a Open combustion chambers (Fig 2)

b Turbulence chambers (Fig 3)

c Precombustion chamber (Fig 4)

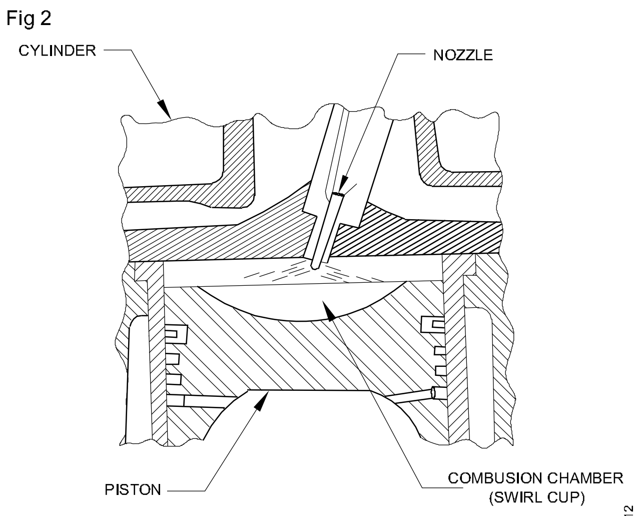
d Air cells (Fig 5)

e Energy cells (Fig 6)

a **Open combustion chambers :** An open type of chamber is that in which all thte air is contained in a single space at the time of injection. It is the simpest form of combustion chamber in which the injection nozzle sprays fuel direct into the combustion chamber. This arrangement is known as open system or direct injection system.

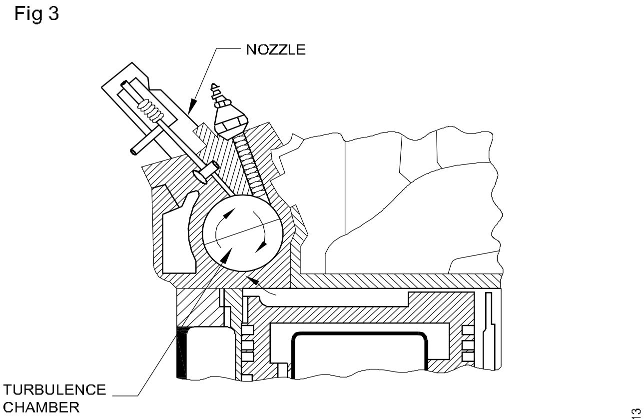
In this type of chamber, the fule motion is greater than air upon which the nature of combustion largely depends. In order to bring fuel and air together, the flat head pistion has been replaced by concave head pistion in modern engines. The deep cut-out swirl cup on the piston crown is being widely used.

Open system combustion chambers are widely used in medium and large-bore engines operating at low and medium speeds.



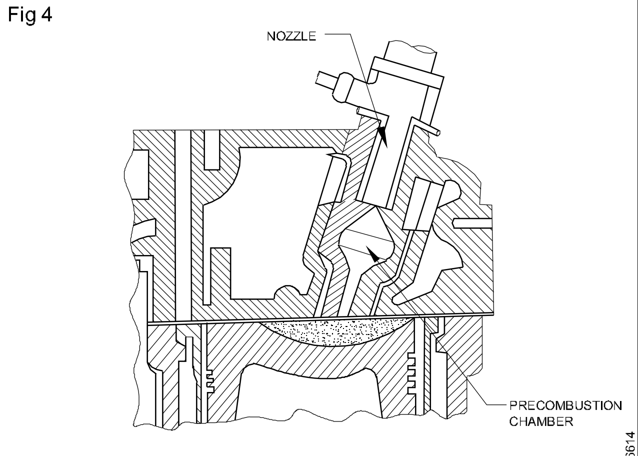
OPEN COMBUSTION CHAMBER WITH SWIRL CUP

b **Turbulence chambers:** In this type of chamber, the fuel is injected into an auxiliary chamber known as turbulence chamber with the cylinder by an orifice. The auxiliary chamber houses almost full charge at the end of compression and is nearly spherical in shape. The pistion forces air charge into the turbulence chamber and sets uo a rapid rotary motion. As the piston rises up, the velocity of air increases through the throat of orifice and reaches at the peak somewaht befre T.D.C. Near T.D.C. the injector nozzle injects fuel into the turbulent air currents which results in goold mixing during combusion.



TURBULENCE CHAMBER OF WAUKESHA DESIGN

C Precombustion chamber: This chamber is located at the cylinder head and is connected to the engine cylinder by small holes. It occupies 40% of the total cylinder volume. During the compression stroke, air from the main cylinder enters the precombustion chamber. At this moment, fuel is injected into the precombustion chamber and combustion begins. Pressure increases and the fuel droplets are forced through the small holes into the main cylinder, resulting in a very good mix of the fuel and air. The bulk of the combustion actually takes place in the main cylinder. This type of combustion chamber has multi-fuel capability because the temperature of the prechamber vaporizes the fuel before the main combustion event occurs.

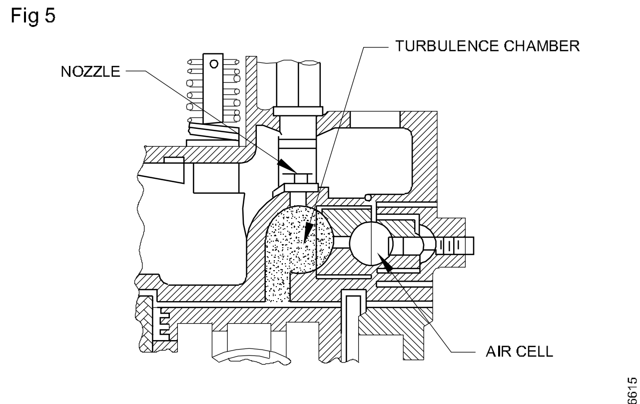


PRECOMBUSTION CHAMBER

d Air cells: Combustion chamber an air cell is a space provided in the cylinder head or pistion crwon in which a large part of air is trapped during compression. In air cell systems, the injector nozzle sprays fuel direct into the main chamber where combstion takes place.

When the piston moves down on its working or power stroke, air pressure is at its maximum in the cell and pressure in the main combusion chamber starts to fall down. The higher pressure in the air cell causes its air to expand and blow out into the main chamber. Thus an additional turbulence is created and complete combustion of fuel charge is ensured.

As a portion of air remains trapped without combustion in the cell so in improved designs, air cell is used in combination with turbulence or precombustion chamber to obtain better performance.

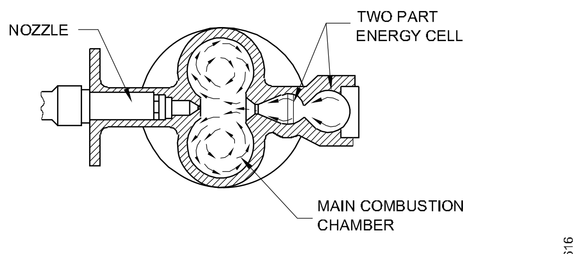


AIR CELL

e Energy cells: The difference between air cell and energy cell is that fuel is blown into the energy cell where it burns using air in the cell. In air cell system, thte cell simply stores and given up an air charge. The combusion in the energy cell creates a high pressure and grater turbulence and leaves no idle air in the cell.

The energy cell system consists of two rounded spaces cast in the cylinder head. The intake and exhaust valves open into the main combustion chamber. The horizontal the nozzle sprays fuel across the main chamber in the direction of energy cell mouth. While the fuel charge is passing across the centre of main chamber, nearabout half the fuel mixes with hot air and burns at once. The remaining fuel enters the energy cell and starts to burn there. At this point, the cell pressure rises rapidly, tending the combustion products to flow back into the main combustion chamber at a high velocity. As a result of this, a sharp swirling movement of fuel and air is set up in each lobe of main chamber, promoting final mixing of fuel and air and ensuring complete combustion. The two restricted openings of energy cell control the time and rate of expulsion of blast from energy cell into main combustion chamber.

Fig 6



ENERGY CELL

The energy-cell combustion systems fulfil the requirements of high speed engines and give high power output without high excessive pressures in the main combustion chamber.

Effect on size of intake and exhaust passages

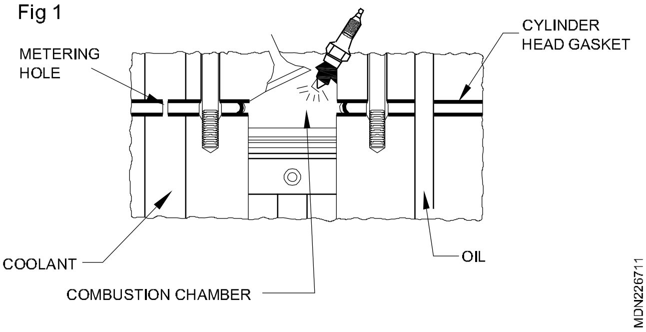
Objectives: At the end of this lesson you shall be able to
- **state the effect and size of intake of exhaust passages**
- **importance of cylinder head gasket**
- **types of cylinder head gasket materials.**

The size of inlet valve: Is too larger than exhaust valve. Beacuse they want to fill more quantity of Air/Fuel mixture (petrol) or Air (Diesel) in the conbustion chamber to requlate the engine efficiency. Beacuse engine efficiency depends upon VOLUMETRIC EFFICIENCY of an combustion chamber (Fig 1). There are two reasons behind the inlet valve larger than exhaust valve. One main reasin is to INCREASE THE VOLUMNETRIC EFFICIENCY OF AN ENGINE.Another one is acting pressure behind the inlet valve. Exhaust gas pressure only react to the face portion of the valve. But in an inlet valve, the inlet air pressure are reacted to the behind /Rear portion the inlet valve face & larger face can withstand this pressure without any damage. For that reason also the inlet valve face are designed to larger size than exhaust valve.

The main reason for the size difference is to avoid preignition and knoking.

Cylinder head gaskets: Form the most critical sela on an engine - between the cylinder head and the engine block deck.

Fig 1



The head gasket must seal combustion pressures up to 1,000 psi (689.5 kPa) in gasoline engines and 2,700 psi (1,862 kPa) in turbocharged diesel engines. In addition, the head gasket must withstand combustion temperatures that are in excess of 2,000°F (1,100°C).

The head gasket also must seal coolant and hot, thin oil flowing under pressure between the block and head. Modern coolant formulas and oil detergents and additives tend to cling to surfaces and soak into gaskets. Gaskets materials must be chosen carefully to resist these fluids and maintain an effective seal. many head gasket coolant holes also meter the coolant flow to ensure proper circulation.

Head gaskets must resist the forces that tend to scuff gasket surfaces and inhibit proper sealing. One factor is engine vibration and head sifting and flexing that result from combustion pressures.

Another factor is the differing expansion rates of bi-metal (aluminum head and cast iron block) engines. Aluminium expands about twice as much as cast iron . The uneven expansion rates create a shearing action that the head gasket must accommodate.

Head gaskets also must resist crushing from cylinder claiming forces that may be unevenly distrubuted across the head. These claiming forces run as high 200,000 lbs (90,800 kg).

The following materials are used in cylinder head gasker

1 Copper - as bestor gasket

2 Steel - as bestor - copper gasket

3 Steel - as bestor gasket

4 Single steel ridged gasket

Valves

Objectives: At the end of this lesson you shall be able to
- **describe the function of the engine**
- **state the constructional features of valves**
- **list out the different types of valves and their material.**

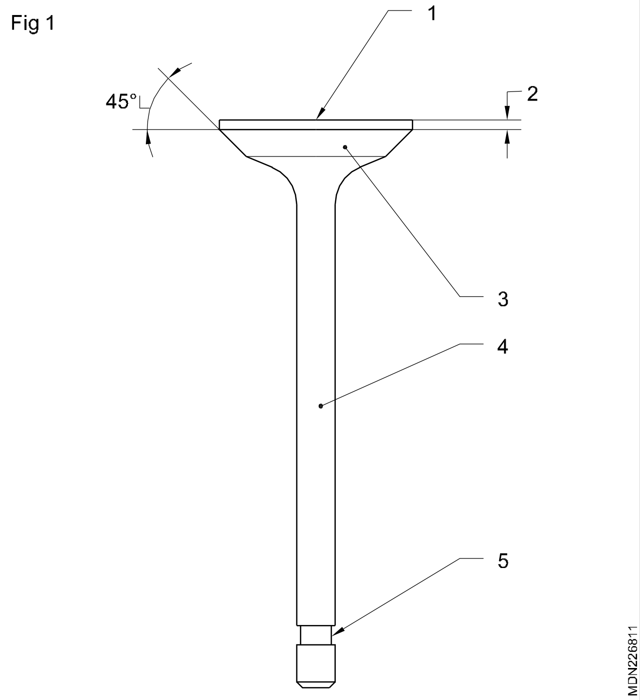
Functions of valves

- To open and close the inlet and exhaust passages of the cylinder.
- To dissipate heat, through its seat to the cylinder head.

Construction of a valve

The head (1) of the valve is ground with a margin (2) to provide strength. (Fig 1)

Fig 1



The valve face (3) is ground to 30° or 45° angle which matches with the seat angle to avoid leakage. The valve stem (4) is of a round shape. The length of the stem varies from engine to engine. At the end of the stem a groove (5) is provided to hold the spring lock.

In some heavy duty engines, the valves are hollow, and sodium is filled inside, which helps in the quick cooling of the valve.

Types of valves

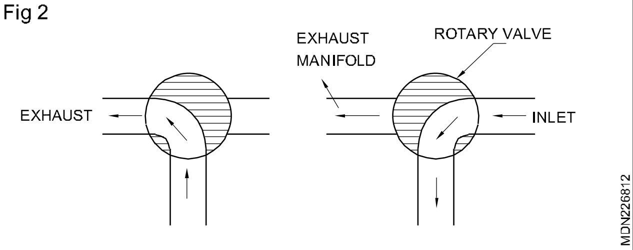
- Poppet-valves
- Rotary valves
- Reed valves
- Sleeve valves

Poppet-valves

As the name indicates these valves pop on their seat. Three types of poppet-valves are in use.

- Standard valve
- Tulip valve
- Flat top valve

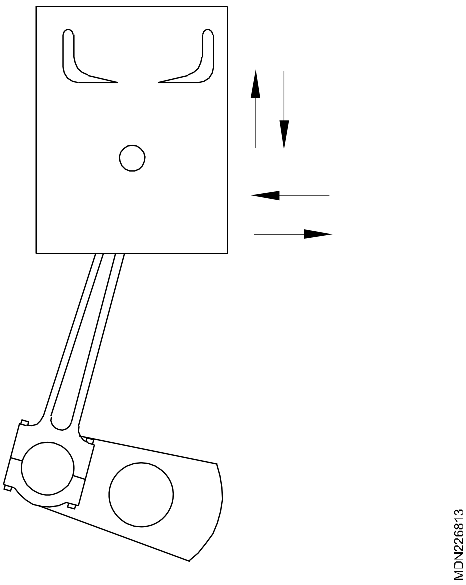
Fig 2



Rotary valve

In this type a hollow shaft runs in the housing which is attached to the cylinder head. This hollow shaft has two ports cut in it, and it aligns the opening in the cylinder head with the inlet manifold, and at the time of the exhaust stroke its opening aligns with the exhaust manifold. (Fig 2 & Fig 3)

Fig 3



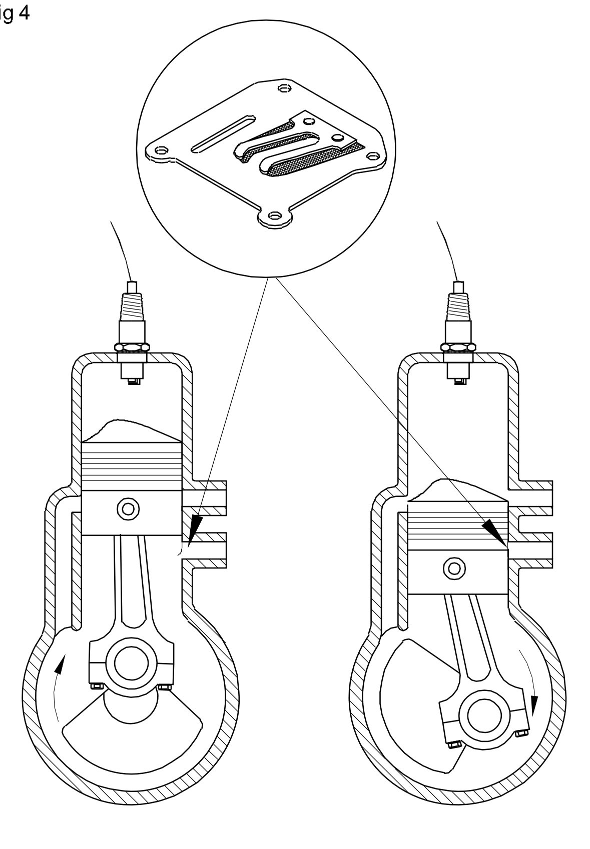
Reed valve

It is a metallic strip hinged at one end. It covers the passages and allows air or charge to flow in one direction only. It is normally used in two-stroke engines and air compressors. (Fig 4)

Sleeve valve

In this type, ports are cut in the cylinder liner. It runs with a slight up and down motion. It is also having rotary motion in another sleeve. This aligns with the inlet and exhaust ports at a set time when the inlet and exhaust manifold open.

Fig 4



valve operating mechanism

Objectives: At the end of this lesson you shall be able to
- **state the requirements of valve operation**
- **state the types of value operating mechanism**
- **list out the parts of the valve mechanism**
- **state the importance of value seats**
- **method of value seats insets in cylinder heads.**

Requirements for valve operation

1 Valve must seat tightly and properly on its seat.

2 Value must be properly timed.

3 Value must be operate without log.

4 Value tappet clearance must be correct.

5 Valve steam and guide clearance must be correct.

Value operating mechanisms

Two types of value operating mechanism are used in engines. They are as follows.

- Slide valve mechanism

- Overhead valve mechanism

In overhead valve mechanism, the position of camshaft is considered as the types of valve mechanism i.e.,

1 Single overhead camshaft mechanism

2 Double overhead camshaft mechanism

Side valve mechanism (Fig 1): In the side value mechanism both the inlet and exhaust valves are fitted in the cylinder block.

Overhead valve mechanism (Fig 2): In this mechanism, the valves are located in the cylinder head. Push-rods and rocker arms are used in addition to the side valve mechanism.

Working

When the cam shaft rotates, the cam lobe (1) lifts the tappet (2) upward. When the tappet (2) moves up, it pushes the push-rod (3) and one end of the rocker arm upwards. The other end of the rocker arm's (4) tip, moves downward and the valve (5) opens against the spring's (6) tension.

Fig 1

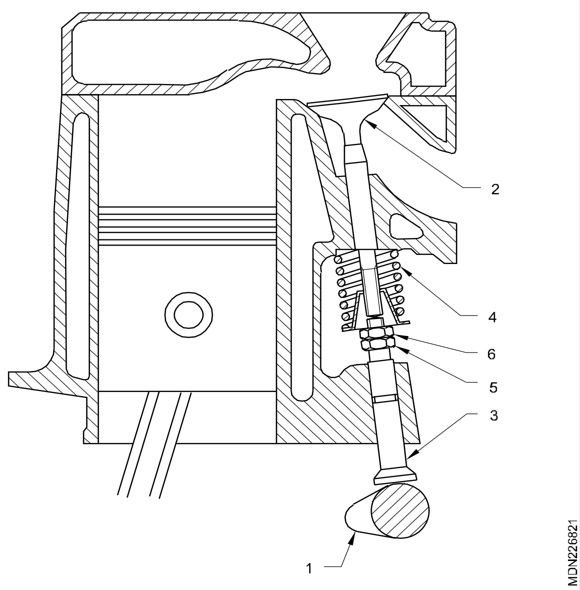
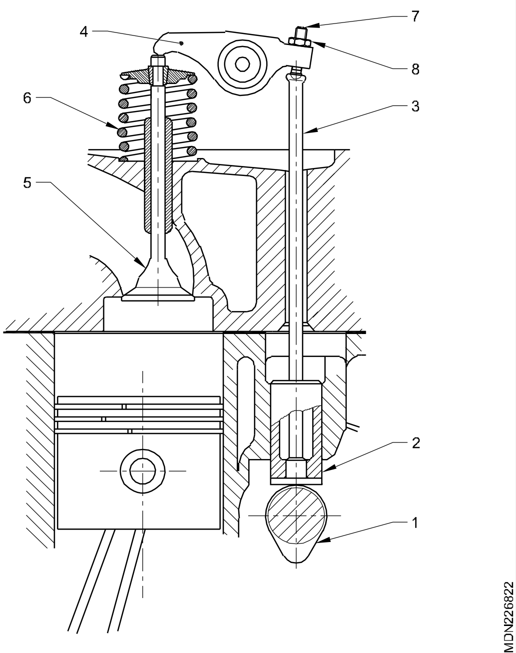


Fig 2



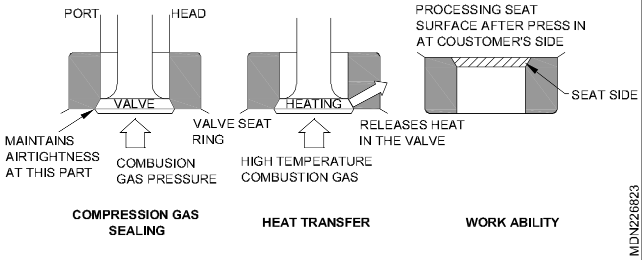
Wen the cam lobe (1) reaches the maximum height, the valve opens fully. Further rotation of the cam shaft causes the tappet (2) to move down and the valve is closed by the tension of the spring (6).

Tappet clearance is provided in between the valve (5) tip and the rocket arm's (4) tip. This clearance can be adjusted by the adjusting screw (7) and the lock-nut (8).

In many cases, even these rockers or followers (Fig 3) and their pivots are dispensed with and the valves are actuated directly by the camshaft (Fig 4) through bucket type.

Importance of value seats: Valve and valve seats are ground to correct and shape so that the valve may seat properly on the seat for effective valve seating and seating. The value face angle must be match the value seat angle. Value seating and sealing is closely realted to the engine performance.

Fig 3



Function of value seats

1 Compression gas sealing prevents compressed gaseous bodies and combustion gas from leaking into the manifold.

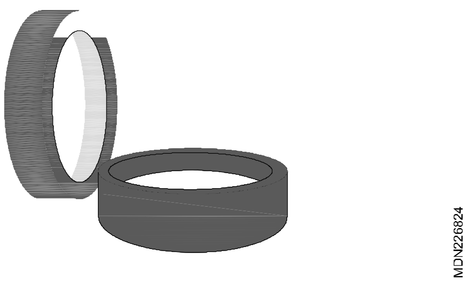
2 Heat transfer releases heat in the valve to the cylinder head.

3 Strength holds tight when the valve is mounted.

4 Wear-resistance hard to wear down under high heat and high load.

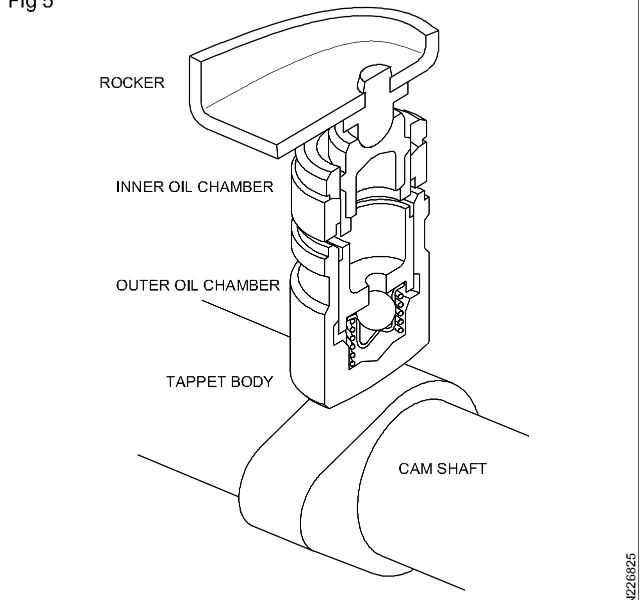
Importance of vale seats inserts in cylinder head

Fig 4



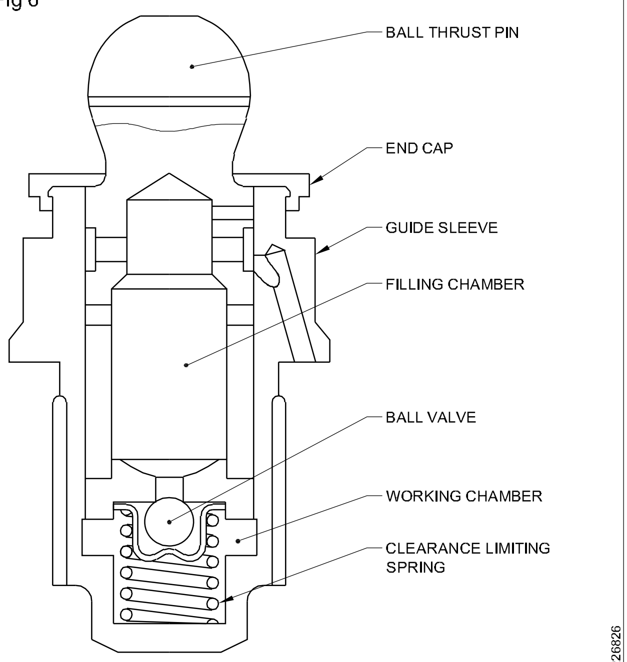
Hydraulic tappet : Hydraulic tappets (Fig 5) enable the valve gear to operate without fixed clearances. They consist of the tappet body, the tappet pistion, a ball valve with spring and the clearance eliminating spring. When the engine is running, lubricating oil from the oil from the oil pump is forced through an oil way to the tappet. It flows through the outer chamber (to lubricate the tappet itself) and hence to the inner chamber (plunger lubrication) and to the interior of the piston. By way of a filling bore, the oil passes through the ball (check) valve to the pressure chamber. The clearance eliminating spring (Fig 6) forces the tappet piston to prevent any valve clearance from occuring. When the camlifts the tappet, the ball valve closes and the oil-filling the pressure chamber acts as an almost rigit link. Thermal expansion of valve gear componets is compensated for by precisely calculated oil loss as a result of tappet piston operating clearance. Although hydraulic tappets are heavier and therefore suffer from increased inertia, this drawback can be compensated for an engines which operate the valves by followers from the overhead camshaft. On these engines, the hydraulic clearance adjuster an be installed in the follower mount instead of in the tappet; it is of similar design to the hydrualic tappet just described.

Fig 5



HYDRAULIC TAPPET

Fig 6



CLEARANCE ELIMINATING ELEMENT

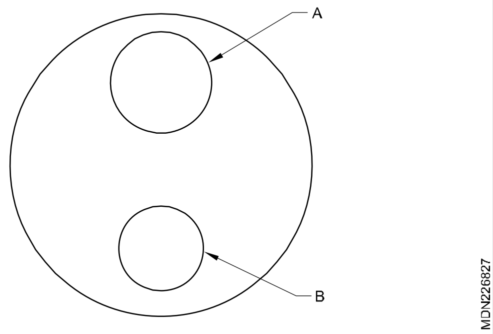
Types of valve arrangement

1 Two valve arrangement in one cylider Fig 7

A One inlet valve

B One exhaust valve

Fig 7

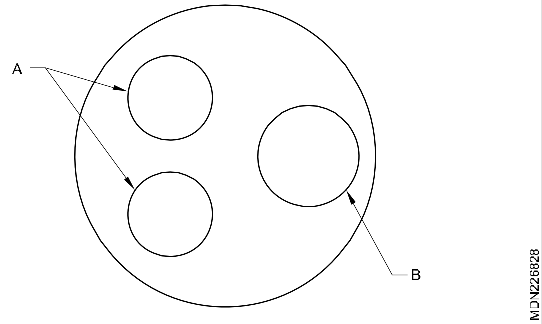


2 Three valve arrangement in one cylider Fig 8

A Two inlet valves

B One exhaust valves

Fig 8

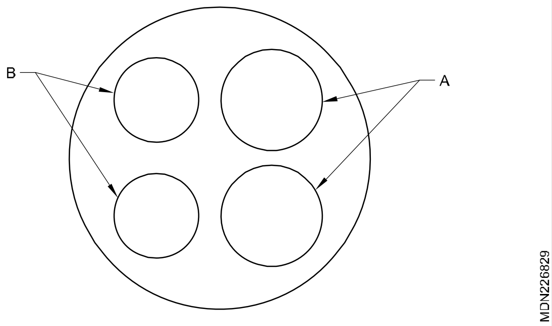


3 Four valve arrangement in one cylider Fig 9

A Two inlet valves

B Two exhaust valves

Fig 9

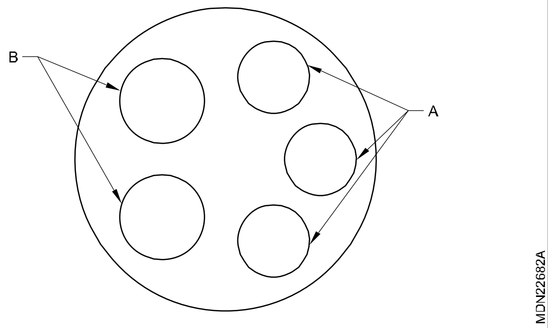


4 Five valve arrangement in one cylider Fig 10

A Three inlet valves

B Two exhaust valves

Fig 10



Valve contructional features and valve timining

Objectives: At the end of this lesson you shall be able to
- **state the function of valve rotation**
- **state the function of valve stem oil seals**
- **state the size of intake value**
- **describe the valve trains**
- **explain valve tunning**
- **concept of variable valve timing.**

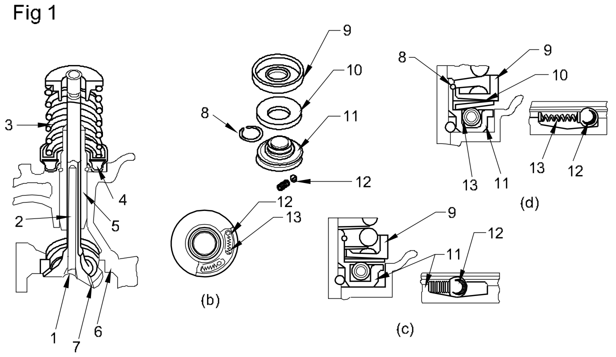
Valve rotation

The main scope of the value and tappet rotation is to reduce the wear, the friction and to increase the life period of the components and maintain the conical value face and seat clean of carbon or soot deposit that might appear on surfaces during valve opening. To uniform the thermal stress of the value head because of the asymmetry exhaust mainfold and uniform the wear of the conical face providing a good scaling of the cylinder.

If the valve is rotating the contact point between value head and seat will varying and in this way the wear marks or crank can be avoided.Value rotation is the uniformity of the oil film in the valve guide on the valve stem. Auxilary rotation system is rotate the value during opening or closing period on those systems components are rotocap, turnomat, rotocoil, rotomat, duomate.

The tapper rotation reduce the wear caused by the contact with the , improves the lubrication of those two surfaces and increases the tapper lift.

Fig 1



VALVE MECHANISM OF AN AUTOMOBILE ENGINE

(a) EXHAUST VALVE COMPELETE WITH VALVE ROTATOR:
(b) VALVE ROTATOR:
(c) VALVE ROTATOR POSITION WITH CLOSED VALVE:
(d) VALVE ROTATOR POSITION WITH OPEN VALVE:

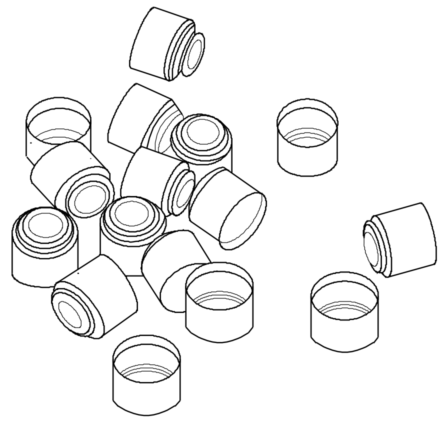
1-STOPPER
2-HOLLOW VALVE STEM
3-VALVE SPRING
4-VALVE ROTATOR
5-VALVE GUIDE
6-INSERT VALVE SEAT
7-VALVE FACE
8-SNAP RING
9-SEATING COLLAR
10-FLEXIBLE WASHER (CONE SPRING)
11-VALVE ROTATOR HOUSING
12-STEEL BALL
13-RETURN SPRING

MDN226831

Function of value stem oil seal

The purpose of the value stem oil seal is to prevent the oil form the cylinder head entering the combusion chamber value stem seals play a critical role in controlling value lubrication as well as oil consumption.

Fig 2



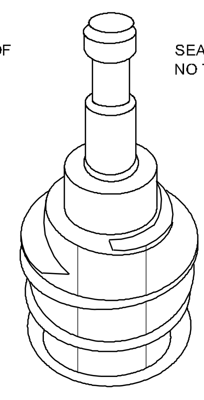
VALVE STEM OIL SEAL

MDN226832

Fig 3

SEAT #3 DOES FIT INSIDE OF SPRING WHEN ON GUIDE

SEAL #4 FIT THE SAME BUT NO TEFLON



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Causes the engine suck will down the guides and into the cylinder

- Seal worn
- Seal cracked
- Scal missing
- Seal broken
- Seal improperly installed

When stem oil seals lose thier ability to control the oil that enters oil though the gude, that can cause a variety of problem.

- Excessive smoke
- High oil consumption
- Carbon deposited in valve and piston
- OFF - throttle braking
- Idel run stop running engine

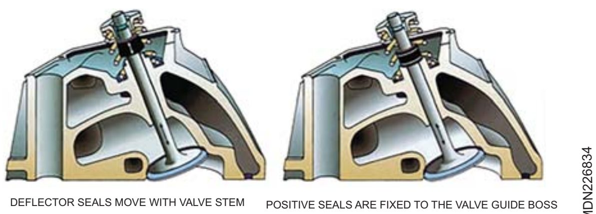
Vaue train: The valve train of an internal combustion engine includes components required to control the flow of gases into and out of the combustion chamber values and related component required to allow the air or air fuel mixture to enter the combustion chamber, the combustion cahmber during compression and combustion and evacuate exhaust gases when combustion is compete valve train used for a reciprocating engine depends on the engine design and whether the engine is a four /two stroke cycle unit.

There are two basic valve stem seal designs

1 Deflector seals - also called umbrella seals, deflect oil away from the valve stem. They are secured to the valve stem and move with the valve to shield the valve guide from excess oil. Umbrella type seals were commonly used prior to the development of positive type seals.

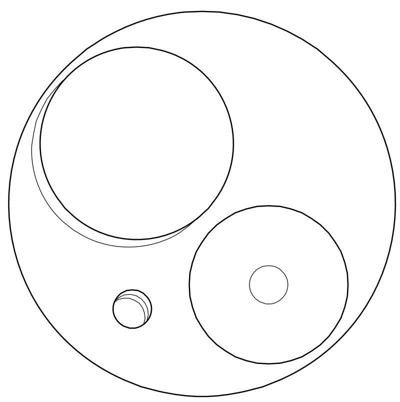
2 Positive seals - attach to the valve guide boss and function as squeegees, wiping and metering oil on the stem as they pass through the seals.State the size of in take valve State the size of intake valve

Fig 4



State the size of intake valve

Fig 5



In order to get adequate air flow into the glinders inlet valve need enough opening with bigger diameter of valve because over come air flow restriction, reduce the intake air heat, allow excess air for complete the combustion to increase the volumetric efficiency and scavanging effect. For exhaust, because you have the pistion during out the exhaust using higher positive pressure so don't need quite as big of valves.

Valve timing

Each manufacturer specifies the timings of the opening and closing of the valves as per the design of the engine to give the maximum output under all loads and speeds.

The opening and closing of the valves in an IC engine in relation to the movement of the piston and flywheel is called valve timing.Fig 6

The opening and closing of the valves exactly at TDC & BDC do not improve the volumetic efficiency of an engine. Burnt gases also are not driven out fully.

Practically, the valves are arranged to open early and close late to fill the cylinder fully and to allow all burnt gases to escape from the cylinder.

Inlet valve

Lead

Inlet valves are made to open certain degrees earlier than T.D.C. This enables aur/air fuel mixture to fill the cylinder to its capacity. It also helps in scavenging burnt gases by using the momentum of intake air/air fuel mixture.

Lag

Inlet valves are made to close certain degrees after B.D.C. to increase the volumetric efficiency by allowing more charge.

Exhaust valve

Lead

Exhaust valves are made to open certain degrees earlier tham B.D.C.

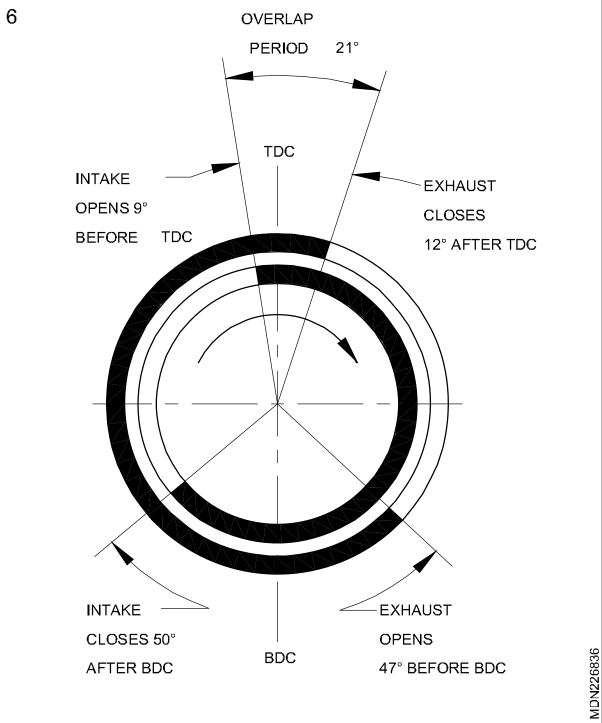
Lag

Exhaust valves are made to close certain degrees after T.D.C. to develop a suction effect by the outgoing gases. It also helps in the scavenging of the exhaust gases by using the intake charge's momentum.

Overlap period

At the end of the exhaust stroke and the beginning of the suction stroke, both the valves remain open for certain degrees. This period during which both the valves remain open is called the valve overlap.

Fig 6



Graphical representation of valve timing

The valve timing is represented by a diagram drawn on the face of the flywheel in defrees of the crankshaft rotation.

Valve timing (Jeep)

- Inlet valve open 9 degrees before T.D.C.
- Inlet valve closes 50 degrees after B.D.C.
- Exhaust valve opens 47 degrees before B.D.C.
- Exhaust valve closes 12 degrees after T.D.C.
- Over lap period 21 degrees

Valve timing varies from one make of engine to another valves are exposed to various chemical, mechanical and thermal stresses during operation. They must maintain their basic shape and dimensions throughout the expected life of the engine. In addition. the integrity of the sealing surface of the valve and mating valve seat is critical to durability and performance. Engineers determine the valve material, shape, specifications, and surface coatings to match the specifica engine family, expected operating environment, and projected length of service. Valves commonly used in small engines are classified as one-piece, projecton-tip welded, or two-piece-stem welded-stem valves.

Variable valve timing (VVT)

Basic theory

After multi-valve technology became standard in engine design, variable valve timing becomes the net step to enhance engine output, no matter powe or torque.

As yoi know, valves activate the breathing of engine. The timing of breathing, that is, the timing of air intake and exhaust, is controlled by the shape and phase angle of cams. To optimse the breathing, engine requires different valve timing at different speed. When the rev increases, the duration of in take and exhaust stroke decreases so that fresh air becomes not fast enough to enter the combustion chamber, while the exhaust becomes not fast enough to leave the combustion chamber. Therefore, the best solution is to open the inlet valves earlier and close the exhaust valves later. In other words, the overlapping between intake period and exhaust period should be increased as rev increases.

With variable valve timing, power and torque can be optimised across a wide rpm band. The most noticeable results are:

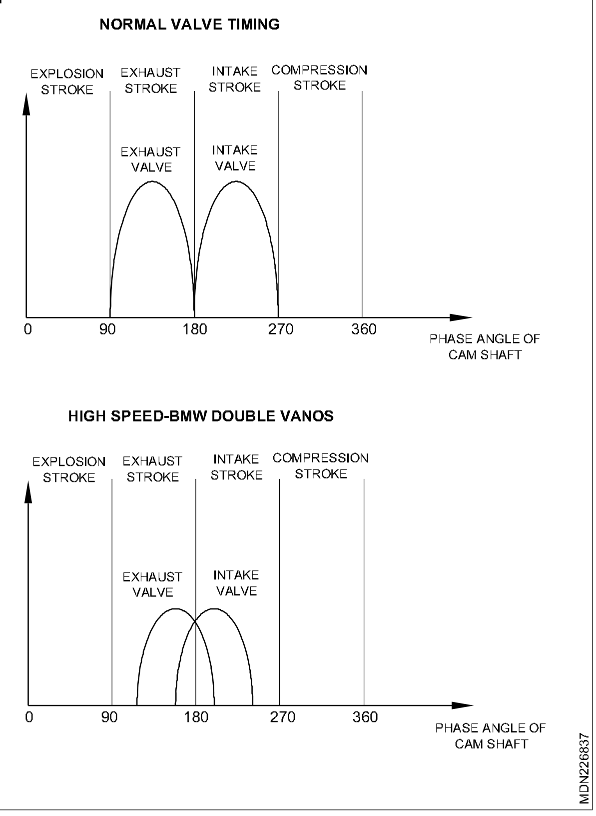
- The engine rev higher, thus raises peak power. For example, Nissan's 2-litre neo VVl engine output 25% more peak power than its non-VVT version
- Low -speed torque increases, thus imporves drivability. For example, Flat barchetta's 1.8 VVT engine provides 90% peak trorque between 2,000 and 6,000 rpm.

Moreoer, all these benfits come without any drawback.

Variable lift

In some designs, valve lift can also be varied according to engine speed. At high speed higher lift quickness air intake and exhaust, thus further optimise the breathing. Ofcourse, at lower speed such lift will generate counter effects like deteriorating the mixing process of fuel and air, thus decease outpur even leads to misfire. Therefore the lift should be variable according to engine speed.

Fig 7



Cam-changing VVT

Honda pioneered road car-used VVT in the late 80s by launching its famous VTEC sysem (Valve timing electronic control).

It has 2 sets of cams having different shapes to enable different timing and lift. One set operates during normal speed, say, below 4,500 rpm. Another substitutes at high speed.

However, cam-changing system remains to be the most powerful VVT, since no other system can vary the Lift of valve as it does.

Example - Honda's 3-stage VTEC

Cam-phasing VVT

Cam-phasing VVT is varies the valve timing by shifting the phase angle of camshafts. For example, at high speed, the inlet camshaft will be rotated in advance by 30° so to enable earlier intake. This movement is controlled by engine mangement system according to need, and actuated by hydraulic valve gears.

Camshaft

Objectives: At the end of this lesson you shall be able to
- **state the function of the camshaft**
- **state the constructional features and material of the camshaft.**

Functions of the camshaft

The camshaft is used to convert the rotary motion into reciprocating motion with the help of the cam lobe. This reciprocating motion is transmitted to the valve through the tappet, push-rod and rocker levers. The camshaft is driven by iron shaft and it rotates half the speed crankshaft. The camshaft also drives the oil pump shaft. In petrol engines the fuel pump and the distributor get their drive from the camshaft.

Construction of the camshaft

The camshaft (2) (Fig 1) is either forged or cast with the cam lobes (1) one for each valve. The camshaft has a series of support bearings along its length.

Fig 1

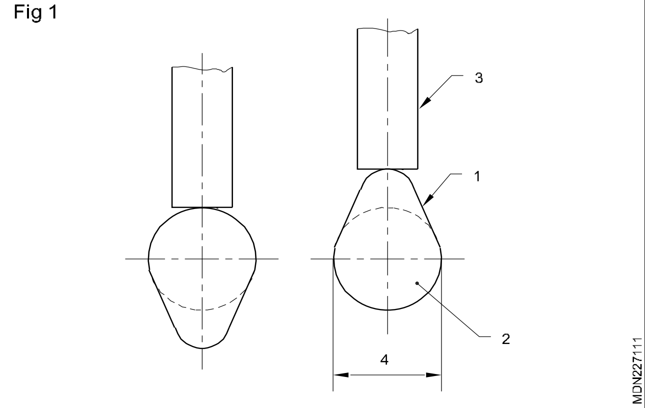
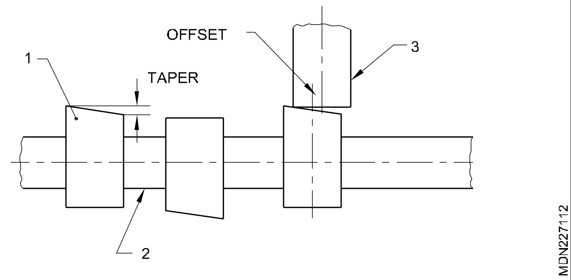


Fig 2



The cam surface (Fig 2) is hardened for longer life. In some engines the axis of the tappet/lifter (3) is slightly offset from the axis of the cam lobe (1). This off set gives a little rotation to tappet/lifter, when it moves up. So the bottom of the tappet/lifter (3) wears out uniformly. The lifter/tappet (3) rests on the cam lobe (1). The lifter (3) remains in its position on the base circle (4). When the cam rotates the lobe lifts the lifter (3).

Material for camshaft

Forged alloy steel

Camshaft drive mechanisms

Objective : At the end of this lesson you shall be able to
- **state the different types of camshaft drive mechanisms.**

The camshaft gets the drive from the crankshaft and rotates at half the crankshaft speed, since each valve opens once in every two revolutions of the crankshaft. There are three types of camshaft drive mechanisms.

- Gear drive
- Chain drive
- Belt drive

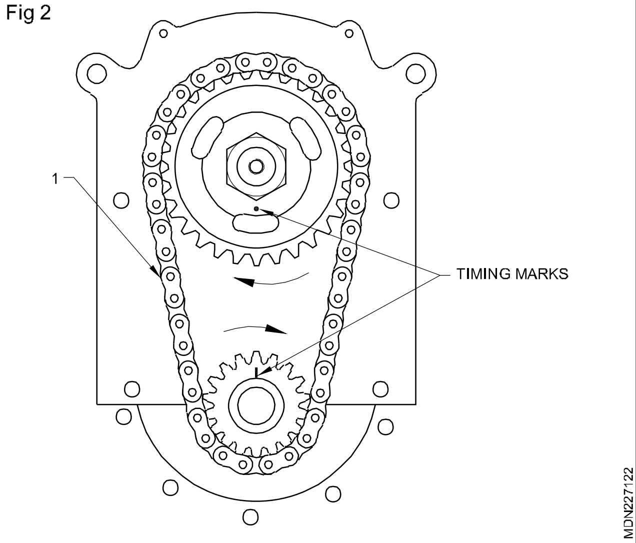
Gear drive

This direct drive (Fig 1) P No 58 is used where the crankshaft and the camshaft are very close to each other. Since the r.p.m. of the camshaft is half of the crankshaft speed, the camshaft gear (1) teeth is twice as many as the crankshaft gear (2) teeth. In this, the engine's camshaft rotates in the reverse direction of the crankshaft. In some engines an idler gear is used to have the same direction of rotation for the crankshaft and the camshaft.

Chain drive

The timing gear sprockets (Fig 2) are driven by a chain (1). Hence this drive is called a sprocket drive. The direction of rotation of the crankshaft and camshaft is the same. It is used when the distance between the crankshaft and the camshaft is more. No idler gear is used in the chain drive.

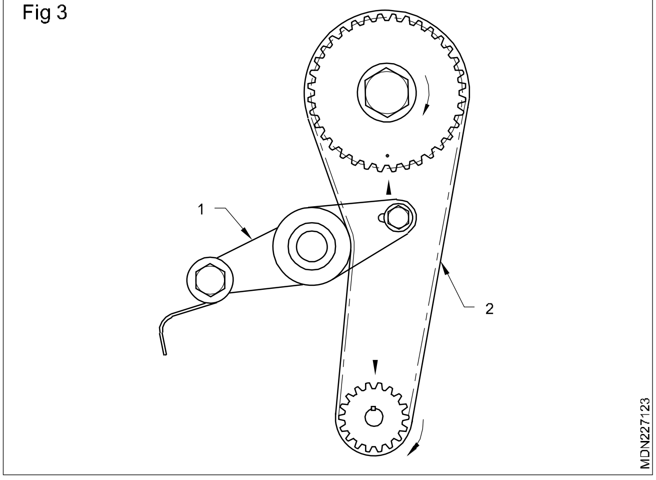
Fig 2



Belt drive

This drive (Fig 3) is similar to a chain drive. Instead of a chain a belt (2) is used to drive the camshaft. The belt drive is mostly used in overhead camshaft design. The direction of rotation of the camshaft and crankshaft is the same. An automatic belt tensioner (1) is used to avoid slipping of the belt.

Fig 3



Cam shaft calssification

Cam shaft are clssified based on its location and number of shafts

1 Bottom mounted traditional cam shaft (OHV Engine)

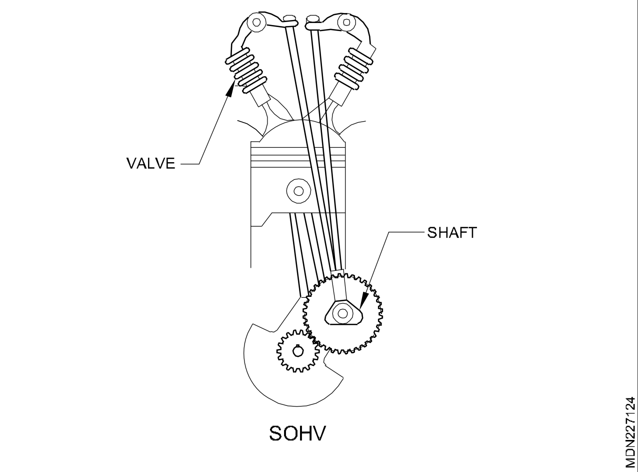
2 Over head cam / Single over head cam shaft (OHC / SOHC)

3 Doube over head cam shaft (DOHC)

The main disadvantages of an OHV design is that it'sdifficult to control precisely the valve timing at high rpm.

Advantages of an OHV engine include lower cost, proven durability, low-end torque and compact size. OHV design is better suited for slow speed engines. In heavy duty engines iffers higher torque at lower rpms. (Fig 4)

Fig 4

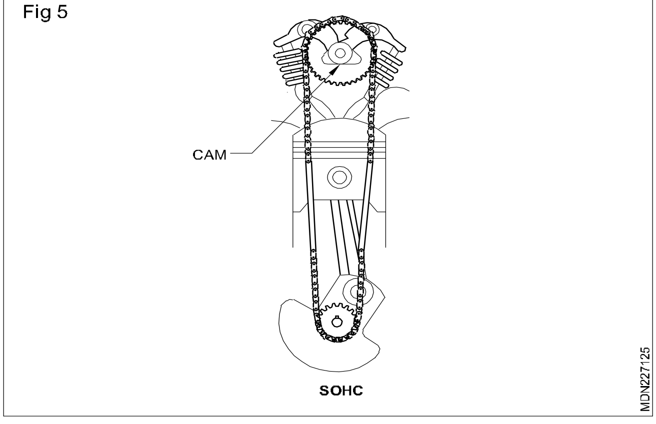


Over head cam/single over head cam shaft (OHC/ SOHC) (Fig 5)

OHC means over head cam in general, while SOHC means single over head cam or single cam. In SOHC engine the camshaft is installed in the cylinder head and valves are operated either by the rocker arms or directly through the lifters.

The main advantage of an OHC design is that valves are operated almost directly by the camshaft, which makes it easier to maintain precise timing at higher rpms. It's also possible to install three or four valves per cylinder.

Fig 5



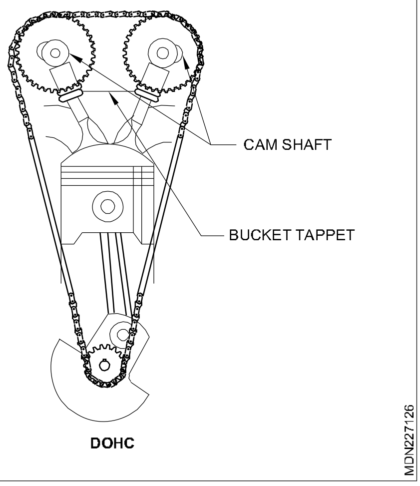
Double over head cam shaft (DOHC) (Fig 6)

DOHC means double over head cam. Most modern vehicles have DOHC engines. DOHC engine has two camshafts and 4 valves per cylinder. One camshaft operates intake, while another camshaft controls exhaust valves. This allows the intake valves to be at a larger abgle from the exhaust valves, so the vlumetric efficieency increases and produces more horse power out of smaller engine voulme.

The main advantage of the DOHC design allow th technologies like direct injection, variable valve timing and variable valve lift cab be easily implemented in a DOHC engine, further improving fuel efficiency.

The main disadvantage of the DOHC technology inclides a larger size and more compex design with additional timing belt or chain components. A timing belt needs to be replaced at recommended intervals, adding to maintenance costs.

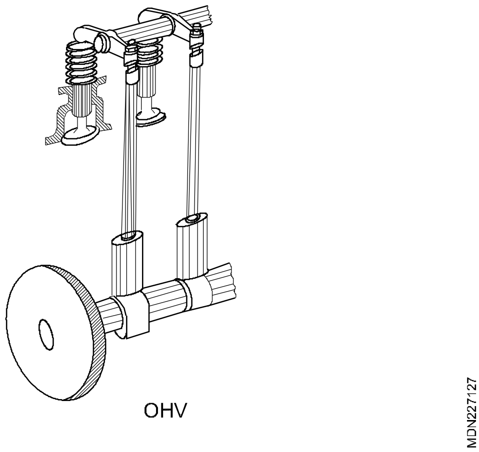
Fig 6



Bottom mounted traditional cam shaft (OHV Engine) (Fig 7)

OHV in general means oer head valve, or valves are fitted in the cylinder head. Oftern the term “OHV is used to describe the engine design where the camshaft is fitted inside the engine block and vlves are operated through lifters, pushrods and rocker arms. This design is alos known as a “Pushrod” engine. The OHV design has been successfully used for decades.

Fig 7



Piston and piston rings

Objectives: At the end of this lesson you shall be able to
- **state the function and the requirements of a piston**
- **state the constructional features of a piston**
- **list out the different types of pistons**
- **list out the different types of piston rings**
- **state the constructional features of piston rings**
- **list out the material of piston rings.**

A piston is of a cylindrical shape which reciprocates inside the cylinder bore. The main functions of the pistons are:

- to transmit the power developed by fuel combustion to the crankshaft through the connecting rod
- to transfer the heat generated due to combustion to the cylinder wall.

Requirements of a piston

A piston should be:

- able to withstand high temperature and pressure of combustion.
- a good conductor of heat.
- light enough to minimise the inertia load.

Construction of a piston

It has a special shape at different portions according to the design. A piston is designed with five portions according to the purpose and functional features.

The crown or head

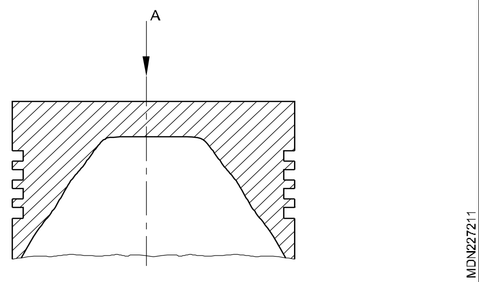
It is the top most portion of the piston. It is subjected to high pressure and temperature due to the combustion of the fuel.

Four types of heads are used.

Flat head

It is simple in shape and is most commonly used. It is simple in construction. Decarbonising of this is very easy. (Fig 1)

Fig 1



Domed head

It has a projection shaped like a dome on the crown. (Fig 2 & Fig 3) The dome acts as a deflector and helps to make a homogeneous mixture of air and fuel.

Fig 2

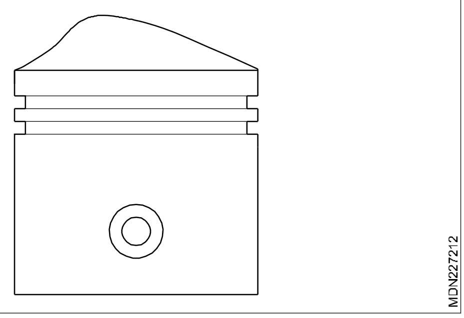
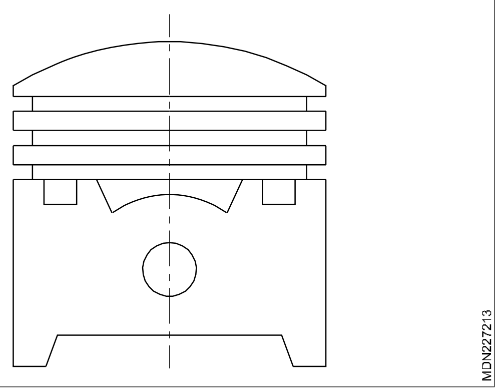


Fig 3

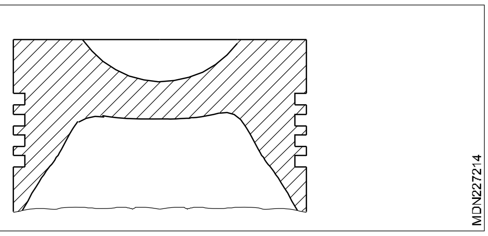


It is used in two-stroke cycle engines. It is difficult to manufacture compared to flat heads.

Concave head

It has a concave cavity on the top. (Fig 4) It is used in high compression diesel engines to reduce the clearance space.

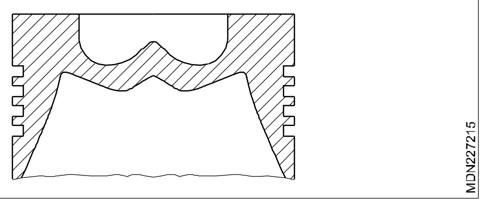
Fig 4



Irregular head (cavity piston)

It has a cavity on the top, (Fig 5) and a conical shaped projection is provided inside the cavity. This helps in swirling of air and thereby making for it better homogeneous burning, and it improves combustion. It is used in high compression diesel engines.

Fig 5



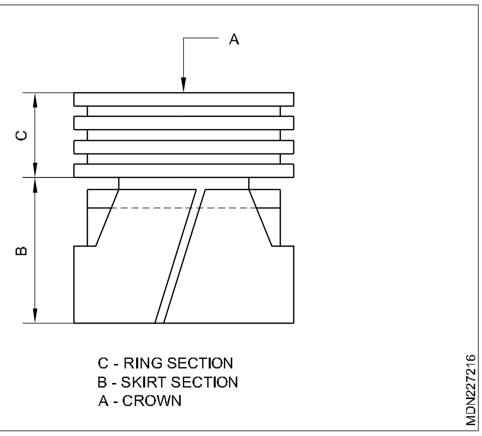
Skirt

Skirt is the lowest portion of the piston. It works as a guide to the piston in the bore and enables the piston to move in a straight line. The skirt has the least clearance with the liner. The piston to liner clearance is measured at the skirt.

Ring section

It is the portion between the top of the piston and the last ring groove. It has more clearance with the cylinder than with the skirt. There are two types of piston ring grooves. (Fig 6)

Fig 6



- Compression ring groove

These grooves accommodate compression rings.

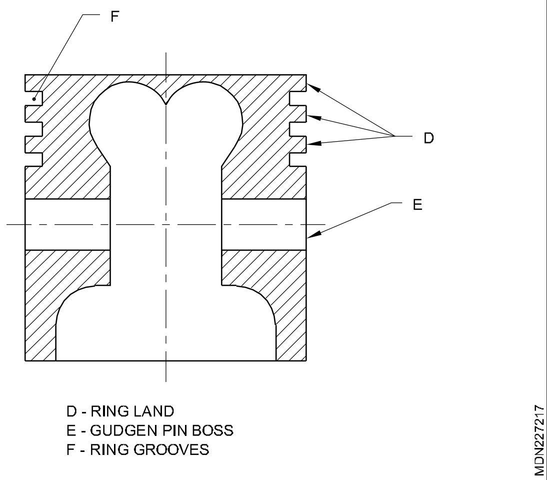
- Oil ring groove

These grooves accommodate the oil scraper rings.

Land

This is the piston's circumference left above the top ring groove and between the ring grooves. (Fig 7)

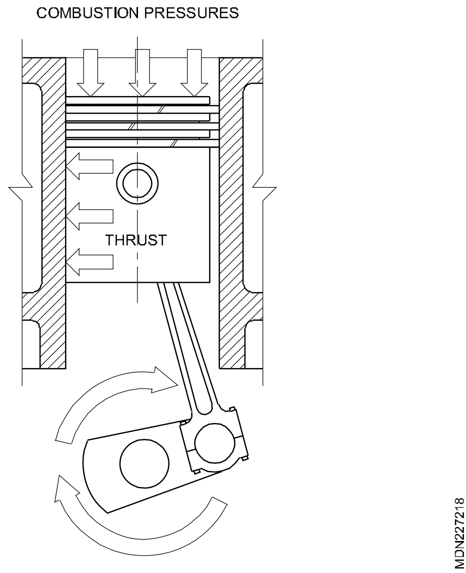
Fig 7



Gudgeon pin boss

At this portion (Fig 8) of the piston a gudgeon pin is fitted to connect the piston and the connecting rod. In some cases it is reinforced with ribs to withstand the combustion pressure. When the engine is running in clockwise direction, seen from the front of the engine, the left side of the piston is the maximum thrust side and right side is the minimum thrust side.

Fig 8



Designs/Types of pistons

Solid skirt piston

These pistons are used in compression, ignition engines or heavy petrol engines. This design can take heavy loads and thrusts. (Fig 9)

Slipper pistons

This type of pistons are used in modern engines to increase the area of contact at thrust faces. It is lighter in weight compared to the solid skirt piston. (Fig 10)

Fig 9

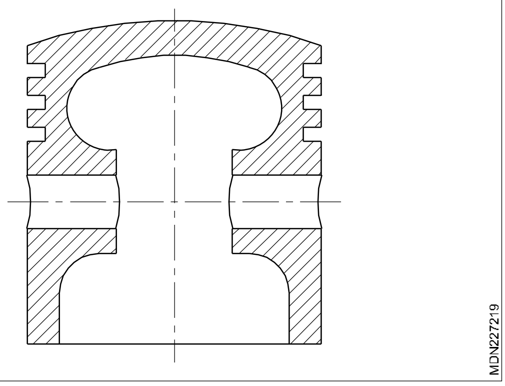
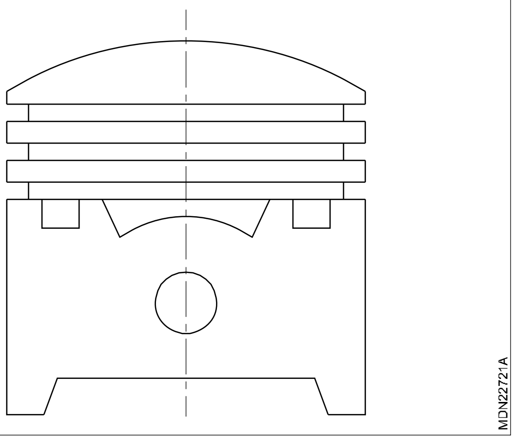


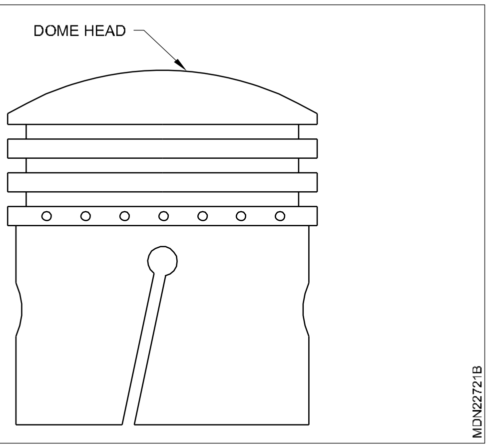
Fig 10



Split skirt piston

It is widely used in two-stroke scooters and mopeds. It is lighter in weight and has less inertia load. (Fig 11)

Fig 11



Piston with steel alloy inserts

Steel alloy inserts (1) are cast between the thrust faces on the inside of the gudgeon pin bosses. This gives strength and controls expansion of the piston at high temperature. (Fig 12)

Steel-belted pistons

A steel ring is cast above the gudgeon pin boss for strength. It controls expansion. This type of pistons are used in heavy duty engines. (Fig 13)

Fig 12

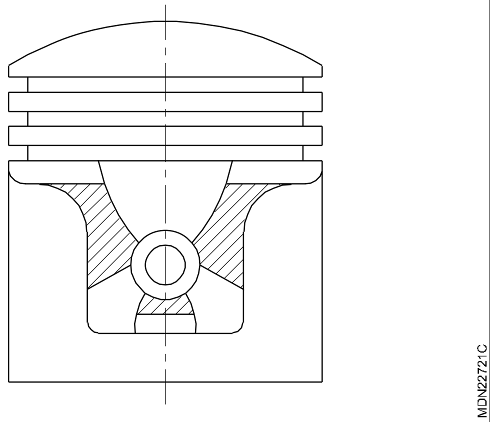
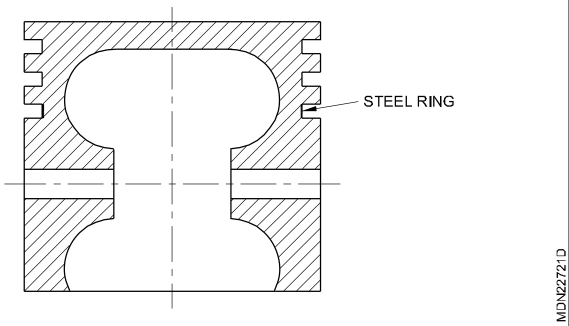


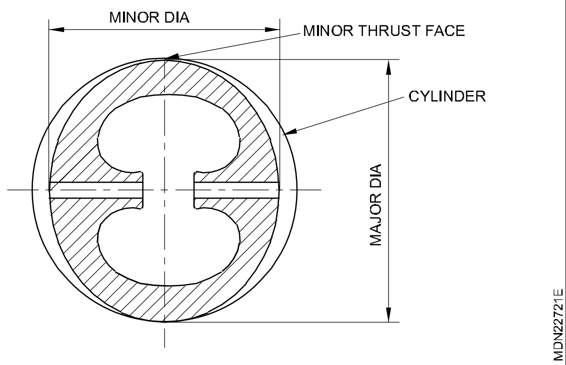
Fig 13



Cam ground pistons

The skirt of this piston is ground oval in shape. The diameter across the gudgeon pin boss axis is less at the thrust side. When the engine runs and the piston heats up, the bosses expand outwards making the piston round, and the clearance with the cylinder bore uniform all round. (Fig 14)

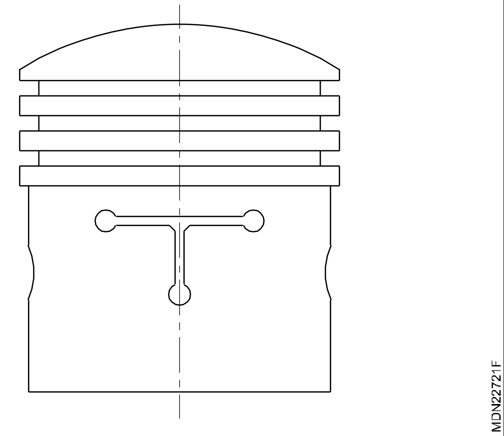
Fig 14



Constant clearance pistons (Slot skirts)

These pistons have one or two slots cut in the piston skirt. When the piston gets heated up, the width of the slots decreases. It helps in maintaining a constant clearance with the cylinder bore. These slots are located under the oil ring groove at the minimum thrust side. The end of the slots is divided with holes to avoid stress concentration. (Fig 15)

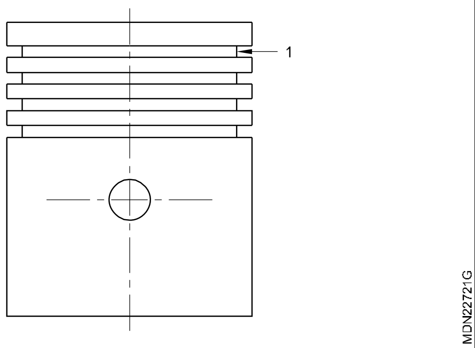
Fig 15



Heat dam pistons

These pistons have an extra groove (1) cast in between the top ring groove and piston crown. It is known as heat dam. It reduces the heat path on the piston head to the skirt. It enables the piston to run cooler. In this groove no ring is fitted. (Fig 16)

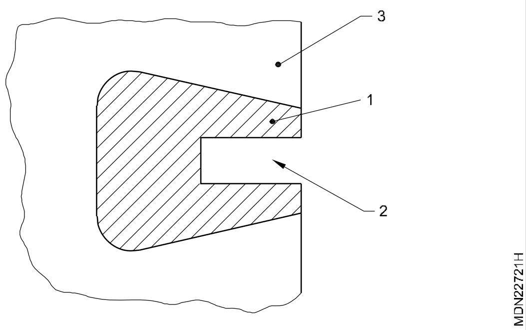
Fig 16



Alfin piston/ring carrier piston

Wear in the ring groove will result in excess oil reaching the combustion chamber. To reduce the wear on the top ring groove in piston(3), a ferrous ring (1) is inserted. This insert reduces the wear of the top ring groove (2). (Fig 17)

Fig 17



Piston rings

Types

- Compression ring
- Oil control ring

Compression rings

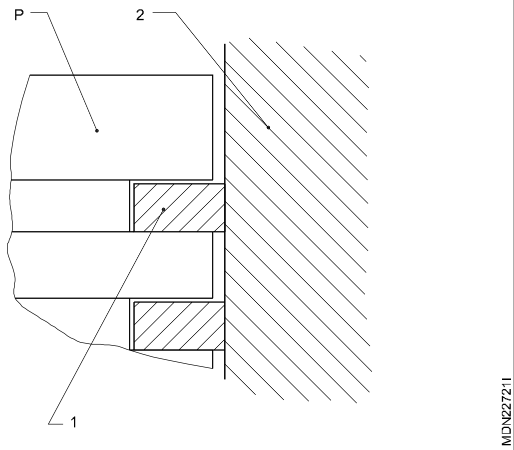
These rings effectively seal the compression pressure and the leakage of the combustion gases. These are fitted in the top grooves. They also transfer heat from the piston to the cylinder walls. These rings vary in their cross-section.

The following types of compression rings are used.

Rectangular rings

These rings are very popular and easy to manufacture at a lower cost. The face of the rings (1) remains in full contact with the wall of the liner (2). (Fig 18)

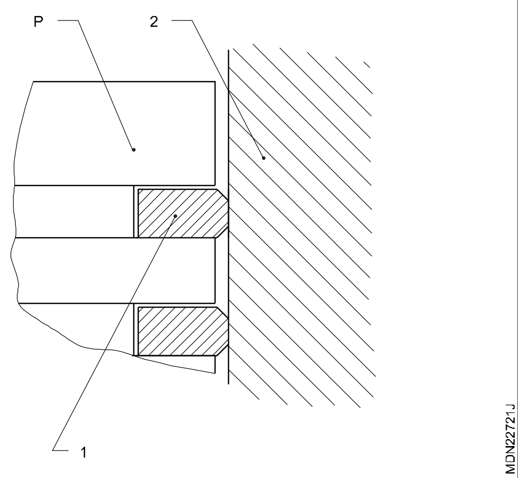
Fig 18



Taper-faced rings

The face of the ring (1) is tapered (Fig 19). The lower edge of the ring is in touch with the liner (2). These rings are good for controlling oil consumption by scraping all the oil from the liner (2). These rings cannot effectively control blow-by.

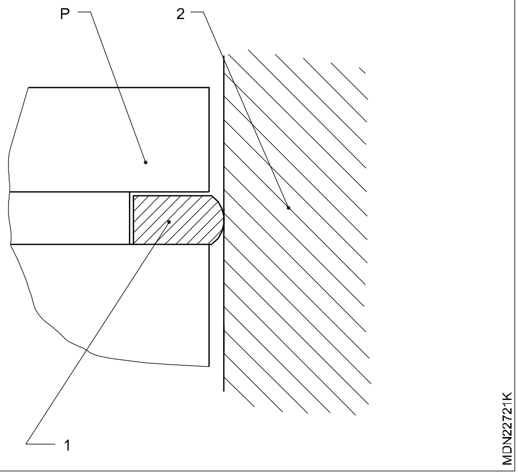
Fig 19



Barrel-faced rings

In this type, the corners of the rings (1) are rounded off to give a barrel shape. These rings are used only for top grooves to prevent blow-by. (Fig 20)

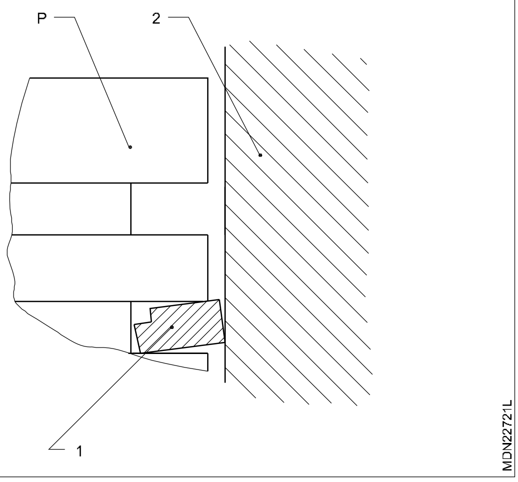
Fig 20



Inside bevel rings

In this type a step is cut on the top surface at the inner diameter of the ring (1). The step allows the ring to twist slightly when the piston moves. It is more effective in preventing blow-by. These rings are used in second grooves. (Fig 21)

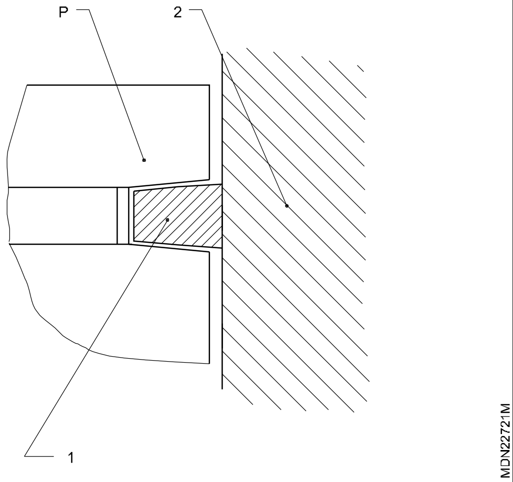
Fig 21



Keystone ring

This types of rings (1) does not allow carbon to settle in the ring groove. It is generally used in heavy vehicles. (Fig 22)

Fig 22

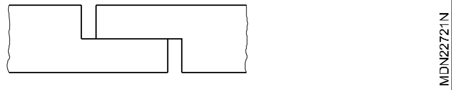


Joints of compression rings

Step joint

It is considered to be one of the best to prevent blow-by. It is difficult to manufacture, and to set a correct gap while fitting. These types of joints are not used much in automobiles. (Fig 23)

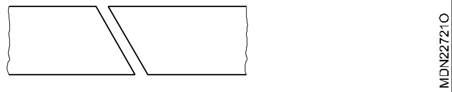
Fig 23



Angle joint (Diagonal cut)

This type of joints is easy to manufacture and the gap can be set quickly. It is commonly used in automobiles. (Fig 24)

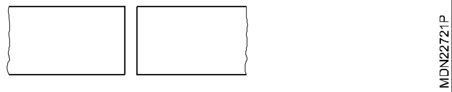
Fig 24



Straight joint

These rings are easy to manufacture and the gap can be set easily. Most of the engine rings have straight joints. (Fig 25)

Fig 25



Oil control rings

The main purpose of an oil ring (2) is to scrape the excess oil from the liner and drain it back to the oil sump during the downward movement of the piston. It prevents the oil from reaching the combustion chamber. One or two oil control rings are used in a piston. If two rings are used, one is fitted above and the other is fitted below the gudgeon pin in the piston.

These rings exert enough pressure on the cylinder wall to scrape the oil film. To keep the sealing and avoid metal-to-metal contact, a thin film of oil stays on the liner. These rings are provided with drain holes or slots. These slots allow the scraped oil to reach the oil sump through the piston holes.

Types of oil scraper rings

One piece (Solid rings)

These rings are easy to install. They have greater force against the cylinder wall and reduce oil consumption.

Fig 26

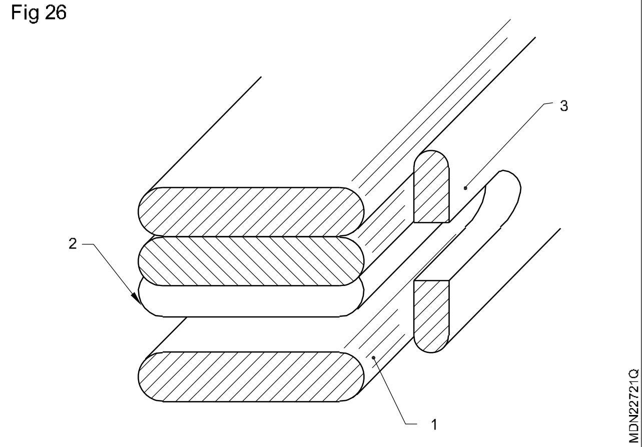
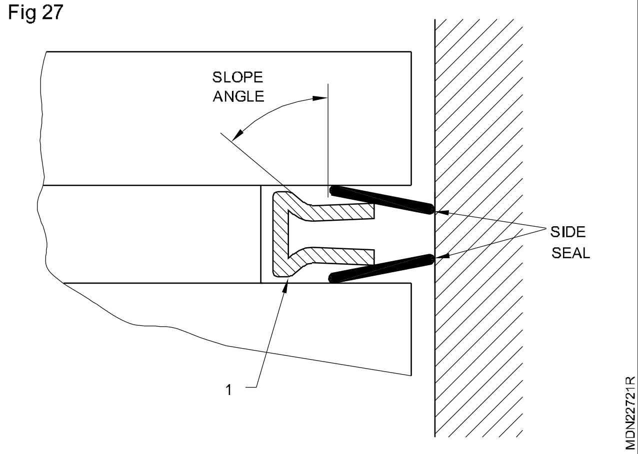


Fig 27



Duraflex rings (Three pieces)

These rings (Fig 26) are used specially for re-ringing jobs, where the cylinder has worn out excessively. One set of rings consists of rails, a crimped spring and expander. The rail (1) is of a circular shape. It is made of high quality, polished spring steel. The number of rails vary in accordance with the width of the groove. It wipes oil from the liner. The crimped spring (2) keeps the rail space apart and seals the top and bottom of the groove. It ensures the ring tightens in the groove irrespective of wear. The expander (3) exerts the correct amount of pressure against the rail and provides a sealing effect on the cylinder wall. The main advantage of this type of ring is that it provides enough pressure irrespective of cylinder wear in all conditions.

`T' Flex rings

It has one `T' shaped expander (1) with two scraper rails (2). The rails (2) also serve as spacers. The expander (1) forces the rails (2) against the cylinder wall. This enables the ring to scrape excess oil. The steel rail provides an effective side sealing of the cylinder walls. (Fig 27)

Materials

Piston rings are made of high grade cast iron, centrifugally cast and ground. This provides good elasticity, and minimises vibration. In some cases steel- chromium plated rings are also used in cast iron cylinders. Chromium plated rings are only used in the top groove.

These rings have less friction, less wear and longer life.

Material

The piston pins are made of nickel/chromium alloy steel. The outer surface is ground, chromium plated and case hardened.

Piston ring

Objectives: At the end of this lesson you shall be able to
- **state the recommended clearances for rings**
- **state the piston rings fitting precautions**
- **state the causes and remedies of pistion rings**
- **state the compression ratio.**

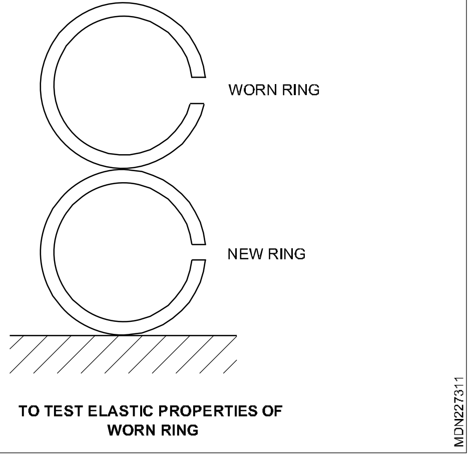
Piston clearance

Piston rings have gap so that they may be installed into the piston grooves and removed when worn out by expanding them. The gap ensures radial pressure against the cylinder wall thus having effective seal to prevent leakage of heavy combustion pressure. This gap must be checked because if it is too great due to cylinder bore wear, the radial pressure will be reduced. To check this gap clean the carbon from the ends of the ring and then check it with feeler gauges. This gap may be in the region 0.178 - 0.50 mm governed by the diameter of the bore but if it exceed 1 mm per 100 mm of bore diameter, new rings must be fitted. Fig 1

The gap between the ring and the groove in the piston should also be checked by feeler gauges. This gap is usually 0.038 - 0.102 mm Fig 2 for compression rings and a little less for the oil control rings.

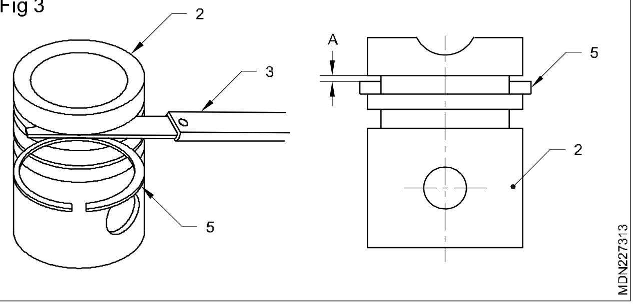
The gap between piston and limer is measured by feeler gauge from the bottom of the limer (skirt) is 25.4 mm Fig 3.

Fig 1



TO TEST ELASTIC PROPERTIES OF WORN RING

Fig 3



Precautions while fitting rings in the piston

There are two types of piston rings (compression ring and oil scraper ring) used in an i.e engines. While fitting the piston rings follow the precaution.

1 Remove the ridge in the linner.

2 Use proper ridge cutter.

3 Measure the end gap of new ring.

4 Use piston ring culter to remove exerse material.

5 Use piston ring frooves cleaner to remove carbon from groose.

6 Clean the piston groovve, limmer rings with specified cleaning liquid.

7 Excess piston ring expand lead broken , so limit the ring expansion as need

8 Use the ring expander to fit the ring in the piston.

9 Check the end gap clearance of the ring.

10 Check ring side clearance in the piston’s groove.

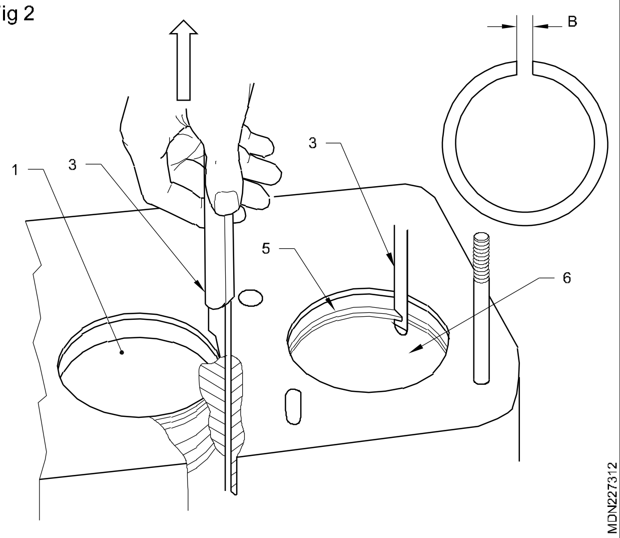
11 Ensure the piston rings and gap should not be inline.

Causes and remedy

1 Wear in the piston ring grooves causes the rings to rise and fall during movement of piston and its pumping action resulting in high oil consumption.

2 Exercise gas blow by, loss of compression will also take place if gap is too much (cylinder wall and piston ring).

Fig 2



3 During service the piston ring may have lost some of its elastic properties due ti which radial pressure will be reduced on the cylinder wall. THis properly can be checked by pressing together worn and a new ring and observing whether the gap of the worm ring closes more than the new ring.

Compression ratio

It is ratio of the volume of the charge in the cylinder above the piston at bottom dead centre and the volume of the charge when the piston is at top dead centre. Since the volume above the piston at bottom dead centre is the displacement of the cylinder plus the clearance volume; and the volume above the piston at top dead centre is the clearance volume, the compression ratio can be stated as:

$$\frac{\text{Clearance volume} + \text{Displacement volume}}{\text{Clearance volume}}$$

For example, if clearance volume is 90 cm^3 and displacement volume is 540 cm^3, the compression ratio will be,

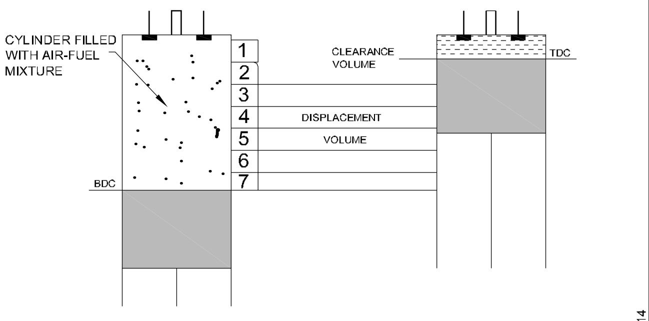
$$r - \frac{90+540}{90} = \frac{630}{90} = 7:1$$

The compression ratio 7 : 1 is illustrated in Fig. Early automobile engines had low compression ratios 3:1 to 4:1. They are known as low compression engines. The fuel available at that time could not be subjected to greater pressure without detonation. The modern gasoline engines have compression ratios 7:1 to 10:1. Diesel engines have much higher compression ratios from 11: to 22:1.

The compression ratio of an engine will be increased by any condition that will decrease the size of the clearance volume such as the accumulation of carbon deposits. High compression ratio results in decreased operating efficiency and grater power output for a given engine.

The pressure of the mixture at maximum compression is determined by the compression ratio. Some other factors are also considered like engine speed, temperature, degree of vapurisation of the fule and leakage past the piston rings.

Fig 4



COMPRESSION RATIO

Description & function of connecting rod

Objectives : At the end of this lesson you shall be able to
- **describe the function of connecting rod**
- **decribe the construction and materials of big and small end bearing of connecting rod.**

Connecting rod

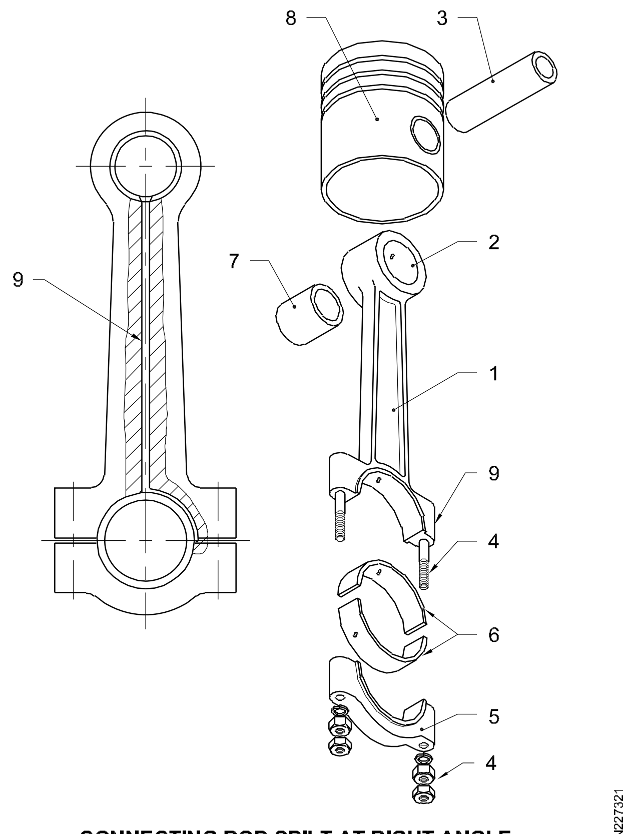
Functions

It is fitted in between the piston and crankshaft. It converts the reciprocating motion of the piston to the rotary motion in the crankshaft. It must be light and strong enough to withstand stress and twisting forces.

Construction

The connecting rod (1) (Fig 1) is made of high grade alloy steel. It is drop-forged to 'I' shape. In some engines aluminium alloy connecting rods are also used. The upper end of the connecting rod has a hole (2) for the piston pin (3). The lower end of the connecting rod (1) is split, so that the connecting rod can be installed on the crankshaft. The top and bottom halves (5) of the lower end of the connecting rod are bolted together on the big end journal of the crankshaft, by bolt and nut (4).

Fig 1

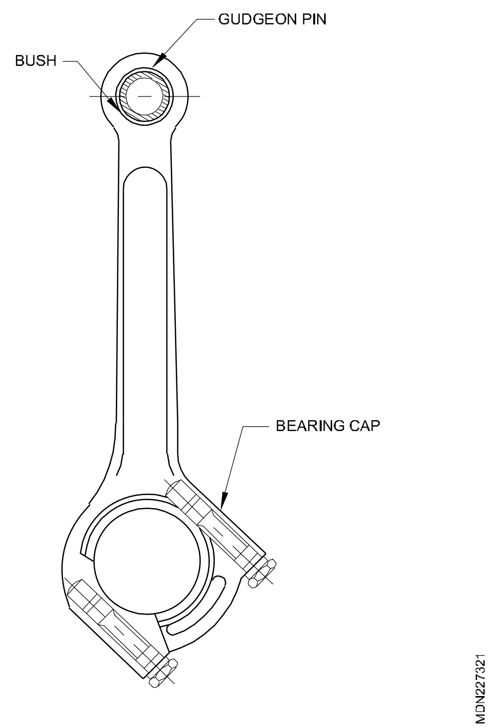


CONNECTING ROD SPILT AT RIGHT ANGLE

A large bearing area is provided to take the load, heat and wear. The split halves are usually fitted with babbitt bearings (6) or bearing lining steel-backed copper lead. In the upper end of the connecting rod a bronze bush (7) is fixed. The small end of the connecting rod is connected to the piston (8) by means of a piston pin (3).

In some engines a hole (9) is drilled in the connecting rods from the big end to the small end. It allows oil to flow from the big end to the small end bush.

Fig 1



Control split at an angle (Oblique cutting)

The connecting rod big end is split at an angle for assembly easily on the crankpin.

Locking methods of piston pin

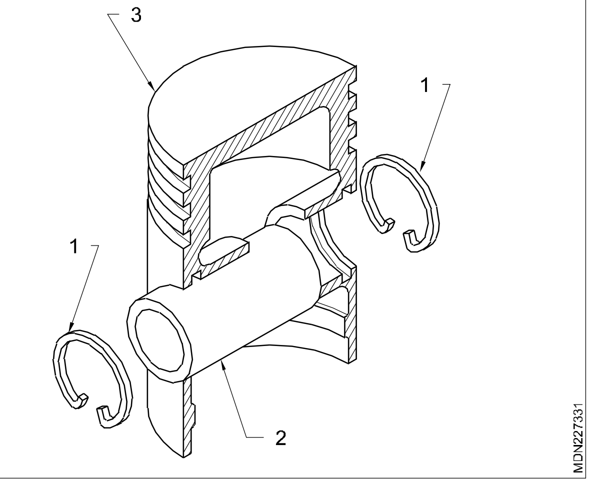
Objective : At the end of this lesson you shall be able to
- **list out the various types of piston pins locking method and material of the position pin.**

The piston pin or gudgeon pin connects the piston with the connecting rod. It should be strong enough to transmit power and withstand pressure of combustion. Piston pins are made hollow to reduce inertia load due to the reciprocating motion.

Types of piston pins

Fully floating piston pin

Fig 1

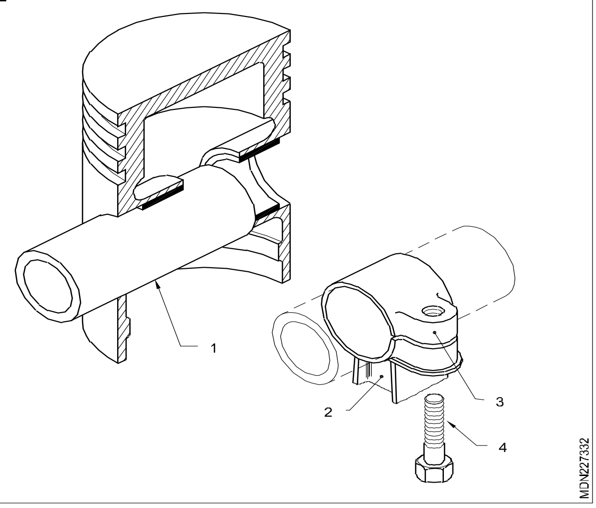


In this type (Fig 1) there are circlips (1) on either side of the piston pin (2). The pin (2) is free to rotate both in the piston (3) and the connecting rod.Circlips (1) are fitted into the grooves provided in the piston boss. This type of pins is used in engines which carry heavy loads. One gun metal or bronze bush is used between the small end of the connecting rod and the piston pin. Small two-stroke engines may have a needle bearing cage instead of a bush.

Semi-floating piston pin

The pin (1) is fastened to the connecting rod (2) with a clamp (3), screw (4) and nut. In this the piston boss forms the bearing. (Fig 2)

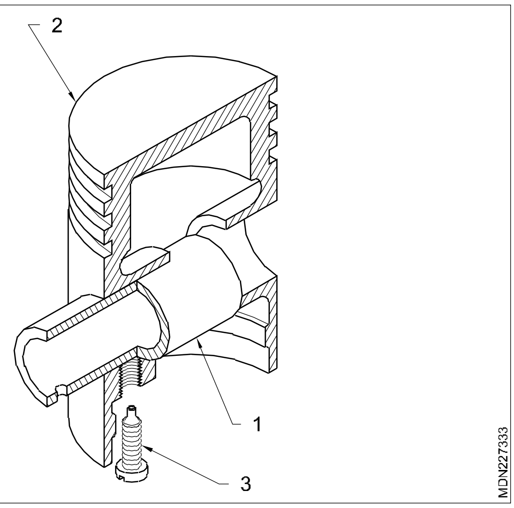
Fig 2



Set screw type piston pin

The pin (1) is fastened to the piston (2) by a set screw (3) through the piston boss and is provided with a bush in the small end of the connecting rod. (Fig 3)

Fig 3



Description and function of crankshaft

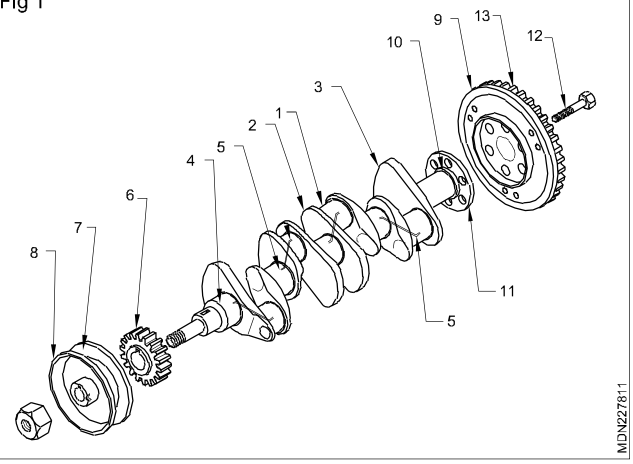
Objectives: At the end of this lesson you shall be able to
- **state the function of the crankshaft**
- **state the constructional features of crankshafts**
- **state the material of crankshaft**
- **state the necessity for heat treatment, and the balancing of the crankshaft**
- **state the constructional features of bearing shells**
- **list out material of the bearing shells.**

Functions of a crankshaft

The crankshaft converts the reciprocating motion of the piston into rotary motion, and transmits the torque to the flywheel.

Construction

Fig 1



A crankshaft consists of a crank pin (1) (Fig 1), webs or crank arm (2) and balancing weights (3) which are provided on the opposite side of the crank arms for balancing the main journals (4). Crankshafts have drilled oil passages (5) through which oil flows from the main bearings to the connecting rod bearings.

The front end of the crankshaft carries the gear or sprocket (6) to drive the cam shaft. A vibration damper (7) and a fan belt pulley (8) are fitted in front. The pulley (8) drives the water pump, engine fan and generator/alternator, through a fan belt.

At the rear end of the crankshaft, a flywheel (9) is fitted. The inertia of the flywheel (9) tends to keep the crankshaft to rotate at a constant speed. Next to the rear end main journal an oil seal (10) is fitted. In some engines, oil return threads are provided which return the lubricating oil to the sump.

Materials

A crankshaft has to withstand the centrifugal force, the impact force by the piston and the connecting rod. It should be light in weight. It is made of the following material.

- Nickel steel
- Chrome, vanadium steel
- Nickel chrome steel
- Nickel chrome molybdenum steel

Heat treatment of the crankshaft

A crankshaft is made of forged and heat-treated alloy steel. It is machined and ground to provide suitable journals for the connecting rods and main bearings. The following methods are used to harden the crankshaft journals.

- Nitriding
- Carburising
- Chrome plating

In the above process the case of the crankshaft journal is hardened. These process give very little depth of hardness. Some manufacturers recommend hardening of the crank-shaft journals after regrinding.

Induction hardening

Induction hardening gives more depth of hardness, and, therefore, the crankshaft need not be hardened again and again.

Crankshaft bearings

These bearings are made into two halves. These bearings operate at critical loads and high rotational speeds. These bearings run quieter and are easy to replace.

These bearings are also called thin wall bearings. These are made of a thin steel shell base with a thin lining on it.

The lining materials are copper-lead or lead-bronze or tin-lead or soft aluminium alloy. Cadmium alloy with copper or cadmium alloy with silver withstands high pressure. Iridium with copper and lead has excellent wear and corrosion resistance. The lining is plated to a thickness of about five thousandth of an inch.

Half shells are provided with an oil groove (1) (Fig 2, 3 & 4) and oil feed holes (2). The bearing shell also has a locking lip (3) on it to fix it on the lip slot (4) of the bore and cap. In some cases dowel pins (5) are provided in the parent bore which aligns with the hole on the bearing shell and avoids rotation of the shell.

Fig 2

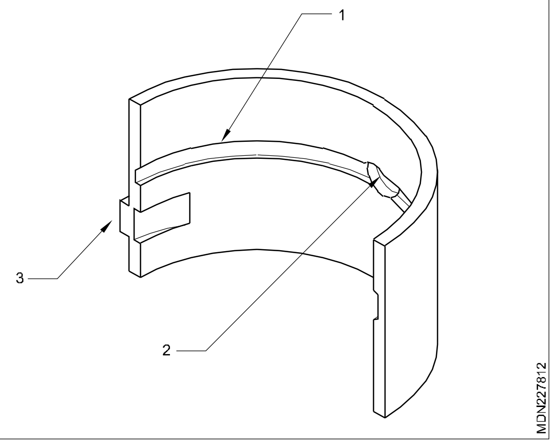


Fig 3

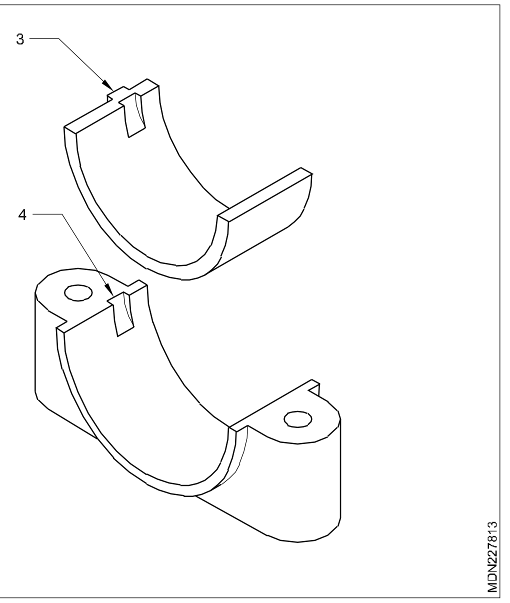
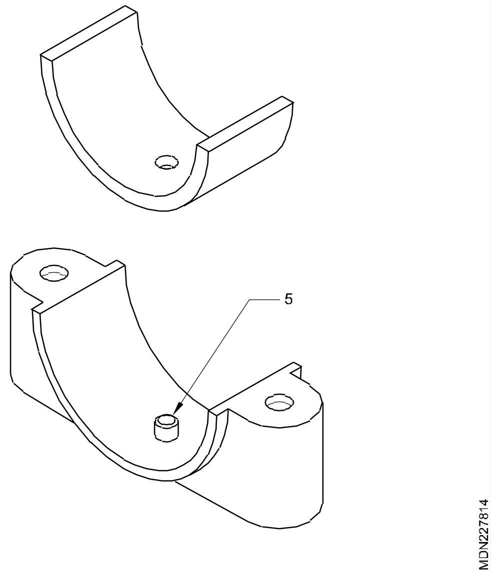


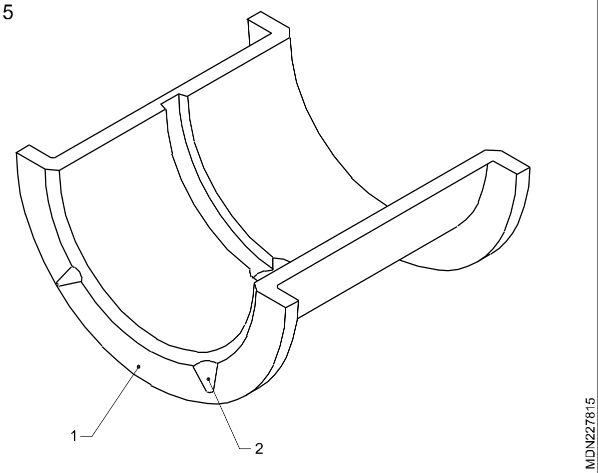
Fig 4



Thrust bearings

This type of bearing (Fig 5) takes care of thrust loads. The bearing shells on the crankshaft, which has thrust faces (1) on it, takes the end thrust of the crankshaft when it is in operation. The thrust faces have oil notches (2) to hold lubricating oil. In some cases separate thrust washers made up of bearing material are also used to take the end thrust.

Fig 5



Bearings

Objectives: At the end of this lesson you shall be able to
- **understand the need of bearings**
- **list out the different types of bearings used in vehicle**
- **list out the uses of the different types of bearings**
- **explain the function and application of different types of bearings.**

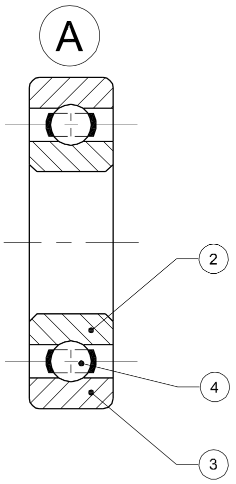
Bearings are used to support rotating components and to reduce friction between the static and rolling components.

The following types of bearings are used in automobiles.

- Shell bearing
- Bush bearing
- Ball bearing
- Roller bearing
- Needle roller bearing
- Taper roller bearing

Bush bearings are made of copper-lead, tin-aluminium, tin-copper and used in the small end of the connecting rod, camshaft, oil pump drive shaft etc.

Fig 1

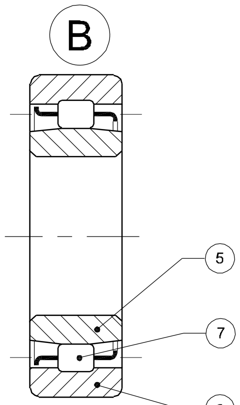


Ball bearings (A) (Fig 1) reduce friction between rotating parts to a minimum, and can take radial as well as axial load.

Ball bearings consist of an inner race (2), outer race (3) and balls (4). These bearings are used in the gearbox.

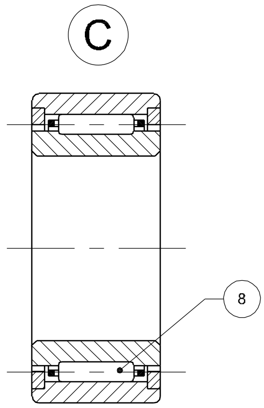
Roller bearings (B) also consist of an inner race (5), outer race (6) and rollers (7). (Fig 2) These bearings can take heavy radial load but no axial load and are used in the final drive, flywheel, water pump etc.

Fig 2



Needle roller bearings (C) (Fig 3) are similar to roller bearings except that the ratio between the length of the needle roller (8) and the diameter of the roller is much more than that of a roller bearing.

Fig 3



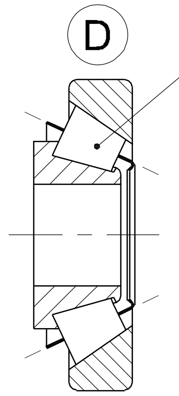
Taper roller bearings (D) (Fig 4) have taper rollers (9) instead of plain rollers. In automobiles, these bearings are generally used in pairs and these can take axial and radial loads. These bearings are used in the differential assembly, wheel hubs etc.

Details of engine bearings

Engine bearings

These are also called "Shell bearings or sliding function bearings or precision insert bearings. These are largely used for free rotation of crankshaft, connecting rods and camshaft. They provide low frictional areas for these shafts to rotate smoothly under different speeds and loads.

Fig 4



Shell bearings

These have been dealt in I Year Trade Theory. In this lesson, some more useful points are discussed on the shell bearings. They are stated as below:

- Qualities of engine bearings
- Bearing materials
- Bearing spread and crush
- Bearing failures and remedies
- Connecting rod and camshaft bearings
- Load on precision insert bearings
- Advantages of using insert bearings.

Qualities of engine bearings

The bearing should have

- Excellent fatigue strength
- Good conformability
- Fine embeddability
- Superior surface action
- High temperature strength
- Adequate corrosion resistance
- Quick thermal conductivity

Fatigue strength

The capacity of the bearing to withstand high loading and impact loads, without being crushed for a reasonable period of life is known as fatigue strength.

Conformability

The capacity of the bearing to adjust to the conditions of crankcase distortion and crankshaft warpage and conform to the journal at all times is termed as conformability.

Embeddability

The bearing should be able to absorb dirt and metal particles and keep them below their working surface to avoid abrasive wear on the journals. This aspect is called embeddability.

Surface action

The bearing should have enough self lubricating properties to withstand metal to metal contact between journals and bearings. This property is termed as surface action.

Temperature strength

Bearings are subjected to higher temperature condition during operation and as the temperature raises, they become softer. The bearing should not become too soft and loose its load carrying strength, at operating temperature.

Thermal conductivity

The bearing should quickly conduct the heat through the shell and parent bore to the block and keep its temperature low. Bearing materials are selected in such a way to suit each engine design requirements in these areas.

Bearing materials used

Different varieties of materials now in use are :

- Tin base babbitt
- Lead base babbitt
- Cadmium nickel or silver alloy
- Copper lead alloy (with tin overlay)
- Aluminium alloy
- Silver lead

Tin base babbitt

Low fatigue strength but has good conformability, embeddability, surface action and corrosive resistance. This is popularly used on heat engines. (Petrol engines)

Lead base babbitt

Improved fatigue strength compare to tin base babbitt and similar to them in other respect. This is popularly used in petrol engines.

Cadmium nickel or silver alloy

Fatigue strength is further improved but not very good in conformability, embeddability and surface action popularly used in high speed high pressure engines.

Copper lead alloy

Superior fatigue strength even at higher temperature. These are improved by overlay tin coating or tin base micro babbitt surface and popularly used in high speed diesel engines.

Aluminium alloy

Aluminium alloy excels with respect to fatigue strength, load carrying capacity, corrosion resistance and freedom from scoring tendencies. In case of seizures, only bearing get affected and journals are saved from scoring when aluminium bearings are used. The sticking bearings material can be easily removed from the journals. Due to poor embeddability, improved hardening of the journals is necessary.

Silver lead bearings

These alloys have the greatest load carrying capacity, but, prohibitively expensive. Limited to aeronautical purposes where this factor is of great importance. Embeddability is poor with these alloys.

Bearing spread and crush

Bearing spread

The bearing should have full contact with its parent bore and for this purpose bearing spread and crush are provided. Both main bearing and con-rod inserts have the outer dia. at parting forces slightly larger than the housing bore dia. This will be about .005" to .020" in the case of main bearings and .020" for con-rod bearings in excess of the bore dia. This is known as bearing spread and this helps to hold the inserts in place during assembly.

Bearing crush

The parting faces when assembled stand proud of the parent bore half. When bearing caps are tightened, a radial pressure is exerted at the parting faces and forces the inserts tightly into the housing bore to ensure complete contact. This is about .004" to .008" for main and big end bearings. This is checked by torquing the both ends to recommendations, then loosening one end and inserting feeler gauge between cap face and crankcase face.

Camshaft bushings

Precision bearings are used for camshaft in many engines. But they are not split but pressed into the block as a full bush and held thereby means of a press fit. These bushings are designed for radial loads only. But, end thrust is being taken by a special thrust plate bolted to block.

Small end of connecting rod

The small end of connecting rod is fitted with a phosphor bronze bush and the small end is joined to the piston by a means of a piston pin passing through this bush.

Load on the precision insert bearings

- The precision insert bearing used as a main bearing in an engine take up radial and the thrust loads applied to the crankshaft.
- The connecting rod bearings are normally constructed for radial loads only. The thrust will be taken up by the crank cheeks which are machined surfaces to match the machined side faces of big end of the connecting rod.

Advantages of using precision insert bearings

- Variety of bearing materials may be used.
- Desired structure can be obtained
- Controlled babbitt thickness is possible
- Easier and quicker replacements can be done.
- Improved load carrying characteristics is possible.

Application bearing, failure of its causes and care of maintenance

Objectives: At the end of this lesson you shall be able to
- **state the application of bearing**
- **state the causes for bearing failure**
- **state the care and maintenance of the bearing.**

The device for supporting the rotating shaft is called bearing, bearings are used in all types of machineries, engines and mechanism for supporting and controlling the motion of rotating, soldering or reciprocating parts, shafts, spindles, axles, rods & pins.

The contact surface of bearing may wear out due to friction and rubbing by rotating or moulding parts. To moulding parts. To minimise the frictional resistance, bearing are lubricated and adjusted that they serve their purpose with a minimum of friction power loss and generation of heat.

Application of the bearing: Bearings are different types depending upon the construction and direction of load act on the bearing. Generally bearings are classified there catagories.

1 Radial or journal bearing

2 Pillot or foot step bearing

3 Thrust or collor bearing

Radial bearing supports the rotating shaft is a fixed position against the load acting perpendicular to the axis of the shaft.

Fig 5

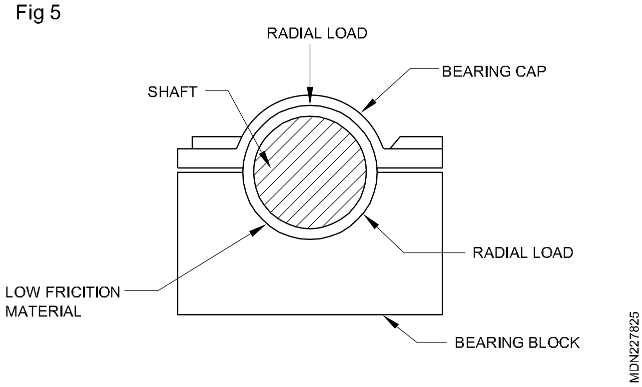
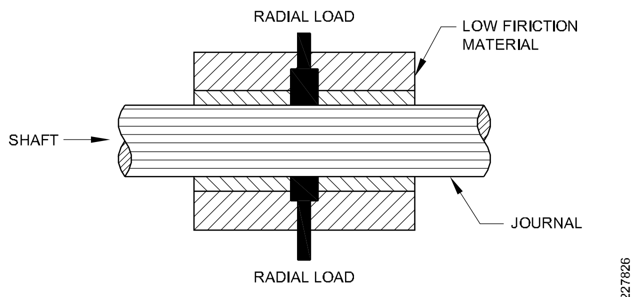


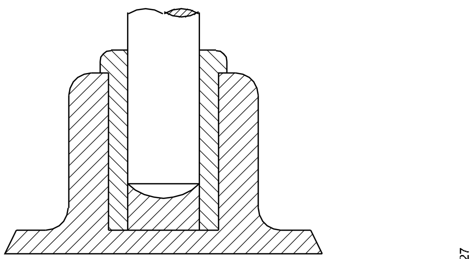
Fig 6



RADIAL OR JOURNAL BEARING

A pivot or foot step bearing supports the vertical shaft as its end.

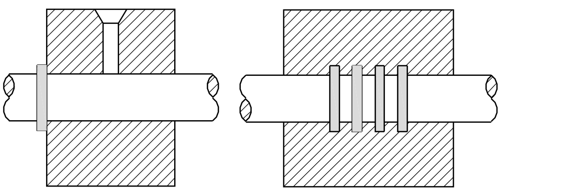
Fig 7



PIVOT OR FOOTSTEP BEARING

Thrust bearing supports the rotating shaft against the side thrust of the shaft side collar are provided on the shaft to resist the side thrust.

Fig 8



THRUST OR COLLAR BEARING

Bearing failures

Fatigue failure

This is identified by small sections of bearing material detaching from the steel back and this spreads to the entire bearing. Excessive loading, detonation, inadequate lubrication, high temperature build up are the major causes for this problem.

Foreign matter on bearing surface

Dirt, dust, metal particles left before assembly, due to improper cleaning, dirty oil, due to inadequate maintenance result in suspended hard particles staying the lub. system. These find a way into the bearings under pressure with lub. oil and when they are too big to pass through the bearing clearances, they get embedded into the bearings, displacing the bearing material. continued condition of such nature, lead to the bearing surface getting full of such particles which work on the journals as an abrasive and score them. This will accelerate bearing and journal wear. Hygienic conditions in the system and also during assembly is therefore very important.

Improperly seated bearing

This is possible due to existence of foreign matter or dirt between bearing back and seating at parent bore, filed parting faces or bearing caps or shims below the bearing shells or between parting faces when not needed. This will affect full contact with parent bore, oil clearance and load distribution, thermal conductivity etc. and the problems following them. Localised wear or peeling of bearing material or seizure may be the result.

Dirt between bearing and the seat is due to improper cleaning before assembly, Bearing crush may be lost by filing parting faces and even the bearings may start working loose in the parent bore. This may lead to bearing rotation and complete seizure very quickly.

Filed bearing caps result in out of round parent bores. This is ignorantly attempted to reduce oil clearance. This may lead to excessive crush and insufficient oil clearance and landing up in a total bearing failure.

Con.rod mis-alignment

Bend and twisted con.rods wear the bearing unevenly. This affects bearing clearances also.

Shifted bearing caps

This can be caused by

- Improper doweling or by damaged dowel holes or dowels.
- Using too bigger socket spanner for the cap screws.

P.T.F.E. bearings

Polytetrafluoro ethylent (PTFE) is extremely insert plastic material with an unusually low dry co-efficient of friction its use is limited by its thermal properties. This bearing particularly suitable for applications where corrosive liquids would attach conventional bearing materials.

Care and maintenance of bearing

- Identify correct size of bearing for selected application.
- Clean the dirt, dust, rust and metal particules on the bearing before use.
- Setting prper bearing clearance and proper seating in its place
- Specified lubricant use for bearing lubrication.
- Periodically change the lubricant for increase the bearings life.
- Replace the damaged worn bearings.
- Use the quality of bearings as specified in service manual.

Types of bearings damages

- Abrasive damage
- Erosion damage
- Fatigue damage
- Corrosion damage
- wipring damage
- Cracks, scoring, overheating

Types of bearing damages and causes

- Edge wear	- Less clearance
- Score of scraches (situational wear)	- Bad workmanship
- Overheating & surface	- Insufficient lubrication
- Cautiation of erosin	- Interior quality of material
- Corrosion	- water mix with lubricant
- Cracks in galvaine layer	- Overheat and overload
- Pitting of fretting	- Metal particals in lubricant

Factors affecting bearing clearance

- Desired operating temperature extemely critical
- Engine speed
- Oil flow rate
- Oil flin thickness
- Working viscosity of lubricant
- Load carrying capacity
- Operating temperature of engine

Bearing defect simptoms

- Low oil pressure
- Reduce load capacitor
- High impact load on crankshaft
- Noise

Crankshaft balancing, firing order of the engine

Objectives: At the end of this lesson you shall be able to
- **state the types of crankshaft balancing**
- **state the importance of the crankshaft balancing**
- **state the function of firing order.**

Balancing of crankshaft

Internal combusion engines have reciprocating parts and they create vibrations, when the engine is running. Every two revolutions of the crankshaft one power impluse in four stroke engine. Balancing of the engine is necessarly required for smooth running of the engine.

The crankshaft is subjected to trosional vibration and engine vibration. Engine vibration is due to the uneven weight distribution on the crankshaft and the unbalanced reciprocating forces of pistons and connecting rods. Balancing is achieved by removing materials (by drilling) in the crank web or by adding weight to the shaft between centres in a special balancing machine.

Types of balancing

There are two types engine balance, (i) power balance (ii) mechaincal balance

Power balance: When the engine power impulses occur at regular intervals with relation to the revolution of the crankshaft and each power of the engine impulse exerts the same force.

Mechanical balance: Engine mouring parts crankshaft connecting rod and pistons are rotating in reciprocating motion, so that crankshaft counter balance in operation mechaically minimize the vibration of the engine. The rotating parts of an engine can be balance by bringing them into static and dynamic balance. The main rotation parts are balanced mechanically by crankshaft counter weight and flywheel piston of connecting rods shocks on crank-shaft are called primary intertia forces. The angularity of the connecting rods produce secondary lubrication, it is called secondary intertia forces. The perfect static and dynamic balance of crankshaft and flywheel reduce the vibration.

Firing order: The sequence of power impulses occur rider engine is called firing order. The firing order in which cylinder deliver their power strokes is selected as a part of the engine design to obtain the best engine performance. The firing order is shown by the sequence of the number of cylinder in which the cylinder deliver their power strokes. Which is the nearest cylinder to radiator is designated as number one cylinder in and in line engine

Three cylinder 1 -3 -2

Four cylinder 1 -3-4-2

Five cylinder 1-3-5-4-2

Six cylinder 1-5-3-6-2-4

Eight cylinder inline engine 1-8-7-3-6-5-4-2

Eight cylinder v8 engine 1-3-2-5-8-6-7-4

Flywheel

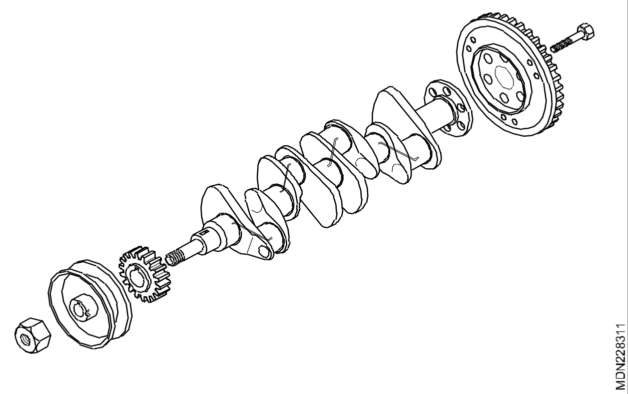
Objectives : At the end of this lesson you shall be able to
- **state the function of flywheel**
- **state the construction of flywheel.**

The flywheel stores energy during the power stroke and supplies it to the crankshaft during the idling stroke i.e. suction, compression and exhaust. In many engines the flywheel also serves as a mounting surface for the clutch.

Construction

The flywheel Fig 1 is attached to the rear end of the crankshaft (1) by means of bolts (4). A large ring gear (3) is attached to the flywheel. While starting, the engine starter motor's gear engages with the ring gear (3), and the flywheel (2) rotates to crank the engine. When an automatic transmission is used the torque converter assembly acts as the flywheel. The flywheel also serves as a mounting and frictional surface for the clutch assembly. The size of the flywheel depends upon the number of cylinders and general construction of the engine.

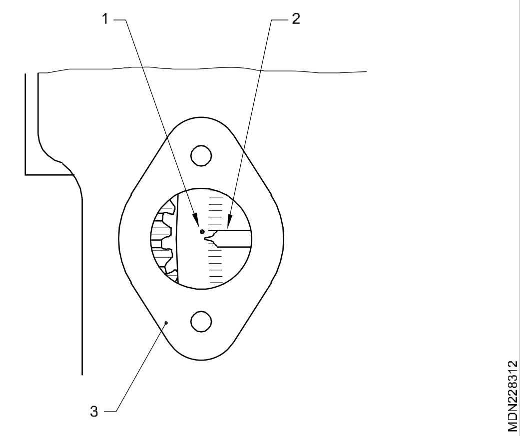
Fig 1



Timing marks of the flywheel

An engine is provided with timing marks (Fig 2) on a rotating men member and a stationary pointer. The timing mark (1) is punched on the circumference of the flywheel/crank pulley. A pointer (2) is fixed on the flywheel housing (3) / timing cover. Timing is adjusted when the pointer (2) coincides with the flywheel mark (1) and at this time distrubutor contact should just start ot open.

Fig 2



Vibration damper

Objectives: At the end of this lesson you shall be able to
- **state the function of vibration damper**
- **Functions of a vibration damper**

Vibration dampers are fixed at the front end of the crankshaft.

The main function of a vibration damper is to reduce torsional vibrations and stress. It helps in reducing the flywheel weight and increases the crank-shaft life.

Types and Construction

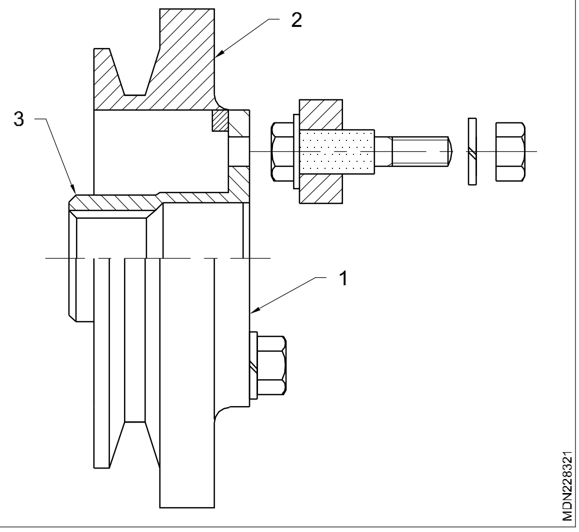
There are mainly two types of vibration dampers in use.

Rubber floating type

The damper (Fig 1) is made into two parts, a small inertia ring or damper flywheel (1) and the pulley (2). They are bonded to each other by a rubber insert (3).

As the crankshaft speeds up or slows down, the damper flywheel has a dragging effect. This effect slightly flexes the rubber insert (3) which tends to hold the pulley and crankshaft to a constant speed. This tends to take on the twist and untwist action and torsional vibrations of the crankshaft.

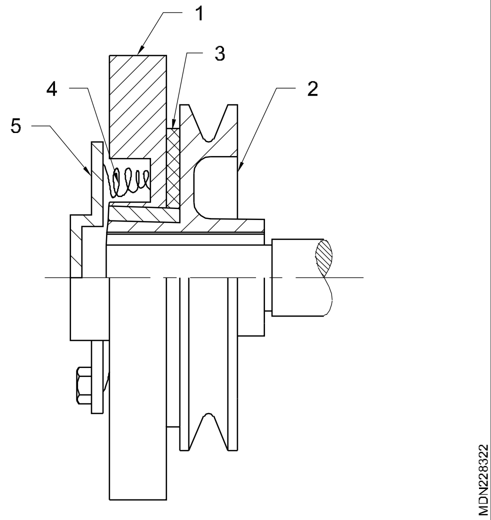
Fig 1



Clutch and rubber bush dampers

In this type (Fig 2), in between the damper (1) and the pulley (2), two friction facings (3) are provided. A spring (4) and a plate (5) are fixed to control the friction between the damper (1) and the pulley (2).

Fig 2



Timing Gear Drive

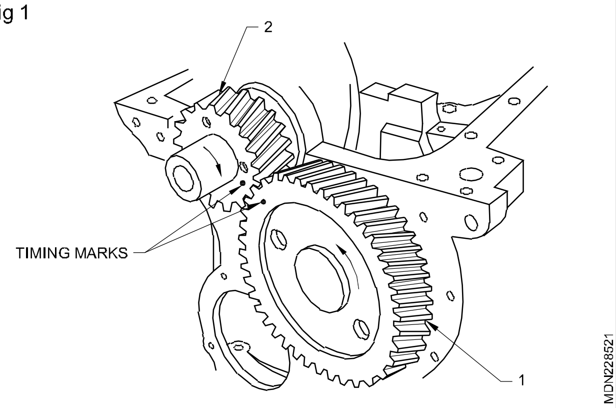
Objectives : At the end of this lesson you shall be able to
- **state the timing gear drive.**

- Timing Gear drive
- Timing Chain drive

Timing Gear drive

This direct drive (Fig 1) is used where the crankshaft and the camshaft are very close to each other. Since the r.p.m. of the camshaft is half of the crankshaft speed, the camshaft gear (1) teeth is twice as many as the crankshaft gear (2) teeth. In this, the engine's camshaft rotates in the reverse direction of the crankshaft. In some engines an idler gear is used to have the same direction of rotation for the crankshaft and the camshaft. When camshaft and crankshaft is assembled after overhauling the engine the turning marks should be coincids as in Fig 1.

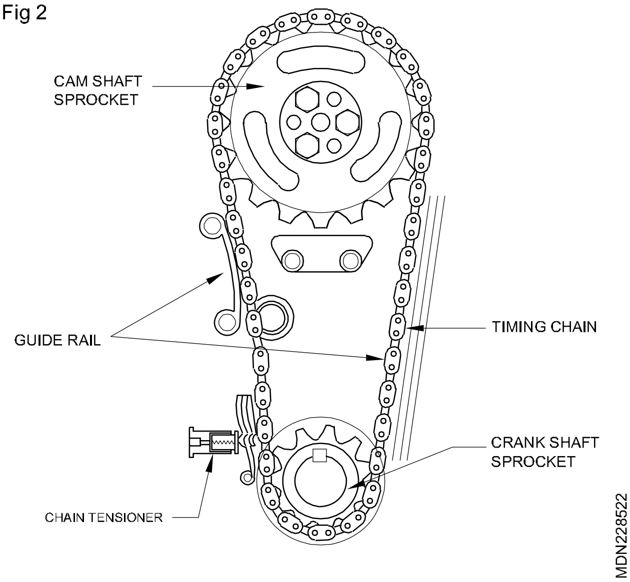
Fig 1



Timing chain (Fig 2)

With this type of sproket drive the camshaft is driven by means of a chain with the aid of various.

Fig 2



Auxiliary components

Single or multiple chains are used in this type of drive.

The chain is usually tensioned by means of a hydraulic chain tensioner which is controlled by the engine oil pressure.

The chain is addtionally guided in rails to the chain vibration and noise.

The direction of crank shaft and camshaft is same.

The chain and chain tensioner are only subject to minimal wear so that servicing is unnecessary. If need be, i.e. in the event of excessive wear, the chain must be renewed. If a fault is found the chain tensioner is changed.

1 Camshaft sprocket
2 Timing chain
3 Crankshaft sprocket
4 Chain tensioner
5 Guide rail

Clutch

Objectives: At the end of this lesson you shall be able to
- **state the need for a clutch**
- **list out different types of clutch**
- **state the function of the clutch**
- **state the construction of fluid coupling**

Need for a clutch

Depending upon the different loads are requiring change of speed to match the rated power available in the engine. Vehicle speed can be changed by shifting gears.

While shifting gears, the speed of the sliding sleeve and the respective gear on the main shaft should be synchronised to avoid gear collision noise. This is achieved by disconnecting the transmission of power from the engine flywheel to the gear box shaft with the help of the clutch. Thus, clutch is used to connect and disconnect transmission of power from the engine flywheel to the gear box drive shaft.

Function of the clutch

- The clutch should connect the power from the engine to transmission smoothly gradually without affecting the other components.
- It should damp vibrations and shocks during operation.
- It should not slip under high torque transmission.

Torque transmission by clutch depends upon the:

- contact area of the clutch plate.
- co-efficient of friction of lining material.
- spring pressure.
- number of clutch plate used.

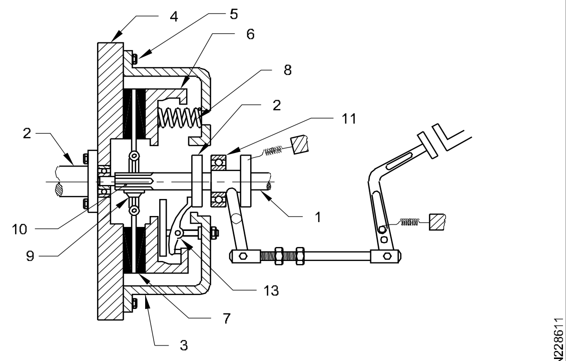
Different type of clutches

They are

- Single plate clutch
- Multi - plate clutch
- Dual clutch
- Dry and wet clutches
- Cone clutch
- Dog clutch
- Diaphragm spring type clutch
- Fluid coupling

Single plate clutch (Fig 1)**:** A clutch consists of driven (1) and driving shafts (2). A clutch cover (3) is mounted on the flywheel (4) by a set of screws (5). A pressure plate (6) presses the clutch plate (7) against the flywheel by the pressure of springs (8). The clutch plate hub (9) is splined (10) on the gear box drive shaft. The clutch plate rotates along with flywheel and power is transmitted to the drive shaft. When the clutch pedal is pressed, the release bearing (11) pushes the thrust plate (12) through the linkages.

Fig 1

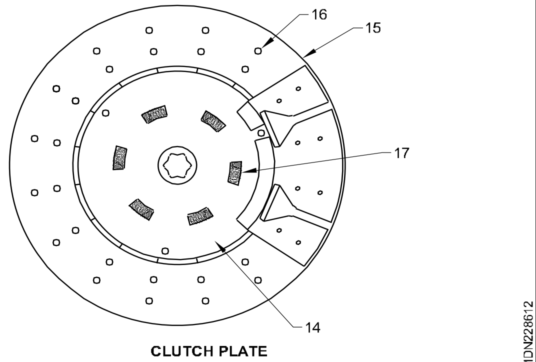


WORKING OF SINGLE PLATE CLUTCH

The thrust plate pushes the clutch finger (13), the clutch finger swivels and moves the pressure plate away from the flywheel. When the springs are compressed, the pressure plate does not exert pressure on the clutch plate and in turn the clutch plate does not transmit power from the flywheel to the drive shaft.

The clutch plate (Fig 2) consists of a torque plate (14) and clutch lining (15) made of frictional material fixed on the torque plate by reverts (16). Damper spring (17) are fixed in the torque plate to dampen shocks and vibrations during clutch operation.

Fig 2

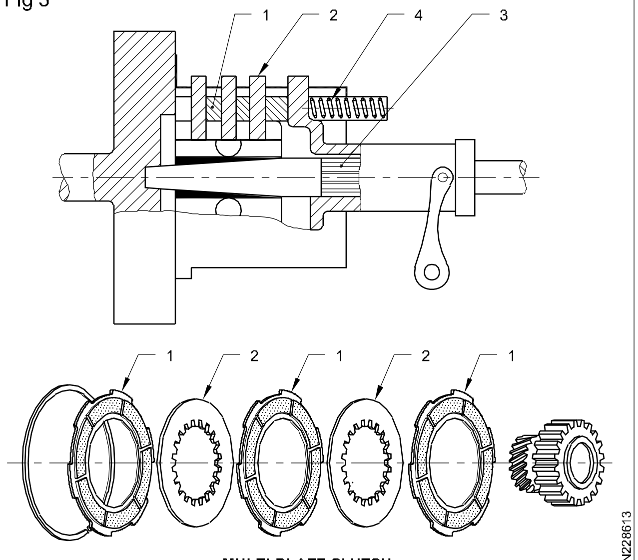


CLUTCH PLATE

Multi-plate clutch (Fig 3)

To transmit more torque, more contact area is necessary. Instead of using a larger diameter clutch plate, two or three small clutch discs are used to increase in frictional area. The pressure plates (2) and clutch plates (1) are alternatively arranged on the clutch shaft (3) and compressed by a number of pressure springs (4). This type works in the same way as a single plate clutch does.

Fig 3

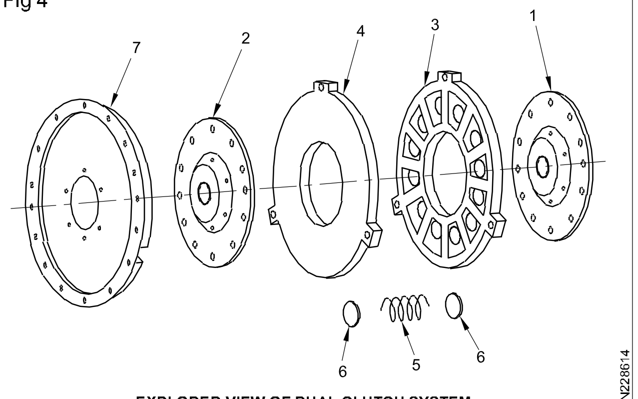


MULTI-PLATE CLUTCH

Dual clutch (Fig 4)

Dual clutches are combination of the primary master clutch (1) transmitting torque to the driving wheel and secondary P.T.O clutch (2) to drive P.T.O shaft. Dual clutch is mounted into the flywheel with primary pressure ring plate (3) and PTO pressure ring plate (4) (Fig.4) Disc spring (5), inserted in between two pressure rings, through insulating pad (6), pressing on both plates with there outer friction surface is the pressure element. Clutch guard (7) is mounted on the flywheel for safety reason. When clutch pedal is pressed partially , it disengages gearbox, while when pressed completely P.T.O drive is cut off.

Fig 4



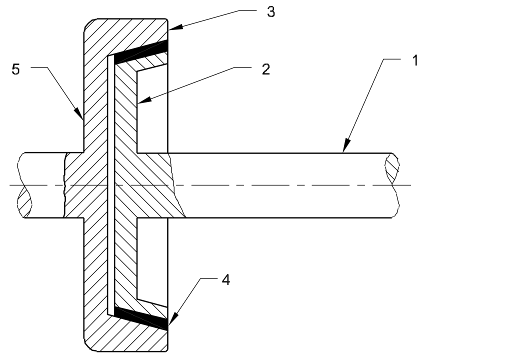
EXPLODED VIEW OF DUAL CLUTCH SYSTEM

Dry and wet clutches: These clutches may be dry or wet. When the clutch is operated dry without oil, it is called a dry clutch, but where the oil is used in the clutch it is called a wet clutch. Oil is used to cool the friction plate. The wet clutches are generally used along with or as a part of automatic transmission. These types of clutches are mostly used in heavy tractor and earth moving machineries.

Cone clutch (Fig 5)

In this case friction plates are in the shape of a cone. When the clutch is engaged the friction surfaces (4) of the male cone (2) on the clutch shaft (1) engage with the female cone (3) on the flywheel (5) due to the force of the spring. When the clutch pedal is pressed the male cone slides on the splines of the clutch shaft against the spring force. It gives more frictional area and is simple in construction. It is practically absolute and the same principle/device is used in the synchroniser unit in a synchro-mesh gear box.

Fig 5

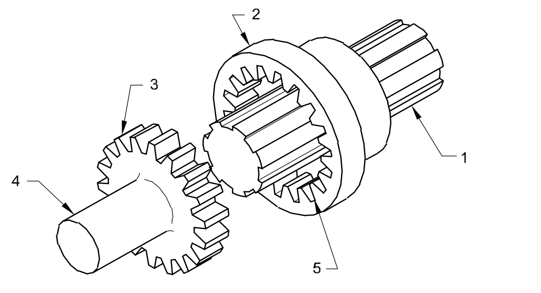


CONE CLUTCH

Dog clutch (Fig 6)

This type of clutch is used to lock two shafts together or to lock a gear to a shaft. When the sleeve (2) slides on a splined shaft (1) its internal teeth (5) match with the dog clutch (3) teeth of the driving shaft (4) and the clutch is engaged in this type there is no possibility of a slip as both the shafts revolve exactly at the same speed.

Fig 6

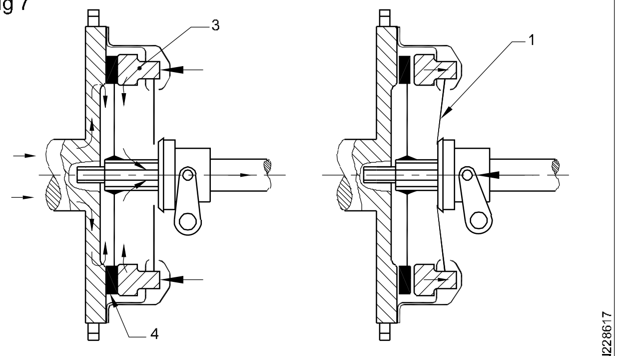


DOG CLUTCH

Diaphragm spring type clutch (Fig 7)

In some tractor, instead of using coil spring a conical dish shaped steel plate diaphragm spring (1) is used. It exerts force on the pressure plate (3) to press the clutch plate (4) firmly for engaging the clutch. It does not have release levers. The slots start from the centre of the diaphragm to form a number of release fingers (2). It requires very little pedal effort to disengage the clutch and it works noise free.

Fig 7



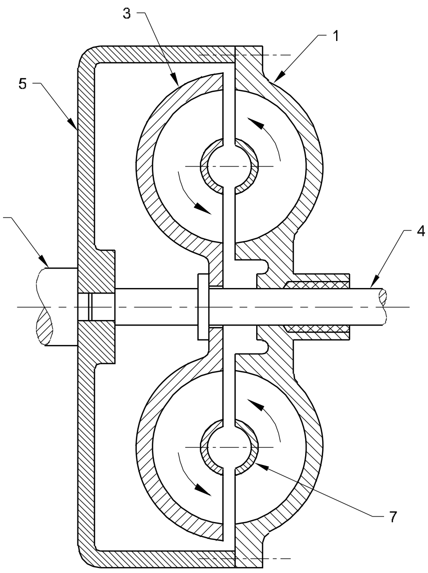
DIAPHRAGM SPRING CLUTCHES

Fluid coupling (Fig 8)

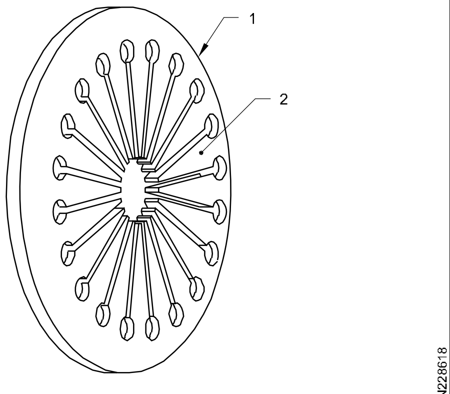
Fluid coupling consists of two half shells fitted with interior fins (7) which rotate from the hubs. These unit are mounted very close to each other with their open ends. So that they can turn independently without touching each other. A housing (5) surrounds both units to make a complete assembly inside, the assembly is fitted with 80% of fluid. The driving unit impeller (1) is linked to the crankshaft (2) rotates. The driven impeller (3) is mounted on the driven shaft (4) due to the movement of the oil, the impeller (3) rotates and transmits torque to the driven shaft (4).

Fluid coupling enables the driver to use the clutch and gear with less skill and fatigue than the conventional clutch. Wrong clutch engagements or selection of improper gear will not produce any of noise or sound. Any sudden load is also cushioned and absorbed by the fluid coupling. Dynamic stresses or breakages of the gear teeth of the mechanism and final drive are reduced to minimal. Fluid coupling is used with the epicyclic gear box as the output shaft (drive shaft) is always in motion.

Fig 8



FLUID COUPLING



DIAPHRAGM SPRING TYPE CLUTCH

cylinder block

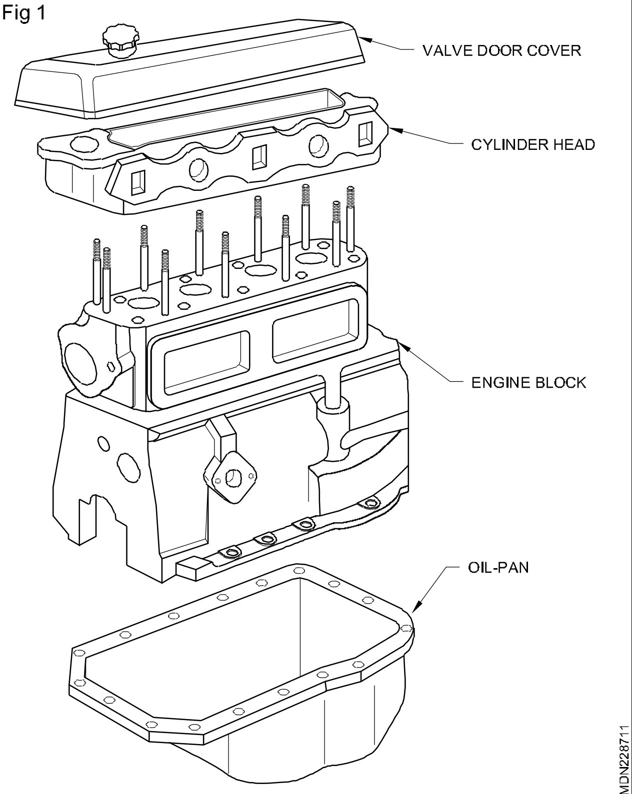
Objectives: At the end of this lesson you shall be able to
- **describe the function of the cylinder block**
- **state the constructional features of the clinder block**
- **state the function of crankcase**
- **state the function of the cylinder liner**
- **list out the various types of cylinder liners**
- **list the material of cylinder liners.**

Cylinder block: It forms the base of the engine. Two types of cylinder blocks are used in vehicles.

Cylinder block construction

Single piece casting: In this the type cylinder block and crankcase are cast as one piece. It gives better rigidity and it is easy to cast, which reduces the cost of manufacturing. (Fig 1)

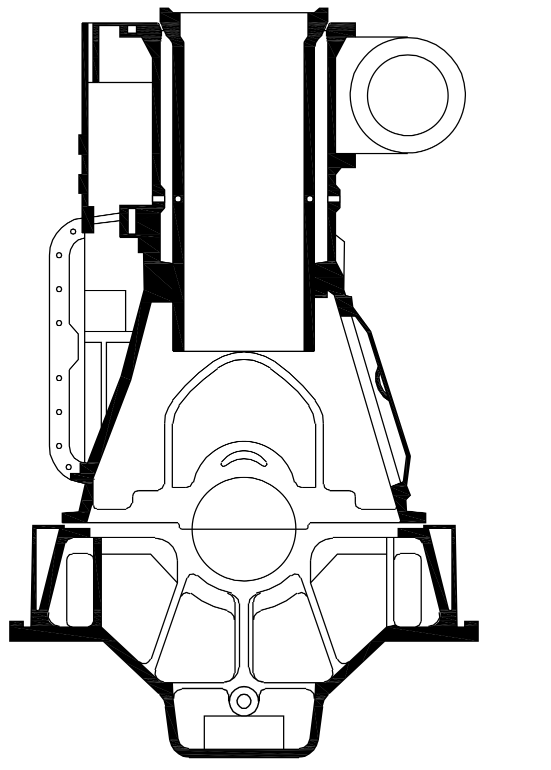
Fig 1



Two-piece casting (Fig 2)**:** In this type the cylinder block and crankcase are cast separately. The crankcase is bolted to the cylinder block. It reduces the problem of lifting the cylinder block from crankcase, during repairing or overhauling. This type of casting is used in heavy generating sets.

The cylinder block is made of cast iron or aluminium alloy. Inside the cylinder block, water jacket passages for the coolant and lubricating oil are provided. The cylinder head along with the valve assembly is fitted on the top of the cylinder block by nuts and bolts. The oil sump is bolted to the cylinder block /crankcase from the bottom. The crankshaft is supported on split type bearings. The half bearing is fixed on the web which is cast with the cylinder block, the other half bearing is fixed in the bearing cap. The bearing cap is fastened with the web by nuts and studs. This portion where the crankshaft is fixed is known as the crankcase. In the cylinder block passages are provided for the camshaft and camshaft bearing, push rods, tappets etc.

Fig 2



TWO-PIECE FRAME

Crankcase

Crankcase is attached to the bottom space of the cylinder block. It act as base of the engine and supports the crankshaft oil pan and also provides the arms for supporting the engien of the frame. The oil pan and the lower part of the cylinder block together are called the crank case.

Crank case material

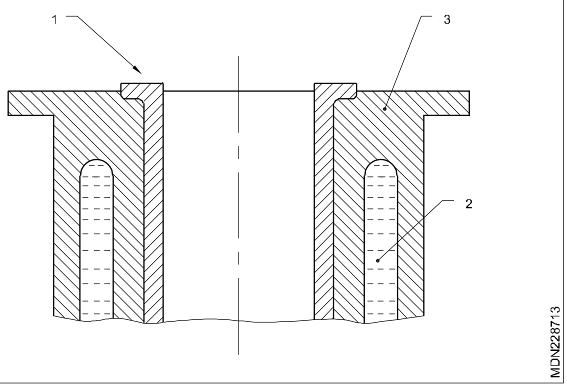
The cylinder block and upper half of the crankcase usually made of a ferrous alloy or semi steel to provide a stronger and harder casting. The use of stringer and together materials permits timer casting walls, thus saving weight and improving of cooling effect and good thermal condictivity.

Liners: A liner is a thin cast iron circular shell which is centrifugally cast. It contains chromium for hardness. It protects the cylinder block from rapid wear and damage due to combustion. The life of the cylinder block is increased by using a liner, since the block does not bear combustion pressure and temperature directly.

Dry type

In the dry type liner (1) the cooling water (2) of the engine does not come in direct contact with the liner. These liners have an interference fit with a cylinder block (3). In the dry type liner a special process is required to insert them into the bores, and to remove them from the bore. (Fig 3)

Fig 3



Wet type

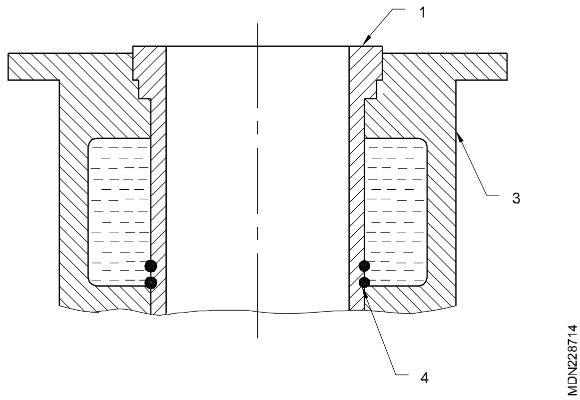
In a wet type liner (1) , the liners are in direct contact with the cooling water. (Fig 4)

Wet type liners are loose in the cylinder block (2) and these are supported between a recess in the block and the cylinder head. Gaskets or sealing 'O' rings (3) are used in liner grooves to seal against gas, oil and water leakage. Removal and fitment of these liners is easier than it is in the case of dry type liner.

Materials

Materials used for liners are nitrided steel, nitrided cast iron, chromium-coated alloy steel. Liners are harder than the cylinder blocks.

Fig 4



Engine assembling special tools

Objective: At the end of this lesson you shall be able to
- **use of special tools**

Cylinder block assembly

1 Place the crankshaft in position at the crankcase

Engine Assembly	Special Tools
1.Refitting of liner	Hydraulic press
2 Bearing oil - clearance	Plastic gauge
3 **Piston assembly**	Arbor press, Mallet & copper hammer
(a) piston clearance	Feeler gauge
(b) Piston pin assembly	Copper Drift, circlip plier
(c) Piston ring expander	Piston ring assembly
(d) Piston ring groover cleaning	Piston ring groover
(e) Piston ring clearance checking	Feeler gauge
4 Inserting of piston into cylinder block	Piston ring compressor
5 **connectting rod**	Connectting rod alignment fixture
6 **Crankshaft Assembly**	Crankshaft balancer , Dial gauge, Feeler gauge, Out side micrometer.
7 **Cylinder bore ovality and taper**	inside micrometer/ Telescopie gauge

Cylinder Head	Special Tools
Valve assembly	Valve spring compressor
Valve measurement	Vernier caliper ,bevel protrector, valve guide gauge
Valve Recontioning	Valve refacing m/c
Valve seat reconditing	Valve seat grinding m/c , valve seat cutter
Valve spring	Valve spring tester
Valve leakage cheacking	Valve leakage Tester
Spring checking	Try squear, surface plate
warpage	Strightedge, Feeler guage
Cyliner block crack	Ultrasonic tester , megnetic particl inspection test

Gas turbine

Objectives: At the end of this lesson you shall be able to
- **describe gas turbines**
- **state stages of turbine**
- **compare the gas turbine and diesel engine.**

Gas turbine

A gas turbine Fig 1 is a continuous combustion, internal combustion engine. There are three main components:

1 Gas compressor

2 Turbine on the same shaft

3 Combustion chamber

Some attachments used to increase efficiency, and also to convert power into mechaincal or electrical form.

The basic operation of the gas turbine is a Brayton cycle. Fresh atmospheric air flows through the compressor that brings it to higher pressure. Energy is than added by spraying fuel into the air and igniting it. So the combusion generates a high-temperature and pressure. This high-temperature high-pressure gas enters a turbine, where it expands. THis producing a shaft work output in the process.

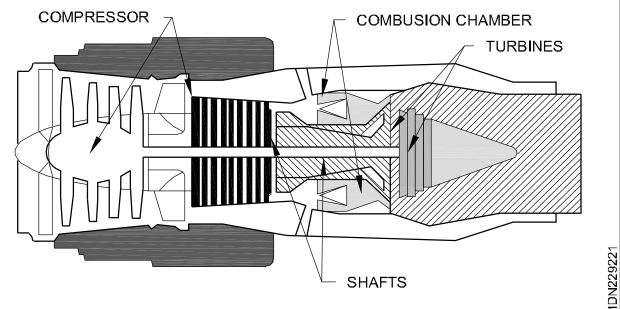
The turbine shaft work is used to drive the compressor. The energy that can also be (not used for shaft work comes out in the exhaust gases) produce thrust which is used to push aircraft. The purpose of the gas turbine determines the design so that the mose diesirable split of energy between the thrust and the shaft work is achieved. Separate cooling system not required as gas turbines are open systems that do not use the same air again.

Gas turbines are used to power aircraft, trains, ships, electrical generator, pumps, gas compressors, and military war tanks.

Stages in turbine

The two primary parts of turbine stage are the stator nozzle and the trubine rotor blades. The stage consists of a ring of fixed blades followed by the rotor blade ring. Most of the

Fig 1



Difference between turbine and diesel engine

Turbine	Engine
Large power achieved by relatively small size	Less power generated with occupying more space
High efficiency	Low efficiency
Simple design	Complicated in design
High RPM	Low RPM
High torque	Low torque
Needs very less maintenance suitable for stationary only	Needs very frequent maintenance suitable for both stationary and mobile.
Needs to have more safety conscious (More hazardous)	Less hazardous

Cooling and lubricating system

Objectives: At the end of this lesson you shall be able to
- **state the necessity of the cooling system**
- **list out the different types of cooling systems**
- **state the advantages of the forced type of cooling system**
- **draw the water circulation path in an engine block**
- **state the function of the water pump, radiator, temperature indicator, pressure cap**
- **state the need and function of the thermostat valve, recovery system**
- **state the different types of thermostat valves.**

Combustion of fuel inside a cylinder develops a very high temperature (Appx. 2200^{0}C). At this temperature the engine parts will expand and tend to seize. Similarly the lubricating oil will loose its property. Therefore it is necessary to keep the engine temperature to operating limits. This is done by the cooling system. Heat is removed from the engine by cooling media (water or air) and is dissipated to the atmosphere.

Types of cooling systems

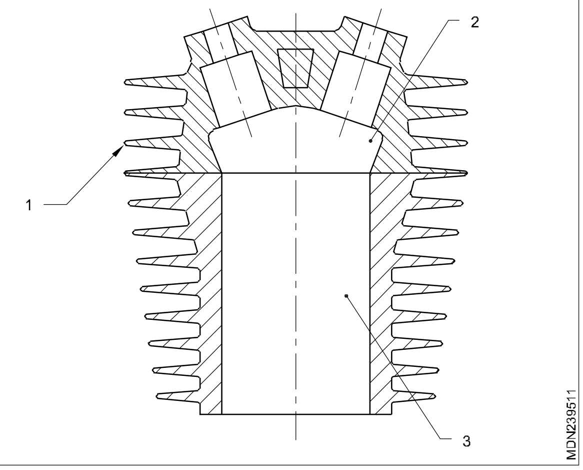
There are two types of cooling systems used in engines.

- Direct cooling - air cooling.
- Indirect cooling - water cooling.

Air-cooled engines

In air-cooled (Fig 1) engines, cylinders are semi-independent. They are not grouped in a block. Metal fins (1) are provided on the head (2) and cylinder (3), to help dissipate heat from the engine. In some engines fans are also used to improve air circulation around the cylinders and heads. This type of cooling system is employed in two-wheelers and small stationary engines. These are used in both S.I. and C.I. engines.

Fig 1

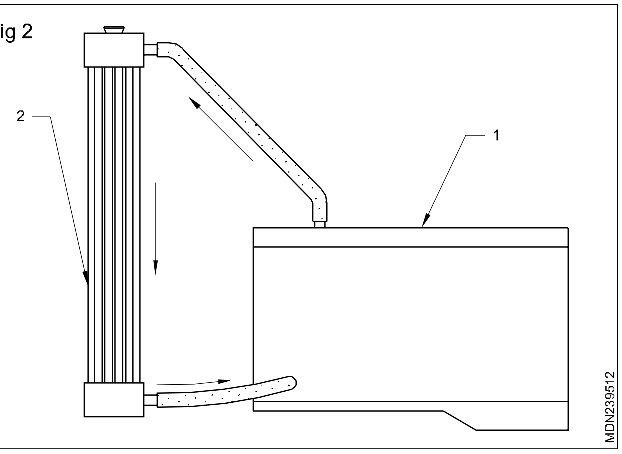


Water cooling

Two types of water cooling systems are used.

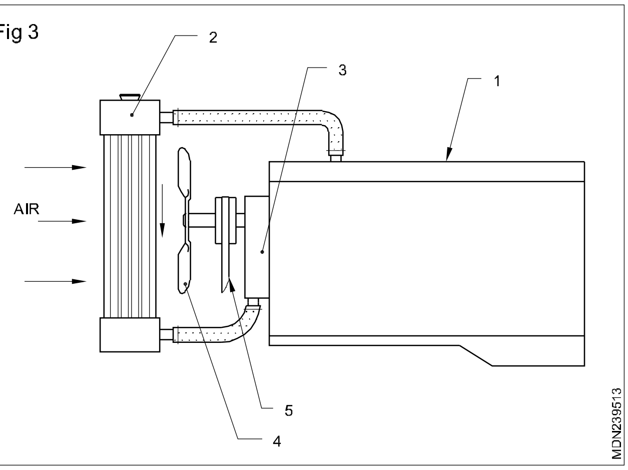
- Thermo-siphon system (Fig 2)

Fig 2



- Forced circulation system (Fig 3)

Fig 3



Thermo-siphon system

In this system no pump is used for water circulation. Water circulation is obtained due to the difference in the densities of hot and cold water. Water absorbs the heat and rises up in the block (1) and goes to the radiator's (2) top side. Water is cooled in the radiator (2). It again goes to the water jackets in the engine. To maintain a continuous flow of water the level of water is maintained at certain minimum level. If the water level falls down the circulation will discontinue. This system is simple but the rate of cooling is very slow.

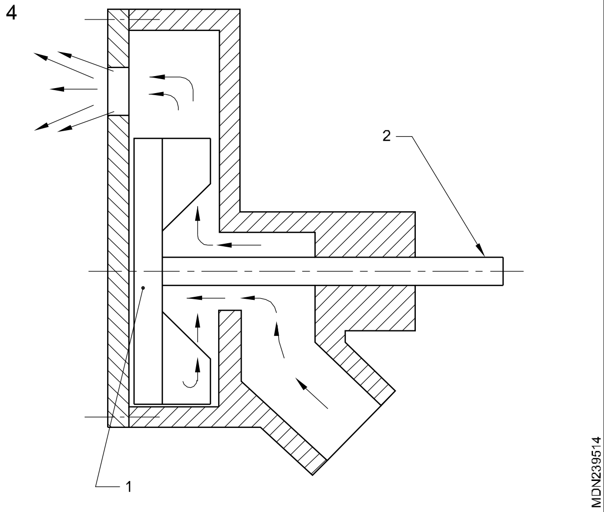
Pump circulation system (Forced feed system)

In this system water is circulated by a pump (3). The pump is driven by a belt (5) which is connected with the crank-shaft pulley. The circulation depends upon the engine speed. More water is circulated at higher engine speed.

The water absorbs heat from the engine and flows to the radiator's (2) top tank. Water from the top tank of the radiator (2) flows down to the bottom tank. The fan (4) draws the air through the radiator's fins and cools the hot water. Cold water from the bottom tank is again pumped to the engine and the cycle is repeated.

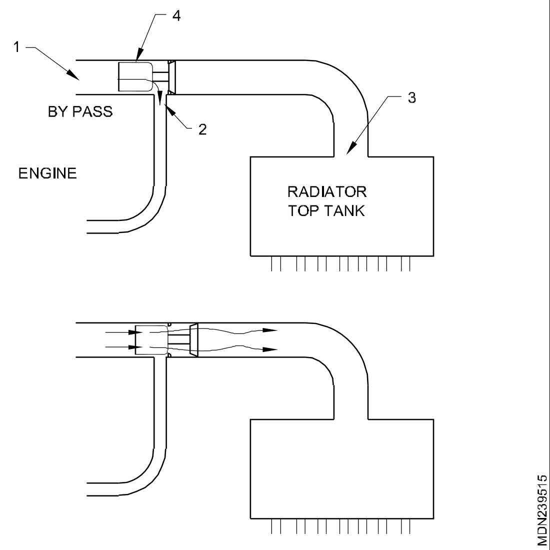
Water pump

Fig 4



The centrifugal type water pump (Fig 4) is used in engines. It is mounted on the front side of the cylinder block or head. The water pump is driven by the crankshaft pulley through the fan belt. The impeller (1) is mounted on one end of the water pump shaft (2). The shaft (2) is fitted in the pump housing with bearings. A water seal is provided in the pump to prevent leakage of water and to prevent water entering into the bearings. When the impeller rotates it draws water from the lower tank of radiator, and pumps water to the engine block, by centrifugal force under pressure. The fan is mounted on the water pump pulley.

Fig 5



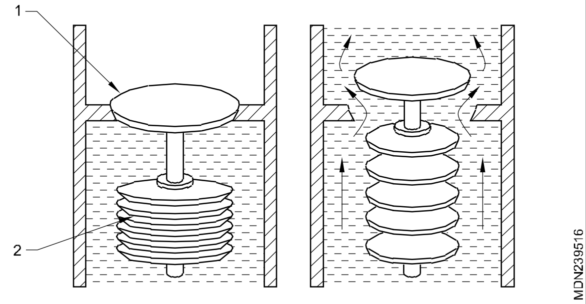
Thermostat

The thermostat (Fig 5) helps to bring the cold engine to the operating temperature quickly.

It is fitted in between the water outlet of the cylinder head (1) and the inlet (2) of the radiator in the water cooling system. When the engine is cold, the thermostat (4) is closed. It does not permit water to enter the radiator. Water recirculates in the engine through the bypass hole (2) and the engine reaches the operating temperature quickly. Once the engine has reached the operating temperature the thermostat (4) opens. It closes the bypass hole (2) and now permits water to enter the radiator tank (3). Thermostats are rated to open at different temperatures. Two types of thermostats are used.

- Bellows type (Fig 6)
- Wax type (Fig 7)

Fig 6



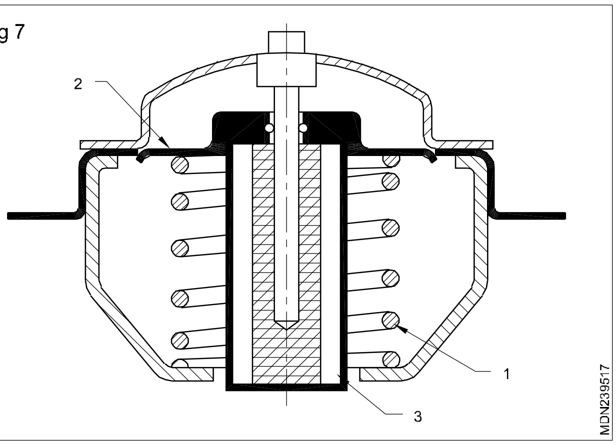
Bellows type

It has a flexible metal bag closed at both ends. The metal bag is partially filled with ethyl which has a low boiling temperature.

When the engine is cold the valve (1) closes its outlet passage and does not allow water to reach the radiator top tank from the engine, but is circulated through the bypass port to the engine.

When the water reaches the working temperature, ethyl in the closed bellow (2) expands and opens the valve (1). Now the water reaches the radiator top tank from the engine. In the valve's opened position the bypass passage is closed.

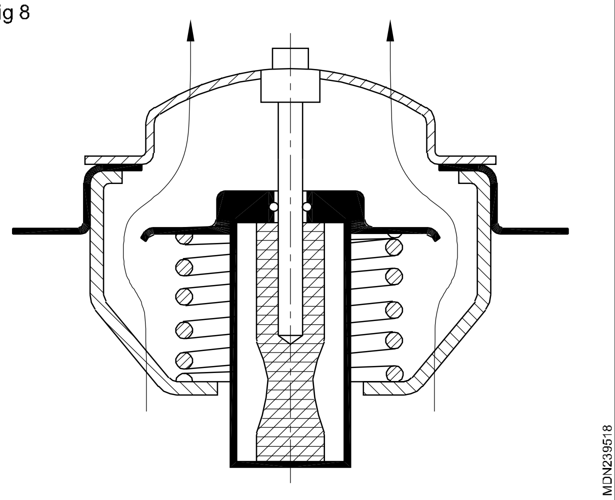
Fig 7



Wax pellet type

In this type a wax pellet (3) (Fig 8) is used as a heating element. When the circulating water's temperature is lesser than the operating temperature, the spring (1) keeps the valve (2) in the closed position and the water does not reach the radiator top tank from the engine.

Fig 8



As the water reaches the operating temperature the wax pellet expands and forces the valve (2) to open against the spring tension. Now the water reaches the radiator top tank, from the engine. At this position the bypass port is closed by the valve.

Components of water cooling system

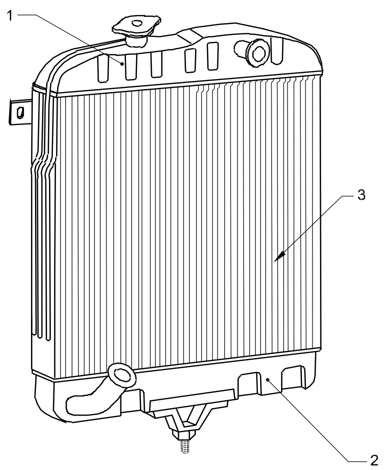
Objectives: At the end of this lesson you shall be able to
- **state the constructional features of a radiator**
- **state the need of a pressure cap**
- **explain the marine engine cooling system**
- **explain the open cooling system.**

Radiator

The purpose of a radiator in the cooling system is to cool hot water coming out of engine.

It has a large cooling surface area to allow enough of air to pass through it. Water circulated through it is cooled by the passing air.

Fig 1



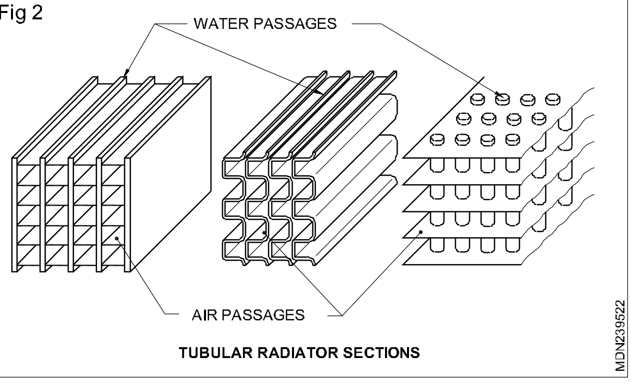
The radiator (Fig 1) consists of an upper tank (1),a lower tank (2) and in between the upper and lower tank radiator cores (3) are provided. The upper tank (1) is connected to the water outlet of the engine through a rubber hose. The lower tank (2) is connected to the water pump through rubber hoses.

Radiator cores are classified into two types.

- Tubular core (Fig 2)
- Cellular core (Fig 3)

Tubular core

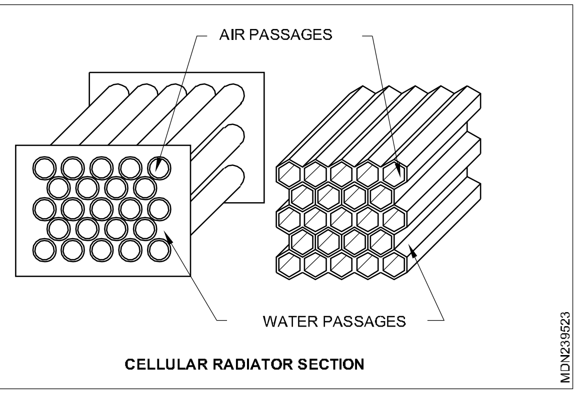
Fig 2



In a tubular type the upper and lower tanks are connected by tubes. Water passes through these tubes. Cooling fins are provided around the tubes, to absorb and radiate heat to the atmospheric air.

Cellular cores

Fig 3



CELLULAR RADIATOR SECTION

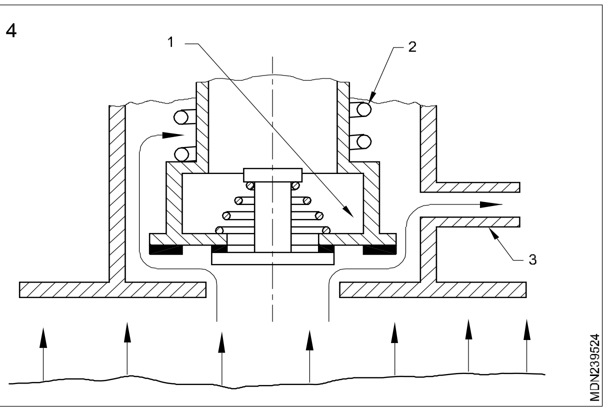
In the cellular type a large number of individual air cells are provided and surrounded by water. Because of its appearance, the cellular type is known as a 'honeycomb' radiator.

The material of the core is of copper and brass. The parts are normally connected together by soldering.

Pressure cap

In normal atmospheric conditions water boils at 100°C. In higher altitude height the atmospheric pressure is low and water boils at a temperature below 100°C. To increase the boiling temperature of water the pressure of the cooling system is increased. This is achieved by providing pressure caps to seal the system. The coolant loss, due to evaporation is also minimized, by using a pressure cap. (Fig 4)

Fig 4



It also permits the engine to operate at a higher temperature so that better efficiency of the engine is achieved.

The pressure cap is fitted in the filler neck portion on the top of the radiator tank. If pressure is increased by 15 P.S.I., the boiling temperature raises to 113°C. The pressure cap has two valves.

- Pressure valve
- Vacuum valve

Pressure valve

If the pressure in the system rises it may damage the components. To avoid this a pressure relief valve (1) is used to release the excess pressure. It is a spring- loaded valve. The spring's (2) tension depends on the system's pressure.

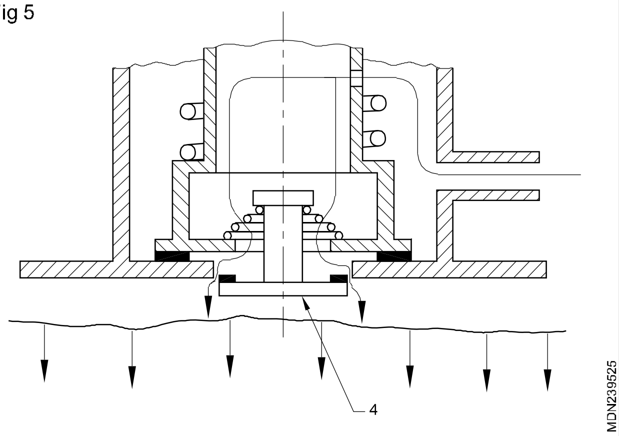
When the cooling water of the engine is heated up it expands which results in high pressure in the system. If the force due to pressure is more than the spring's (2) tension the valve opens and water vapour/steam escapes through the overflow pipe (3) until the pressure is lowered to the preset value.

Vacuum valve

When the engine cools down the pressure in the system decreases due to loss of the coolant and a vacuum is created.(This valve is also located in the cap and fitted in the filler neck of the radiator.)

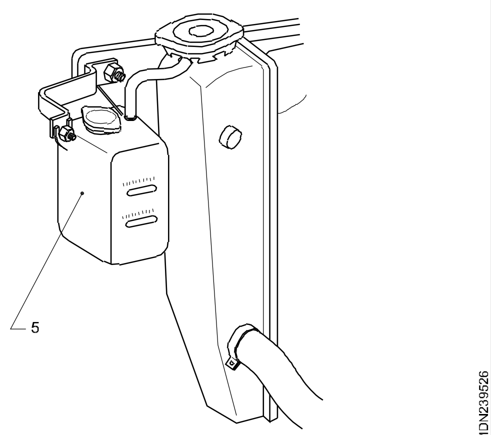
At this time the vacuum valve (4) (Fig 5) opens and air flows into the system until the vacuum is filled up in the system.

Fig 5



In some engines an overflow pipe is connected to an expansion tank (5). The expansion tank (5) (Fig 6) collects the water vapour during the pressure valve operation, and the same vapour, after condensing, goes to the radiator when the vacuum valve is in operation.

Fig 6



Marine engine cooling system

There are two types of cooling system used in marine engines.

1 Heat exchange cooling system

2 Keel cooling system

Heat exchange cooling system

Heat exchange cooling system consists of the following units.

Water cooled exhaust manifold.

Engine coolant pump.

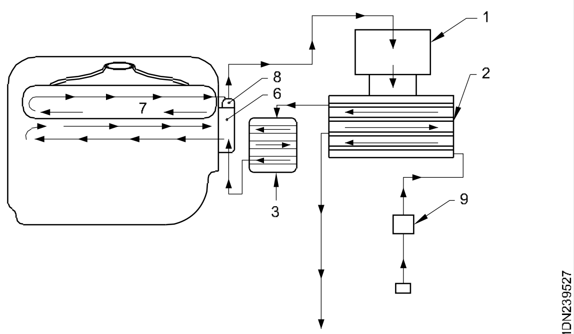
Heat exchanger.

Expansion tank.

Operation

The coolant flows (Fig 7) from the expansion tank (1) around core cells (2). These core cells contain sea water. The sea water is circulated through the core by the water pump (9). Hot engine coolant flows outside of the core (2) and it is cooled by the sea-water inside the core.

Fig 7



Coolant as fresh water is circulated through an expansion tank (1). From the expansion tank (1) it flows down around the cores (2). From the cores (2) to the oil cooler (3) and then through inlet of engine's coolant pump (6). It is then pumped to the engine and sent to the expansion tank (1) through the exhaust manifold (7) and thermostat (8).

A separate pump (9) is used to circulate sea water to cool cores (2) and back.

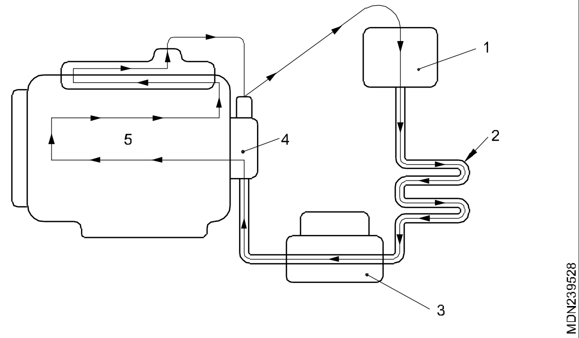
Keel cooling system

In this system coolant flows from the expansion tank (1) to the keeling coil (2) and goes to the engine (5) through an oil cooler (3). A pump (4) is used to circulate the coolant in system.

Open cooling system

In this system (Fig 8) water is stored in a reservoir and circulated in the engine by a water pump. Hot water from the engine is pumped to the reservoir where it flows from a height and gets cooled.

Fig 8



Colant hoses

Hose pipes

It is made of synthetic rubber

1 Upper hose: It is connected between the cylinder head and radiator upper tank.

2 Lower hose: It is connected between the cylinder block as radiator lower tank.

3 Bypass hose: It is connected between the cylinder head coolant/water outlet and water pump intake side.

Fan

The is mounted behind the radiator on the water pump shaft. It is driven by the belt that drives the water pump. It drawn the air through radiator to cool the pins & pipe (core).

In latest vehicles the fan is mounted an frame behind the radiator. It is operated electrically by ECM.

Fan does not start toll the coolant/water temperature reaches at normal working temperature (Ex. 90°C).

Temperature indicator

The temperature indicator is fitted on the instrument panel it indicates the temperature of the water in engine water jackets. There are two types of temperature indicator used in an automobile.

1 Mechanical type

2 Electric type

mechanical type temperature indicator consistes of a scaled bulb that fits in the cylinder head water jacket and connected by a fine tube to temperature pressure gauge on the dash board.

The electric type water temperature scalling unit is fitted in the cylinder head water jacket and it is conected through electric wire from ignition switch to temperature use sending units cold terminal through panel indicator bulb, another wire is conected from temperature sending units hot terminal to temperature warning lamo. When the engine temperature reaches normal, the green light circuit is completed by the engine unit and the dial indicates green ligjt. When the engine is over heated the engine unit complees read light circuit and the dial indicates the red light.

In latest vehicle engine coolant temperature (ECT) sensors are using.

Thermo switch

THis divice is prevents the engine from over heating by activating radiator cooling fan, measuring the coolant temperature and controlling the level gaugesand warning lights on the engine control unit. This device have upto four terminals and be installed on the radiator, the cooling system tubes or thermostate, so that the coolant flows across the sensing element (bimetela disc or thermistor).

Function of thermo switch

Theremo switch operates independent from any current supply, temperature detection is effected by means of a by metal disk switch on temperature. When this fixed switch on temperature is reached this bimetal disk well snap over, closing a contack the circuit system and there by closing the electric of device to be started. After cooling down and reaching the cut off temperature. The bimetal disk will auto mechanically return into its original position and open the contact. The electric circuit is opened again.

Coolant properties

A efficient colling system removes 30 to 35% of the heat generated in the combustion chamber.

- Coolant should be remove heat at a fast rate, when the engine is hot.
- Coolant should be remove heat at a slow rate when the engine is started until the engines reaches at its normal operating temperature.
- Coolant should not remove too much heat from the engine. Too much removal of the heat decreases thermal efficiency of the engine.
- It should circulate freely in the coding system.
- It should be prevent frequency and rust formations.
- It should be reasonbly cheap.
- It should not waste by voporization.
- It should not deposit any foreign mater in the water jackets/radiator.

Change of engine coolat interval

1 Coolant should be replace as per specified by the manufacture.
2 Coolant should be replace during major repari is an engine or radiator.
3 Coolant should be replace at dilute (oil mix with water).

Anti- Freeze mixtures

1 Wood alcohol
2 Denatured alcohol
3 Gycerine
4 Ethylene glycol
5 Propylene glycol
6 Mixture of alcohol and glycerine

Engine lubricating system

Objectives: At the end of this lesson you shall be able to
- **list out the different types of engine lubricating systems**
- **explain the function of each system**
- **draw the oil circulation path in an engine block**
- **state the function of the pressure relief valve**
- **state the types of the pressure relief valve**
- **list out the different types of crankcase ventilation**
- **explain positive crankcase ventilation.**

Types of lubricating system

The following types of lubricating systems are used in engines.

1 Petrol-oil lubrication

2 Dry sump lubrication

3 Splash lubrication

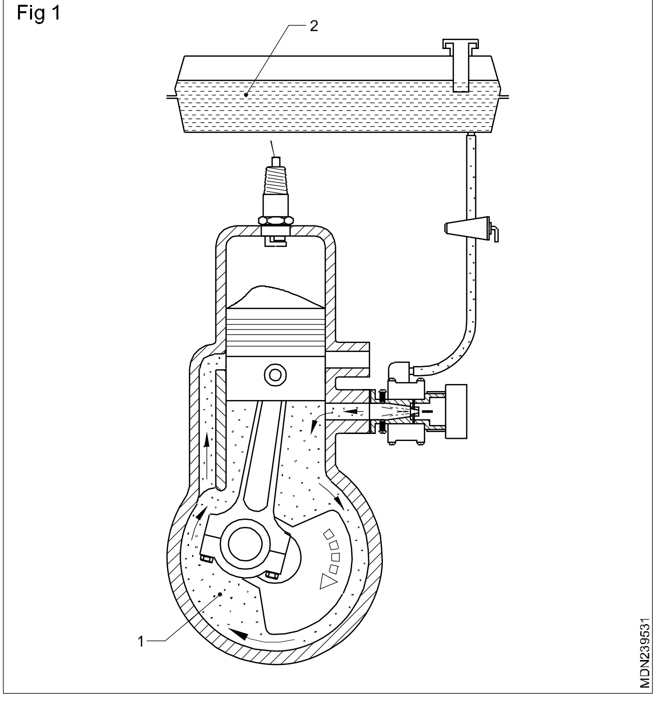
4 Pressurized lubrication

5 Combined lubrication

Petrol-oil lubricating system (Fig 1)

In this system the lubricating oil is mixed with the petrol(2). The ratio of petrol and oil is 20:1. When fuel goes in the crankcase chamber (1) and crankshaft bearings, the oil mist sticks to the moving parts and gives the lubricating effect. This system is mostly used in two-stroke engines.

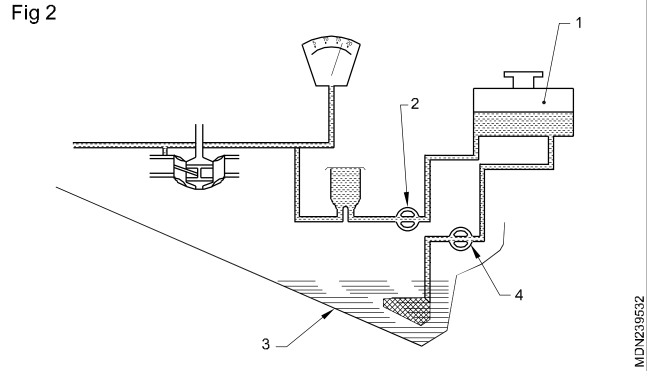
Fig 1



Dry sump lubricating system (Fig 2)

In this system the lubricating oil is delivered from a separate tank (1) to the components by an oil pump (2). The oil lubricates the moving parts and flows back to the oil sump (3). A scavenging pump (4) is provided to pump oil from the sump to the tank.

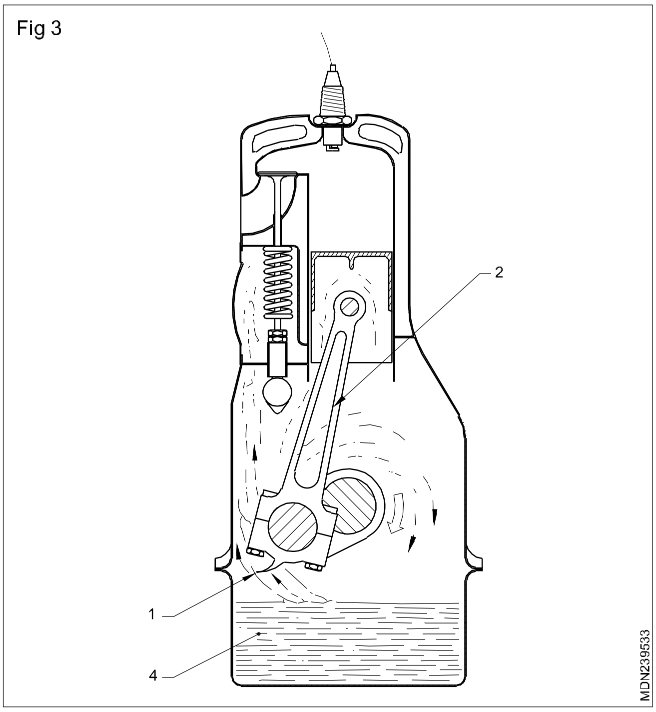
Fig 2



The lubrication effect is not affected when the vehicle is climbing up or moving down.

Splash type lubricating system (Fig 3)

Fig 3



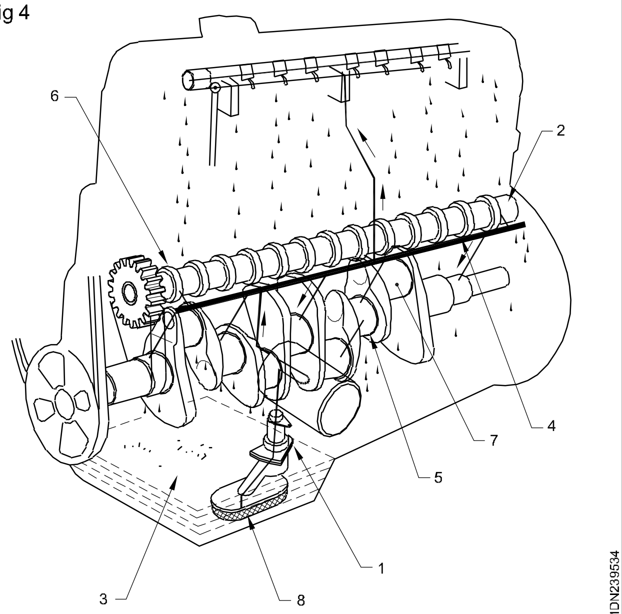
In this system the lubricating oil is stored in a sump(4). A dipper (1) is made at the lowest part of the connecting rod (2). When the crankshaft rotates the dipper (1) dips in the oil once in every revolution of the crankshaft and splashes oil on the cylinder walls.

Pressure lubricating system (Fig 4)

In the system the lubricating oil is circulated to all the moving parts of the engine under pressure, by the oil pump (1) driven by the camshaft (2).

The oil from the sump (3) is sucked by the oil pump (1) through the strainer (8) and suction pipe. The strainer filters the solid dust particles. The oil flows to the main gallery (4) from the filter's outlet. From the main oil gallery (4) the oil flows to the crankshaft main journals (5) and camshaft bushes (6).

Fig 4



From the crankshaft main journal (5) the oil flows to the crankpin (7). From the camshaft bush it flows to the cylinder head and lubricates the rocker bushes. When the crankshaft rotates the oil splashes from the connecting rod bearings and lubricates the piston rings and liner. In some engines an oil hole is drilled from the connecting rod big end to the small end to lubricate the gudgeon pin bush.

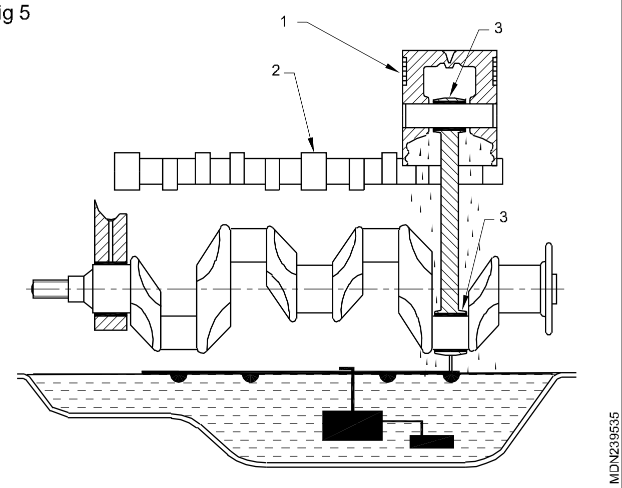
A relief valve is provided in the path between the oil pump and the filter. The relief valve limits the maximum pressure of the oil in the system. An oil pressure gauge or indicating lamp is provided to indicate the oil pressure.

After lubricating the various parts of the engine, the oil reaches the oil sump.Combined lubricating system

Combined lubricating system (Fig 5)

It is a combination of splash lubricating system and pressure lubricating system. Some parts are lubricated by the splash lubricating system - such as the cylinder wall (1), camshaft bearings (2), connecting rod bearing (3) and the remaining parts are lubricated by pressure lubricating system.

Fig 5



Pressure relief valve

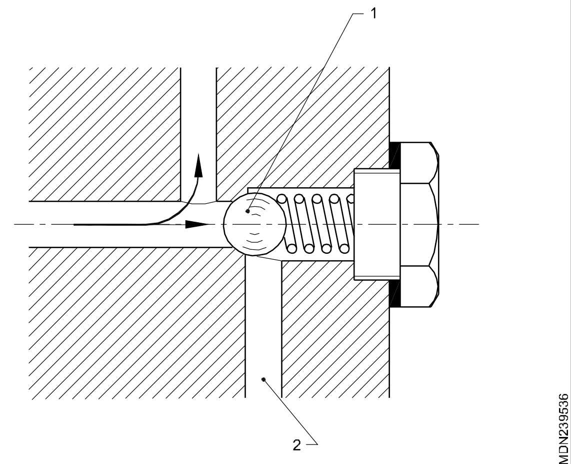
The pressure relief valve is used to limit the maximum pressure of the oil. When the oil pressure increases more than the prescribed limit, the relief valve opens and allows oil to return back to the oil sump directly.

Following types of relief valves are used.

- Ball type
- Plunger type

Ball type (Fig 6)

Fig 6

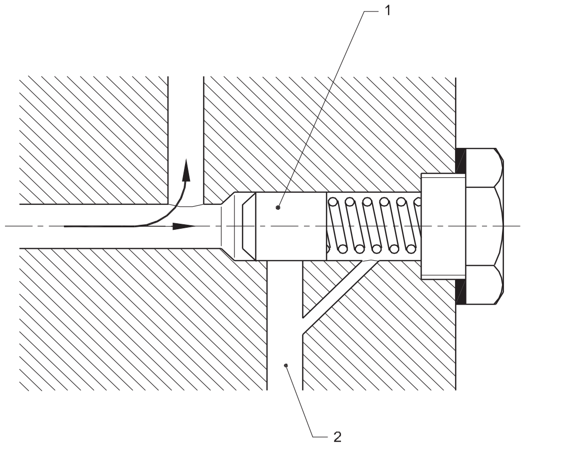


In this type of relief valve a spring-loaded ball (1) opens the connection to the return channel (2) when the oil pressure over comes the spring force. The oil flows through the return channel back to the oil sump.

Plunger type relief valve (Fig 7)

This type of relief valve is similar to that of the ball type except that a plunger (1) is used instead of a ball. A leakage oil relurn passage is provided to allow oil to return to the oil sump which has passed through the plunger (1).

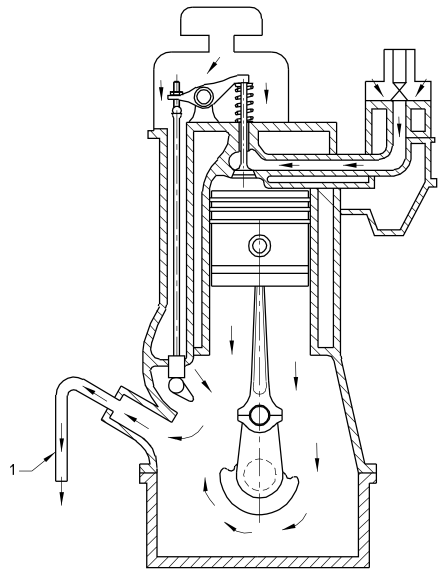
Fig 7



Crankcase ventilation (Fig 8)

In the crankcase oil gets diluted due to the mixture of blow by gases, carbon particles, metallic particles, sand, dust, dirt and the acids formed out of the exhaust gas condensation such as sulphuric acid and phosphoric acid. This affects lubrication and forms a sludge (accumulation of dirty oil). Frequent cleaning and change of oil is needed. To overcome this problem, crankcase ventilation is provided. Fresh air is allowed in the crankcase which passes out after circulation through a breather pipe (1) in the rear. This arrangement is known as OPEN TYPE CRANKCASE VENTILATION.

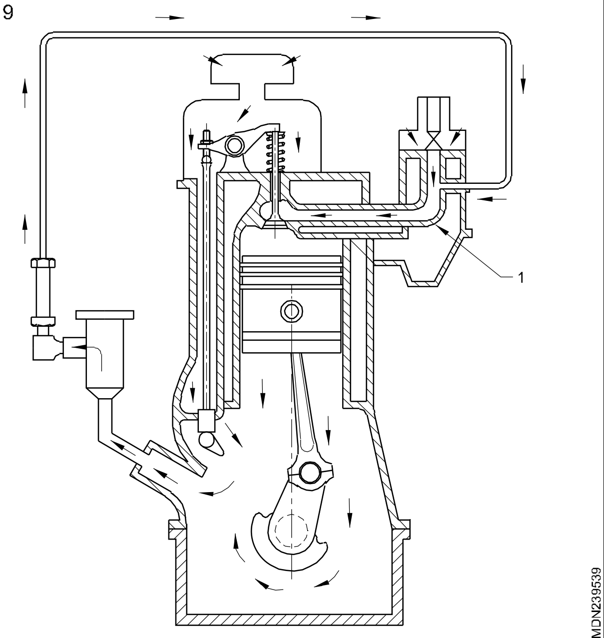
Fig 8



Positive crankcase ventilation (Fig 9)

The exhaust gases and other particles going out of the engine are toxic and injurious to public health. To overcome this positive crankcase ventilation or closed type ventilation is provided. In this arrangement all air flowing out of the engine crankcase is drawn back into the inlet manifold (1) and fed into the engine. This prevents the flow of gases outside the engine.

Fig 9



Function of sump

Oil sump is the lowest part of the crank case (Engine). It provides a covering for the crankshaft and contains oil in it. In unit sump lubricating system, the oil is taken out from the sump and after lubricating different parts oil drops in oil sump. It is made of steel pressing/aluminium/east iron. It contains drain plug at its lowest part to drawn out the oil. In dry sump lubricating system the oil is contansed in a separate oil tank.

Oil collection pan

Oil pan is the lowest part of the engine. In dry sump lubricating system oil pan is collect the oil after lubricating different parts oil drops in an engine and then oil is sent back to the oil tank by a separate delivery pump.

Oil tank

In dry sump lubrication system, two oil pumps are used one for feed the oil from tank to lubricating sysem and another pump delivery pump is sent oil from dry sump to oil tank. In this system oil is not stored in oil sump.

Pick up tube

In dry sump lubricating system pick up tube is connected between delivery pump and oil tank, to pick up the oil from sump to oil tank

Oil pump & Filter

Objectives:
- **list out the types of oil pumb**
- **list out the type of oil flow system**
- **purpose of the oil cooler**

Oil level indicator

It is a steel stick graduated at the front end for measuring the level (amount) of oil in the sump. The graduatuons are "Fukk", "Half", "Low" marks are provided on the bottom end of the dip stick. These marks show whether the oil is up to the required full or half level or the level is so low. The low level oil may cause danger to engine life.

For measuring oil level, remove the stick from the engine, clean and dipped into the oil sump and again taken out to see graduation oil has sticked.

Oil pressure indicator

Oil pressure gauge or oil waring light is provided on the dash board to indicate the lubrication

Oil pressure during of an engine running.

Oil pressure gauge

It is equipped with pressure lubricating system to warm the engine operator, what is the oil pressure is in the engine. The oil pressures are following types

1 Pressure expansion type

2 Electric type

   a Balancing type

   b Binmetal thermal type

Oil pressure indicating light

The light comes when the ignition switch is turned on and the oil pressure is low. The circuit uses four stage diaphragm switch, which operates a warning lamp according to the pressure required for different engine speeds. The switch is located at the oil main gallory. Its connection with the warning light is through the ignition switch. When engine.

Components of the lubrication system

Oil pumps

The oil pump is used to pump oil from the oil sump to the oil galleries at a certain pressure.

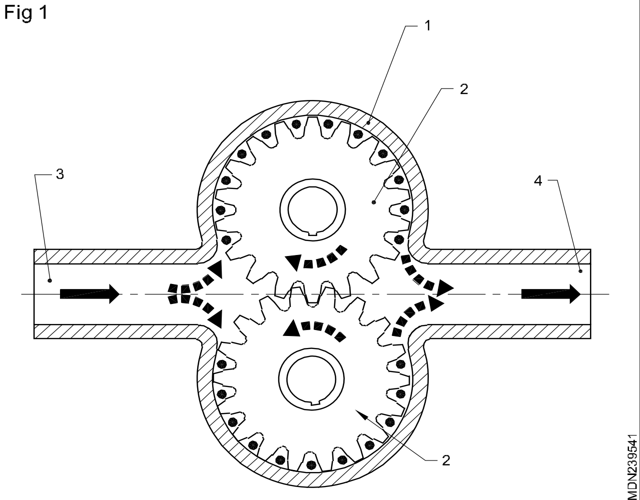
It is located in the crankcase and is driven by the camshaft. Foru types of oil pumps are used.

- Gear type oil pump
- Rotor type oil pump
- Vane type oil pump
- Plunger type oil pump

Gear type oil pump (Fig 1)

In this type two gears are fixed in the pump housing (1). The gears (2) have little clearance with the pump housing (1). When the gears rotate a vacuum is created in the casing. Oil is sucked through the inlet (3) and pumped to the oil gallery through the outlet (4).

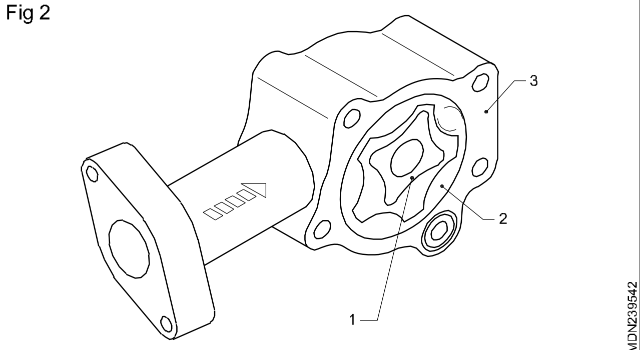
Fig 1



Rotar type oil pump (Fig 2)

The rotor type oil pump consists of an inner driving rotor (1), and an outer drive rotor (2) which rotates freely in the pump housing (3) and runs eccentrically in realation to the inner rotor.

Fig 2

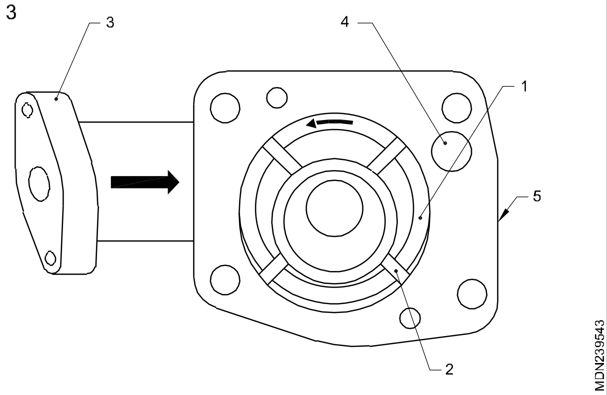


The oil is sucked into the pump in the side where the volume between the rotor teeth increases and is pumped out on the side where the volume decreases.

Vane pump (Fig 3)

In the vane tyoe pump the rotor (1) runs eccentrically in the pump housing (5). Spring- loaded vanes (2) slide against the pump housing walls. Suction us created by the vanes (2) when the rotor (1) rotates. Oil is sucked through the inlet duct (3) and discharged through the discharge duct (4).

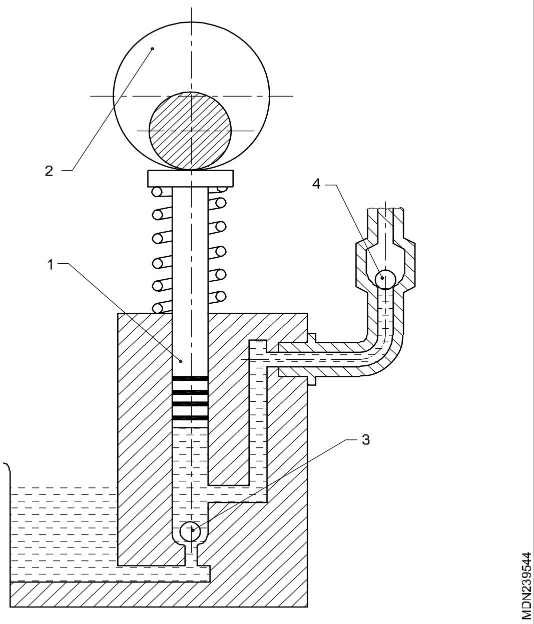
Fig 3



Plunger type oil pump (Fig 4)

In this type of plunger (1) moves uo and down in the cylinder. It is operated by a special eccentruc cam (2). THis pump has two non-return ball valves (3) & (4). These valves are spring-loaded balls. One of these is on the suction side (3).

Fig 4



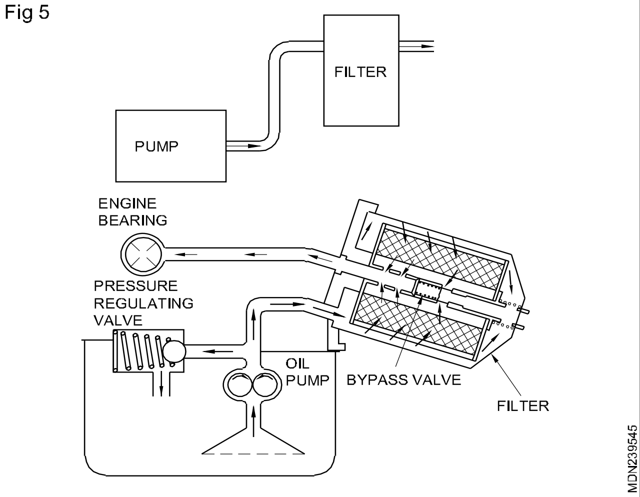
During the upward stroke the oil is sucked through the valve (3). During the downward stroke the non-return valve (3) closes. The other non-return valve (4) which is on the delivery side opens and permits the oil to flow out from the pump. This type of plunger pump is used in medium and high pressure lubricating systems.

Oil filter

Full flow oil filter system (Fig 5)

In this system all the oil passes through the filter before reaching the main oil gallery. One bypass valve is provided in the filter which allows oil to reach the main oil gallery directlu if the filter is choked.

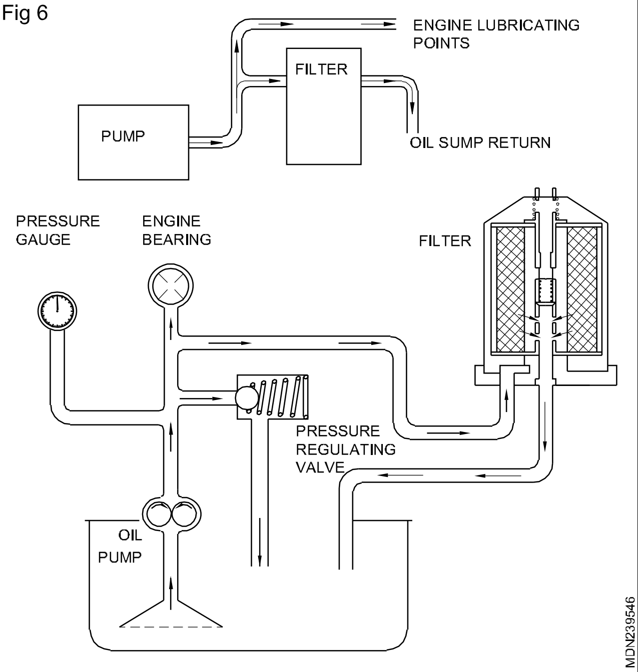
Fig 5



Bypass oil filter system (Fig 6)

In this system only a part of the engine oil enters the filter. After filtering, the oil goes to the oil sump. The remaning oil goes directly to the main oil gallery.

Fig 6



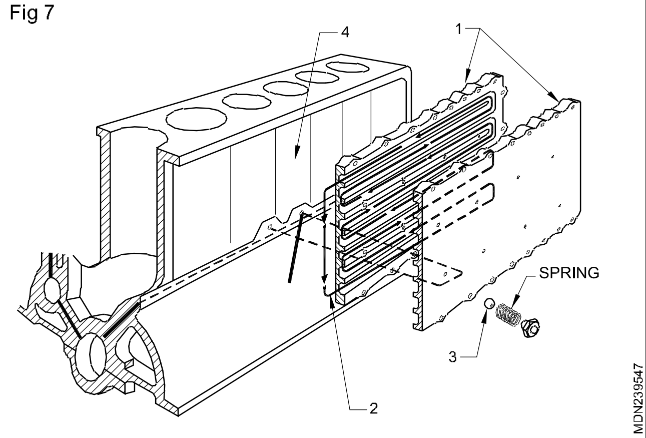
Filter element

Filter elements are made of felt, cotton waste, cloth and paper. Oil filters are replaced after certain kilometres of running of the engine as specified by the manufacturer.

Oil coolers (Fig 7)

OIl cooler consists of two halves (1). Passages (2) are provided in between the cooler's halves for oil circulation. A ball valve (3) is provided to maintain the required oil pressure. THis is made of cast iron. The purpose of the oil cooler is to tansfer the heat from engine oil to cooling water and cool the engine oil.

Fig 7



The inner wall of the oil cooler is in contact with cooling water. The engine oil which is made to circulate through the passages provided in the oil cooler, transfers its heat to the cooling water circulating in engine block (4), and the inner wall of oil cooler. This maintains the temperature of the engine.

Note: Oil cooler shift to next page oil cooler heading is working and there is sifficient oil pressure in the pressure system, the indicating light switching light switch is open due to oil pressure effect on it and no current blows to the light, during this occassion warng light is off. When the pressure system fails due to any breakdown in the system or stoppage the engine, the warning light switch is closed and light starts to glowing.

Oil cooler purpose (Fig 8)

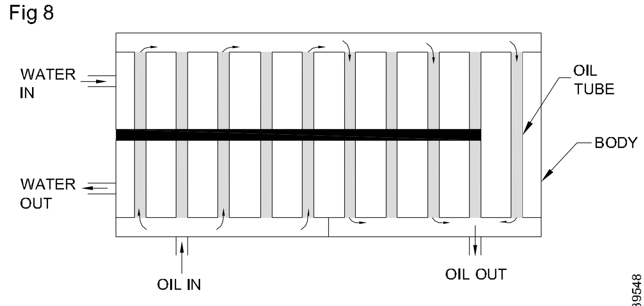
The purpose of an oil cooler us to cool the lubricating oil in heavy duty engines where the oil temperature become quite high the oil must be kept cold in the lubricating system.

An oil cooler is just like a simple heat exhanger. The oil may be cooled in it either by cold

water from the radiator. At the time of starting when the water is hotter that the oil, the oil is heated to provide complete circulation in the system. At higher temperatures, when the oil becomes hotter than water, the water cools the oil.

A water type oil cooler, simply consists of tubes in which oil circulates. The water circulates outside the tubes in the casing of the cooler. The heat of the oil is carries away by the circulating water.

Fig 8



Spurt holes and maingallory

The engine parts are lubircated under pressure feed. The oil pump takes the oil through oil strainer and delivers it at pressure of 2.4 kg/cm2 to maingallory. Further thr pressurised oil goes through different size of spurt holdes to main bearing camshaft bearing cranks pin, rocker arm and valves, main gallory is get as hub for oil distribution to engine moveable working parts.

Definition

Lubrication

The most effective method of reducting friction 15 minimum and save the metals from wear and tear is called lubrication.

Lubricant

The substance is used for the purpose of lubrication is called lubricant.

Lubrcicant

Objectives: At the end of this lesson you shall be able to
- **state the need of lubricating an engine**
- **list out the properties of lubricating oils**

Functions of a lubricant

The main function of a lubricant is to minimise the friction between two moving surfaces which are in contact with each other.

It also helps to:

- absorb heat form the moving parts due to friction.
- Minimise wear and tear of the components.
- Provide a cushioning effect between the moving parts.
- Clean the parts by carrying away metal chips with it.
- Protect parts from corrosion.
- Prevent blow-by of gases by provinding an oil film between the rings and the liner/bore.

Properties of a lubricant

- It should have viscosity to suit the operating condions.
- The viscosity should remain the same in both hot and cold conditions.
- Its boiling temperature should be high.
- It should be corrosion-resistant.
- It should not develop foam.
- It should withstand critical operating pressure.

Viscosity

It is most important properties of lubricating oils for it determines their ability to flow. An oil with excessively high viscosity is very thick, and it is difficult for it to penetrate the clearance between the rubbing engine parts, while an oil with too low viscosity flows easily and does not stay in the clearances. So that the engine oil should be used as particular engine specifications and the seanson (plain area or high attitude area).

Oil additives

Any mineral oil by it self does not posses all the properties. The oil companies add a number of additives into the oil during the manufacturing process the main additives.

- Pour point depressents
- Oxidation inhibitors
- Corrosion and rust inhibitors
- Foaming resistance
- Detergents disperssents
- Extreme pressure resistance

Synthetic oil

- Synthetic oils manufactured oils made from substances other than crude oil
- They can be made from vegetable oils

Types

1 Polyalkylene glycols and their derived

2 Silicon which are manufactured from coal and saud

Application

a This oil can provide longer service life, less friction and improved fuel economy than convention oil.

b It costs more than regular motor oil.

When expected atmospheric temperature are-	Single viscosity graded oil	Multi viscosity graded oil
Below minus 10° F	SAE5W	SAEFW-20
Above minus 10° F	SAE10W	SAE10W-20, or SAE10W-30
Above plus 10° F	SAE20W	SAE 20W-30 or SAE10W-30
Above 32° F	SAE20 or 20 W SAE 30 Some manufacturers	SAE 20W-30 or SAE10W-30
Above 90° F	SAE 30 SAE 30 Some manufacturers	SAE 20W-30 or SAE 10W -30

Description of diesel induction and exhaust system

Objectives: At the end of this lesson you shall be able to
- **state the function of induction system**
- **state the function of exhaust system**

Diesel induction system

In diesel engine only air is drawn into the cylinder from atmosphere through air cleaner, turbocharger, induction manifold, intake port and inlet value. The induction manifold provides passage for the flow of fresh air from air cleaner a turbo charger toward the engine cylinder. The intake value provides entrance for the fresh air charge into the combustion chamber and cylinder. The following air into the flow system is used in diesel induction system.

Air cleaner - Turbo charger - Induction manifold - Intake port - Inlet value - Combustion chamber and cylinder

Diesel exhaust system

The diesel engine used gases go out of the cylinder and combustion chamber through exhaust value, which act as gate to promide exit for the burnt gases. The gases flow out through exhaust value mouth space to the connecting passage of exhaust port into the exhaust manifold. The used exhaust gases from the manifold are let out into the atmosphere through catalystec converter muffler and tail pipe. The catalystic converter reduced the emission from the exhaust gases and muffler silence the noise of exhaust gases by reducing the pressure of the exhaust gases by slow expansion and cooling.

Further exhaust gases used for exhaust broke system to control the vehicle speed and to drive the turbo charge's turbine unit. The flow of exhaust gases.

Engine cylinder - used exhaust gases - exhaust port- exhaust manifold - exhaust braje catalytic converter - muffler - tail pipe- atmosphere.

Aircompressor, exhauster and turbocharger

Objectives: At the end of this lesson you shall be able to
- **explain constructional features of an air compressor**
- **explain operation of an air compressor**
- **explain constructional features of an exhauster**
- **explain operation of an exhauster**
- **explain constructional features of a turbocharger**
- **explain operation of a turbocharger.**

Air Compressor

An air compressor is part of an engine. It is driven either from the timing gear or from the camshaft to maintain air pressure for different purposes.

Normally, it is of a single cylinder type consisting of a piston assembly, connected to the crankshaft by means of a connecting rod. It has an inlet valve and a delivery valve. An aircompressor is having an inbuilt air cooling system with fins on its head. Valves are automatic in action and consist of hardened and lapped spring loaded steel discs against removable seats. Engine lubricating oil is circulated to lubricate the parts of air compressor

Operation

During the downward stroke of piston partial vacuum is created in cylinder which opens the inlet valve, air to enter into the cylinder. During the upward stroke, the pressure closes the inlet valve. So air is compressed in the cylinder which opens the delivery valve sending compressed air to the reservoir.

Exhauster

Vane type exhauster

Exhausters are fitted on diesel engine to develop vacuum to assist the pneumatic governor of F.I.P. A vane type exhauster is held by bolt over an opening in the engine and consists of a rotor, keyed to a shaft. The rotor is mounted eccentrically to the barrel (body) of the exhauster. Vanes are fitted with sliding fit in the slots of the rotor. A shift valve fitted on the exhauster, limits the vacuum to a predetermined pressure.

Impeller type exhauster

The impeller type exhauster has two spindles. One has an impeller. It is driven by auxiliary driving shaft and the other spindle has rotor whose vanes engage with those on the driven rotor.

Operation of exhauster

The vane type exhauster unit works on the principle of centrifugal force. When the engine is running due to centrifugal action, the vanes which have a sliding fit, fit into the slots in the rotor, which come out to the interior surface of the body (barrel). Air is thus evacuated through out the section and is discharged into the crank case. Lubrication for vanes is provided by splash of oil from the crank case.

Supercharges

A supercharger is a device which increase the pressure of the airfuel mixture from the carbutettor before it enters the engine. It is connected between the carburettor and the cylinder in the way of intake manifold. It is usually driven by the engine through suitable gears and shafts. There are three general types of superchargers:

1 Centrifugal type

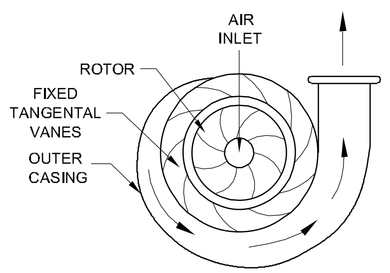
2 Vane type

3 Roots air-blower type

Centrifugal type supercharger (Fig 1)

It consists of an impleller which rotates at a very high speed, about 10,000 r.p.m. The air-fuel mixture enters the impeller at the centre and after passing through the impeller and diffuser vanes goes out of the casing to the engine cylinder. Due to the high spped of the impeller, the mixture is forced into the cylinder at a high pressure.

Fig 1

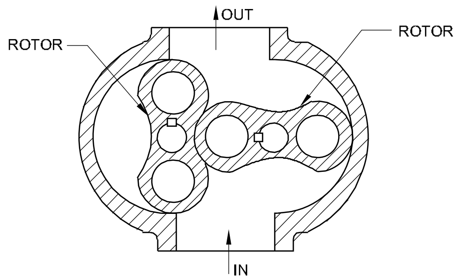


CENTRIFUGAL TYPE SUPERCHARGER

Roots air-blower type supercharger (Fig 2)

It consists of two rotors of epicycloid shape. Each rotor is fixed to a shaft by a key. The two shafts are connecred whether by means of gears of eaual size the two rotors rotate at the same speed. The working action of such a supercharger is just like a gear pump, so that the mixture at outlet side is at a high pressure.

Fig 2

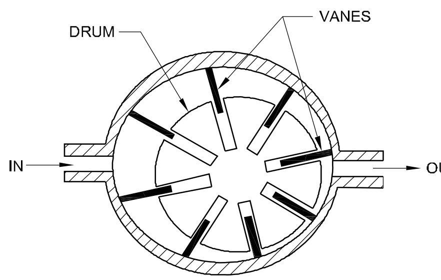


ROOTS AIR-BLOWER TYPE SUPERCHARGE

Vane type supercharger (Fig 3)

It consists of a drum on which a number of vanes are mounted in such a manner that they can slide in or out against some spring force, so that all the times they are in contact with the inner surface of the surpercharger body. The space berween the body and the drum goes on decreasing from the inlet to the outlet side. Thus, the air-fuel mixture entrapped between any two vane at inlet goes on decreasing in volume and increasing in pressure as in reaches the outlet.

Fig 3



VANE TYPE SUPERCHARGER

The roots syoercharger is simpler in construction and requries least mainteneace. It ha scomparatively ling life. It works well even at lower speed ranges. Centrifugal type supercharger has poor working charateristics at lower speeds. Vane type supercharger has the problem of wear of vane tips.

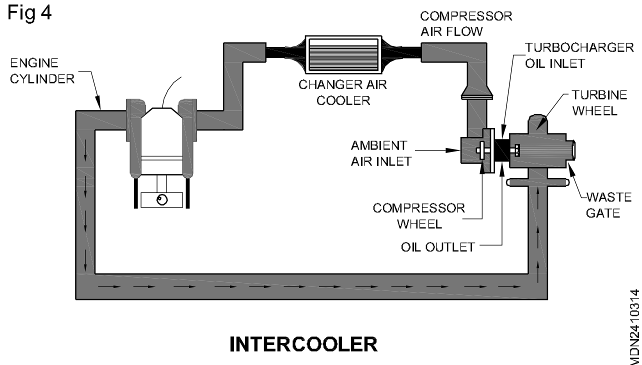
Turbo charger passes compressed hot arrists in color and it heats up expands air the pressure increase from a turbocharger is the result of heating the air before it goes into the engine. In order to incrase the power of the engine and get more air molecules into the cyliner.

The intercooler (Fig 4) is an additional component that looks like a radiator, except that air passes through the inside as well as the outside of the intercooler. The intake air passes through sealed passageways inside the cooler, while cooler air from outside is blown across fins by the engine cooling fan.

Intercooler (Fig 4)

The intercooler further increases the power of the engine by cooling the pressurized air coming out of the compressor before it goes to the engine. The inter cooled system will put cooler air, which is denser and contains more air molecules than warmer air.

Fig 4



INTERCOOLER

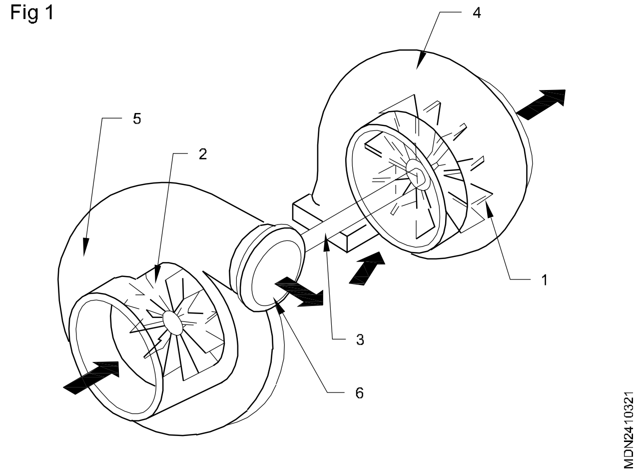
Turbocharger

Objectives: At the end of this lesson you shall be able to
- **explain constructional features of a turbocharger**
- **explain operation of turbo charger**
- **explain types of turbocharger.**

Turbocharger (Fig 1)

Turbo charger is mounted on the engine. It increases the amount of air delivered to the engine cylinder, thereby more fuel can be burnt which increases engine power. Whenever the density of air is less than the density at atmospheric pressure specially at higher altitudes, turbo charges helps the engine to get the sufficient air. An engine may have one or more turbo chargers.

Fig 1



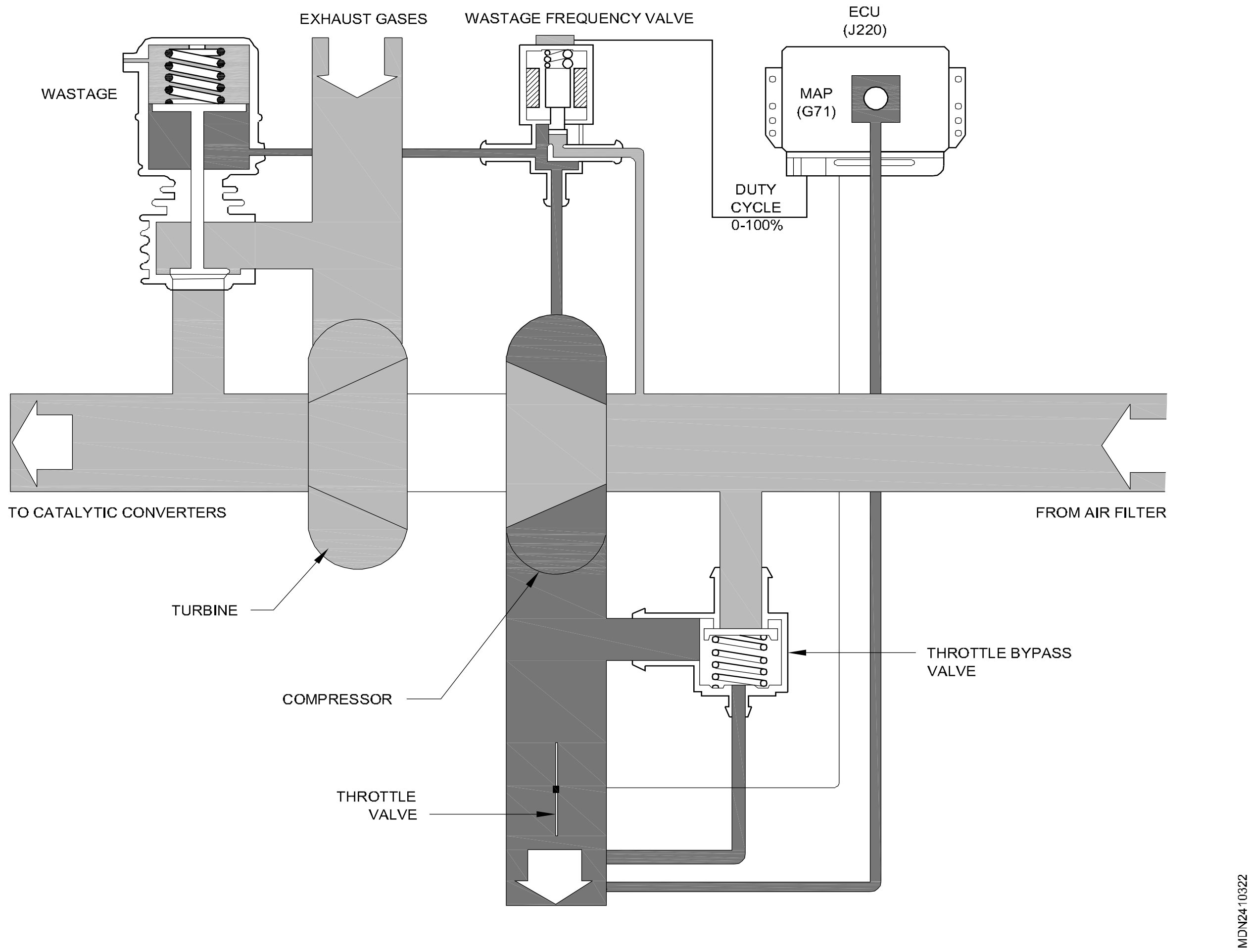
A turbocharger is mounted on the exhaust manifold. It has a turbine wheel (1) and a compressor wheel (2) on the same shaft (3). Exhaust gases enter in turbine housing (4) and rotate the turbine wheel (1). Compressor housing's (5) inlet is connected to the air cleaner and compressed air is discharged to inlet manifold through the outlet (6).

Turbocharger

Fixed Geometry Turbochargers (FGT)

A turbocharger consists of a turbine and a compressor linked by a shared axle. The turbine inlet receives exhaust gases from the engine exhaust manifold causing the turbine wheel to rotate. This rotation drives the compressor, compressing ambient air and delivering it to the air intake manifold of the engine at higher pressure, resulting in a greater amount of the air and fuel entering the cylinder. In FGT, (Fig 2) the amount of compressed air which has to be entered in the engine is controlled by a waste gate valve which regulates the turbo output depending on engine's speed.

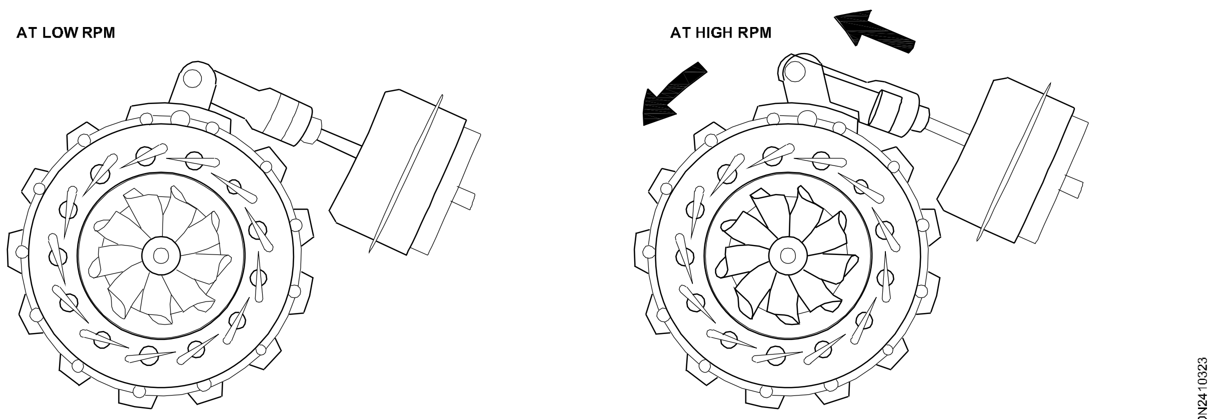
Fig 2



Variable Geometry Turbochargers (VGT)

Variable geometry turbochargers (VGTs) (Fig 3) are a family of turbochargers, usually designed to allow the effective aspect ratio of the turbo to be altered as conditions change. This is done because optimum aspect ratio at low engine speeds is very different from that at high engine speeds. If the aspect ratio is too large, the turbo will fall to create boost at low speeds; if the aspect ratio is too small, the turbo will choke the engine at high speeds, leading to high exhaust manifold pressures, high pumping losses and ultimately lower power output. By altering the geometry of the turbine housing as the engine accelerates, the turbo's aspect ratio can be maintained at its optimum. Because of this, VGTs have a minimal amount of lag, have a low boost threshold, and are very efficient at higher engine speeds.

Fig 3



Air cleaner and air cooler

Objectives : At the end of this lesson you shall be able to
- **state the need of an air cleaner**
- **state the different types of air cleaners**
- **state the function of indication manifold**
- **state the function of an air cleaner.**

Atmospheric air consists of a large quantity of dirt and dust. Uncleaned air will cause faster wear of and damage to the engine parts, so air is filtered before entering inside the cylinder bore.

Purpose of air cleaner

- It cleans the intake air.
- It reduces the noise of the intake air.
- It acts as a flame arrester during engine backfire.

Location

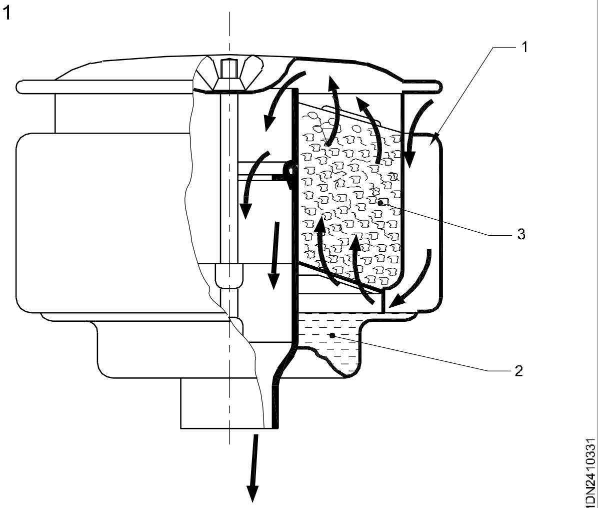
It is mounted on the top of the air inlet manifold.

Types

- Wet-type (Fig 1)
- Dry-type (Fig 2)

Wet type air cleaner

Fig 1

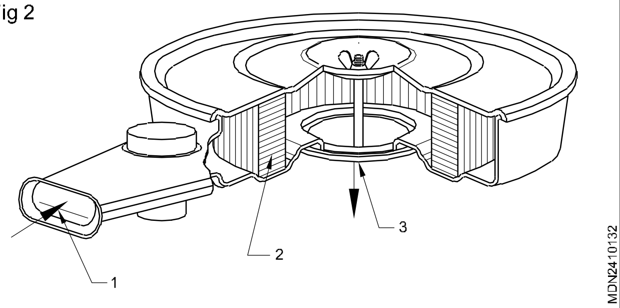


The atmospheric air enters the air cleaner through the side passage (1) and strikes on the surface of the oil (2). Heavy dust particles are absorbed by the oil. The partially filtered air, along with oil particles, moves upward through the filter element (3). Fine particles and oil particles are collected by the filtering element (3). Cleaned air then passes through the passage to the inlet manifold.

Dry type air cleaner

In this type of air cleaner, a specially treated paper element is used to filter the intake air.

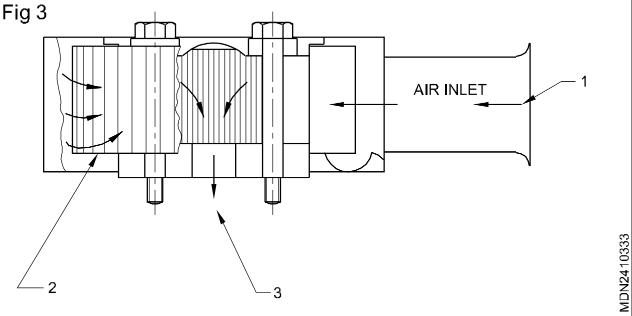
Fig 2



Function

The atmospheric air enters the air cleaner (Fig 3) through the air entrance (1) and passes through the paper element (2). The filtered clean air goes to the intake manifold entrance (3).

Fig 3



Charge air cooler and turbo charger

Charge air cooler and turbo charge are part of a high tech induction system that increases engine combustion efficiency. The turbo charger uses exhaust gases to compress air before it entire the charge - air cooler.

The compressed air going through the charge-air cooler is then cooled by the ambiant air flowing across the cooler fins. The cooled air is more dense than warm air. So when it flow into the intake side of the engine, the increased density improves horse power, fuel economy and reduce the emissions.

Induction manifold

The intake manifold is connected with air cleaner and cylinder head intake port of the cyliner head. It is allow the fresh air to flow from air cleaner to cylinder through inlet valve. The intake manifold is made of a cast iron or aluminium.

Manifolds and silencer

Objectives: At the end of this lesson you shall be able to
- **explain the purpose of the inlet manifold**
- **explain the purpose of the exhaust manifold**
- **explain the purpose of the muffler and tail pipe**
- **explain the constructional features of the mufflers**
- **list out the different types of mufflers.**

Manifolds and silencer

The inlet manifold is used to supply the air-through from the carburettor to the intake ports in the cylinder head. The inlet manifold is generally made of aluminium cast iron.

Fig 1

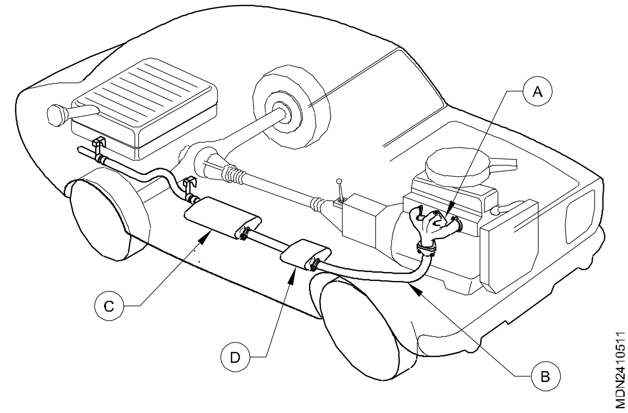
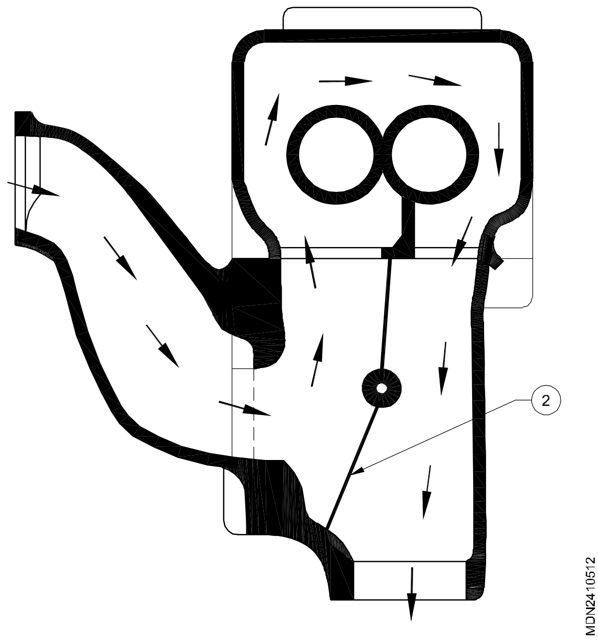


Fig 2



The exhaust manifold (A) is used to collect the exhaust gases from the different cylinders and send them to the silencer. The exhaust manifold is generally made of cast iron. The exhaust manifold may include a heat control valve (Fig 2) or a heat riser which has a thermostatically operated butterfly valve (2) fitted in exhaust manifold. (Fig 2) When the engine is cold, the valve is closed and hot gases are directed around the inlet manifold. When the engine attains operating temperature the valve opens and the exhaust gases are directly sent to the muffler.

Exhaust pipes

The exhaust pipe takes the burnt gases from the manifold to the muffler. The pipes are steel tubes, suitably shaped and routed below the chassis to lead the gases away from the vehicle at the rear and to direct the gases down and under the vehicle. It is kept in place by flanges or clamps at either end. In some vehicles, a flexible mounting to the body or chassis is used.

Muffler

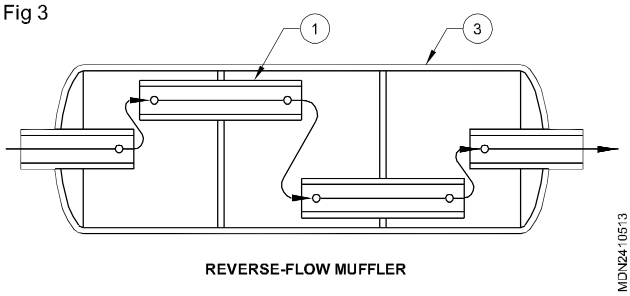
The muffler (C) (Fig 1) is normally located under the body of the vehicle and attached to the body or chassis with flexible mountings. In some trucks in which exhaust gases are directed upward, the muffler is mounted at the rear end of the cab and surrounded with a guard to prevent acciden-tal touching. The muffler reduces the engine exhaust noise. It is a large cylindrical shaped container, fitted with passages and chambers that absorb and dampen the noise of the exhaust gases. Often a small or pre-muffler (D) is fitted in the exhaust system between the manifold and the main muffler.

Types of mufflers

i Reverse flow muffler (Fig 3)

In this type, small pipes (1) (Fig 3) are placed in the housing (3) of the muffler. Exhaust gases flow in a zigzag way, thus reducing the sound, by travelling through a longer length.

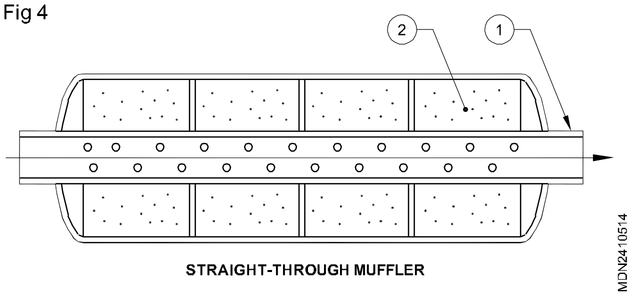
Fig 3



ii Straight through muffler

In this type a straight perforated tube (1) (Fig 4) is placed throughout the length of the muffler. Glass wool or steel wool (2) is filled in between the perforated tube and the muffler housing, which acts as a sound absorbent.

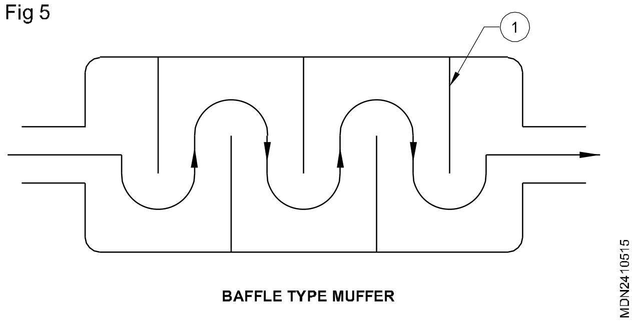
Fig 4



iii Baffle type

In this type, a series of baffles (1) (Fig 5) are placed in the muffler which causes restriction and back pressure to the exhaust gases, thereby reducing the sound of the exhaust gases.

Fig 5



Skill Information

Mufflers

Objectives: At the end of this lesson you shall be able to
- **describe the back pressure**
- **describe the back pressure muffler**
- **describe the electronic muffler.**

Back pressure

Any restriction to exhaust flow in the exhaust system creates back-pressure. Some back-pressure can be beneficial, excessive back-pressure reduces volumetric efficiency and reduces engine efficiency.

Variable flow exhaust/Back pressure muffler

A movable valve fitted within the exhaust system is used to change the amount of exhaust back-pressure. At higher engine speeds when exhaust noise levels are unacceptable, the valve is closed, thus reducing the bore of the exhaust. This enables greater back-pressure and noise reduction is the result. The valve can be operated by

- Pneumatics - exhaust gas pressure
- Electronics - a computer

When a variable flow exhaust is added to the baffle and chamber system, quieter noise emissions are the result. This is because the system can partially respond to changes in engine speed and load.

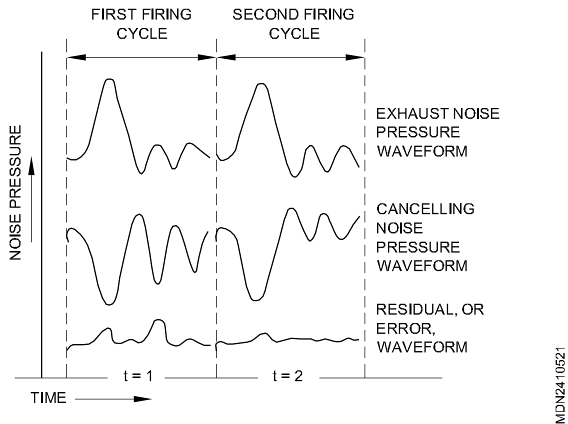
Electronic mufflers

Electronic mufflers are designed to produce anti noise without restricting exhaust flow. This computer-controlled system uses a microphone to detect the sound waves produced within the exhaust system. As the exhaust gas leaves the tail pipe, computer driven loudspeakers are operated to generate the correct amount of anti-noise.

The result is virtually silent exhaust without generating additional and unwanted back-pressure across all engine operating conditions. This increases fuel economy and reduces exhaust emissions.

Sensors and microphones pick up the pattern of the pressure waves an engine emits from its exhaust pipe (Figure 1 & 2). This data is analyzed by a computer. A mirror-image pattern of pulses is instantly produced and sent to speakers mounted near the exhaust outlet. Opposite waves are created that cancel out the noise. Noise is removed without creating back pressure in the muffler. Electronic mufflers can be designed to emit certain sounds or no sound at all.

Fig 1



Extractor manifolds

The extractor exhaust manifold system for an internal combustion engine, which improves its efficiency by sing precise geometry to reflect the pressure waves form the exhaust value at a particular time in the cyle.

Advatagees of extractor manifold

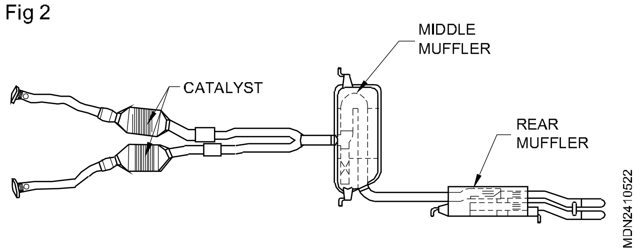
- Separating the gas flow from the individual cylinders.
- Avoid the inter cylinder gas interference
- Maintaining an optimum gas velocity by chosen tube diameter
- Allowing the individual cylinders to assist one anoter where the individual exhausts merge.

This type of exhaust system can be used with or without a muffker and so can be used on both race and road vehicles.

Absorption mufflers in exhaust system

This type of mufflers are almost indispenble element of modern exhaust systems. The absorption material is just modern exhaust systems. The absorption material is just as important as a calculation method for designing the mufflers in order to ensure that they are optimally used.

Fig 2



Absorption

Automotive exhaust noise can be attenuated is several ways. A distinction is generally made between active and passve attenuation. The modern engine exhaust system consist of more than one abosorption muffler to reduce the noise and pollution. The absorption mufflers are disspate the sound energy through the use of porous materials.

Noise absorbtion components

Reactive / abosorption silencers in single package unit

Flexible connection

The exhaust pipe takes the burning gases from the exhaust manifold. The silencer pipes are fitted under the chasis body to lead the exhaust gases away from the manifold. The silencer pipes are mounting with flexible connection to the chasis or body of the vehicle. The flexible connection is prevent from damages by heavy jerks or rough up and down movement of the vehicles.

Ceramic coating

Ceramic coating is capable of with standing of high temperature and it has very good chemical and corrosion resistance and possess excellent thermal barrier characteristics, providing a dramatic reduction in radiated heat. It is self-cleaning properties last for upto 5 years.

Ceramic coatings contain the gaseous heat with in exhaust pipes. The causes the gasses to heat up and expand as a result exhaust flow is boosted.

Fuel and feed system

Objectives: At the end of this lesson you shall be able to
- **explain the types of fuel**
- **explain the specification and characteristics of fuel**
- **state the different types of fuel feed systems**
- **draw the layout of the fuel the flow system in a petrol engine vehicle**
- **state constructional features of the fuel tank.**

Different types of fuel feed systems

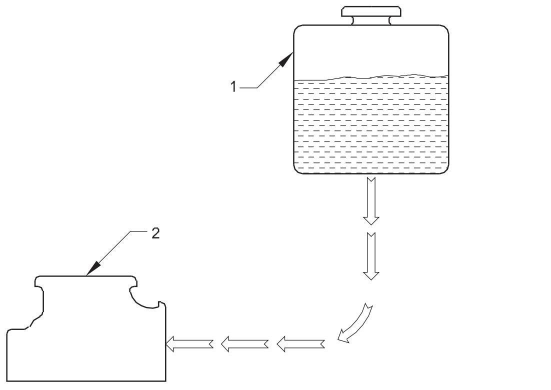
There are three types of fuel feed systems.

- Gravity feed system
- Vacuum feed system
- Forced feed system

Gravity feed system (Fig.1)

In the gravity feed system, the fuel tank (1) is kept at a higher level than the carburettor. The fuel flows to the carburettor (2) by its own gravity. This system is used in motor cycles, scooters and stationary engines. This is a simple and less expensive system.

Fig 1



GRAVITY FEED SYSTEM

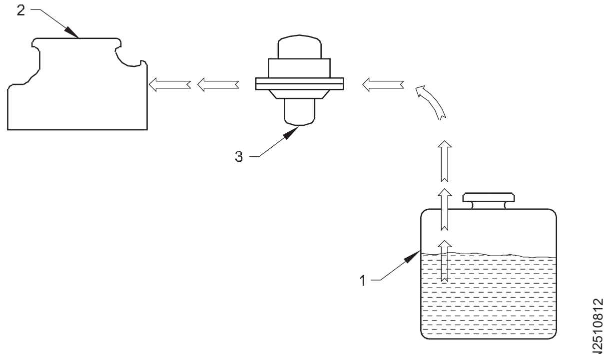
Vacuum feed system

In this system the fuel tank is placed below the level of the carburettor. The fuel from the tank is sucked by a separate unit (auto-vac) with the assistance of the inlet manifold vacuum. Then the fuel is fed to the carburettor by gravity.

Forced feed system (Fig.2)

In this system, the fuel tank (1) is placed at a distance and also below the level of the carburettor (2). A fuel pump (3) is used to pump the fuel from the tank to the carburettor. This system is used in almost all the vehicles, except two wheelers.

Fig 2

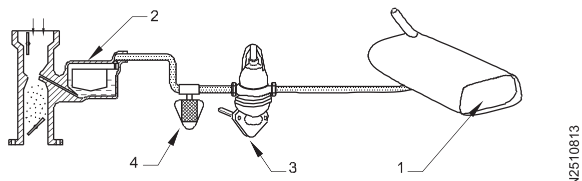


FORCED FEED SYSTEM

Layout of the fuel feed system (Fig.3)

The fuel from the tank (1) is pumped to the carburettor (2) by the fuel pump (3) through the fuel filter (4). In fuel pipes connecting between tank and pump are called suction pipe (5) .

Fig 3



LAYOUT OF THE FUEL FEED SYSTEM

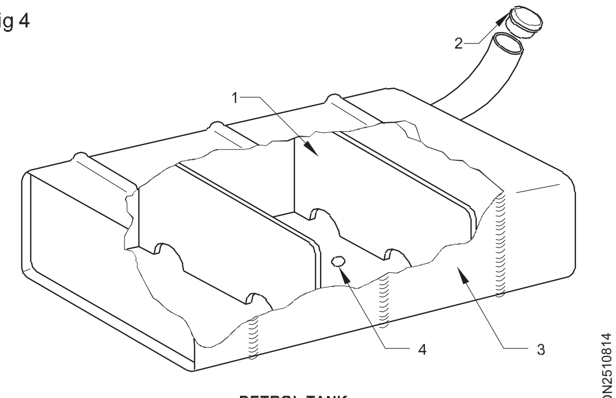
Components of the fuel feed system

The fuel pipe between feed pump to pump is called pressure pipes (6)

Petrol tank (Figs 4 &5)

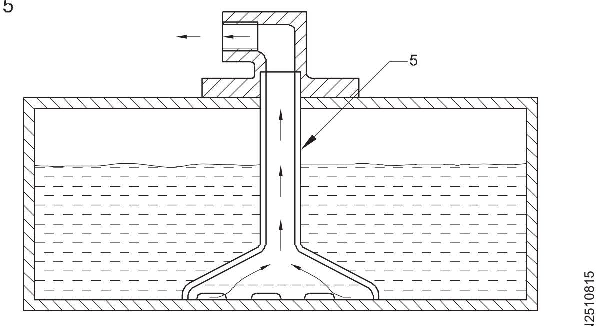
Location: The location of the fuel tank on the vehicle varies from vehicle to vehicle. It may be fixed in the rear, under the seat or in the front etc. The tank should be protected from flying stones when the vehicle is moving.

Fig 4



PETROL TANK

Fig 5



PETROL TANK

Construction: The fuel tank is made of galvanised mild steel sheets coated with lead/tin alloy to protect against rusting. Some tanks are made of aluminium and plastics such as polythene. Internal baffles (1) with a passage for fuel transfer are provided to avoid fuel slashing (strikings against the walls of the tank).

A filler cap (2) is provided to seal the tank (3). A vent hole is provided either in the filler neck or in the cap to have atmospheric pressure in the tank above the fuel. The tank is mounted on a frame by straps. A drain plug (4) is provided to drain the sediments and condensed water periodically. A fuel line tube (5) is provided in the tank. The tube (5) inlet is kept at least 1/2" above from the bottom of the tanks to avoid suction of water, if it has been deposited in the tank.

Fuel feed pump and filter

Objectives: At the end of this lesson you shall be able to

- **list out the different types of the fuel feed pump (petrol engine)**
- **state the functions of a mechanical type fuel feed pump**
- **state the function of an electrical type fuel feed pump**
- **state the functions of fuel filters.**

Function

The function of the fuel feed pump is to pump the fuel from the tank to the carburettor.

Types

There are two types of fuel feed pumps.

- Mechanical
- Electrical

Mechanical type feed pump

A mechanical pump is mounted on the engine and is operated by a camshaft. This pump consists of an air chamber divided in the centre by a flexible diaphragm.

Operation of feed pump (Fig.1)

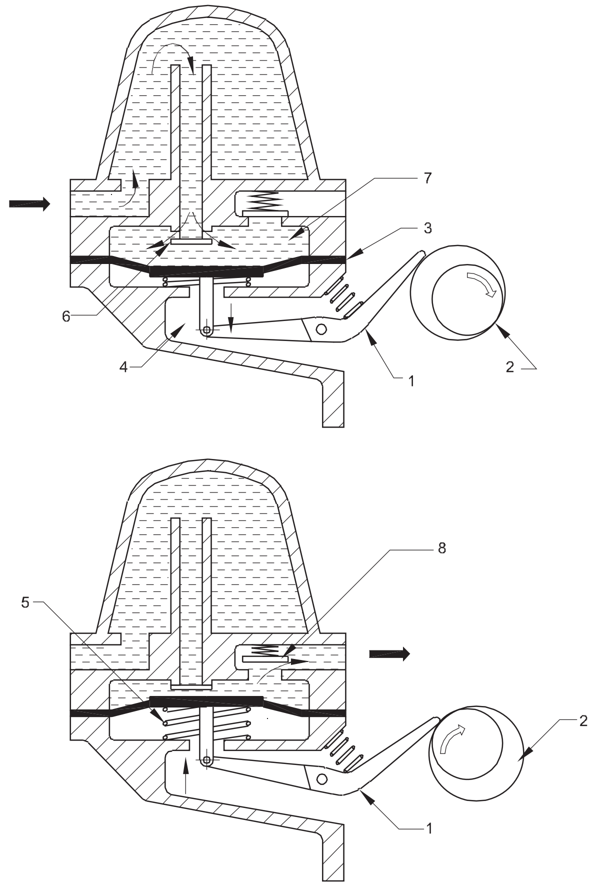
The rocker arm (1) is actuated by the camshaft (2) and moves to and fro. This makes the diaphragm (3) to move up and down along with the spindle (4) and the spring (5). During the downward motion of the diaphragm, a partial vacuum is created and the inlet valve (6) opens, allowing the fuel to be sucked into the top chamber (7).

When the diaphragm moves upward, the inlet valve (6) closes and the fuel is forced through the outlet valve (8) into the pipe line to the carburettor float chamber. The pressure developed is 0.18 kg/cm^2 to 0.3 kg/cm^2.

Idling action (Fig.2 &3)

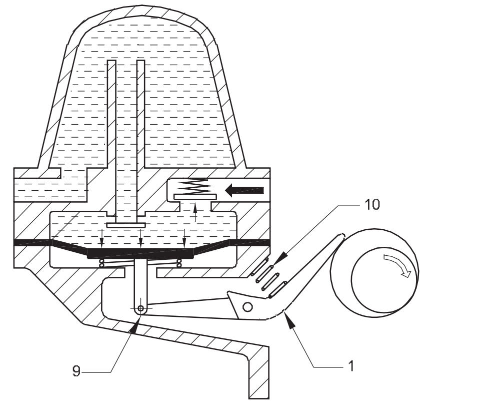
When the carburettor float chamber is full, the pumping action has to be stopped, to avoid flooding of the carburettor. At this condition the needle value in the float chamber remains closed and a back pressure develops in the pipeline. This pressure keeps the diaphragm depressed and the link (9) remains in the downward position. The rocker arm (1) moves without affecting the motion of the diaphragm.

Fig 1



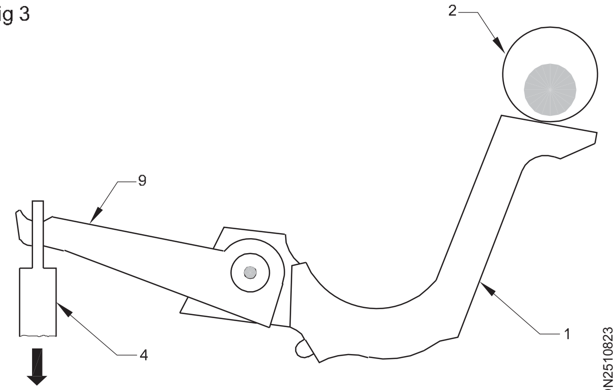
OPERATION OF FEED PUMP

Fig 2



IDLING ACTION

Fig 3



IDLING ACTION

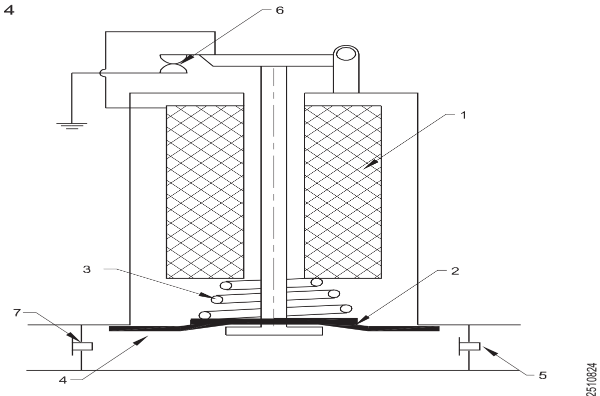
A spring (10) is provided between the rocker arm (1) and the pump body to avoid any rattling noise of the rocker arm (1) during the idling operation.

Electrical type fuel feed pump (Fig.4)

A battery operated fuel feed pump can be mounted at any convenient position. These are of two types.

- Diaphragm type
- Bellow type

Fig 4



ELECTRICAL TYPE FUEL FEED PUMP

When the ignition is switched on, the solenoid (1) of the pump is energised and the armature (2) is attracted to the magnetic core against the spring's (3) tension. This causes the diaphragm/bellow (4) to flex. It creates a partial vacuum in the pumping chamber. Petrol is sucked in the pump chamber through the inlet valve (5) from the petrol tank. When the armature (2) reaches its stop position, the bronze plunger opens the contact points (6) and cuts off the electric connections to the solenoid (1).

This results in de-energisation of the solenoid (1). Now the spring's (3) pressure moves the armature along with the diaphragm/bellows (4) downwards, and the fuel in the chamber flows out to the carburettor through the outlet valve (7). This movement of the armature makes the contact points close and again the cycle is repeated at the rate of 50 to 60 times per minute till the float chamber is filled up.

Idling action of the pump

Once the float chamber is full, the needle valve in the float chamber closes the inlet passage of the carburettor. This results in back pressure being developed in the pipeline.

Due to this back pressure, the armature is always pressed in the upward position which keeps the contact points open. This keeps the pump out of action till the fuel level in the float chamber goes down.

Carburettor systems

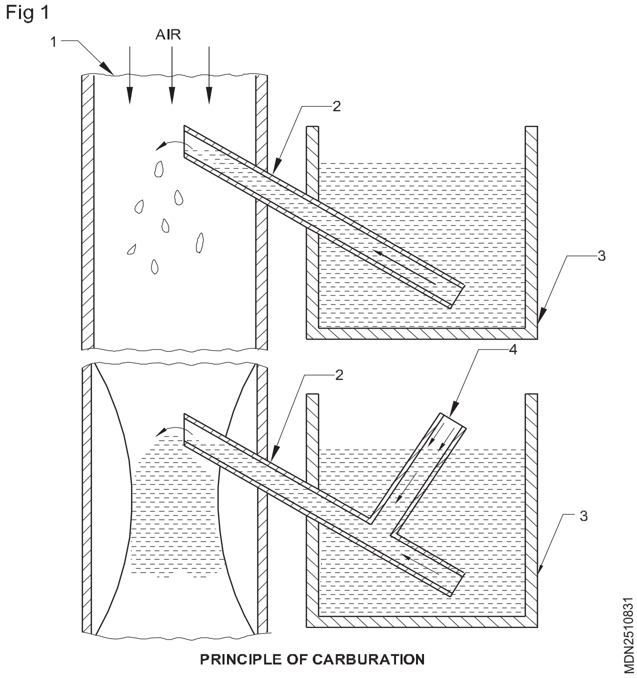
Objectives: At the end of this lesson you shall be able to
- **state the principle of carburettor**
- **list out the different types of carburettors**
- **state the various circuits in the carburettor**
- **state the function of various circuits in a solex carburettor.**

Carburettor

Principle of carburation (Fig.1)

The carburettor is a device for atomising and vapourising fuel and mixing it with air in varying proportions to suit the changing operating conditions such as varying engine speed, load and operating temperature of the motor vehicle engines.

Fig 1



PRINCIPLE OF CARBURATION

During the suction stroke air is drawn through the air cleaner and it passes through the air horn (1). A discharge tube (2) is connected between the air horn (1) and the fuel bowl (3). When the air passes through the air horn (1) it creates a vacuum at the tip of the discharge tube (2), and sucks fuel from the fuel bowl (3).

An air bleed (4) is provided on the jet tube (2) which helps in breaking the fuel particles into very fine particles. This is known as atomising. The fuel and air mixture is then sucked into the cylinder.

This process of breaking up fuel and mixing it with air is called carburation.

Types of carburettors

Carburettors are divided into two types.

- Constant choke
- Constant vacuum

Again they are classified as stated below. As per draft

- Up draft
- Down draft
- Horizontal draft.

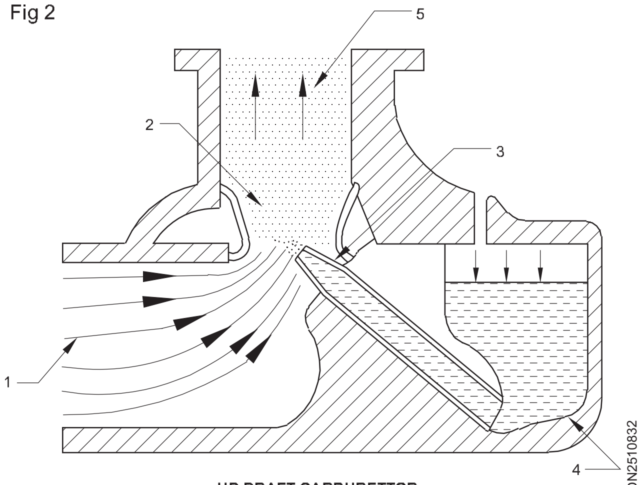
As per venturi arrangement

- Single venturi
- Double venturi
- Triple venturi
- Multi-venturi

Up draft Carburettor (Fig.2)

This type of carburettor is fitted under the inlet manifold. The air enters through the pipe (1). Air is drawn upwards through the venturi (2) due to the suction stroke. Because of the venturi, high velocity and high vacuum is created. The fuel is sucked from the nozzle (3) which is connected to the fuel bowl (4). The fuel thus sucked gets the vapourised and gets mixed with air in the chamber (5). This air/fuel mixture is then sucked into the cylinder.

Fig 2

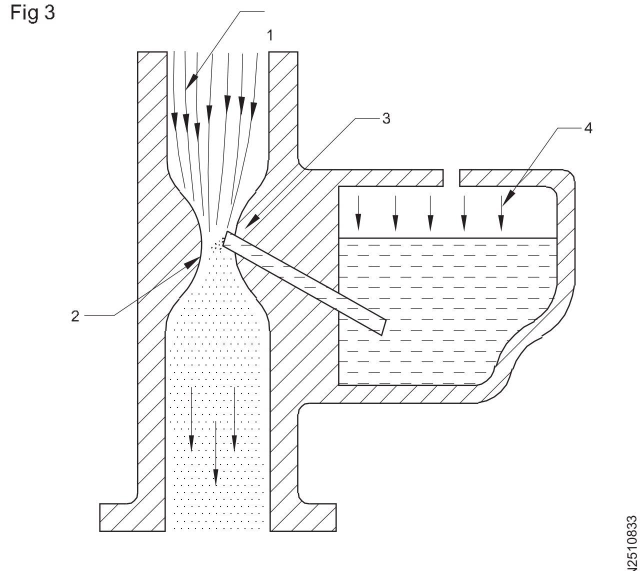


UP DRAFT CARBURETTOR

Down draft (Fig.3)

This type of carburettor is fitted on the inlet manifold. The air enters through the chamber (1), moves downwards and passes through the venturi (2). It sucks fuel from the float chamber (4) through the nozzle (3). The fuel/air mixture is sucked into the cylinder during the suction stroke.

Fig 3

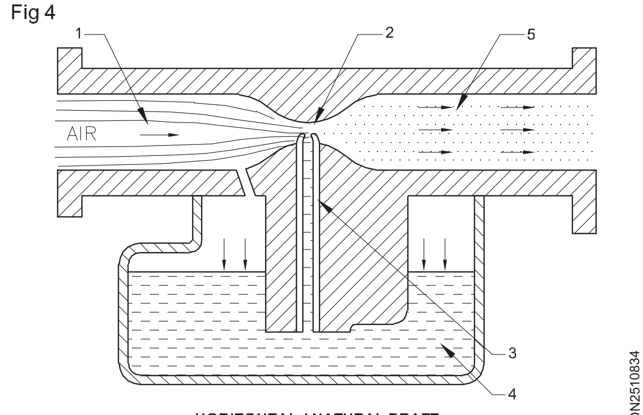


DOWN DRAFT

Horizontal/natural draft (Fig.4)

In this type the carburettor is fitted in line with the manifold. Due to suction, air flows from the chamber (1) to the chamber (5) through the venturi (2), and sucks fuel from the float chamber (4) through the nozzle (3). This air/fuel mixture is then sucked into the cylinder.

Fig 4



HORIZONTAL / NATURAL DRAFT

Venturi arrangements

Different types of venturies and more than one venturi are also provided in a carburettor. Each type is designed to provide decreased pressure, to draw fuel from the discharge jet and to create a vacuum to help vapourisation. Multiple venturies also help to keep the fuel away from the carburettor walls to reduce condensation.

Functions of a carburettor

The functions of a carburettor are to:

- atomise fuel into small drop lets
- vaporize the small droplets of fuel and mix it with air to make a homogeneous air/ fuel mixture
- supply fuel to the engine continuously in the required quantity according to load, r.p.m. etc.

To carry out the above functions, the carburettors are made up of jets and different circuits to supply correct air/ fuel mixture according to the needs of the engine at different loads and speeds.

The following are the different circuits in carburettors.

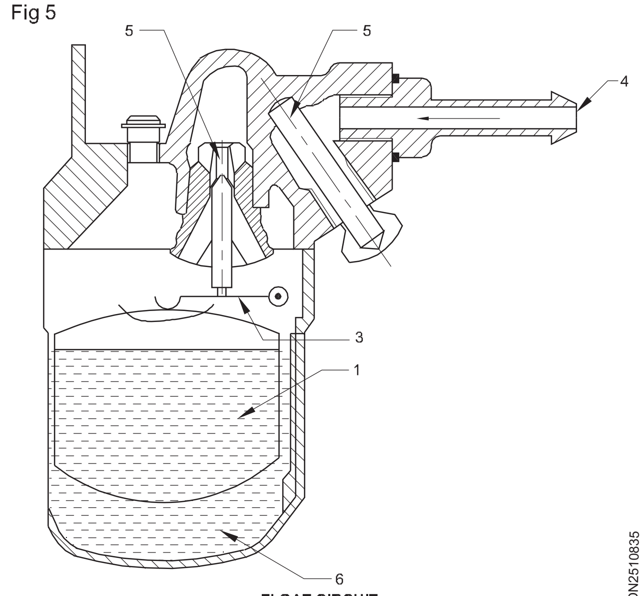
- Float circuit
- Starting circuit
- Idling and low speed circuit
- High speed main circuit
- Accelerator pump circuit
- Power circuit.

Carburettor (solex)

Float circuit (Fig.5)

The float system regulates the fuel supply in the carburetor. It controls the static head above the main jet and the level of petrol in the spraying well.

Fig 5



FLOAT CIRCUIT

The correct setting of the fuel level is determined by three main factors.

- The weight of the float (1)
- The size of the needle valve (2)
- The thickness of the fibre washer

The needle valve (2) is offset and the float movement is transmitted via the float toggle (3).

Petrol is fed through the inlet (4) and is filtered by the fine filter (5) before passing through the needle valve assembly (2) to the float chamber (6).

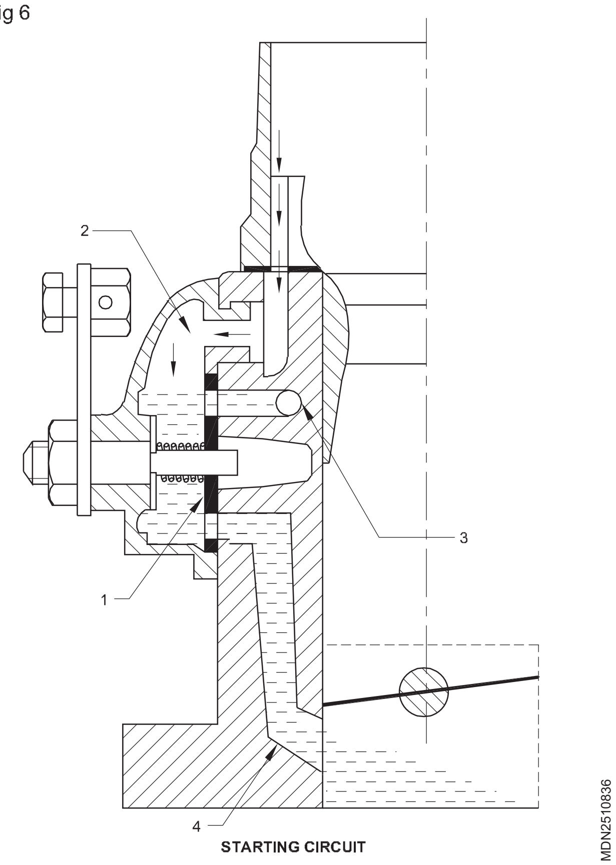
When the fuel level rises in the float chamber ,the float (1) is lifted and it presses the needle valve (2) against the float valve seat and cuts off the flow of fuel to the chamber. When the fuel is consumed, the level in the float chamber drops; the needle valve (2) leaves its seat and fuel flows again into the float chamber.

The valve regulates the flow of petrol into the float chamber. It is maintained at a constant level.

Starting circuit (Fig.6)

While starting the engine, a rich mixture is required. The starting circuit provides the necessary mixture to the engine.

Fig 6



STARTING CIRCUIT

It has three positions.

- Starter lever fully home - no action.
- Starter lever half pulled out - warm up.
- Starter lever fully pulled out - cold starting.

The operation of the starter is activated by rotation of the starter valve (1). It is connected to the dashboard by a lever and a flexible cable. When the dashboard knob is fully pulled out for cold starting, air is drawn though the float chamber cover via the starter air jet (2) and petrol via the starter petrol jet (3). Petrol is mixed with air from the starter air jet (2). The air and petrol pass through (4) and finally go to the cylinder.

Idling /slow speed circuit (Fig.7)

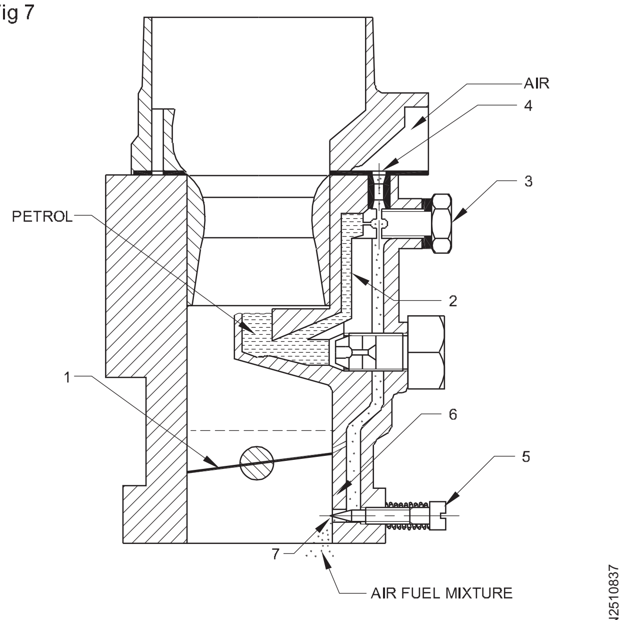
The combined idling and transfer system supply the petrol and air mixture to the engine when the throttle (1) is closed and when the throttle progressively opens for the purpose of driving the vehicle.

The vacuum created underneath the throttle when the engine is idling causes petrol to flow from the reserve well (2) to the pilot jet (3), and pass through the orifice (7).

The quantity of petrol is controlled by the pilot jet (3) and the air quantity by the air bleeder (4).

The volume of air/fuel mixture in idling is controlled by the position of the volume control screw (5).

Fig 7



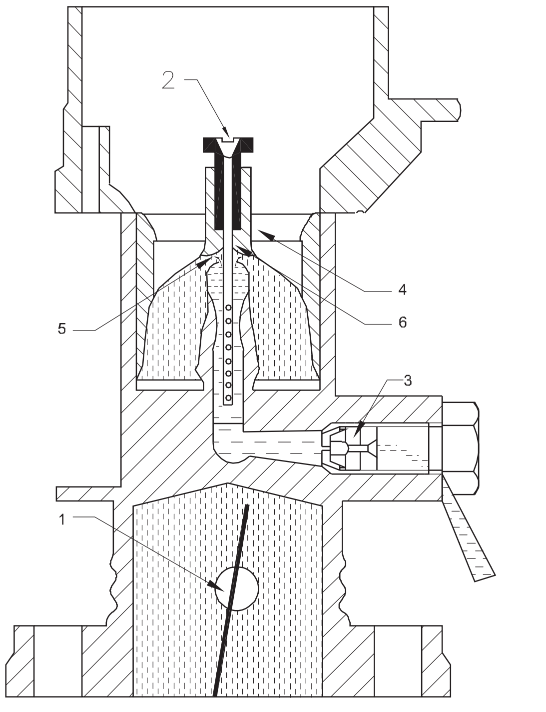
IDLING / SLOW SPEED CIRCUIT

Loosening of the volume control screw increases the volume of air/fuel mixture passing below the throttle. The adjusting screw for slow running controls the idling speed. For specified setting of the idling speed, it is necessary to use both the volume control screw for air/fuel mixture strength and the slow running adjustment screw for speed. When the accelerator pedal is pressed, the throttle (1) opens and the vacuum reaches to the bypass orifice (6). The bypass orifice (6) then discharges the mixture into the air stream passing through the throttle (1). This adds air to the mixture discharged through the orifice (7). This allows the engine to accelerate smoothly from the idling position.

Main circuit/accelerating circuit (Fig.8)

For acceleration up to the maximum speed and full power performance, the fuel is fed through the main jet (3) and the air by the air correction jet (2). When the accelerator pedal is pressed the throttle (1) opens and the air velocity in the choke tube (4) increases. It creates a vacuum across the spraying orifices (5). Now the petrol is drawn through the main jet (3), and similarly the air is drawn through the air correction jet (2). An emulsion tube (6) with lateral holes helps emulsification of air and fuel. Then the spray passes through the spraying nozzle holes.

Fig 8



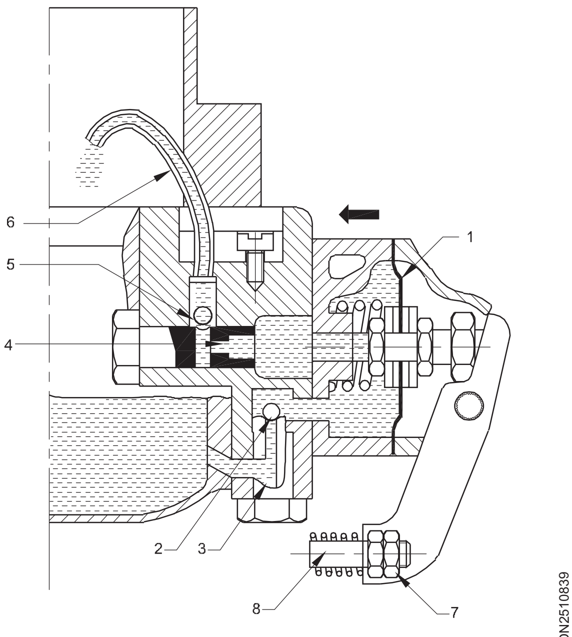
MAIN CIRCUIT / ACCELERATING CIRCUIT

Pump circuit (Fig.9)

A sudden wide opening of the throttle would allow a large amount of air to pass through the choke tube to the engine. A partial vacuum is developed in the choke tube which is not sufficient to get the necessary discharge of fuel from the main spraying well. Due to lack of petrol at this condition, the mixture becomes too weak and the engine does not pick up speed. This condition is avoided by supply of more petrol, by the accelerating pump though momentarily. The pump is actuated by a lever which is attached to the throttle spindle by a spring-loaded rod(8). When the throttle is closed, the tension of the pump spring pushes the diaphragm assembly (1) back, thus drawing the petrol to the pump chamber through the non-return ball valve (2) after passing through a fine filter (3).

On opening the throttle, the lever pushes the diaphragm (1) forward, pushing petrol out of the chamber which is metered by the pump jet (4) through the non-return ball valve (5). Finally the petrol reaches the choke tube through the injector tube (6). At the same time, the ball valve (2) is forced to its seat preventing the petrol to return to the float chamber. The travel of the lever is adjusted by the pump control rod nut (7), controls the rate of flow. This action enriches the fuel supply to give a quick and smooth acceleration.

Fig 9

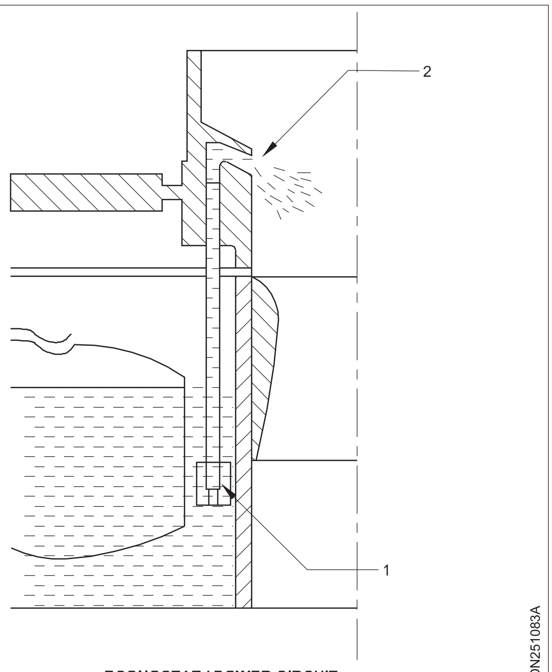


PUMP CIRCUIT

Econostat/power circuit (Fig.10)

This allows maximum fuel economy at the cruising speed range and provides accurate, metered fuel under full throttle condition. The econostat jet (1) runs through a float chamber to the injector tube (2). When enough vacuum is created at the tip of the injector tube, petrol is sucked through the econostat jet to the injector tube (2).

Fig 10



ECONOSTAT / POWER CIRCUIT

Diesel fuel

Objective: At the end of this lesson you shall be able to
- **state the fuel requirement**
- **explain fuel specification and characteristics of fuel.**

In this system at the end of compression stroke in diesel engine.

If the amount and rate of fuel being injected is not measured, will result in uneven running of engine and it leading to vibrations and loss of power diesel fuel injection should be fully atomoized into five particles for it spreads one immediately in the combustion chamber to mix up the with hot compressed air for high combustion. The fule injection should take place at the correct time, according firing order of the engine.

Fuel system must full the following requirement

- Time the fuel injection and distribute the fule properly in the combustion chamber.
- Measure the correct quantity of fuel injected.
- Control the rate of fuel injection.
- Fully atmomize the fuel.
- Develop pressures well in excess of the combustion chamber pressure.

An engine converts heat energy of fuel into mechanical energy. The engine fuel may be solid, liquid or gas. Solid fuel (coal) is used in external combustion engine. e.g. steam engine. Liquid gases and fuel are used in internal combustion Engines.

The most common fuel used in engines are diesel and petrol.

Specification and characteristics of fuel

Octane number

It is a measure to determine the burning quality of the gasoline. It has the tendency to resist knocking in an engine. The higher the octane number the lesser the tendency to knock.

Volatility

Volatility is the ability of the gasoline to evaporate, so that its vapour will adequately mix with air for combustion. Vapourised fuel will burn easily.

Viscosity

This indicates quality of fuel to flow. Lower viscosity fuel will flow more easily than that of higher viscosity.

Sulphur content

Gasoline contains some sulphur. Sulphur present in fuel increases corrosion of engine and therefore it is reduced at the refinery to the maximum possible extent.

Additives

Several additives are put in gasoline to control harmful deposit and to increase anti-freezing quality of the engine.

Detergents are also added to clean certain critical components inside the engine

Diesel fuel

Diesel engine fuel is a highly refined distillate fuel obtained from fractional distillation of crude oils

There are light medium and heavy diesel fuel available in the market, which are used as per the recommendations of engine manufacturers.

Cetane number

Cetane number (cetane rating) is an indicator of the combustion speed of diesel fuel and compression needed for ignition. It is an inverse of the similar octane rating for gasoline. The CN is an important factor in determining the quality of diesel fuel, but not the only one; other measurements of diesel's quality include energy content, density, lubricity, cold-flow properties and sulphur content.

Concept of quiet diesel technology

Technology for quieter, smoother diesel

The combustion pressure in diesel engine cylinder rises intensely and the maximum pressure is extremely high compared with a petrol engine, because of the differences in the combustion method. As a result, diesel engines generally produce more noise, vibration and harshness (NVH) than pertrol engines, and this is a major complaint among diesel users. Efforts to reduce the NVH to the level of petrol engines by making full use of the latest technology.

Pilot injection system to reduce combustion pressure

The sudden rise in combustion pressure is a major source of diesel engine noise. By the development of the common rail high-pressure injection system and electronic fuel injection, flexible and precise control over the injection timing and amount made possible. The fuel pressure rise controlled by smoothing the combustion process by pilot injection, a method in which a small amount of fuel is injected and ignited just before the main fuel injection process. This is known as pilot injection control process.

Increased rigidity of engine structure

The maximum cylinder pressure in diessel engine is considerably high and the pressure rise during combustion is very rapid, causing the engine vibration and noise. Also, diesel engine components such as the piston are solidly built in order to endure the high pressure and pressure increase ratio. The extra weight of these components translates into increased inertia, the scale of vibration. it is possible to control noise generation by reforming the engine structure to absorb vibration and to reduce the overall level of vibration. Moreover, vibration travels from the pistion to the connecting rod, crankshaft and engine block. This form of vibration attenuated by employing a ladder frame structure with a more rigid crankshaft bearing.

Other technologies used to reduce NVH (Noice vibration and harshness.)

A secondary balancer is use to help smooth out the vibrations characteristic of four-cylinder engines.

pairs of gears or scissors gears, working side by side with the same numbers of teeth, help to reduce mechanical engine noise by reducing the gear play.

The two sides of the flywheel, which face the engine and the transmission respectively, are each fitted with a spring and damper to absorb driventrain vibration caused during changes in speed.

Clean diesel technology

Clean diesel is a new generation of diesel made up of a three part system.

1 Advanced engines

Highly efficient diesel engines

1 Cleaner diesel fuel

Ultra-low sulfur diesel

1 Effective emissions controls

Advanced emissions control

This new system ensures that advanced diesel engines will continue to play an important role in the transport of people and goods in the future, while helping meet greenhouse gas and clean air objectives in the world.

Technical innovation has helped progresively to lower vehicle emissions - over the last 15 years, nitrogen oxides (NOx) limits for diesel car engines have been reduced by 84% and particulates (PM) by 90%.

15% less CO_2 Emissions/km than equivalent petrol-powered vehicles. Diesel vehicles contribute to reducing CO_2 emissions from road transport and therefore to reduce climate change.

Fuel tank and fuel pipes

Objectives: At the end of this lesson you shall be able to
- **explain the function of the fuel tank**
- **explain the function of each part of fuel tank**
- **explain the function of fuel pipes.**

Fuel Tank

The Fuel tank is provided for storing diesel required for running the engine. It is constructed of either pressed sheet metal with welded seams and special coating to prevent corrosion or fiber glass reinforced plastic materials.

It may be round or rectangular in shape. It is mounted above the engine assembly.

Parts of the fuel tank

Filler neck and cap

Baffle

Fuel gauge sensing unit (Float)

Filter

Sediment bowl and drain plug

Filler neck is provided for pumping diesel into the fuel tank. A cap is provided for closing the tank tightly. A vent hole is provided either in filler neck or in cap to maintain atmospheric pressure in the tank above the fuel.

Baffles are provided in the fuel tank to minimize the slushing of fuel due to movement inside the tank.

Fuel gauge sensing unit is provided to know the level of fuel available in tank. It consists of a float resting on the surface of the diesel in the tank. The float with the help of the electrical sensing system indicates the level of the fuel available in the tank, on the dash board fuel-gauge.

Filter is provided at the lower end of the suction pipe. It filters heavy foreign particles.

At the bottom of the fuel tank a drain plug is provided to collect sediments and drain it out of the tank.

Fuel pipe

Fuel pipe between the fuel tank and the feed pump is called suction pipe, the pipes between F.I.P. and the injectors are called high pressure pipes. An over flow pipe is provided on fuel filter bowl and injectors to supply excess fuel back to fuel tank.

Fuel filter

Objectives: At the end of this lesson you shall be able to
- **state the need of a fuel filter**
- **explain the types of fuel filter systems**
- **explain the need for blending the fuel system**
- **state the function of water.**

Need of fuel filter

Effective filtering of fuel, oil is most important for long trouble free functioning of the engine. Diesel fuel while transporting and handling has chances of getting contaminated by water, dirt, bacteria and wax crystals. Dirt is the worst enemy of the fuel injection equipment. Dirt contamination can be the result of careless filling of the fuel tank. When fuel tank is not filled, moist air condenses inside the metal wall of the fuel tank resulting in water contamination of the fuel.

For these reasons a very efficient filtering system is required to remove these impurities.

Types of fuel filter system

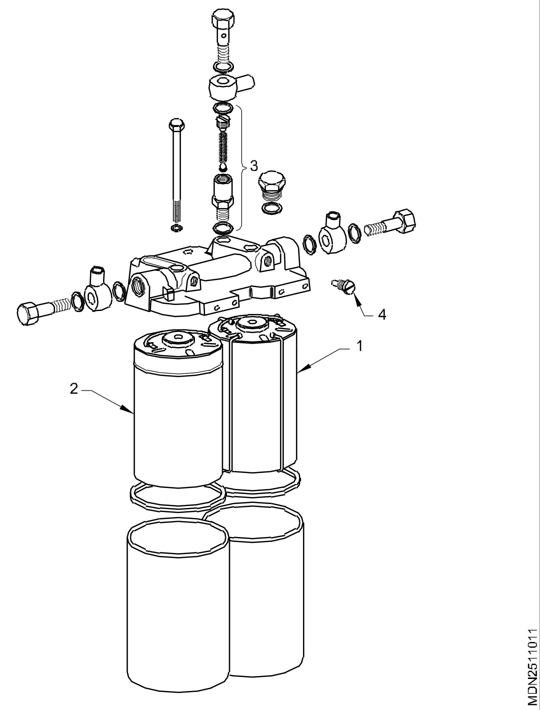
There are two types of fuel filtering system.

Single filter system

Two stage filter system

In a single filtering system one single filter assembly is used in between feed pump and fuel pump. The single filter in this system is capable of separating dirt from fuel. It should be replaced periodically as per the recommendations of the manufacturers.

Fig 1



In a two stage filter system, primary filter (1) (Fig 1) is used for filtering large solid contaminants and most of the water in the fuel is also removed by this filter. The secondary filter (2) is made of a paper element. This filter controls the size of the particles allowed to pass into the fuel injectors. It also separates any water that might have passed through the primary filter. An overflow valve assembly (3) is used to send back excess fuel to fuel tank. A bleeding screw (4) is provided to bleed the air from fuel system.

Fuel filter element

A paper element is most suitable because important properties which determine filter quality such as pore size and pore distribution can be effectively maintained. Generally paper filter elements are used at the secondary stage filtration process.

Coil type paper filter inserts are wound around a tube and neighbouring layers are glued together at the top and bottom. This forms a pocket with the openings at the top.

In the star type paper filter inserts, the fuel flows radially from outside to inside. The paper folds are sealed at the top and bottom by end covers.

Cloth type filter inserts are used for primary stage filtration. In this the fuel flows radially from outside to inside. The cloth is wound over a perforated tube whose ends are sealed at the top and bottom by end covers.

Bleeding of the fuel system

Bleeding is the process by which air, which is present in the fuel system, is removed. Air locking in the fuel system will result in erratic running of the engine and may result in stopping of the engine. Bleeding is carried out by priming the filter. A slight loosening of the bleeding screw allows locked air to escape as bubbles along with the fuel. When locked air escapes and the system is free of air, the screw is tightened finally.

Diesel fuel water separator

A fuel water separtor is device that works to ensure flean fuel is delivered to the engine.

The fuel water separtor is a small filtering device used to remove water from the diesel fuel before it reaches to the sensitive parts fo the engine. Water and contaminants have a great impact on the service life and perfomance of diesel engines.

Besides being abrasive to engine components and cylinder walls, water and combination displaces diesel fules lubrication coating on precision injector components, causting tolerance erosion, surface fitting, fuel loss and poor performance.

The first stage of the fuel water separtor uses a plated paper element to change water paticles into large enough droplets that will fall by grauity to a water sump at bottom of the filter. The second stage is made of silicone treated nylon that acts as a safety device to prevent small particles of water that avoid the fire stage from passing into the engine. To remove the water from the fuel water separator, open the valve to drain the water from filter if the water separator fails, water in the fuel can wear away lubricants on the diesel fuel injectors so that fuel water separator is important part of fuel system.

Fuel water separator filter (FWSF)

Components of fuel water, separator filter provide a better way to filter fuel and it have twist fuel filter water separting system.

- Filter
- Water collection bowl
- Water drain valv with WIF senior or threaded part

Benefits

- Protect engine components
- Extand equipment life

Features

It is easy to switch over water from fuel

- Water separating fuel filter with standard twist & drain.
- Water collection bowel for easy usual inspection.
- Alternative twist and drain valve with water in fuel (WIF) sendor or threaded port.

Fuel feed pump

Objectives: At the end of this lesson you shall be able to
- **explain the function of a feed pump**
- **explain the construction of a feed pump**
- **explain the working of a feed pump.**

Function

A feed pump is usually mounted on the F.I.P. and is driven by the camshaft of F.I.P. It sucks fuel from fuel tank and supplies it to fuel filters.

Construction

The fuel feed pump consists of a barrel, a plunger, a plunger return spring, spindle, roller tappet, suction and delivery valves, hand primer and pre-filter.

Working

The feed pump plunger (1) (Fig 1 & Fig 2) is driven by the cam (2) provided on the F.I.P. camshaft (3). When the plunger moves "downwards" by means of roller tappet (4) and pressure spindle (5) a portion of the fuel present in the suction chamber (6) is delivered through the pressure valve (7) to the pressure chamber (8) and the plunger spring (9) compressed in an intermediate stroke. Towards the end of this stroke the spring loaded pressure valve closes again.

Fig 1

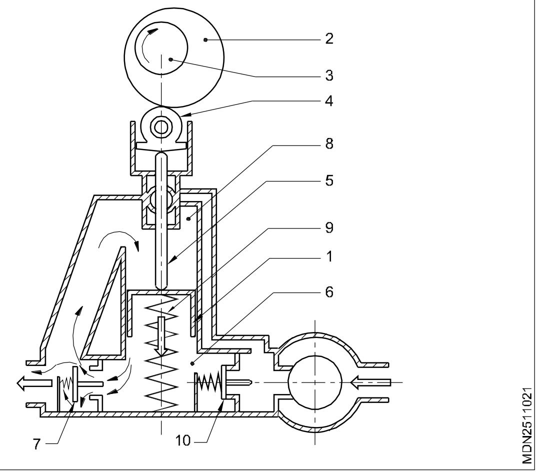
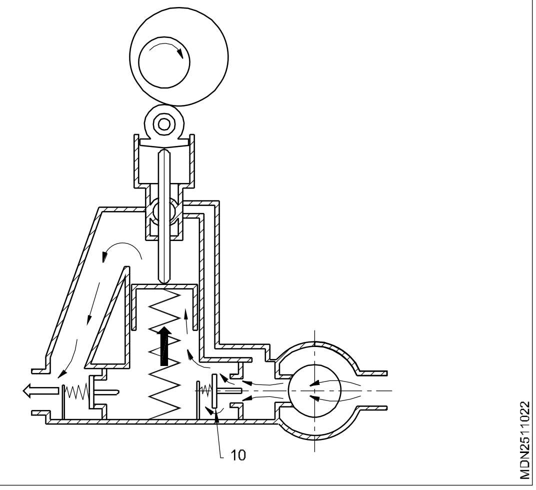


Fig 2



As soon as the cam or eccentric has passed its maximum stroke, plunger, pressure spindle and roller tappet move "upward" due to the pressure exercised by the plunger spring. A portion of the fuel present in the pressure chamber is thereby delivered to the fuel injection pump through filter. However, fuel is sucked simultaneously from the fuel tank to the suction chamber through the primary filter provided in the feed pump and suction valve (10).

When the pressure in the feed pipe exceeds a specified, pressure the plunger spring lifts the plunger only partially. The quantity of fuel delivered per stroke in this is comparatively smaller. When the fuel pipe line is full and the F.I.P. does not need further fuel the feed pump should be put out of action. Due to the excess fuel in the fuel outlet line the pressure in the pressure chamber, holds the plunger in the top position putting the feed pump out of action. During this period only spindle works. The moment the pressure falls down the spring forces the plunger down and the pumping action is resumed. This action during which fuel is not supplied by feed pump is known as idling of feed pump.

Hand priming device

The hand priming device is screwed into the feed pump above the suction valve. When the engine is at rest, with the aid of the hand priming device fuel can be pumped from the fuel tank through the filter to the F.I.P. In order to operate the primer the knurled knob is screwed out until the plunger can be pulled upwards causing the suction valve to open for fuel to flow into the suction chamber.

When the plunger is pressed down the suction valve closes while the pressure valve opens and fuel flows through the feed pipe and the filter to the F.I.P. After the use it is essential to screw the knob again in its original position.

Preliminary strainer

The preliminary strainer is usually attached to the feed pump. The function of the preliminary strainer is to prevent the coarser impurities at a very early stage. It consists of a housing with a nylon/wire gauge insert or a wire mesh sieve.

Fuel injection pump

Objectives: At the end of this lesson you shall be able to
- **explain function of F.I.P.**
- **explain constructional features of F.I.P.**
- **state the need of calibration**
- **list out types of fuel injection system**
- **explain air injection and airless injection**
- **state the need of a governor**
- **list out different types of governors**
- **explain constructional features of governors**
- **explain operation of governor**
- **explain specifications shown on F.I.P. plate.**

Function of the F.I.P.

Fuel Injection Pumps are designed to deliver specific quantity of fuel to the combustion chamber through an injector at a specific time.

Types of F.I.P.

There are two types of F.I.P.

Inline pump

Distributor or rotary type pump.

The inline pump has a plunger and barrel assembly for each cylinder of the engine. The assemblies are grouped together in one housing that resembles cylinders of an engine block.

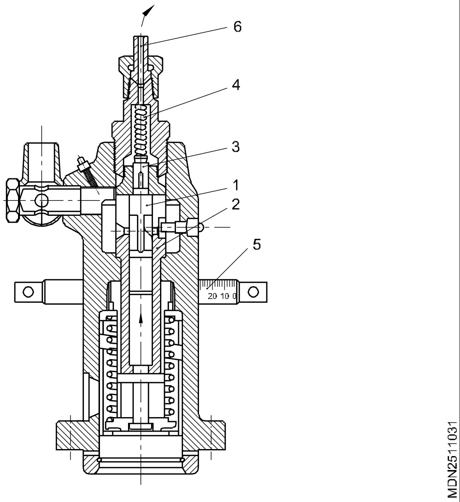
Distributor or rotary type of fuel injection pump has a single pumping element, which supplies fuel to all the cylinders. Distribution to the individual injector is effected by a rotor having a single inlet and delivery, in turn to the appropriate number of outlets. This is done with the help of rotor. Cylindrical plungers and drilled holes in the bore.

Working of a F.I.P.

When the plunger (1) (Fig 1) is at its bottom position fuel enters through the barrel's (2) inlet port from the feed pump, fills the space above the plunger in the barrel and excess fuel flows out through the spill port. In a primed system, the barrel(2), all the pipes and the entire system is filled with the fuel. As the plunger rises up due to cam operation, certain amount of fuel is pushed out of the barrel through the ports. As soon as the ports are closed by the plunger, the flow of fuel is stopped and the fuel above the plunger in the barrel is trapped and is pressurized. The pressure increases to as high as 400 to 700 bar (kgf/cm²) .

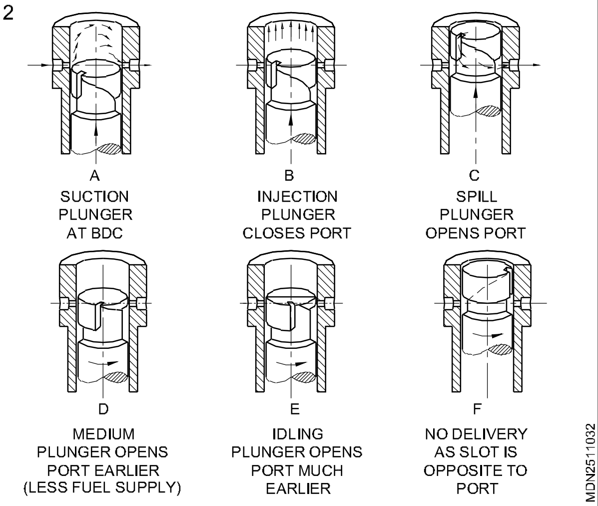
This pressure lifts the fuel delivery valve (3) and the fuel enters the fuel line (6) which is connected to the injector. As the pipe is already full of fuel the extra fuel which is being pumped causes a rise in the pressure throughout the line and lifts the injector valve. This permits the fuel to be sprayed into the combustion chamber in a fine mist form. It continues until the lower edge of the helical groove in the plunger uncovers the port in the barrel. As soon as the port is uncovered, the fuel by passes downwards through the vertical slot and flows to the port. This causes a drop in pressure and delivery valve closes under its springs (4) pressure. With the consequent drop in the fuel line the injector valve also closes and cuts off the fuel injection.

Fig 1



The plunger stroke is always constant. But by rotation of the plunger in the barrel, it is possible to deliver the fuel earlier or later in the stroke and control the quantity of fuel sprayed. (As shown in Fig 2) The rotation of the plunger is obtained by operating the control rack (5), which is in turn connected to the governor.

Fig 2



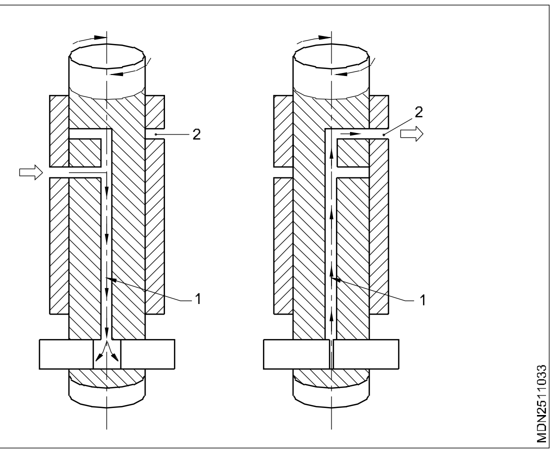
The governor controls all engine speeds upto a maximum, according to pedal pressed by driver. Different positions of the plunger and the fuel flow is given in the figure.

Constructional features of distributor type F.I.P.

It has a single pumping element which supplies fuel to all cylinders. The distribution to the individual injector is effected by a rotor having a single inlet and delivery equal to the number of cylinders. This ensures in built and uniform delivery to all injectors.

The pumping element consists of two plain opposed cylindrical plungers in a diametrical hole in the rotor head, an extension of which forms the distributor. An axial hole (1) (Fig 3) drilled in this extension connects the pumping chamber with a racked hole which registers in turn with racked delivery ports (2) due for each cylinder of the engine.

Fig 3



Need for calibration

In a multi cylinder engine it is necessary that equal and specified quantity of fuel is supplied to each cylinder by fuel injection pump at specified time. The measurement of fuel delivered by each plunger with the control rod in a fixed position and its comparison is called calibration of F.I.P. The adjustment for varying the fuel delivery can be done by altering the position of the control sleeve of each plunger. It is achieved by caliberating the F.I.P. on a test bench by a correct chart as recommended by the manufacturer.

Phasing is the process of testing the pump for the accuracy of their supplying fuel at correct intervals.

Types of fuel injection system

There are two types of fuel injection system for diesel engines.

Air blast injection.

Mechanical injection.

Air blast injection

In the air blast injection system, a high pressure air blast drives the fuel at a very high velocity into the cylinder where it is mixed with the compressed air in the cylinder and ignites.

Mechanical injection

In mechanical fuel injection system, fuel is forced in from a mechanical fuel injection pump through injectors. These are of two types -

Low pressure fuel supply system.

Metering injection system.

All fuel supply systems use the same components, although the components vary in size and location within the system.

Low pressure fuel supply system

The low pressure fuel supply system consists of one or more fuel tanks, a feed pump, fuel filters, hand priming pump, overflow valve and a return orifice.

Metering injection system

It consists primarily of injection pump and injector and categorized as below, depending on the metering system.

(i) Pump controlled system

This is operated with a high pressure plunger and metering mechanism

(ii) Unit injectors system

This system is similar to the pump controlled system except that the high pressure pumping and metering mechanism are an integral part of the fuel injector.

(iii) Common rail system

This type of system uses a high pressure fuel pump that is connected to a common fuel rail. Each cylinder's fuel injector is connected to the common fuel rail.

Governors

The governor is a device for holding any speed steady between idling and maximum speed. The fuel injection pump operates in conjunction with a governor, which is required to control the injected quantity of fuel so that the engine neither stalls when idling nor exceeds the maximum speed for which it is designed.

Following Types of Governors are used

Mechanical

Pneumatic

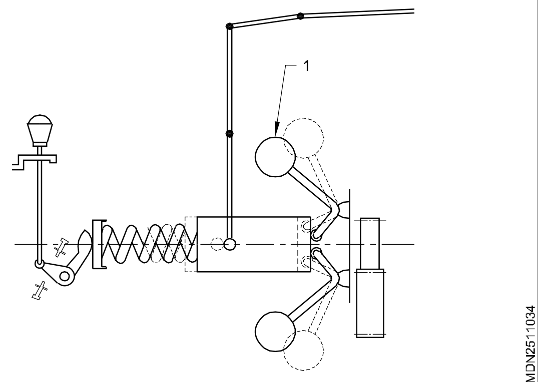
Servo

Hydraulic

Mechanical Governor

Mechanical governors have speed measuring mechanism and fuel controlling mechanism actuated by mechanical arrangement. Two fly weights (Fig 4) (1) are mounted to the governor's drive gear or directly fastened to the camshaft. The centrifugal force of the fly weights actuates the fuel control mechanism.

Fig 4



Cooling and librication

The single-plunger injection pump can be mounted in any position. In operation, its interior is completely filled with Diesel fuel under slight pressure in order to prevent intrusion of air and dust; and also to prevent rust formation caused by condensation. Excess fuel is recirculated within the pump to provide adequate colling and lubrication.

Nozzles

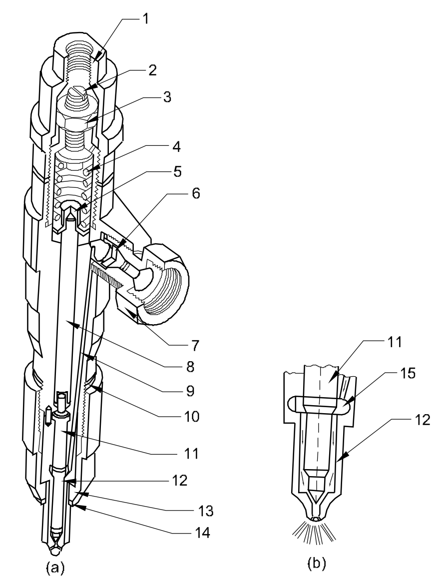
Objectives: At the end of this lesson you shall be able to
- **explain function of injectors**
- **list out different types of injectors**
- **explain special features of various types of nozzles**
- **explain specification of nozzle and nozzle holder.**
- **explain cumming & detrit diesel injection**
- **state the functioning of glow plug.**

Fuel Injectors Fig 1

The function of the fuel injector is to deliver finely atomized fuel under high pressure to the combustion chamber for the engine. All component parts of the injector are carried in nozzle holder 10. The main part of the injector is the nozzle comprising nozzle body 12 and nozzle valve 11.The nozzle body and needle valvel are fabricated from alloy steel. They are thoroughly machined and have high surface harness necessary for operation in condion of high temperatures and elevated pressures. The bore in the nozzle body and the nozzle needle valve are lapped to a close tolerance and are a matched set, so that neither the nozzle body nor the needle valve may be replaced individually. The needle valve is pressed against a conical seat in the nozzle body by spring 4 acting through the intermediary of stem 8. The spring pressure, hense injection pressure, is adjusted by adjusting screw 2. The adjusting screw is screwed in the bottom of the injector spring cap nut which in turn is screwed in the nozzle holder. Lock nut 3 is used to prevent the adjusting screw from unscrewing spontaneously. The screw is covered by nozzle holder cap nut 1 provided with a threaded hole to connect the leak-off pipe through which the leak-off fuel (used to lubricate the nozzle valve) filling the pressure spring and adjusting screw area is returned to the fuel tank or the secondary fuel filter.

In operation, fuel from the injection pump enters pressure chamber (gallery) 15 in the nozzle body through supply passage 9 and a high-pressure pipe. When the fuel pressure in the pressure chamber becomes so high that the force acting on the pressure taper of the needle valve from below exceeds the set spring force on the stem, the needle valve lifts off its seat and comes to rest with its upper shoulder against the face of the nozzle holder. Fuel is then forced out of the nozzle spray holes into the combustion chamber in a spray pattern which depends on the type of nozzle used.

Fig 1



(a) Construction :
(b) Illustrating the operation of the injector :
1-Cap nut.
2-Adjusting screw.
3-Lock nut.
4-Spring.
5-Spring nut
6-Screen filter.
7-Inlet fitting.
8-Spindle.
9-Fuel passage.
10-Nozzle holder.
11-Nozzle needle valve.
12-Nozzle body.
13-Nozzle cap nut.
14-Washer.
15-Nozzle pressure chamber (gallery)

FUEL INJECTOR

After the injection of fuel has been ended, the fuel delivery from the injection pump ceases, the pressure in pressure chamber 15 of the nozzle drops instantly, and the pressure spring snaps the needle valve onto its seat, preventing unpressurized fuel from leaving the nozzle. The fuel injector is installed in a brass injector tube, or sleeve, which is fitted in a hole in the cylinder head, and is held in place by a special clamp.

Injectors are provided to atomise the fuel into engine cylinder. This is done to achieve complete combustion.

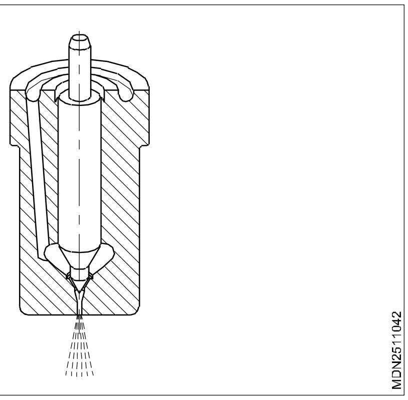
Following types of nozzles are used in engine.

- Single hole type (Fig 2)
- Multihole type (Fig 3)
- Longstem type (Fig 4)
- Pintle type (Fig 5)
- Delay nozzle (Fig 6)
- Pintaux nozzle (Fig 7)

Single hole type

In this type, one hole is drilled centrally or in an angle through its body which is closed by nozzle valve.

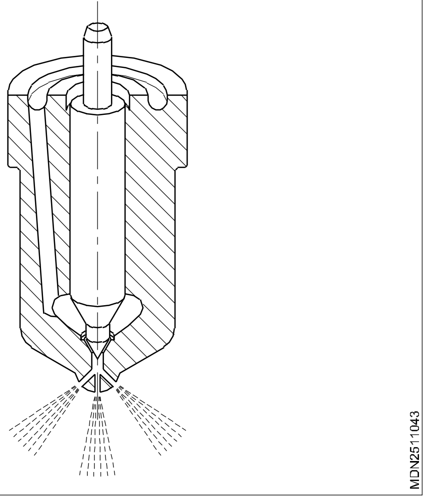
Fig 2



Multihole type

In this type varying number of holes are drilled at the end of the body. The actual number of holes depend upon the engine requirement.

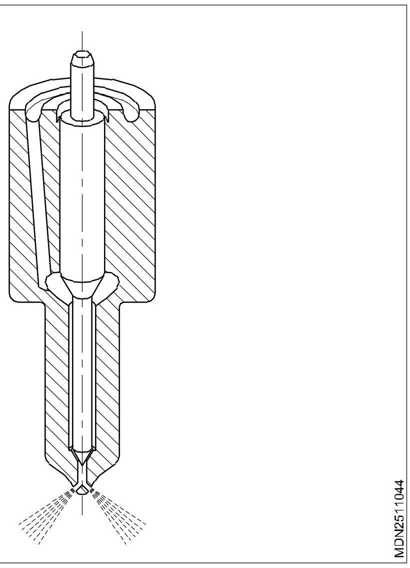
Fig 3



Longstem type

For providing adequate cooling for the standard short stem nozzle, a different type of nozzle with a small diameter extension has been developed. This is called long stem nozzle.

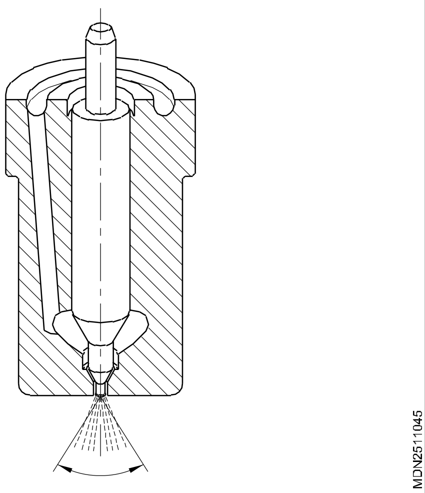
Fig 4



Pintle type

In this type the valve stem is extended to form a pin or pintle which protrudes through the month of the nozzle body.

Fig 5



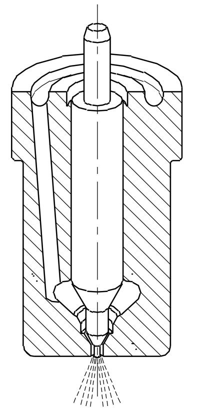
Delay nozzle

In this type spray pattern is controlled by the modification in pintle design. This will reduce the amount of fuel in combustion chamber, when the combustion begins. This modified nozzle is known as delay nozzle.

Pintaux nozzle

This is the further development of pintle type nozzle, having an auxillary spray hole to assist easy starting under cold condition.

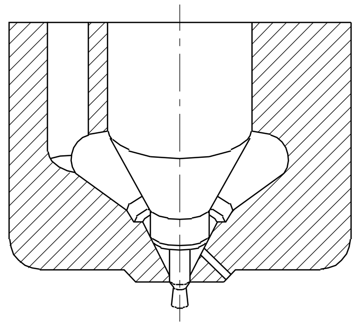
Fig 6



DELAY

MDN2511046

Fig 7



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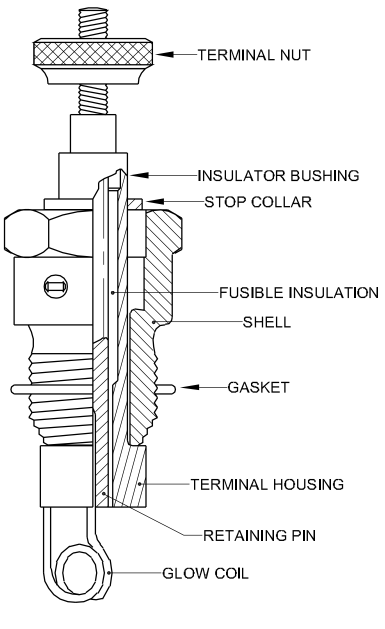
Need

A heater plug or glow plug is used in a Diesel engine having a pre-combustion chamber for igniting the diesel fuel spray. This arrangement makes for an easy starting of a diesel engine in cold weather. Most diesel engines use heater plugs. Figure 9 shows parts of a heater or glow plug.

Description of a glow plug (Fig 8)

Fig 8



CONSTRUCTION OF THE DUAL - POLE GLOW PLUG

MDN2511048

The glow plug consists of a heating element (glowing coil) and is provided with an insulator shell and other parts. One such glow plug is shown in Fig 9. In a multi-cylinder engine the number of glow plugs depends on the number of cylinders. They are connected in series (Fig 10), parallel with the battery, through a glow plug switch, (control switch) a resistor and a red indicator light and they are provided on the dashboard (panel) of the vehicle. The glow control switch is a three-way one, connecting to the starter also for starting purposes. The glow control switch serves to connect and disconnect the battery with the glow plug as and when required. The red indicator light indicates to the driver, the working of the glow plug or its failure.

Working of the circuit (Fig 9)

When the switch is closed, the heating element becomes very hot due to the passage of current from the battery, and the surrounding air is heated up. When the engine is cranked heated air is drawn into the cylinder giving the compressed air a higher temperature for ignition. The fuel particles, which happen to be very near the hot air, will be ignited directly, thus initiating combustion. After combustion begins, the burning air-fuel mixture comes out of the pre-combustion chamber and enters into the main chamber. There it gets mixed up with the combustion chamber air and thus combustion is completed.

Precautions

- After the engine is started the glow plug is to be cut off from the circuit. Otherwise the glow coil will be heated up additionally and gets burnt up eventually, resulting in the replacement of the glow plug.
- The glow plug switch should not be operated for more than three seconds.
- The glow coil is having low electrical resistance and hence it will be very hot when connected to the circuit. Do not touch it, when it is hot.

Detroit diesel cummins diesel

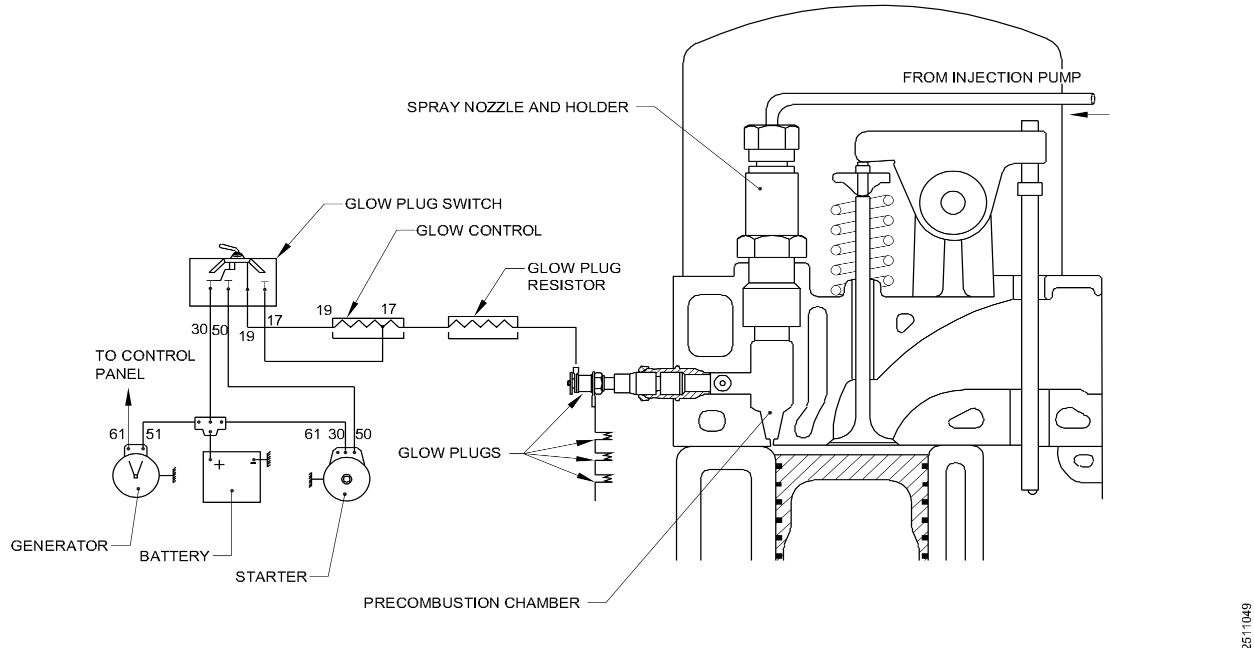
Detroit diesel cummings diesel well known for favouring unit injectors, in which the high-pressure pump is contained within the injector itself. This leads to the development of the modern unit injector.

Cummings PT (pressure-time) is a form of unit injection where the fuel injectors are on a common rail fed by a low-pressure pump and the injectors are acturated by a third lobe on the camshaft. The pressure determines how much fuel the injectors get and the cam determines the time.

Design of the unit injector eliminates the need for high-pressure fuel pipes, and with that their associated failures, as well as allowing for much higher injection pressure to occur. The unit injector system allows accurate injection timing, and amount control as in the common rail system.

The unit injector fitted into the engine cylinder head, where the fuel supplied via integral ducts machined directly into the cylinder head. Each injector has its own pumping element, and in the case of electronic control, a fuel solenoid valve as well. The fuel system is divided into the low pressure <5 bar fuel supply system, and the high-pressure injection system <2000 bar.

Fig 9



IGNITION CIRCUIT DIAGRAM OF GLOW PLUG SYSTEM IN A DIESEL ENGINE

Electronic diesel control (EDC) system

Objective: At the end of this lesson you shall be able to
- **state the function of electronic diesel control device.**

Electronic diesel control Fig 1 is a diesel engine fuel injection control system for the precise metering and delivery of fuel into the combustion chamber of modern diesel engines used in trucks and cars.

The electronic control, the system which provides greater abillity for precise measuring, data processing environment flexibility and analysis to ensure efficient diesel engine operation.

- It receives the information from sensor, analyze/ calculate it and sends the instructions to the acturators.
- It converts information from analog to digital.
- It consists of microprocessors to process the information from sensor to ECM and ECM to actuators.
- Number of microprocessors are depends upon the number of sensors and acturators.
- It also consists of memory to store the data.
- Speed is in the form of 8 Bit, 16 Bit, 32 Bit, 64 Bit etc., to pass the information from sensor to ECM, ECM to actuator and also in networking system.
- Individial programmes have to be made for each sensor and acturator.

Fig 1

ELECTRONIC DIESEL CONTROL DEVICE

MDN2511411

Note: Move the below figure under the common rail direct injection system (Fig 2)

Main control systems in diesel engine

- It controls the fuel for idling.
- It controls the fuel for high speed.
- It controls the fule according to the speed and load conditions.
- It controls the exhaust gas recirculation (EGR) valve.

Fig 2

COMMON RAIL WITH FUEL INJECTORS

MDN2511412

Working

It gets the input from the different sensors named are as follows.

1 Throttle position **TP** (intake air quantity)

2 Cam position **CMP** (for valve timing)

3 Crank positon **CKP** (for RPM and firing order)

4 Engine coolant temperature **ECT** (Cylinder temperature)

5 Inlet air temperature **IAT** (temperature of inlet air)

6 Manifold absolute pressure **MAP** (inlet air pressure)

7 Oxygen **O2** (percentage of oxygen in exhaust gas)

After recieving the above inputs, it analyzes/calculates the amount of fuel is required for the cylinder, accordingly it supplies the voltage to the injector solenoid. The solenoid will open the injector to supply the fuel into the combustion chamber. The minimum injector opening period is $1/10^{th}$ second.

Minimum 3 important sensors (TP, CKP & CMP) inputs are required at the time of starting, if any one of the sensor fails, engine does not start.

Rest of the sensors (IAT, ECT, MAP, and O2) fails; engine will start but the performance of the engine will affect.

Note:

- **In a vehicle minimum one EDC/ECM is required**
- **More than one EDC/ECM are used depends on number of controls.**

Example of control units EDC/ECM in a vehicle

1 Engine management

2 Automatic tranmission

3 Power steering

4 SRS (Air Bag) supplemental restraint system

5 ABS (Antilock braking system)

Exhaust gas recirculation (EGR) EGR value allows the exhaust gases into the inlet manifold, to burn the unburn gases to reduce the emission.

The opening angle of the valve is controlled by the EDC, depending upon the amount - (%) of oxygen passing through exhaust gases.

EDC gets the percentage of oxygen from the oxyten sensor.

Sensor

It senses the information in the form of physical or chemical variables and sends that information to the ECM in the form of voltage i.e. between 0-6 volts or 0-12 volts.

Ex: Throttle valve opening position (angle) information sends to the ECM in the form of voltage.

ECM

It analyzes or calculates the information which havec come from the sensors and gives the instruction to the actutors.

Ex: It supplies the current to the solenoid to open the injector opening duration depends on Inputs

Actutors:

Based on instructors from the ECM, it does the mechanical work.

Ex: Injector opens duration depends on ECM instruction.

Schematic layout system components

Input from senders & switches		Output from ECU
Engine speed sender CKP		Fuel pump relay
Hall sender CMP		Fuel pump for pre-supply
Accelerator pedal position APP		Injection valves
Air mass meter HFM		Valve for fuel dosage
Intake air temperature IAT		Fuel pressure regulating valve
Coolant temperature ECT	→ ECU →	Solenoid valve for cahrge pressure control
Radiator outlet coolant temperature		Intake manifold flap motor
Charge pressure sender G31		Throttle valve module
Fuel temperature sender		Exhaust gas recirculation valve
Fuel pressure sender		Radiator Fan
Exhaust gas recirculation potentiometer		Automatic glow period control unit
Lambda probe		Lambda probe heater
Exhaust pressure sender		
Cutch position		
Throttle valve potentiometer		
Brake ligjt switch		

ECM Electronic control module (or) system

Objectives: At the end of this lesson you shall be able to
- **describe E.C.M Electronic control module (or) system**
- **state various control devices**
- **explain the fuel injection control system**
- **explain the fuel pump control system**
- **explain the injection control system**
- **explain the radiator fan control system.**

Electronic control system

The electronic control system consist of various sensors which detect the state of engine and driving conditions, ECM which controls various devices according to the signals from the sensors and Various controlled devices.

The systems are

- Fuel injection control system
- Idle speed control system
- Fuel pump control system,
- Radiator fan control system,

Idle speed control system

This system controls the bypass airflow by means of ECM & IAC valve for the following purposes. To keep the engine idle speed as specified at all times. The engine idle speed can vary due to load applied to engine, to improve starting performance of the engine to compensate air fuel mixture ratio when -decelerating, to improve drivability while engine is warmed up. IAC valve operates according to duty signal sent from ECM. ECM detects the engine condition by using the signals from various signals and switches and controls the bypass airflow by changing IAC valve opening. When the vehicle is at a stop, the throttle valve is at the idle position and the engine is running, the engine speed is kept at a specified idle speed.

Fuel pump control system

ECM controls ON/OFF operation of the fuel pump by turning it ON, the fuel pump relay under any of the conditions. For two seconds after ignition switch ON. While cranking engine (while engine start signal is inputted to ECM). While crankshaft position sensor or camshaft - position sensor signal is inputted to ECM.

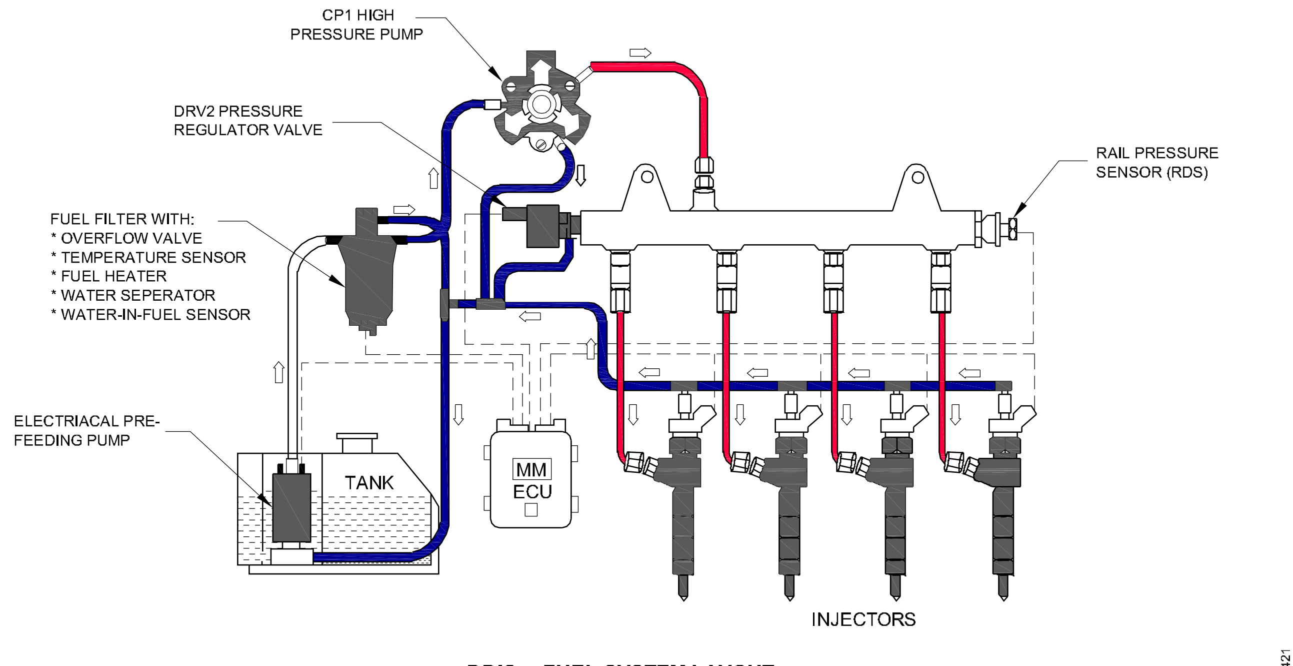
Common rail diesel injection CRDI

Objectives: At the end of this lesson you shall be able to
- **describe the construction of CRDI**
- **explain the working of the CRDI**
- **list out the merits and demerits of the CRDI.**

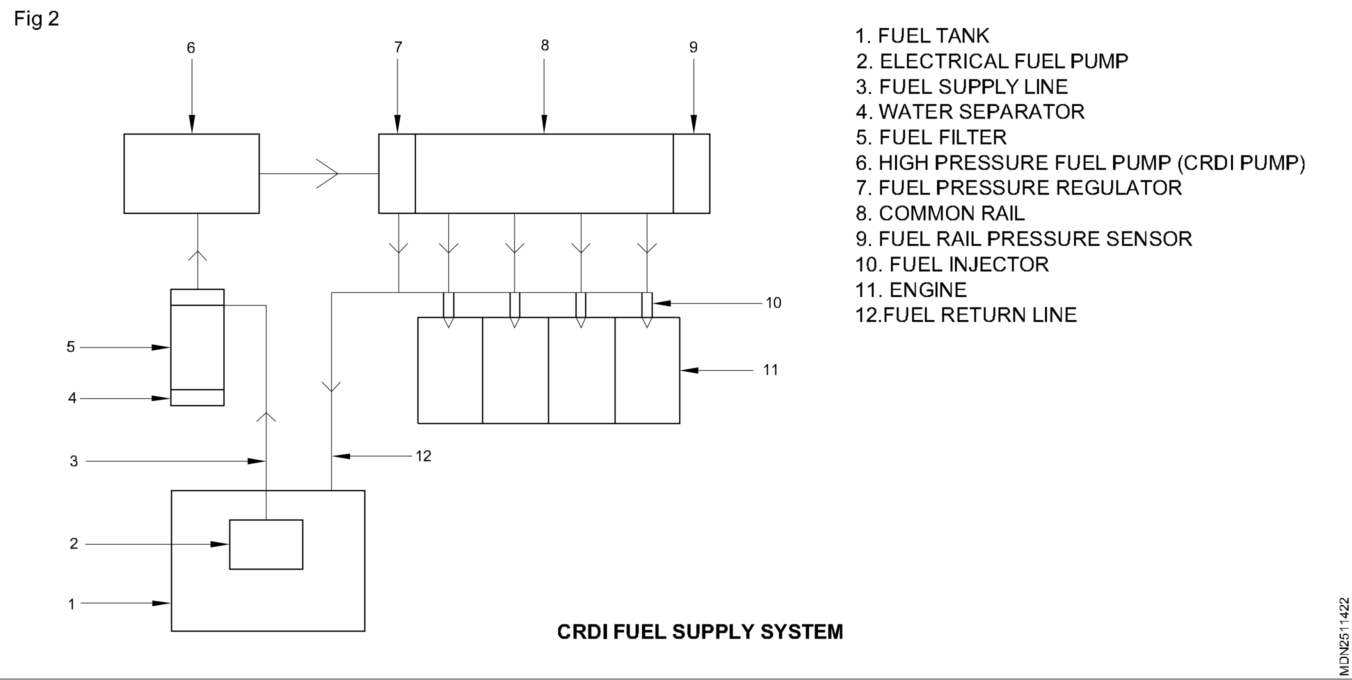
Construction and working of CRDI system (Fig 1 & 2)

The common rail consists of fuel tank, electrical fuel pump (low pressure) in placed inside the fuel tank, It develops pressure upto 6 bar and supplies to the high pressure fuel pump (CRDI) through fuel filter and water separator. The high pressure fuel pump develops pressure 200 to 2000 bar and supplies to the common rail and common rail to fuel injectors inject fuel into the combustion chamber. Fuel injector are operator by ECM through solenoid valve. Common rail consists of fuel pressure regulator rail pressure sensor and fuel pressure regulator supplies the excess amount of fuel to the fuel tank ($\leq$ 1 bar pressure) Common rail will distribute the fuel to all the cylinder with equal pressure,Rail pressure will give the information of existing fuel pressure in the common rail. then all cylinders will develop uniform power, which will reduce vibration and noise of the engine.

Fig 1



DDIS -- FUEL SYSTEM LAYOUT



CRDI FUEL SUPPLY SYSTEM

HEUI Hydraulically actuated electronically controlled unit injector

Objectives: At the end of this lesson you shall be able to
- **describe the HEUI (Hydraulically Actuated Electronically Controlled Unit Injector)**
- **explain basic components**
- **explain its working principle**
- **advantages of HEUI.**

HEUI (Hydraulically Actuated Electronically Controlled Unit Injector)

HEUI Fuel System represents one of the most significant innovations in diesel engine technology in the diesel technology. HEUI made easy of many limitations of mechanical and conventional electronic injectors, and sets new standards for fuel efficiency, reliability and emission control. The highly sophisticated HUEI system uses hydraulic energy instead of mechanical energy to operate fuel injectors. Working along with the engine's ECM (Electronic Control Module), the HEUI system provides extremely accurate control of fuel metering and timing, so that it ensures unmatched engine performance and economy.

Unmatched engine performance and economy.

In the traditional common rail fuel system, the entire fuel line is under high pressure. With the HEUI system, fuel remains at low pressure until it is injected into the cylinder. Fuel pressure is created hydraulically in response to a signal from the Electronic Control Module (ECM).

The HEUI fuel system consists of four basic components:

HEUI (Fig 1) Injector Uses hydraulic energy (as opposed to mechanical energy from the engine camshaft) from pressurized engine lube oil for injection. The pressure of the incoming oil (800 to 3300 psi) controls the rate of injection, while the amount of fuel injected is determined by the ECM.

Electronic Control Module (ECM) This sophisticated on-board computer precisely manages fuel injection and other engine systems. The HEUI injector solenoid is energized by an electronic signal generated in the ECM. Using input from multiple sensors, the ECM's dual microprocessors use proprietary software and customer supplied performance parameters to produce maximum engine performance under any conditions.

High Pressure Oil Pump The variable displacement axial pump features a built-in reservoir to immediately supply oil at cold starts.

Injector Actuation Pressure Control Valve This electronically operated valve controls oil pump output and injection pressure.

Working principle

HEUI is divided in two sections. One is low pressure fuel chamber. Another one is high pressure oil chamber, fuel is supplied at low pressure and oil is supplied at high pressure to the respective chamber.

At the time of injections allows the high pressure oil in to the injection body and actuates the intensifier. The intensifier in turn pressurizes the diesel on the other side of it. So that the intensifier pressurizes seven times of the oil pressure and increases the pressure of the diesel. After then the injector lifts the spindle and injects the diesel through the holes of an injector.

Improved fuel economy The ability to inject fuel at any crank angle results in up to 2.7 percent better fuel economy compared to scroll mechanical injectors. Optimum fuel economy also means reduced gaseous emissions and less white smoke during cold engine starts.

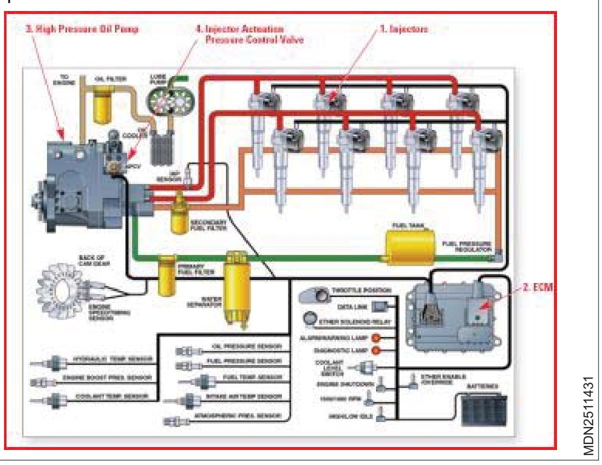
Optimum performance The control of fuel delivered during ignition delay and main injection, known as rate shaping, is made possible by the HEUI's ability to operate independent of engine speed. Rate shaping modifies engine heat release characteristics, which also helps reduce emission and noise levels. Rate shaping optimizes engine performance by varying the idle and light load rate characteristics independent of rated and high load conditions.

Reduced smoke and particulate emissions

Since the HEUI injector's performance does not depend on engine speed, it can maintain high injection pressures through a wide operating range. Electronic control of these pressures helps improve emissions and low-speed engine response.

Reduced engine noise A split injection feature leads to a more controlled fuel burn and lower noise levels. Additional benefits include reduced shock loads as well as less wear and tear on drive train components.

Fig 1



Sensors

Types of sensors

1 Engine coolant temperature (ECT)

2 Manifold absolite pressure (MAP)

3 Inlet air temperature (IAT)

4 Oxygen (O_2)

5 Throttle position sensor (TP)

6 Cam postion (CMP)

7 Crank postion (CKP)

8 Anti-lock bracking system (ABS)

The above sensors are being used for the engine management system.

Recently one more sensor is added i.e ABS

Apart from the above so many other sensors are using in the vehicle.

In idest vehicles 10 to 100 plus sensors are using.

Classification & working principle of sensors

Switches

Resistive sensor

Current generating sensor

Hall effect sensor

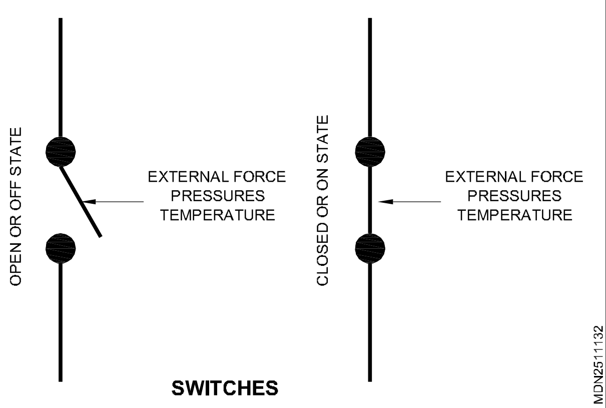
Hot film air mass meter

Lambda sensor

Switches (Fig 2)

Switches are basically on-off sensors & the input given to ECU is normally in two states i.e either “ON” or “OFF” physical position of the switch can be change by operating condition like temperature, pressure, external force etc.

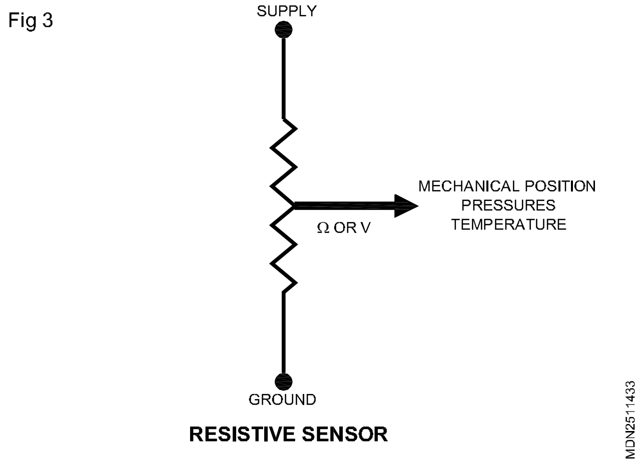
Fig 2



Resistive sensor (Fig 3)

In resistive sensor the variation is resistance happens due to change in input data like position, temperature pressure etc. Input to the control unit is not necessarily the resistance but can be the voltage also.

Fig 3

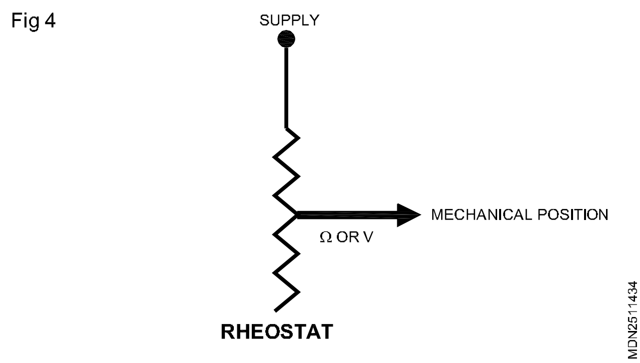


Types of resistive sensor

1 Rheostat (Fig 4)

Generally 2 wire sensor. Change is resistance happen due to change in mechanical position. Value of resistance or voltage is interpreted by ECU for calculation. Meaurement of value happen inside the control unit.

Fig 4



2 Potentiometer (Fig 5)

Generally 3 wire sensor. Change is resistance happen due to change in mechanical position. Value of voltage is interpreted by ECU for calculation. Meaurement of value happen outside the control unit.

3 Thermister (Fig 6)

Thermister are those sensors whose resistance value changes due to change in temperature. Thermister are supplied with constant voltage. Out put voltage changs due to change in resistance which is continuoisly monitor by control unit to decide the temperature value. Thermister can have either negative temperature co efficient [NTC] or positive temperature co efficient [PTC].

Fig 5

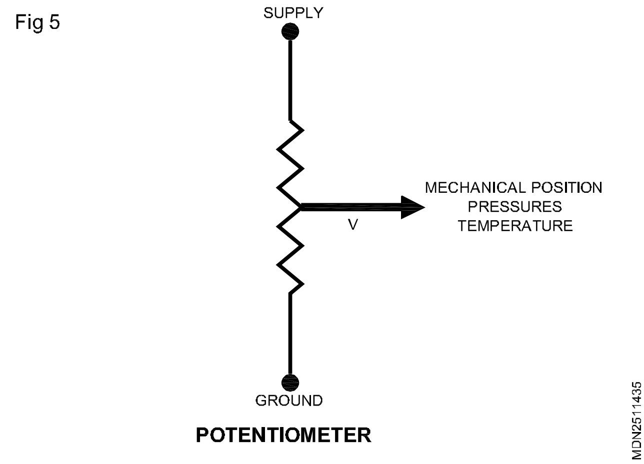
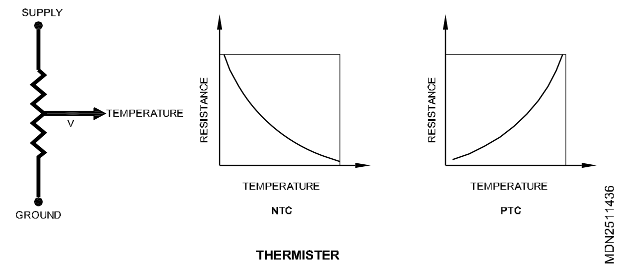


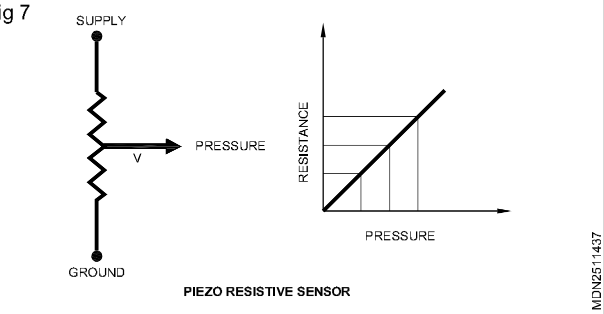
Fig 6



4 Piezo resistive sensor (Fig 7)

Piezo resistive sensors are those whose resistance changes die to change in pressure. They are subjected to external pressure which causes change in resistance. Constant voltage is supplied & out put voltage changes due to change in pressure which is interpreted by control unit to decide the pressure value.

Fig 7



5 Current generating sensor

Certain sensors generate the voltage when subjected to change is physical phenomenon such as pressure, position etc. They are mainly classified as follows.

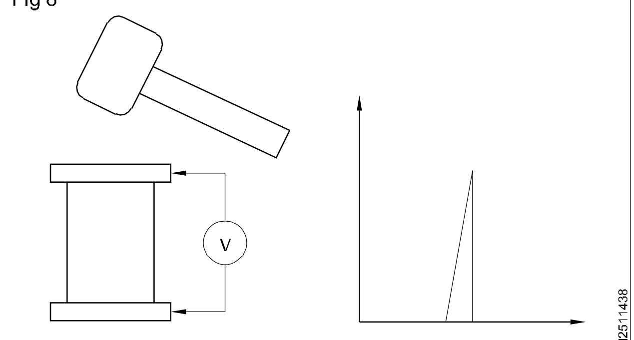
1 Piezo electric sensor

2 Magnetic induction sensor

6 Piezo electric sensor (Fig 8)

Certain crystal such as quartz when subjected to a pressure generate potential difference on its surfacce. The phenomenon is reversible.

Fig 8

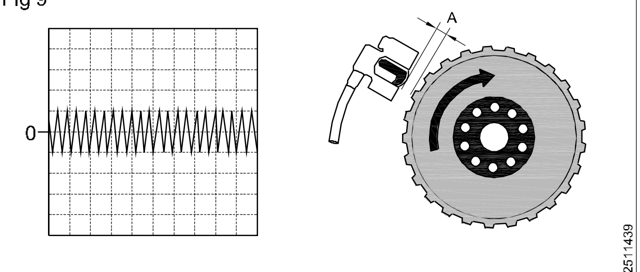


PIEZO ELECTRIC SENSOR

7 Magnetic inductive sensor (Fig 9)

This kind of sensor are consist of coil woud around the permanent magnet. When the magnetic filed is disturb by external means current is generated inside the coil terminals. The pattern of current obtained is depends on the kind of disturbance produce.

Fig 9

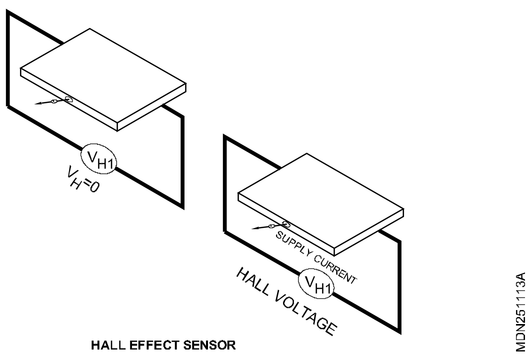


MAGNETIC INDUCTIVE SENSOR

8 Hall effect sensor (Fig 10)

When a current passes through the semiconductor plate there is no current develop at right angles to the direction of current. However when this plate is subjected to a magnetic filed, voltage is developed at right angles to the direction of current. The magnitude of this voltage is proportionate to the magnetic field through the semiconductor.

Fig 10

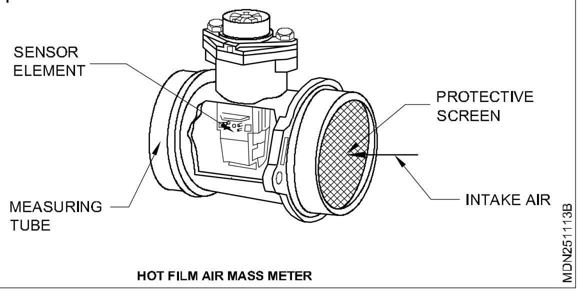


HALL EFFECT SENSOR

9 Hot film air mass meter (Fig 11)

This sensor is used to measure the air flow in engine management system. It consist of measuring tube & sensor electronic with sensor element. The sensor element consist of heating resistors, two thermister R1 & R2, & intake air temperature sensor.

Fig 11

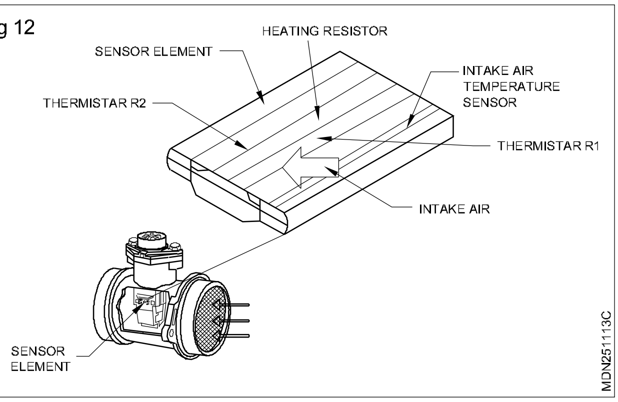


HOT FILM AIR MASS METER

10 Sensors & actuators (Fig 12)

Sensors element is heated at constant temperature appr. 120°C above intake air temperature. Due to air flow there is a temperature difference at R1 & R2. This difference is recognized by electronic module & the intake air mass is calculated. THis alos decide the direction of air flow.

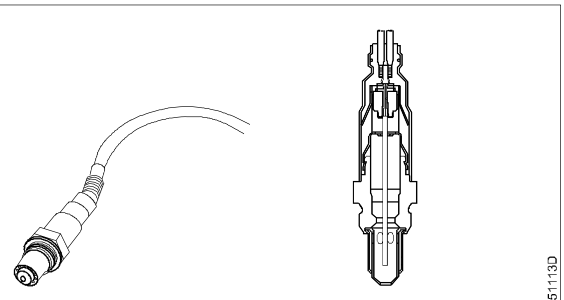
Fig 12



11 Lambda (oxygen) sensor (Fig 13)

This sensor is normally used in petrol engine to decide the oxygen content in exhaust gas. Based on the input from this sensor the ECU do minor correction to the amount of fuel being metered.

Fig 13

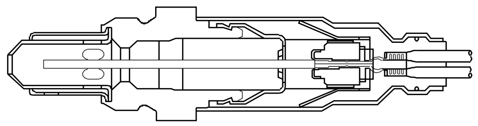


LAMBDA (OXYGEN) SENSOR

12 Lambda (oxygen) sensor (Fig 14)

The difference in oxygen content between the exhaust gas & ambient air causes a change in the electrical voltage within the probe. A change in the composistion of the air fuel mixure produces a sudden voltage change by which $\lambda = 1$ can be identified.

Fig 14



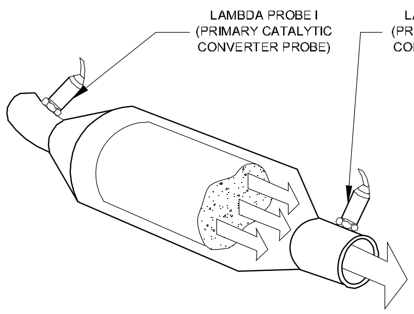
LAMBDA (OXYGEN) SENSOR

MDN251113E

13 Sensors & actuators (Fig 15)

In connection with OBD II, second lambda sensor is connected after catalytic converter. It test correct functioning of the catalytic converter.

Fig 15



MDN251113F

Actuators

1 Injectors

2 Power windows

3 Wiper motos

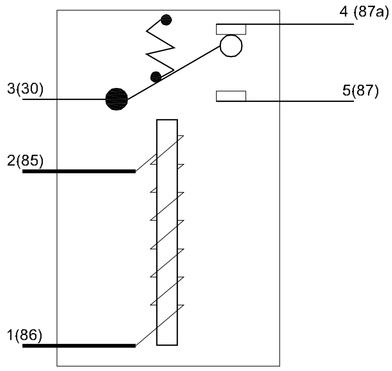
4 Relays etc

Number of actudors depends upon the devices to be operated.

14 Relay (Fig 16)

A relay is an electrically operated switch. many relays use an electromagnet to operate a switching mechanism mechanically, but other operating principles are also used. Relays are used where it is necessary to control a circuit by a low-power signal (with compete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal.

Fig 16



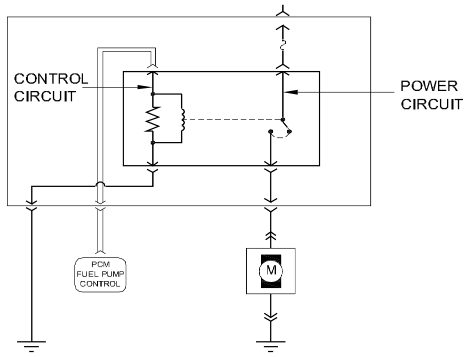
RELAY

MDN251113G

1 **Control circuit:** Control the operation which are activated by control unit or switch. It required very less power to activate. (Fig 17)

2 **Power circuit:** Connected to the load. Main current flows through this circuit. (Fig 17)

Fig 17

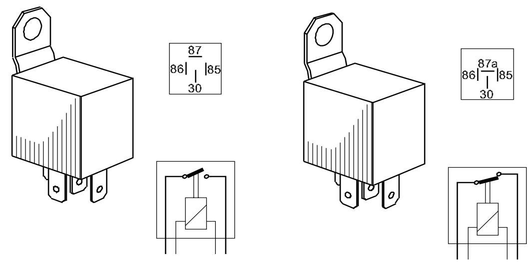


MDN251113H

1 **Normally open relay [NO]: (Fig 18)** Power circuit is in open position. Circuit closes when control circuit is activated.

2 **Normally close relay [NC]: (Fig 18)** Power circuit is in close position. Circuit opens when control circuit is activated.

Fig 18



NORMALLY OPEN RELAY

NORMALLY CLOSE RELAY

MDN251113I

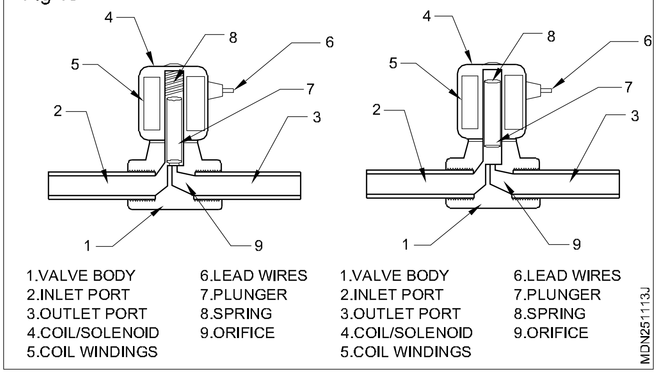
Working principles of acturators

DC Motors

Solenoid (Fig 19)

A solenoid is an electromechaincal switch/ valve that is controlled by an electric currnet. The electric current runs through a solenoid, which is a wire coil wrapped around a metallic core. A solenid creates a controlled magnetic field when an electical current is passed thrigh it. This magnetic field affects the state of the solenoid valve, causing the valvce to open or close.

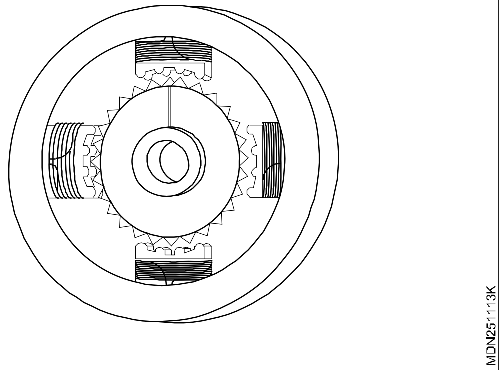
Fig 19



Stepper motor (Fig 20)

Stepper motors provide a means for precise positioning and speed control without the use of feedback sensors. The basic operation of a stepper motor allows the shaft to move a precise number of degrees each time a pulse of electricity is sent to the motor. Since the shaft of the motor moves only the number of degrees that it was designed for when each pulse is delivered, you can control the pulses that are sent and control the positioning and speed. The rotor of the motor produces torque from the interaction between the magnetic field in the stator and rotor. The strength of the magnetic fields is proportional to the amount of current send to the stator and the number of turns in the windings.

Fig 20



Marine engine

Objective: At the end of this lesson you shall be able to
- **state the starting system**

Marine engine

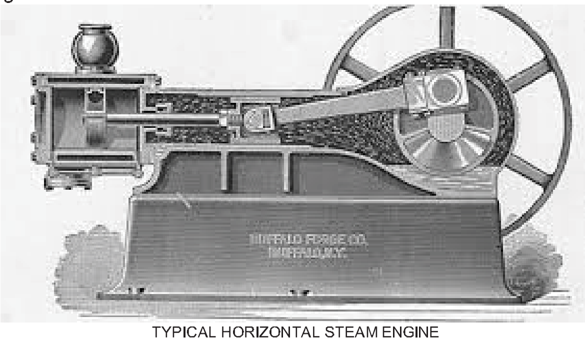
Marine automobile engines are types of automobile petrolor diesel engines that have been specifically modified for use in the marine envionment. The differences include changes made for the operating in a marine environment, safety, performance, and for regulatory requirements. The act of modifying is called 'marinisation'.

Marine automobile engines are water-cooled; drawing raw water in from a pickup underneath the boat. In an open cooling configuration, the raw water is circualted directly through the engine and exits after passing through jackets around the exhaust manifolds. In a closed cooling configuration anti-freeze circulates through the engine and raw water is pumped into a heat exchanger. In both cases hot water is released into the exhaust system and blown out with the engine exhaust gasses. The transmission oil cooler is also cooled by raw water. (Fig 2)

Double acting engine (Fig 1)

A double-acting cylinder is a cylinder in which the working fluid acts alternately on both sides of the piston. In order to connect the piston in a double-acting cylinder to an external mechanism, such as a crank shaft, a hole must to provided in one end of the cylinder for the piston rod and this is fitted with a gland or 'stuffing box' to prevent escape of the working fluid. Double-acting cylinders are common in steam engines but unusual in other engine types. Many hudraulic and pneumatic cylinder use them where it is needed to produce a force in both directions. Engine which is fitted to produce a force in both directions. Engine which is fitted with double acting cylinders referred as double acting engine.

Fig 1



TYPICAL HORIZONTAL STEAM ENGINE
WITH DOUBLE-ACTING CYLINDER

MDN2611511

Fig 2

MERINE ENGINE

MDN2611512

Opposed piston engine (Fig 3)

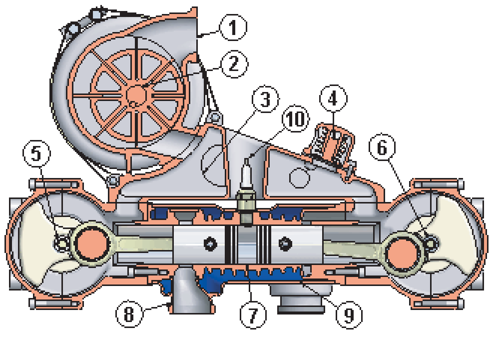
Opposed Piston Engine is a type of diesel engine which has two pistons working in the same cylinder. Technically, opposed piston engine is just a variation in the design of conventional engine. Each of the cylinders of the engine has two pistons, one at each end. The main advantage of opposed piston arrangement over others is that they have a higher power to weight ratio.

As mentioned earlier, in an opposed piston engine, there are two pistons at both the ends of the cylinder. The cylinders of opposed piston engine are generatlly longer in size than those of the conventional engines. The arrangement of cranks is also such that both the pistons move towards and away from each other simultaneously. Moreover, the system works on a two stroke cycle and a uniform method of scavenging. In opposed piston engine the combustion chamber is the sapce left between the two pistons when both are at innder dead centre positions. It is this place between the pistons where in the fuel injection valve, air starting valve pressure relief valve and indicating cocks are fixed.

Most of the opposed piston engines have two crankshafts, one for the upper piston and other for the lower one. Both the crankshafts are arranged as trunk piston engines and through a series of connected gears. However, the earliest opposed piston engines used to have just one crankshaft in their design. Such arrangement would have three cranks, one at the center which is attached to the lower piston with connecting rod and cross-head. The other two cranks are arranged on the same line as that of the center crank and are connected with the top piston with connecting rods, tie rods and crossheads. The exhaust and scavenge ports at the top and bottom of the cylinder, operates because of the reciprocating motion of the piston. Other equipments such as supercharger, air box etc are attached similar to any conventional diesel engine.

The air fuel mixture is pushed into the space in between the pistons. The ignition of the mixture pushes both the pistons downwards, leading to power stroke. The ignition is usually provided using a spark plug. As both the pistons move downwards, one of the pistons opens the outlet valve, which pushes the gas out of the exhaust, whereas the other piston opens the inlet valve, pushing in the fresh gas mixture. The compression stroke then takes place and the cycle repeats itself.

Fig 3



Advantage - Better Power to Weight Ratio

The main advantage of opposed piston engine is that unlike conventional engines, where the stresses generated due to firing loads are transferred from the cylinders to the bedplates of the engine, no stresses are transferred and thus it have an excellent power to weight ratio. Moreover, the arrangement of opposed piston engines provides a higher degree of balance than the conventional engine.

Marine & stationary engine starting system

The purpose of the starting system is to provide the torque needed to achieve the necessary minimum cramking speed. As the starter motor starts to rotate the fluwheel, the crankshaft is turned and starts piston movement. Small diesel engine; doesnot need to be a great deal of torque generated bya starter. But marine diesel engine need huge amount of troque to requires to cranking speed. THe most common type of starting system uses electrical energy, compressed air and hydraulic energy.

Electric starter motor (Fig 4)

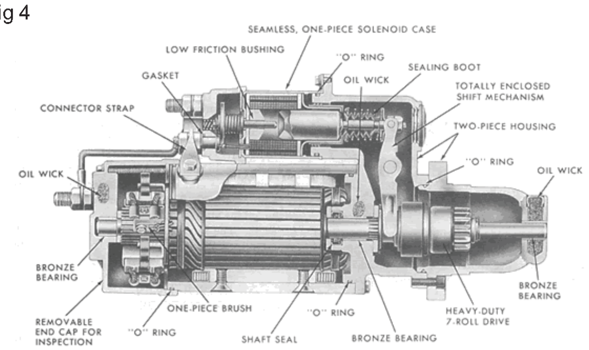
An electrc starter motor take stored electrical energy from battery and covert it into torque at the starter piston gear. The pinion then engages with fly wheel ring gear and gly wheel rotates the engine crankshaft as Fig 4.

Gear reduction starter motor (Fig 5)

In this starter motor components carnature, brushes, brush holder, field coils, pole shoes desolders are the same as direct drive starter. The arnature shaft have a gear output that will drive an intermediate gear that drive other pension gear.

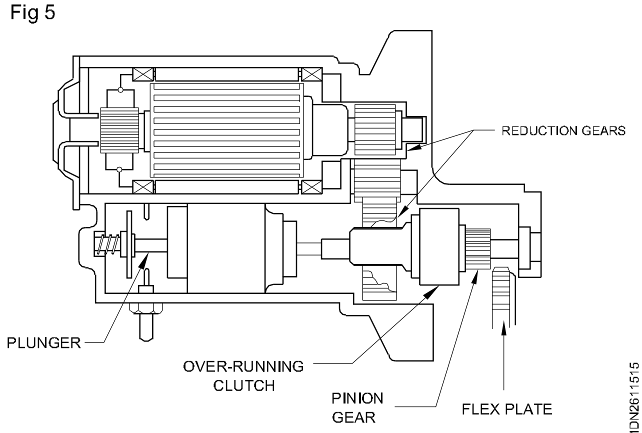
Electric starting system	Air starting system	Hydraulic starting system
Electric starter motor assembly	Air motor starter assembly	Hydraulic motor starter assembly
Battery cables	Air lines	Hydraulic hoses
Starter relay	Relay valve	Directional control valve
Starter interlock system	Starter interlock system	Starter interlock system
Battery (ies) or capacitor	Air tank	Hydraulic accumulator
Starter switch	Starter switch or valve	Starter switch or valve
Wiring harness	Wiring harness (optional)	Wiring harness (optional)

Fig 4



AN ELECTRIC STARTER CUTAWAY

Fig 5



Air Starting system (Fig 6)

Different engine applications could call for an alternative starting system to the electrical starting system. The environment the machine is working in could be flammable and require a spark-proof machine or the cost of replacing batteries in extremely cold environments is seen to be excessive.One alternative is to use a dedicated air supply to spin an air-powered starter motor assembly.

There are some advantages to having an air driven starter. They are much lighter and, therefore, have a higher power to weight ratio than a comparable output electric starter. There is no chance of an air starter overheating from overcranking. Because of their simple design, there is very little that goes wrong with them. The most problematic area that can cause trouble with an air starter assembly is excessive moisture in the air system that can freeze in cold weather.

One disadvantage is how fast the air supply is depleted when the starter is engaged. Most starting tanks will empty within 20 seconds. If the air tank does deplete before the engine starts, this means charging the tank with an external air source from a shop air line, other machine, or service truck.

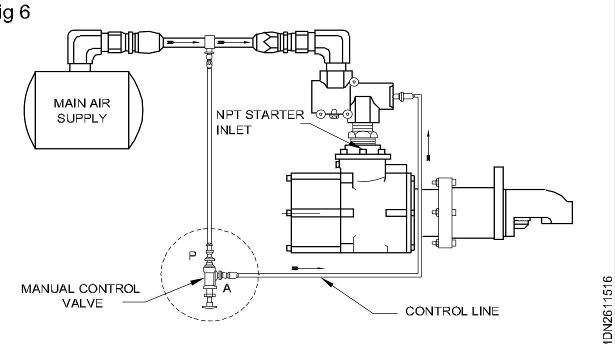
An air starter will generate high cranking speed and torque so that under normal conditions the engine should start before the starter air tank runs out.

There are two main types of air starter motors. One is a vane type that uses sliding vanes in a rotor to convert air flow into mechanical movement. The other type is called turbine, and its rotation is created by air flow pushing on the blades of one or more turbine wheels.

If you look back to the chart comparing air, hydraulic, and electrical starting systems, the main differences are the energy supply, type of motor, air lines, and system control.

The machine will most likely have an air compressor to provide air for other pneumatic systems and to keep the starter air tank charged up. Once the engine starts, it is then up to the machine's air compressor to recharge the starting tank and the machine's other supply tanks. The air starting tank will be charged to between 110 and 150 psi.

Fig 6



To send air to the starter, a relay valve will be controlled by an electric solenoid valve that is activated by the key switch or there could be a floor-mounted air relay valve to send air to the main relay valve. See Figure to see the arrangement of components for an air starting system. When the solenoid valve is energized, it will send air to the relay valve that will open to allow tank air into the starter motor. There are two main types of starter motors: vane and turbine. The motors create shaft rotation that usually has its speed reduced and torque increased through a gear reduction. The torque is then sent out through a drive pinion to engage with the flywheel. Vane-type motors will need lubrication and will usually have diesel fuel drawn into the motor inlet during starter engagement.

It is important to have clean dry air entering air starters and their control circuit. Problems with moist air are magnified in the winter with relay valves freezing and sticking. Air leaks and air restrictions are the only other concern with air starter systems. The motors will last a long time, and if they are found to be worn out, repair kits can be installed to renew the starter assembly.

Hydraulic starting system (Fig 7)

Another nonelectric starting system is one that uses hydraulic fluid to rotate a hydraulic starter motor. The motor will then rotate a drive gear in the same manner as typical electric starters. Hydraulic start systems have an accumulator that keep hydraulic fluid stored under pressure until needed. A control valve is actuated to send pressurized fluid to the motor to get the motor turning. The motor is a fixed displacement axial piston unit, and its shaft drives the pinion gear directly. See Figure for a hydraulic starting system. The control valve could be floor mounted, cable operated, or controlled electrically through an LCD screen touch pad called a human–machine interface (HMI).

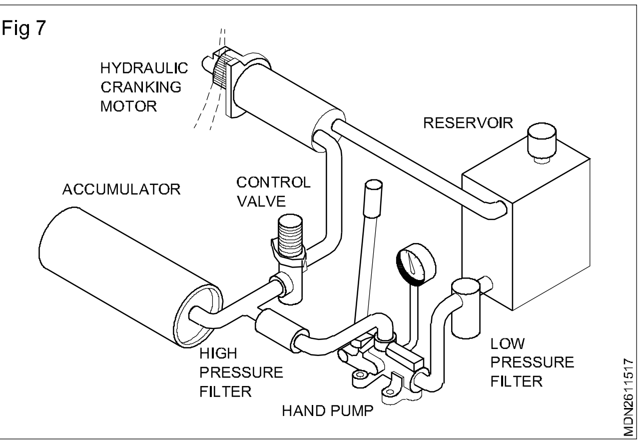
The accumulator for this system has a pre-charge of 1500 psi of nitrogen, and when the oil is pumped into it, the pressure builds to 3000 psi.

This system will have a backup hand pump that could be used to charge the accumulator.

If the system doesn't operate, then just like an electric or air system, perform a good visual inspection. Then check the accumulator pre-charge pressure and the oil pressure after the accumulator has been charged. If these pressures are good, then look for restrictions or leaks past the accumulator toward the control valve. Make sure that the valve is moving as it should, and if there is still a problem, you may have to install pressure gauges throughout the system to see if there is oil pressure getting past the control valve.

As with any fluid power system, cleanliness is crucial so check for fluid contamination. For information on accumulator service and repair.

Fig 7



Air motor starting system for auxilliary engines on ships

Auxiliary Engine Automation System

Objectives: At the end of this lesson you shall be able to
- **Describe the function of auxiliary engine automation system**
- **Describe the function of auxiliary engine stop system**
- **Describe the function of marine engine cooling system**
- **Describe the function of lubricating oil system**

The sensors and indicators are installed on engine properly and connected to the power system panel for control and monitoring. The engine responds to the control signals via pneumatic and electronic mechanism of the engine.

The electrical power of DC24V and compressed air of about 30 bar should be supplied consistently during engine operation. The compressed air supplied from the air reservoir is lowered to a proper pressure through reducing valve around staring air motor, which is used for starting and stopping the engine.

The basic functions of the engine automation system are as follows;

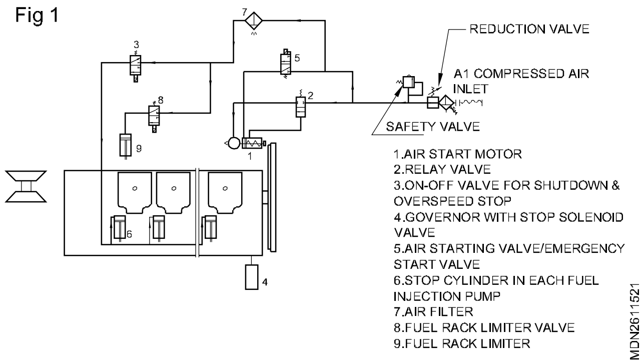
- Engine Starting System.
- Engine Stop System.
- Engine Speed control System.
- Engine Safety system

Auxiliary Engine Starting System (Fig 1)

In air motor starting system, the engine is started by a starting air motor which is operated by compressed air. Figure below shows the compressed air system for starting, stopping and fuel limiting for auxiliary engines on ships.

Refer to the figure above. Compressed air reaches the auxiliary engine at 30 bar pressure. The air pressure is reduced to 6 bar with a reduction valve. A safety valve is also fitted in the line after reducing valve to protect the air starting system components. Air then enters air starting

Fig 1



valve (5) and wait there. When 'START' button on the control panel is activated, starting solenoid valve (5) is opened to supply compressed air into the starting air motor (1). Then, the pinion of the air starting motor is engaged with the gear rim of the engine flywheel. As the pinion moves, relay valve (2) is supplied with air and it allows air to the starting air motor turbine wheel. Now air motor turns crankshaft of the engine. When the engine rotating speed reaches predetermined speed, fuel oil is injected into the combustion chamber. Then, starting is completed and the pinion of the air starting motor is disengaged from the gear rim at predetermined speed.

Purpose of Fuel Rack Limiter

During starting period, the turbocharger is out of normal operation and therefore diesel engine is always in the incomplete combustion due to lack of air, which results in heavy smoke. The fuel rack limiter (9) is used to avoid excessive fuel injected into cylinder during starting period to avoid heavy smoke. During starting period, the engine automation system activate starting solenoid valve to supply compressed air to push the fuel rack limiter (9) piston. A fuel rack limiter valve (8) supplies air to a pneumatic cylinder or fuel rack limiter (9). The limiting position is set to about 50% load normally. The limiting position can be adjusted by guide when loosening locking screw.

On-off valve (3) is for stopping the engine when engine shut down is necessary or over speed trip is activated. This valve provides air to each stop cylinder (6), connected to each fuel pumps and pulls the rack to cut off fuel to the engine.

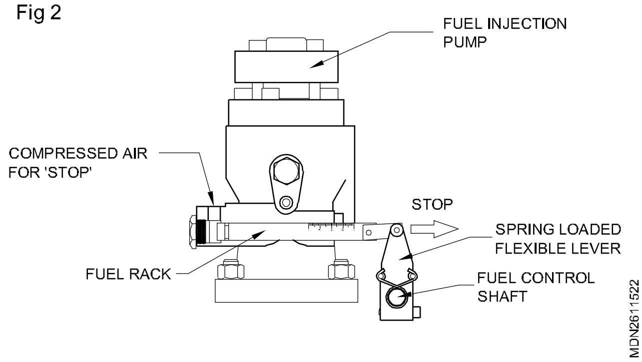
Auxiliary Engine Stop System (Fig 2)

The engine is stopped when pressing 'STOP' button or 'EMERGENCY STOP' button on control panel intentionally, or by 'AUTO STOP' signal. Engine automation system generate 'AUTO STOP' signal when abnormal condition of the engine is detected.

However, the engine is stopped fundamentally when the fuel injection into the combustion chamber is stopped. This means that the rack of each fuel injection pump is moved to stop position by stop signal. Every fuel rack is connected to common control shaft mechanically and also connected to common compressed air line pneumatically.

Therefore, there are two ways of moving fuel racks to stop position (Zero index) as shown in figure below.

Fig 2



The one is by the mechanical stop, which pull the racks to stop position by the governor or the manual control lever. 'STOP' button activates the governor to be 'STOP' position.

The other is by the pneumatic stop by compressed air (as discussed above with on-off valve 3), which pushes the rack to stop position regardless of the governor control. 'EMERGENCY STOP' button or 'AUTO STOP' signals activates the stop solenoid valve to supply the compressed air for all fuel injection pumps. This 'EMERGENCY STOP' signal also activates governor's stop simultaneously.

However, these two ways are mechanically independent each other and the spring-loaded levers provide mechanical flexibility between them.

Marine engine cooling system (Fig 3)

There are two types of cooling system used in marine engines.

1 Heat exhcange cooling system

2 Keel cooling system

Heat exchange cooling system

Heat exchange cooling system consists of the following units.

Water cooled exhaust manifold.

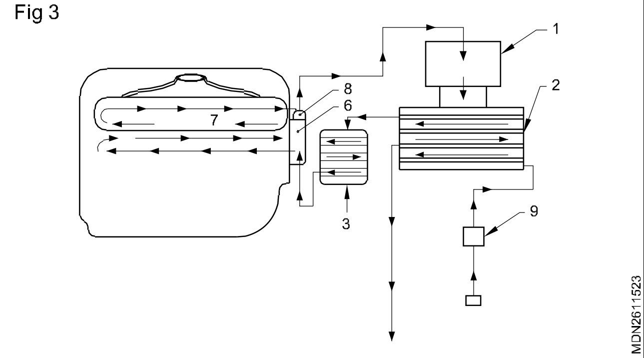
Engine coolant pump.

Heat exhanger

Operation

The coolant flows Fig 3 from the expansion tank (1) around core cells (2). These core cells contain sea water. The water is circulated through the core by the water pump (9). Hot engine coolant flows outside of the core (2) and it is cooled by the sea-water inside the core.

Fig 3



Coolant as fresh wate ris circulated through an expansion tank (1). From the expansion tank (1) it flows down around the cores (2). From the cores (2) to the oil cooler (3) and then through inlet of engine’s coolant pump (6). It is then pumped to the engine and sent to the expansion tank (1) through the exhaust manifold (7) and thermostat (8).

A separate pump (9) is used to circulate sea water to cool cores (2) and back.

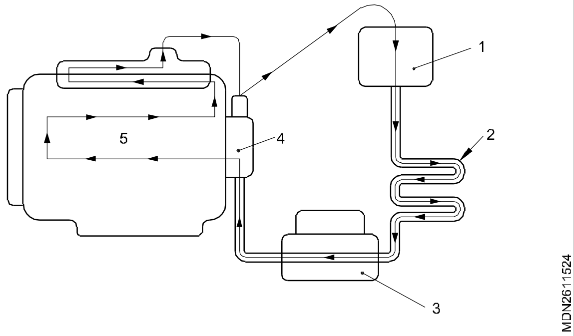
Keep cooling system

In this system coolant flows from the expansion tank (1) to the keeling coil (2) and goes to the engine (5) through an oil cooler (3). A pump (4) is used to circulate the coolant in system.

Open cooling system (Fig 4)

In this system water is stored in a reservour and circulated in the engine by a water pump. Hot water from the engine is pumped to the reservoir where it flows from a height and gets cooled.

Fig 4



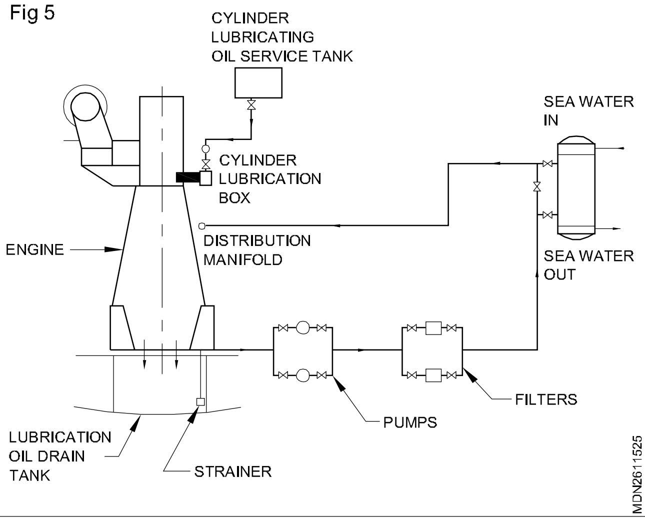
Marine diesel engine lubrication system

Function of lubrication: The lubrication system of an engine provides a supply of lubricating oil to the various moving parts in the engine. Its main function is to enable the formation of a film of oil between the moving parts, which reduces friction and wear. The lubricating oil is also used as a cleaner and in some engines as a coolant.

Main engine lubricating oil system (Fig 5) - This system supplies lubricating oil to the engine bearings, and cooling oil to the pistons. Lubricating oil is pumped from main engine lubricating oil. Circulating Tank, placed in the double bottom beneath the engine, by means of the ME LO Pump, to the main engine lubricating oil. Cooler, a thermostatic valve, and through a full-flow filter, to the engine, where it is distributed to the various branch pipes. Pumps and fine filters are arranged in duplicate, with one as a standby. From the engine, the oil collects in the oil pan, from where it is drained to the ME LO Circulating Tank for reuse. A centrifuge is arranged for cleaning the lubricating oil in the system and the clean oil can be provided from a storage tank.

Lubricating oil system: Lubricating oil for an engine is stored in the bottom of the crankcase, known as the sump, or in a drain tank located beneath the engine . The oil is drawn from this tank through a strainer, one of a pair of pumps, into one of a pair of fine filters. It is then passed through a cooler before entering the engine and being distributed to the various branch pipes.

Fig 5



The branch pipe for a particular cylinder may feed the main bearing, for instance. Some of this oil will pass along a drilled passage in the crankshaft to the bottom end bearing and then up a drilled passage in the connecting rod to the gudgeon pin or crosshead bearing.

An alarm at the end of the distribution pipe ensures that adequate pressure is maintained by the pump. Pumps and fine filters are arranged in duplicate with one as standby. The fine filters will be arranged so that one can be cleaned while the other is operating. After use in the engine the lubricating oil drains back to the sump or drain tank for re-use. A level gauge gives a local read-out of the drain tank contents. A centrifuge is arranged for cleaning the lubricating oil in the system and clean oil can be provided from a storage tank.

The oil cooler is circulated by sea water, which is at a lower pressure than the oil. As a result any leak in the cooler will mean a loss of oil and not contamination of the oil by sea water.

Where the engine has oil-cooled pistons they will be supplied from the lubricating oil system, possibly at a higher pressure produced by booster pumps, e.g. Sulzer RTA engine. An appropriate type of lubricating oil must be used for oil-lubricated pistons in order to avoid carbon deposits on the hotter parts of the system.

Cylinder lubrication

Cylinder oil is pumped from Cylinder Oil Storage Tank to the Cylinder Oil Service Tank, placed min. 3000mm above the cylinder lubricators. The cylinder lubricators are mounted on the roller guide housing, and are interconnected with drive shafts. Each cylinder liner has a number of lubricating orifices, through which the cylinder oil is introduced into the cylinders via non-return valves.

Large slow-speed diesei engines are provided with a separate lubrication system for the cylinder liners. Oil is injected between the liner and the piston by mechanical lubricators which supply their individual cylinder, A special type of oil is used which is not recovered. As well as lubricating, it assists in forming a gas seal and contains additives which clean the cylinder liner.

Lubricating Oil Sump Level

The level of lubricating oil indicated in the sump when the main engine is running must be sufficient to prevent vortexing and ingress of air which can lead to bearing damage.

The sump level is to be according to manufacturers/shipbuilders instructions . The 'Sump Quantity' is always maintained at the same safe operating level and is given in litres. It is essential that the figures are mathematically steady and correct from month-to-month, taking into account consumption, losses and refills and reported.

The 'Sump Quantity' is calculated with the engine stopped, but the lubricating oil pump in operation, thus keeping the system oil in circulation.

Sufficient reserve quantities of lubricating oil must always be held, i.e. to completely fill the main sump and sufficient quantities of other lubes must be held to cover the intended voyage plus 20%. Lubricating oils are a major expenditure item, therefore, all purchasing must be preplanned with the aim of buying the maximum amounts from the cheapest supply sources which are primarily the US, Europe and Singapore. Lub oil requisitions should be sent to the office at least 10 days before the intended port of purchase and clearly indicate if the vessel requires supply in bulk or in drums.

Pre-Lubrication Pumps

They provide an essential part of the lubrication system on many types of engine in particular auxiliary engines with engine driven lubricating oil pumps.

They provide a supply of oil to the bearings prior to start up and limit the length of time that boundary lubrication exists, and shorten the time when hydrodynamic lubrication commences. They must be maintained and operated in accordance with the manufacturers' instructions.

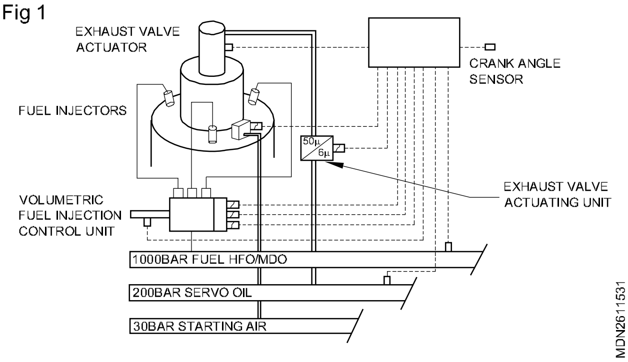
Common rail system of marine engines

Objectives: At the end of this lesson you shall be able to
- **Describe the marine engine CRDI system**
- **Describe the hydraulic coupling system**
- **Describe the electromagnetic couplings system**
- **Describe the reduction gear drive**
- **Describe the marine electrical drive**
- **Describe the super charger**

The common rail system (Fig 1) is a system which is common for every cylinder or unit of the marine engine. Marine engines of the early times had a fuel system, wherein each unit had its own jerk pump and the oil pressure was supplied through the jerk pumps.

However, in common rail system all the cylinders or units are connected to the rail and the fuel pressure is accumulated in the same. The supplied fuel pressure is thus provided through the rail.

Fig 1



The common rail fuel function system was launched even before the jerk pumps, but was also not successful because of few drawbacks. However, latest advancement in technology and electronics, the common rail system has gained popularity.

The common rail engines are also known as smokeless engines as fuel pressure required for combustion is same for all loads or rpm of the engine.

The common rail is employed in the follwing marine engine operating system.

1 for heated fuel oil at a pressure of 1000 bars.

2 for servo oil for opening and closing of exhaust valves at a pressure of 200 bars.

3 control oil for opening and closing of valve blocks at a pressure of 200 bars.

4 compressed air for starting main engine.

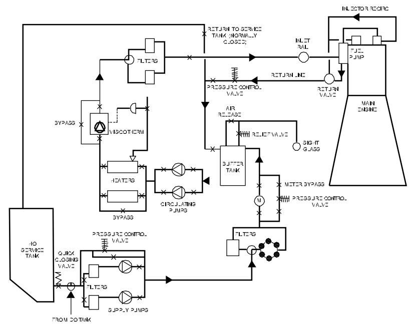
The common rail system consists of a high pressure pump which can be cam driven or electrical driven or both. Pressure requirement will be different for different system. For fuel oil the pressure are as high as 1000 bars, for servo and control oil the pressure is about 200 bars.

Valve Block and Electronic control system (Fig 2)

This is required for the control of the flow of the fuel oil, servo oil, control oil and starting air from the rail to the cylinder. The valve block is operated by the electronic control which operates when it gets a signal indicating that this cylinder is at top dead centre (TDC) and fuel has to be injected and decides when exhaust valve has to be opened. With the help of electronics the injection can be controlled remotely from the computer. For e.g. if we want to cut off fuel to one of the unit, then we need to cut off the signal given from the control system so that the valve will not open.

The fuel oil system this block is known as ICU(Injection control Unit) and for exhaust valve it is known as VCU

Fig 2



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(Valve Control Unit). The control system for opening and closing of ICU and VCU is done by electro hydraulic control with which when the signal for open is present the valve for control oil opens and control oil pushes the valve of ICU and VCU to open. The signal for electronic control is given by crank angle sensor which senses about each cylinder and sends signal to system which decides whether to open a valve or close the valve.

The timing of the opening of the valve can also be controlled by the electronics, which means that if the signal is given to open the valve early it will open early and vice versa.

Marine diesel engines are desined to burn heavy resuduak fuel. This is made up of the residues after the lighter and more costly fuels and gases been taken out of the crude oil at the refinery. The graphic below illustrates the process.

The diagram below shows a fule oil supply system for a large 2 stroke engine. Howeer the set up is typical of any fuel system for a marine diesel engine operating on heavy residual fuel.

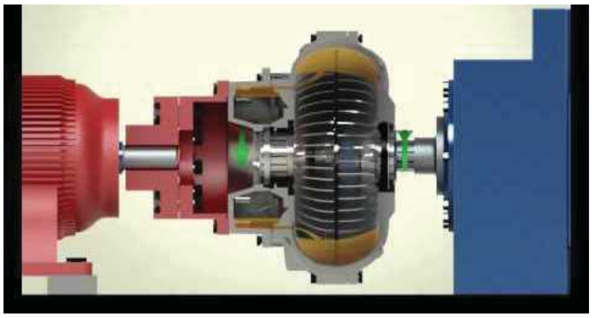
For an explanation of each of the components, place the mouse arrow on the component and click.

Hydraulic coupling/fluid coupling (Fig 3 & 4)

A fluid coupling (Fig 3 & Fig 4) or hydraulic coupling is a hydrodynamic device used to transmit rotating mechaincal power. It has been used in automobile transmissions as an alternative to a mechanical clutch. It also has widespread application in marine and industrial machine drives, where variable speed operation and controlled start-up without shock loading of the power transmission system is essential.

Fluid couplings are used in many industrial application involving rotational power, especially in machine drives that involve high-intertia starts or constant cyclic loading. In some part of the globe it is also used in rail transport and marine engine application for the smooth operations.

Fig 3



HYDRAULIC COUPLING

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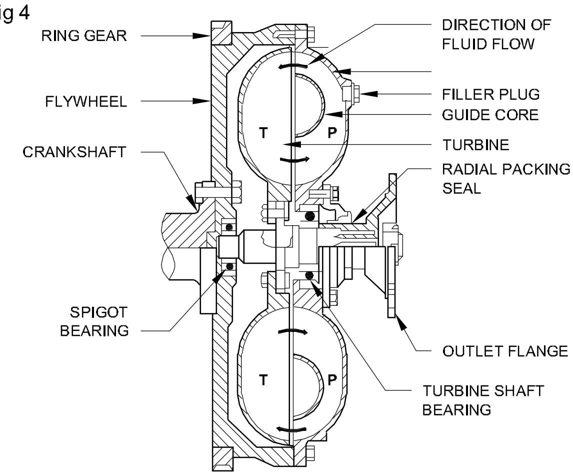
Fig 4



FLUID COUPLING

MDN2611534

Electromagnetic couplings (Fig 5)

Electromagnetic couplings & brakes from binder kendrion antrieon antriebs technik GmbH

An electrically generated magnetic force ensures connection between armature and rotor in an electromagnetic coupling and thus making available. if the voltage dis appears, the magnetic field is removed and the pre-stressed spring will seperate again the armature and rotor.

Application of elctromagnetic couplings

The electromagnetic couplings are usage in following systems.

Fig 5

ELECTROMAGNETC COUPLINGS

MDN2611535

Reduction gear drive

Reduction drives are used in engines of all kinds, to increase the amount of troque per revolution of a shaft, the gearbox, differential and steering boxes of any car is an example of a reduction drive.

Types of reduction gears

There are mainly two type of reduction gears:

- Single reduction gear
- Double reduction gear

Single reduction gear (Fig 6)

The arrangement consists of only one one pair of gears. The reduction gear box consists of ports through which the propeller shaft and engine shaft enters the assembly. A small gear known as a pinion is driven by the incoming engine shaft. The pinion directly drives a large gear mounted on the propeller shaft. The speed is adjusted by making the ratio of the speed reduction to the diameter of pinion and gear proportional. Generally, a single gear assembly has a gear double the size of a pinion

Fig 6

SINGLE REDUCTION GEAR

MDN2611536

Double reduction gear (Fig 7)

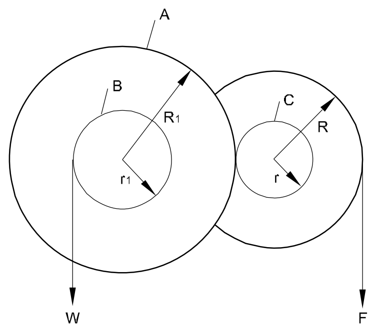
Double reduction gears are generally used in application involving very high speeds. In this arrangements the pinion is connected to the input shaft using a flexible coupling. The pinion is connected to an intermediate gear know as the first reduction gear. The first reduction gear is then connected to a low speed pinion with the help of one more shaft. This pinion is connected to the second reduction gear mounted directly on the propeller shaft. Such arrangement facilitates the reduction of speed to a ratio as high as 20:1.

Reduction drives on marine vessels

Most of the word's ships are powered by diesel engines which can be split into three categories, low speed (<400 rpm), medium speed (400-1200 rpm), and high speed (1200 +rpm). Low speed diesels operate at speeds within the optimum range for propeller usage. THus it is acceptable to directly transmit power from the engine to the propeller. For medium and high speed diesels, the rotational speed of the crankshaft within the engine must be reduced in order to reach the optimum speed for use by a propeller.

Reduction drives operate by making the engine turn a high speed pinion aganst a gear, turning the high rotational speed from the engine to lower rotational speed for the propeller. The amount of reduction is based on the number of teeth on each gear. For example, a pinion with 25 teeth, turning a gear with 100 teeth, must turn 4 times in order for the larger gear to turn once. This reduces the speed by a factor of 4 while raising the troque 4 fold. This reduction factor changes depending on the needs and operating speeds of the machinery. For example the reduction gear ratio of a ship is 3.6714:1.

Fig 7



DOUBLE REDUCTION GEAR
(A,B,C ARE PITCH CIRCLES OF GEARS)

MDN2611537

A large variety of reduction gear arrangements are used in the industry. The three arrangements most commonly used are: double reduction utilizing two pinion nested, double reduction utilizing two-pinion articulated, and double reduction utilizing two-pinion locked train.

The gears used in a ship's reduction gearbox are usually dobke helical gears. THis design helps lower the amount of required maintenance and increase the lifetime fo teh gears. Helical gears are used because the load upon it is more distributed then in other types. The double helocal gear set can also be called a herringbone gear and consists of two oppositely angled sets of teeth. A single set of helical teeth will produce a thrust parallel to the xie of the gear (known as axial thrust) due to created by both sets cancels each other out.

When installing reduction gears on ships the alignment of the gear is critical. Correct alignment helps ensure a uniform distribution of load upon each pinion and gear. When manufactured, the gears are assembled in such a way as to obtain uniform load distribution and toothe contact. Agter completion of construction and delivery to shipyard it is required that these gears achieve proper alighnment when first operated under load.

In order to ensure a reduction drive's smooth working and long lifetime, it is vital to have lubricating oil. A reduction drive that is ran with oil free of impurities like water, dirt, grit and flakes of metal, requires little care in comparison to other type of engine room machinery. In order to ensure that the lube oil in the reduction gears stay this way a lube oil purifier will be installed with the drive.

Marine electrical drive

Marine motor provies an excellent solution to running marine motor as it provies a low running cost, low maintenance and is almost silent and pollution free.

Benefits of elctric drive/propulsion

- The power can be supplied by any number of generator which enables high reducedancy.
- The motor drie combination consumes energy only when ship thrusher is actively turned.
- The environment benefits from lower fuel consumption and exhaust gas emission levels.
- Electruc propulsion is a good platform for the next phase development - bydrodization.

Generally ship is designed with modern electruc propulsion systen as a diesel electric, LNG electric or even fully electric can be quite easily converted a hybridsolution.

Generator and motors

Marine generator operating with diesel engines. The generator power is used for various purposes of the ship etc, lighting propulsion system and communication system. The generator / motor is located between main engine and propulsion shaft, allows the optimum control of propulsion machinery at various speed, which saves energy.

Super charger

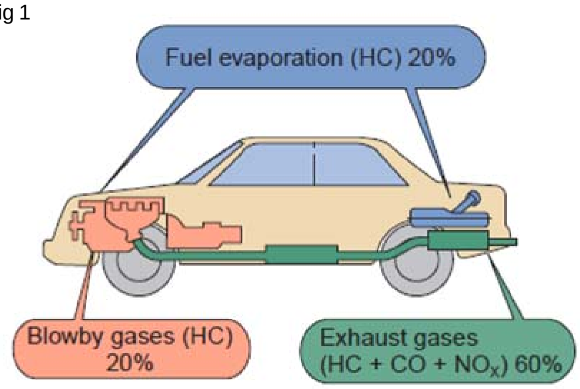
Super charging is eprocess, where a great mass of air is admitted in teh cylinder, for combusion and consequantly a greater amount of fuel is burnt efficiently. The power output of the engine is increased with higher thermal efficiency without increasing size of engine. The supercharge is driven through gears directly from the engine crankshaft. Supercharing system is commonly use in two stroke and four stroke amrine engines, where higher compressed air is needed.

Sources of Emission

Objectives : At the end of this lesson you shall be able to
- **state sources of emission**
- **state different type of emission.**

The power to move a motor vehicle comes from burning fuel in an engine. Emissions from vehicles are the by-products of this combustion process. Emissions from a motor vehicle generally come from four sources

Fig 1



1 The fuel tank

2 The crankcase

3 The exhaust system

Evaporative Emissions

The fuel tank and carburetor allow fuel to evaporate and escape to the atmosphere. These are called evaporative emissions

Exhaust Emissions

The crankcase and exhaust system (Fig 1) emit pollutants directly from the engine into the atmosphere. They are caused when hydrocarbons, lead compounds, and oxygen and nitrogen from the air, are burned in the combustion chamber.

In a compression-ignition engine, emissions originate from the engine, and escape to the atmosphere from the exhaust, and the crankcase breather.

Vehicle emissions standards- Euro and Bharat

Objectives : At the end of this lesson you shall be able to
- **follow the european emission standards for gasoline passenger vehicle, light vehicle and heavy vehicle**
- **follow the european emission standards for diesel passenger vehicle, light vehicle and heavy vehicle**
- **follow the bharat emission standards for gasoline passenger vehicle, light vehicle and heavy vehicle**
- **follow the bharat emission standards for diesel passenger vehicle, light vehicle and heavy vehicle.**

Emission requirements for light road vehicles have existed in the European emission standards (EU) since the early 1970s, while the first requirements for heavy vehicles came in at the end of the 1980s. Today, vehicle emissions are controlled under two basic frameworks: the "Euro standards" and the regulation on carbon dioxide emissions.

Currently, emissions of nitrogen oxides (NOx), total hydrocarbon (THC), non-methane hydrocarbons (NMHC), carbon monoxide (CO) and particulate matter (PM) are regulated for most vehicle types, including cars, lorries, trains, tractors.

While the norms help in bringing down pollution levels, it invariably results in increased vehicle cost due to the improved technology & higher fuel prices. However, this increase in private cost is offset by savings in health costs for the public, as there is lesser amount of disease causing particulate matter and pollution in the air.

Exposure to air pollution can lead to respiratory and cardiovascular diseases, which caused 620,000 early deaths in 2010, and the health cost of air pollution in India has been assessed at 3 per cent of its GDP.

European emission standards define the acceptable limits for exhaust emissions of new vehicles sold in EU member states.

Emission standards for passenger cars and light commercial vehicles are summarised in the following tables.

European emission standards for passenger cars (Category M*), g/km.

Pollutant reduction in a diesel engine

Exhaust gas composition

In addition to nitrogen N_2 and oxygen O_2 as components of the residual air, the exhaust gas of a diesel engine contains assirted reaction products from carbon C, hydrogen H, oxygen O and notrogen N.

Complete combustion

Under optimal conditions (not achievable with engine combustion) hydrocarbon (HC) compounds burn into carbon dioxide (CO_2) and water H_2O).

Incomplete combustion

The diesel engine operates depending on engine load with differing degrees of excess air ($\lambda>1$). At full load with a slight degree of excess air upto λ - 1.3. At part load and at idle with great degree of excess air up to λ - 18. In spite of excess air the fuel is only partically combusted.

Types of emissions

Emissions of many air pollutants have been shown to have variety of negative effects on public health and the natural environment.

Emissions that are principal pollutants of concern include.

Hydrocarbons (HC)

- A class of burned or partially burned fuel, hydrocarbons are toxins. HYdrocarbons are a major contributor to smog, which can be a major problem in urban areas.
- Prolonged exposure to hydrocarbons contributes to asthma, liver disease, lung diesase, and cancer.
- Methane is not directly toxic, but is more difficult to break down in fuel vent lines and a charcoal canister is meant to collect and contain fuel vapors and route them either back to the fuel tank or, after the engine is started and warmed up, into the air intake to be burned in the engine.

Carbon monoxide (CO)

- A product of incomplete combustion, inhaled carbon monoxide reduces the blood's ability to carry oxygen; overexposure (carbon monoxide poisoning) may be fatal. (Carbon monoxide persistently binds to hemoglobin, the oxygen-carrying chemical in red blood cells.
- Nitric oxide (NO_x): Generated when nitrogen in the air reacts with oxygen at the high temperature and pressure inside the engine. NO_x is a precursor to smog and acid rain. NO_x is the sum of NO and NO_2. NO_2 is extemely reactive. NO_x production is increased when an engine runs at its most efficient (i.e. hottest) operating point, so there tends to be a natureal tradeoff between efficeiency and control of NO_x emissions.
- Particulate matter: Soot or smoke made up of particles in the micrometre size range: Particulate matter causes negative health effects, including but not limited to respiratory disease and cancer. Very fine particulate matter has been linked to cardiovascular disease.
- Sulfur oxide (SO_x): A general term for oxides of sulfur, which are emitted from motor vehicles burning fuel containing sulfur. Reducting the level of fuel sulfur reduces the level of sulfur oxide emitted from the tailpipe.

Tier	Date	CO	THC	NMHC	NOx	HC+NOx	PM	P***
Diesel								
Euro 1†	July 1992	2.72 (3.16)	-	-	-	0.97 (1.13)	0.14 (0.18)	-
Euro 2	January 1996	1.0	-	-	-	0.7	0.08	-
Euro 3	January 2000	0.64	-	-	0.50	0.56	0.05	-
Euro 4	January 2005	0.50	-	-	0.25	0.30	0.025	-
Euro 5	September 2009	0.50	-	-	0.180	0.230	0.005	-
Euro 6	September 2014	0.50	-	-	0.080	0.170	0.005	-
Petrol (Gasoline)								
Euro 1†	July 1992	2.72 (3.16)	-	-	-	0.97 (1.13)	-	-
Euro 2	January 1996	2.2	-	-	-	0.5	-	-
Euro 3	January 2000	2.3	0.20	-	0.15	-	-	-
Euro 4	January 2005	1.0	0.10	-	0.08	-	-	-
Euro 5	September 2009	1.0	0.10	0.068	0.060	-	0.005**	-
Euro 6(future)	September 2014	1.0	0.10	0.068	0.060	-	0.005**	-

* Before Euro 5, passenger vehicles > 2500 kg were type approved as light commercial vehicles N1-I

** Applies only to vehicles with direct injection engines

*** A number standard is to be defined as soon as possible and at the latest upon entry into force of Euro 6

† Values in brackets are conformity of production (COP) limits

Emission standards for light commercial vehicles

European emission standards for light commercial vehicles ?1305 kg (Category N1-I), g/km.

Emission standards for light commercial vehicles

European emission standards for light commerical vehicles≤ 1305 kg (category N_1 - I), g/km

Tier	Date	CO	THC	NMHC	NOx	HC+NOx	PM	P
Diesel								
Euro 1	October 1994	2.72	-	-	-	0.97	0.14	-
Euro 2	January 1998	1.0	-	-	-	0.7	0.08	-
Euro 3	January 2000	0.64	-	-	0.50	0.56	0.05	-
Euro 4	January 2005	0.50	-	-	0.25	0.30	0.025	-
Euro 5	September 2009	0.500	-	-	0.180	0.230	0.005	-
Euro 6	September 2014	0.500	-	-	0.080	0.170	0.005	-
Petrol (Gasoline)								
Euro 1	October 1994	2.72	-	-	-	0.97	-	-
Euro 2	January 1998	2.2	-	-	-	0.5	-	-
Euro 3	January 2000	2.3	0.20	-	0.15	-	-	-
Euro 4	January 2005	1.0	0.10	-	0.08	-	-	-
Euro 5	September 2009	1.000	0.100	0.068	0.060	-	0.005*	-
Euro 6	September 2014	1.000	0.100	0.068	0.060	-	0.005*	-

* Applies only to vehicles with direct injection engines

European emission standards for light commercial vehicles 1305 kg - 1760 kg (Category N1-II), g/km

Tier	Date	CO	THC	NMHC	NOx	HC+NOx	PM	P
Diesel								
Euro 1	October 1994	5.17	-	-	-	1.4	0.19	-
Euro 2	January 1998	1.25	-	-	-	1.0	0.12	-
Euro 3	January 2001	0.80	-	-	0.65	0.72	0.07	-
Euro 4	January 2006	0.63	-	-	0.33	0.39	0.04	-
Euro 5	September 2010	0.630	-	-	0.235	0.295	0.005	-
Euro 6	September 2015	0.630	-	-	0.105	0.195	0.005	-
Petrol (Gasoline)								
Euro 1	October 1994	5.17	-	-	-	1.4	-	-
Euro 2	January 1998	4.0	-	-	-	0.6	-	-
Euro 3	January 2001	4.17	0.25	-	0.18	-	-	-
Euro 4	January 2006	1.81	0.13	-	0.10	-	-	-
Euro 5	September 2010	1.810	0.130	0.090	0.075	-	0.005*	-
Euro 6	September 2015	1.810	0.130	0.090	0.075	-	0.005*	-

* Applies only to vehicles with direct injection engines

N_1 - III & N_2) , g/Km

Tier	Date	CO	THC	NMHC	NOx	HC+NOx	PM	P
Diesel								
Euro 1	October 1994	6.9	-	-	-	1.7	0.25	-
Euro 2	January 1998	1.5	-	-	-	1.2	0.17	-
Euro 3	January 2001	0.95	-	-	0.78	0.86	0.10	-
Euro 4	January 2006	0.74	-	-	0.39	0.46	0.06	-
Euro 5	September 2010	0.740	-	-	0.280	0.350	0.005	-
Euro 6	September 2015	0.740	-	-	0.125	0.215	0.005	-
Petrol (Gasoline)								
Euro 1	October 1994	6.9	-	-	-	1.7	-	-
Euro 2	January 1998	5.0	-	-	-	0.7	-	-
Euro 3	January 2001	5.22	0.29	-	0.21	-	-	-
Euro 4	January 2006	2.27	0.16	-	0.11	-	-	-
Euro 5	September 2010	2.270	0.160	0.108	0.082	-	0.005*	-
Euro 6	September 2015	2.270	0.160	0.108	0.082	-	0.005*	-

* Applies only to vehicles with direct injection engines

Whereas for passenger cars, the standards are defined by vehicle driving distance, g/km, for lorries (trucks) they are defined by engine energy output, g/kWh, and are therefore in no way comparable. The official category name is heavy-duty diesel engines, which generally includes lorries and buses.

EU Emission Standards for HD Diesel Engines, g/k wh (smoke in m $^{-1}$)

Tier	Date	Test cycle	CO	HC	NOx	PM	Smoke
Euro I	1992, < 85 kW 1992, > 85 kW	ECE R-49	4.5 4.5	1.1 1.1	8.0 8.0	0.612 0.36	
Euro II	October 1996 October 1998		4.0 4.0	1.1 1.1	7.0 7.0	0.25 0.15	
Euro III	October 1999 EEVs only	ESC & ELR	1.0	0.25	2.0	0.02	0.15
	October 2000	ESC & ELR	2.1	0.66	5.0	0.10 0.13*	0.8
Euro IV	October 2005		1.5	0.46	3.5	0.02	0.5
Euro V Euro VI	October 2008 31 December 2013[15]		1.5 1.5	0.46 0.13	2.0 0.4	0.02 0.01	0.5

* for engines of less than 0.75 dm³ swept volume per cylinder and a rated power speed of more than 3,000 per minute.

EEV is "Enhanced environmentally friendly vehicle".

Bharat stage emission standards are emission standards instituted by the Government of India to regulate the output of air pollutants from internal combustion engine equipment, including motor vehicles. The standards and the timeline for implementation are set by the Central Pollution Control Board under the Ministry of Environment & Forests.

The standards, based on European regulations were first introduced in 2000. Progressively stringent norms have been rolled out since then. All new vehicles manufactured after the implementation of the norms have to be compliant with the regulations. Since October 2010, Bharat stage III norms have been enforced across the country. In 13 major cities, Bharat stage IV emission norms have been in place since April 2010.

The phasing out of 2 stroke engine for two wheelers, the stoppage of production of Maruti 800 & introduction of electronic controls have been due to the regulations related to vehicular emissions.

Table 1: Indian Emission Standards (4-Wheel Vehicles)			
Standard	**Reference**	**Date**	**Region**
India 2000	Euro 1	2000	Nationwide
Bharat Stage II	Euro 2	2001 2003.04 2005.04	NCR*, Mumbai, Kolkata, Chennai NCR*, 13 Cities† Nationwide
Bharat Stage III	Euro 3	2005.04 2010.04	NCR*, 13 Cities† Nationwide
Bharat Stage IV	Euro 4	2010.04	NCR*, 13 Cities†
Bharat Stage V	Euro 5	2020 (proposed)	Entire country

* National Capital Region (Delhi)

† Mumbai, Kolkata, Chennai, Bengaluru, Hyderabad, Ahmedabad, Pune, Surat,Kanpur,Lucknow,Sholapur,Jamshedpur and Agra

The above standards apply to all new 4-wheel vehicles sold and registered in the respective regions. In addition, the National Auto Fuel Policy introduces certain emission requirements for interstate buses with routes originating or terminating in Delhi or the other 10 cities.

Emission standards for 2-and 3-wheelers

Table 2: Indian Emission Standards (2 and 3 wheelers)

Standard	Reference	Date
Bharat Stage II	Euro 2	1 April 2005
Bharat Stage III	Euro 3	1 April 2010
Bharat Stage IV	Euro 4	1 April 2016 (proposed)
Bharat Stage V	Euro 5	1 April 2020 (proposed)

In order to comply with the BSIV norms, 2 and 3 wheeler manufacturers will have to fit an evaporative emission control unit, which should lower the amount of fuel that is evaporated when the motorcycle is parked.

Trucks and buses

Emission standards for new heavy-duty diesel engines-applicable to vehicles of GVW > 3,500 kg-are listed in Table 3.

Table 3: Emission Standards for Diesel Truck and Bus Engines, g/kWh

Year	Reference	Test	CO	HC	NOx	PM
1992	-	ECE R49	17.3-32.6	2.7-3.7	-	-
1996	-	ECE R49	11.20	2.40	14.4	-
2000	Euro I	ECE R49	4.5	1.1	8.0	0.36*
2005†	Euro II	ECE R49	4.0	1.1	7.0	0.15
2010†	Euro III	ESC ETC	2.1 5.45	0.66 0.78	5.0 5.0	0.10 0.16
2010‡	Euro IV	ESC ETC	1.5 4.0	0.46 0.55	3.5 3.5	0.02 0.03

* 0.612 for engines below 85 kW

† earlier introduction in selected regions, see Table 1 ‡ only in selected regions, see Table 1

Emission standards for light-duty diesel vehicles (GVW ? 3,500 kg) are summarised in Table 4. Ranges of emission limits refer to different classes (by reference mass) of light commercial vehicles; compare the EU light-duty vehicle emission standards for details on the Euro 1 and later standards. The lowest limit in each range applies to passenger cars (GVW ? 2,500 kg; up to 6 seats).

Table 4: Emission Standards for Light-Duty Diesel Vehicles, g/km

Year	Reference	CO	HC	HC+NOx	NOx	PM
1992	-	17.3-32.6	2.7-3.7	-	-	-
1996	-	5.0-9.0	-	2.0-4.0	-	-
2000	Euro 1	2.72-6.90	-	0.97-1.70	0.14-0.25	-
2005†	Euro 2	1.0-1.5	-	0.7-1.2	0.08-0.17	-
2010†	Euro III	0.64 0.80 0.95	-	0.56 0.72 0.86	0.50 0.65 0.78	0.05 0.07 0.10
2010‡	Euro 4	0.50 0.63 0.74	-	0.30 0.39 0.46	0.25 0.33 0.39	0.025 0.04 0.06

† earlier introduction in selected regions, see Table 1
‡ only in selected regions, see Table 1

The test cycle has been the ECE + EUDC for low power vehicles (with maximum speed limited to 90 km/h).

Before 2000,emissions were measured over an indian test cycle.

Engines for use in light-duty vehicles can be also emission tested using an engine dynamometer. The respective emission standards are listed in table 5.

Table 5: Emission Standards for Light-Duty Diesel Engines, g/kWh

Year	Reference	CO	HC	NOx	PM
1992	-	14.0	3.5	18.0	-
1996	-	11.20	2.40	14.4	-
2000	Euro I	4.5	1.1	8.0	0.36*
2005†	Euro II	4.0	1.1	7.0	0.15

* 0.612 for engines below 85 kW
† earlier introduction in selected regions, see Table 1

Table 6: Emission Standards for Gasoline Vehicles (GVW ? 3,500 kg), g/km

Year	Reference	CO	HC	HC+NOx	NOx
1991	-	14.3-27.1	2.0-2.9	-	
1996	-	8.68-12.4	-	3.00-4.36	
1998*	-	4.34-6.20	-	1.50-2.18	
2000	Euro 1	2.72-6.90	-	0.97-1.70	
2005†	Euro 2	2.2-5.0	-	0.5-0.7	
2010†	Euro 3	2.3 4.17 5.22	0.20 0.25 0.29	-	0.15 0.18 0.21
2010‡	Euro 4	1.0 1.81 2.27	-	0.1 0.13 0.16	0.08 0.10 0.11

* for catalytic converter fitted vehicles
† earlier introduction in selected regions, see Table 1 ‡ only in selected regions, see Table 1

Gasoline vehicles must also meet an evaporative (SHED) limit of 2 g/test (effective 2000).

3- and 2-wheel vehicles

Emission standards for 3- and 2-wheel gasoline vehicles are listed in the following tables.

Table 7: Emission Standards for 3-Wheel Gasoline Vehicles, g/km

Year	CO	HC	HC+NOx
1991	12-30	8-12	-
1996	6.75	-	5.40
2000	4.00	-	2.00
2005 (BS II)	2.25	-	2.00
2010.04 (BS III)	1.25	-	1.25

Table 8: Emission Standards for 2-Wheel Gasoline Vehicles, g/km

Year	CO	HC	HC+NOx
1991	12-30	8-12	-
1996	5.50	-	3.60
2000	2.00	-	2.00
2005 (BS II)	1.5	-	1.5
2010.04 (BS III)	1.0	-	1.0

Table 9: Emission Standards for 2- And 3-Wheel Diesel Vehicles, g/km

Year	CO	HC+NOx	PM
2005.04	1.00	0.85	0.10
2010.04	0.50	0.50	0.05

Combustion chamber design

Objectives : At the end of this lesson you shall be able to

- **state the importance of combustion Chamber design**
- **state the purpose of air swirl combustion chamber design in CI Engine.**

The level of emissions can be controlled by suitable modification in the Combustion chamber design that increase gas flow rate, and promote vaporization, distribute the fuel more evenly in the combustion chamber.

The basic requirements of a good combustion chamber are to provide:

High power output

High thermal efficiency and low specific fuel consumption

Smooth engine operation

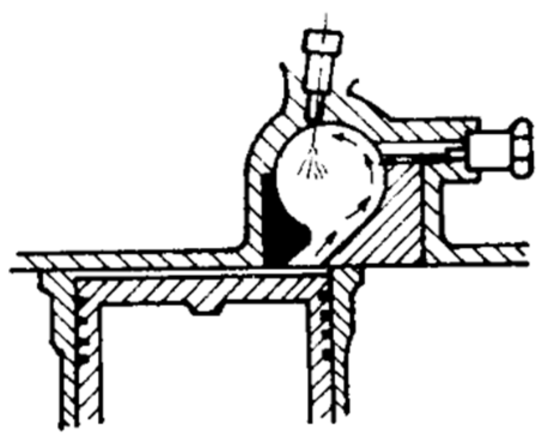
Reduced exhaust pollutants.

Gas flow rate, and volumetric efficiency, can be improved by using 2 intake valves in each cylinder. The effective port opening is increased, and the gas flow rate increases.

Changing valve timing also alters the combustion process. Reducing valve overlap reduces the scavenging effect. It also reduces hydrocarbon emission.

Most important function of CI engine combustion chamber is to provide proper mixing of fuel and air in short possible time. For this purpose an organized air movement called air swirl is to be produced to produce high relative velocity between the fuel droplets and air. (Fig 1).

Fig 1



Combustion process

Objectives : At the end of this lesson you shall be able to
- **State combustion process**
- **define Perfect Combustion**
- **define typical Real-World Engine Combustion Process.**

Most vehicle fuels (gasoline, diesel, natural gas, ethanol, etc.) are mixtures of hydrocarbons, compounds that contain hydrogen and carbon atoms.

In a "perfect" engine, oxygen in the air would convert all of the hydrogen in fuel to water and all of the carbon in the fuel to carbon dioxide (carbon mixed with oxygen). Nitrogen in the air would remain unaffected.

In reality, the combustion process is not "perfect," and automotive engines emit several types of pollutants:

a. "Perfect" Combustion Process:

FUEL (hydrocarbons) + AIR (oxygen and nitrogen) = CARBON DIOXIDE (CO2) + Water (H2O) + Nitrogen

b. Typical Real-World Engine Combustion Process:

FUEL (hydrocarbons) + AIR (oxygen and nitrogen) = UNBURNED or PARTIALLY BURNED HYDROCARBONS (VOCs) + NITROGEN OXIDES (NOx) + CARBON MONOXIDE (CO) + CARBON DIOXIDE (CO2) + Water (H2O)

"Perfect" Combustion process is achieved by Ideal compression pressure is reached within the cylinder, condition of spark plug and timing accurate, Temperatures at correct value for engine, fuel, air, amount of fuel correct according to engines requirement, Precise valve timing, That the engine receives the correct amount of air, Electronically managed fuel injection systems use sensors and catalytic converters to control the combustion process and the air-fuel ratio supplied to the engine at all times

Characteristics and Effect of Hydrocarbons

Objectives : At the end of this lesson you shall be able to
- **state the of different type Hydrocarbon compounds**
- **state the Characteristics of Hydrocarbons**
- **state the Effect of Hydrocarbons.**

- Hydrocarbons are a major source of motor vehicle emissions.
- Gasoline, diesel, LP and natural gas are all hydro carbon compounds.
- Hydrocarbon emissions react with other compounds in the atmosphere to produce photo-chemical smog.
- Gasoline needs to evaporate easily to burn properly in an internal combustion engine. But this property also means it evaporates easily into the atmosphere at ordinary temperatures and pressures.
- When a vehicle is being refueled, hydrocarbon vapors can escape from the filler neck into the atmosphere.
- When the vehicle is left in the sun, its temperature increases, and fuel evaporates from the tank

Hydrocarbons in exhaust gases

Objective : At the end of this lesson you shall be able to
- **state the release of Hydrocarbon compounds in produced during combustion.**

In a 4-stroke gasoline engine, during valve overlap at top dead centre (TDC), some intake charge is drawn out of the combustion chamber into the exhaust port. Raw fuel, a mixture of hydrocarbons and air, is released into the atmosphere.

When combustion occurs in the cylinder, the walls, piston and piston rings are slightly cooler than points closer to the burning mixture. Some of the air and fuel molecules come in contact with these cooler parts, and they cool down, until their temperature becomes too low for combustion to occur. They are left unburned, and when the exhaust port opens, they leave the cylinder.

Misfiring of the ignition can result in unburned fuel leaving the cylinder when the exhaust port opens.

If an excessively rich air-fuel mixture is used, there is too much fuel for the quantity of air. Combustion will be incomplete, and any unburned fuel will leave the cylinder through the exhaust port.

If an excessively lean mixture is used, then combustion takes longer, and the flame may extinguish before it is complete. When the exhaust port opens, unburned hydrocarbons will be exhausted from the cylinder.

Diesel particulate filters (DPF)

Objectives : At the end of this lesson you shall be able to
- **state the purpose of diesel particulate filters**
- **describe the working priniciple of diesel particulate filters**
- **state the importance of regeneration of diesel particulate filters**
- **describe the working priniciple of active regeneration of DPF**
- **describe the working priniciple of passive regeneration of DPF.**

Purpose of Diesel particulate Filters

Diesel particulate filters (DPF) also called as 'particulate traps' have been developed to filter out PM

from the diesel exhaust gases to meet very stringent emission limits.

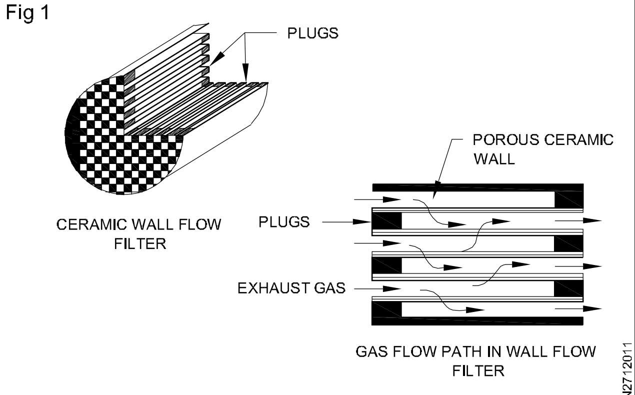
During combustion of the fuel and air mix,a variety of polutant particles generically classified as diesel particulate matter is produced due to incomplete combustion.

Working priniciple of diesel particulate filters

Alumina coated wire mesh,ceramic fiber, porous ceramic monoliths etc., have been studied as filtration media. Presently, ceramicmonolith of honeycomb type structure is used to trap the particulate matter as the gas flows through its porous walls. These filters are also termed as 'ceramic wall flow filters'.

A ceramic honeycomb type particular filter is shown in Fig 1. In this cellular structure, alternate cells are plugged at one end and open at the oppasite end. The exhaust gas enters the cells that are open at the upstream end and flows through the porous walls to the adjacent cells. The adjacent cells are open at the downstream end from where the filtered gas exits to the atmosphere. Flow path of gas through walls of the filter is also shown on Fig 1

Fig 1



CERAMIC WALL FLOW FILTER FOR DIESEL PARTICULATE

Regeneration of DPF

It is relatively easy to filter and collect the particulate matter in the trap but the soot is to be burned in-suitable i.e., 'regenerate' the trap so that pressure drop across the filter is kept always at an acceptable level.

Burning of soot particles begins at about 540º C. Such high exhaust gas temperatures do not occur during engine operation for sufficiently long periods of .time. The diesel exhaust gas temperatures in the exhaust pipe typically reach to about 300ºC only.

Two types of regeneration systems have been investigated and a few developed for employment on production vehicles

Active regeneration

Passive regeneration

Active DPF Regeneration

In the active regeneration systems, sensors are used to monitor pressure drop across the trap. On receiving the signal from the sensor, the exhaust gas temperature is increased above

500º C by any one of the following techniques

Engine throttling - Throttling of air reduces airflow that results in decrease of overall air-fuel ratio, which increases thecombustion and exhaust temperatures.

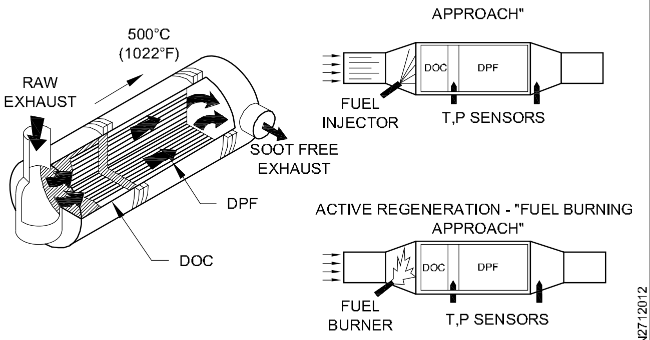
Use of electric heater upstream of filter - power to the electric heater is supplied by the engine alternator. A typical truck DPF regeneration system may require a 3 kw heater.

Use of burner upstream of filter - A diesel fuel burner is placed in the exhaust in front of the filter to regenerate the diesel particulate filter.

Passive regeneration

The passive regeneration systems (Fig 2) employ catalysts to reduce soot oxidation temperatures to the levels that lie within the normal exhaust gas temperature range . The catalyst is either added to diesel added to diesel fuel in the form of additives or is impregnated on the surface of the filter substrate. Another approach for passive regeneration uses a special oxidation catalyst in the front of the ceramic wall flow particulate filter to promote soot oxidation. This system is known as the continuously regeneration trap (CRT).

Fig 2



REGENERATION OF DPF

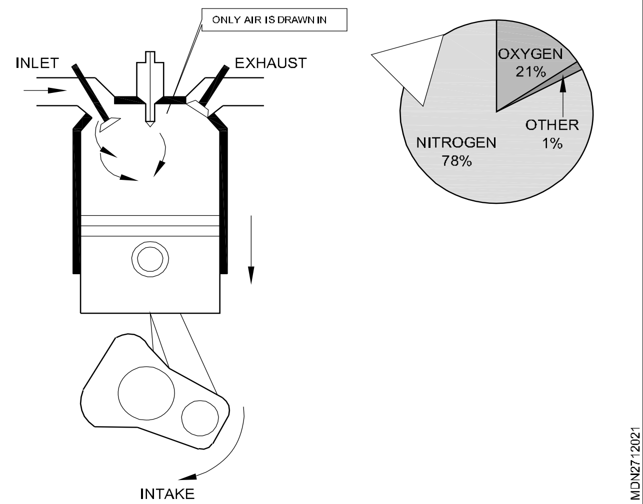
Source of Pollutants

Objectives : At the end of this lesson you shall be able to
- **state the characteristics of Oxides of nitrogen**
- **state the characteristics of Particulates**
- **state the characteristics of Carbon monoxide**
- **state the characteristics of Carbon dioxide (co2):**
- **state the characteristics of Sulfur content in fuels.**

Oxides of nitrogen

Air contains almost 78% Nitrogen (Fig 1). Under the high temperatures and pressure of combustion, this nitrogen combines with oxygen to produce oxides of nitrogen. Almost all internal combustion engine exhaust gases contains these chemicals.

Fig 1



If a lean mixture is used, formation of hydrocarbons and carbon monoxide is reduced, but for oxides of nitrogen, it is increased. This is due to the high temperature, and the increase in available oxygen.

Compression-ignition engines can produce high levels of oxides of nitrogen.

Particulates

Particulates from modern engines are usually carbon-based. Older vehicles may produce lead-based particulates. This is caused by lead compounds used in the fuel to raise its octane rating.

In spark ignition engines, particulates are caused by incomplete combustion of rich air-fuel mixtures.

In compression-ignition engines, they are caused by a lack of turbulence and lack of oxygen. Burning of lubicating oil inside combustarchamber leaves particilates in CI engine.

Carbon monoxide

Carbon monoxide is a colorless, odorless, tasteless, flammable, and highly toxic gas.

Carbon monoxide is a product of incomplete combustion and occurs when carbon in the fuel is partially oxidized rather than fully oxidized to carbon dioxide.

Carbon monoxide reduces the flow of oxygen in the bloodstream and is particularly dangerous to persons with heart disease.

Carbon dioxide (co2):

Carbon dioxide is produced, with water, when complete combustion of air and fuel occurs.

Catalytic converters in gasoline-engined vehicles convert carbon monoxide to carbon dioxide.

Carbon dioxide is also produced by diesel and LPG-fuelled vehicles.

Carbon dioxide does not directly impair human health, but it is considered a "greenhouse gas". In other words, as it accumulates in the atmosphere, it is believed to trap the earth's heat and contribute to the potential for climate change.

Sulfur content in fuels

Gasoline and diesel fuels contain sulfur as part of their chemical composition.

Sulfuric acid is produced when sulfur combines with water vapor formed during the combustion process, and some of this corrosive compound is emitted into the atmosphere through the exhaust.

High sulfur levels in fuel, when combined with water vapor, can also cause corrosive wear on valve guides and cylinder liners, which can lead to premature engine failure. The use of proper lubricants and correct oil drain intervals helps combat this effect and reduces the degree of corrosive damage.

Although regulations have reduced the permissible levels of sulfur in fuel, there are some side effects from using low sulfur diesel fuel.

The refining process used to reduce the sulfur level can reduce the natural lubricating properties of the diesel fuel, which is essential for the lubrication and operation of fuel system components such as fuel pumps and injectors.

Crankcase emission control

Objectives : At the end of this lesson you shall be able to
- **state the purpose of crankcase ventilation**
- **describe the working priniciple of positive crank case ventilation (PCV) system**
- **explain different stages of PCV valve operation**
- **describe the working priniciple of crankcase depression regulator valve (CDRV) for diesel engine.**

Purpose of crankcase ventilation:

The firstcontrolled emission was crankcase vapors. While the engine is running during combustion some unburned fuel and other products of combustion leak between the piston rings and the cylinder walls, down into the crankcase. This leakage is called blow-by. Blow by gases are largely HC gases

Unburned fuel, and water from condensation, also find their way into the crankcase, and sump. When the engine reaches its full operating temperature , the water and fuel evaporate. To prevent pressure build - up, the crankcase must be ventilated.

In earlier vhicles, crackcase vapors were vented directly to the atmosphere through a breather tube, or road draught tube. It was shaped to help draw the vapors from the vapors from the crankcase, as the vehicle was being driven.

Modern vehicles are required to direct crankcase breather gases and vapors back into the inlet system to be burned.

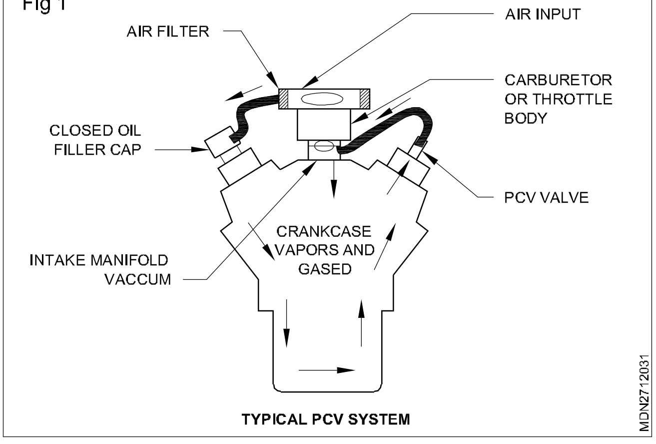
A general method of doing this is called positive crankcase ventilation, or PCV.

PCV working principle:

The PCV vacuum circuit works as follows (Fig 1).Air for the system enters the air cleaner area. The air then goes throught the air filter, through a tube, and through the closed oil filler cap.

The intake mainfold vaccum the draws the crankcase vapors and gases back to the PCV valve. From the PCV valve, the vapors and gases are drawn into the intake of the engine to be burned by combustion.

Fig 1

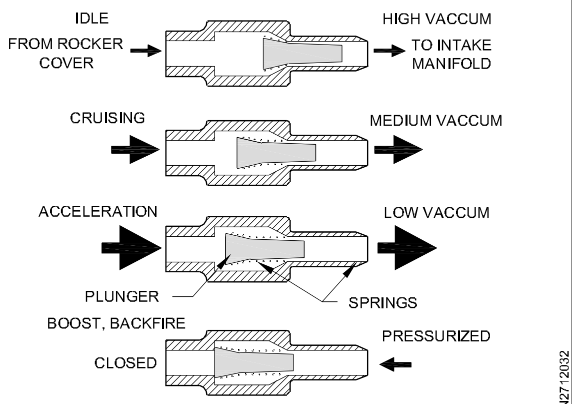


TYPICAL PCV SYSTEM

If too many vapors and gases get into the intake mainfold, it may upset the air-fuel ratio. The PVC valve helps to control the amount of vapors and gases going back into the intake mainfold.

As shown in the diagram (Fig 2), the PCV valve consists of a tapered plunger and two springs, and limits the air flow based on intake mainfold vacuum.

Fig 2



PCV VALVE DESIGN & OPERATION

During idle and deceleration when blow-by gases are minimal, the low pressure (or " high" vacuum) in the intake mainfold pulls the pluger against the springs and restricts the airflow through the valve.

During acceleration and heavy-load operations when blow-by gases are at their maximum, low vacuum in the intake mainfold allows the springs to keep the plunger " back" for maximum airflow through the PCV valve.

In the case when the intake mainfold becomes pressurized, such as during boost on turbocharged engines or during backfire, the plunger's seat is forced against the valve case preventing air from entering the crankcase.

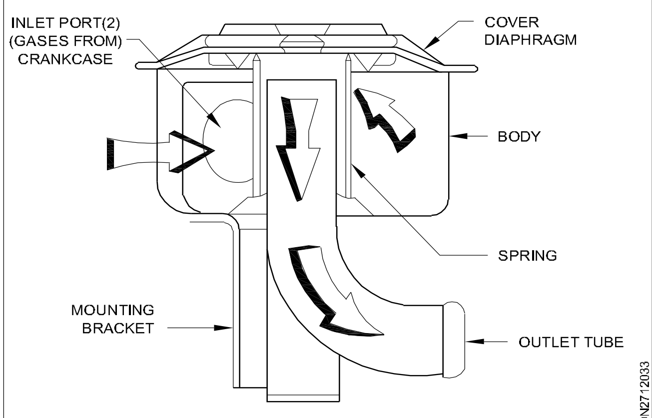
Crankcase depression regulator valve (CDRV) for diesel engine

A crankcase depression regulator valve (CDRV) is used to regulate the flow of crankcase gases back into the engine. This valve is designed to limit vacuum in the crankcase . The gases are drawn from the valve cover through the CDRV and into the intake mainfold.

Fresh air enters (Fig 3) the engine through the combination filter, check valve, and oil fill cap. This air mixes with blow-by gases and enters the opposite valve cover. These gases pass through a filter on the valve cover and are drawn into the connected tubing.

Intake mainfold vacuum acts against a spring loaded diaphregm to control the flow of crankcase gases. Higher vacuum levels pull the diaphragm close to the top of the outlet tube. This reduces the amount of gases being drawn from the crankcase and decreases vaccum in tne crankcase. As intake vacuum decreases, the spring pushes the diaphragam away from the top of the outlet tube allowing more gases into the mainfold. The diesel crankcase ventilation system should be cleaned and inspected every 15,000 miles (24,000 km) or at 12 month intervals.

Fig 3



THE CRANKCASE DEPRESSION REGULATOR VALVE

Exhaust gas recirculation (EGR) valve

Objectives : At the end of this lesson you shall be able to

- **state the purpose of exhaust gas recirculation (EGR) system**
- **describe the working priniciple of EGR valve**
- **describe the working priniciple of linear electronic EGR valve**
- **describe the working priniciple EGR system in diesel engines.**

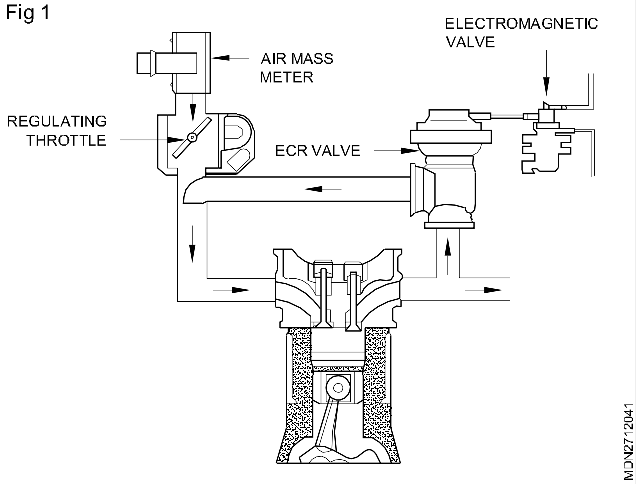
Purpose of exhaust gas recirculation (EGR) system

Purpose of exhaust gas recirculation (EGR) system's purpose is to reduce NOx emissions that contribute to air polution.

Working principle of EGR valve

Exhaust gas recirculation reduces the formation of NOX and engine knock control. By re-circulating a allowing a small amount of exhaust gas into the intake air-fuel mixture on intake mainfold as shown in Fig 1.

Fig 1



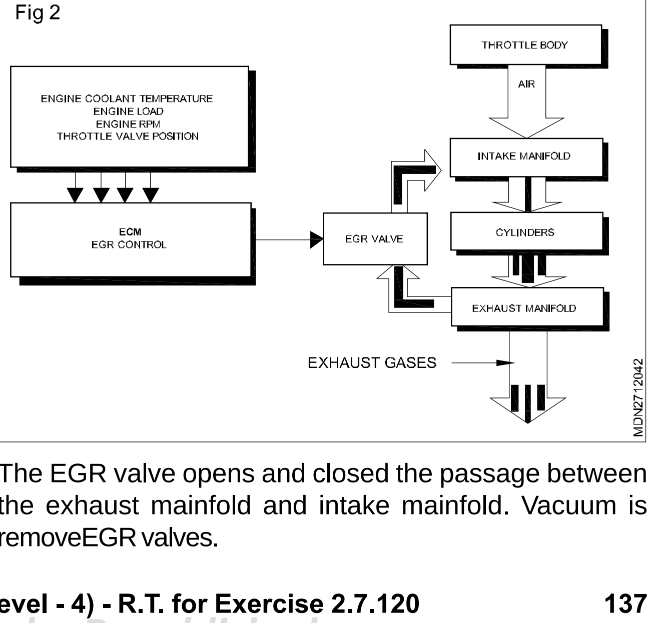
EGR,valve,connected between the exhaust port, or mainfold, and the intake system.

If engine conditions are likely to produce oxides of nitrogen, the EGR valve opens, letting some gases is (only about 6 to 10% of the total) pass from the exhaust, into the intake system. During combustion, these exhaust gases absorb heat from the burning air and fuel. This lowers peak combustion temperatures (below 1500 degrees c) to reduce the reaction between the reaction between nitrogen and oxygen that forms NOx.

Older EGR systems use a vacuum regulated EGR valve while newer vechicles tend to have an electronic EGR valve to control exhaust gas recirulation.

When the engine is idling, the EGR valve is closed and there is no EGR flow into the manifold. The EGR valve remains closed until the engine is warm and is operating under load. As the load increase and combustion temperatures start to rise, the EGR valve opens and starts to leak exhaust back into intake mainfold (Fig 2) This has a quenching effect that lowers combustion temperatures and reduces the formation of NOx.

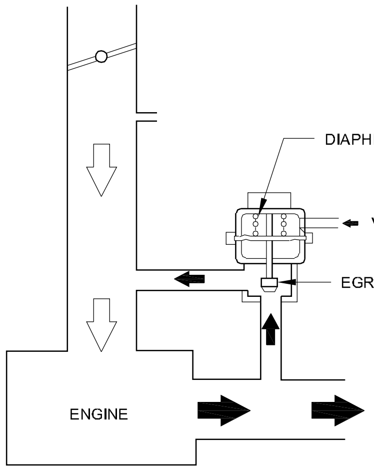
Fig 2



The EGR valve opens and closed the passage between the exhaust mainfold and intake mainfold. Vacuum is removeEGR valves.

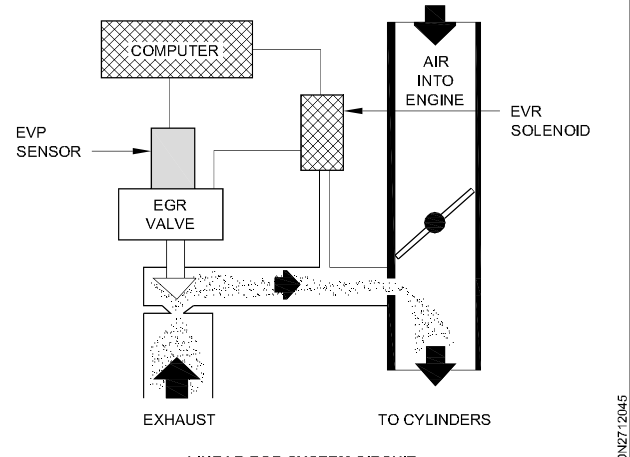
Inside the vacuum actuated EGR (Fig 3) valve is a valve, diaphargm and spring. When vacuum is applied to diaphragm lifts the valve off its seat allowing exahus gases into the intake air stream. When vacuum is removed the spring forces the diapharagm and valve downward closing the exhaust passage.

Fig 3



The EVP sensor (Fig 5) also helps with self - diagnostics because the computer looks for an indication of movement from the sensor when the it commands the EGR valve to open or close. The sensor works like a throttle position sensor and charges resistance. The voltage signal typically varies from 0.3 (closed) to 5 volts (open).

Fig 5



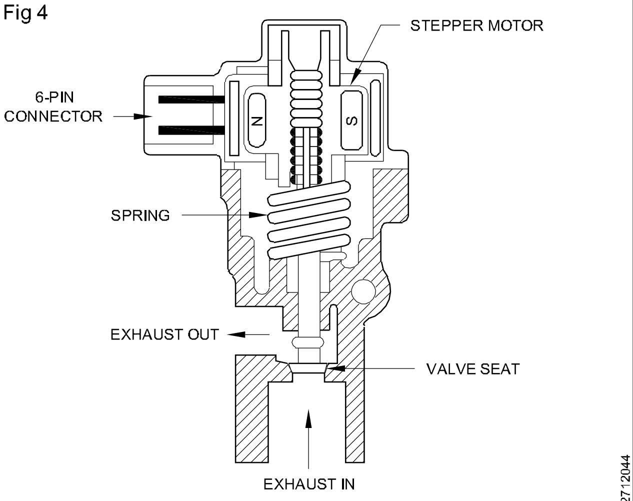
LINEAR EGR SYSTEM CIRCUIT

Current technology of EGR valve:

Linear electronic EGR valves:

Electronic EGR valve is the"linear" EGR valve. (Fig 4) This type uses a small computer - controlled stepper motor to open and close the EGR valve instead of vacuum.

Fig 4



LINEAR EGR VALVE

The advantage of this approach is that the EGR valve operates totally independent of engine vacuum. It is electrically operated and can be opened in various increments depending on what the engine control module determines the engine needs at any given moment in time.

Liner EGR valves may also be equipped with an EGR valve position sensor (EVP) to keep the computer informed about what the EGR valve is doing.

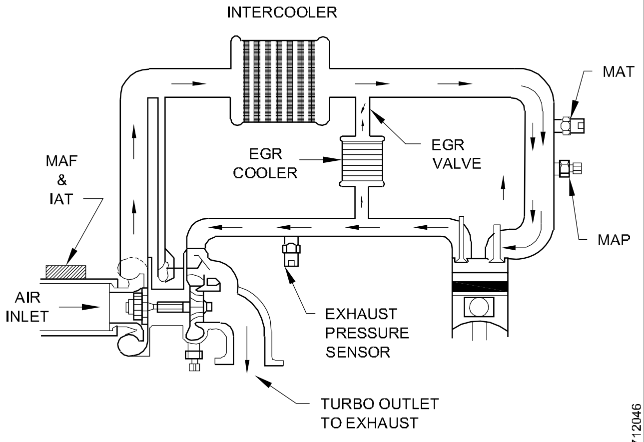
EGR system in diesel engines

The EGR systems (Fig 6) are quite the same as those used in gasoline engines, which means a sample of exhaust introduced into compbustion chambers to reduce combustion temperatures. One of the main different is that most manufactures cool the incoming EGR gases before introducing them into the cylinders. This reduces the temperature of combustion and therefore reduces the amount of NOx emitted by the exhaust as shown in Fig 3.

Most systems with EGR coolers use engine coolant that passes through a separte circuit to cool the recirculated exhaust gases.

The ECU/PCM operates and monitors the EGR system, EGR flow is controlled by tghe ECU/PCM through a digital EGR valve. EGR flow will occur only when the engine is at a predetermined leval and conditions are

Fig 6



INTAKE EGR SYSTEM IN DIESEL ENGINE

Evaporation emission control

Objectives : At the end of this lesson you shall be able to
- **state the purpose of Evaporation emission control (EVAP) systems. Explain the working principle of evaporation emission control (EVAP) systems**
- **describe the EVAP system components.**

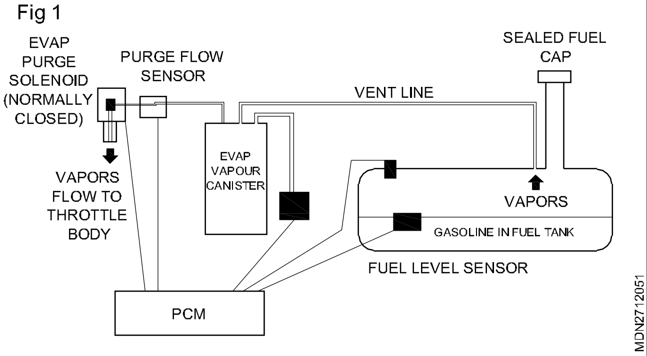
Purpose of Evaporation emission control (EVAP) systems

The Evaporation emission control (EVAP) systems totally eliminate fuel vapours going into the atmosphere.

Vent lines from the fuel tank and carburetor bowl route vapors to the EVAP storage canister, where they are trapped and stored until the engine is started.

When the engine is warm and the vehicle is going down the road, the PCM/ECU then opens a purge valve allowing the vapors to be drain off from the storage canister into the intake manifold. The fuel vapors are then burned in the engine (Fig 1)

Fig 1



EVAP SYSTEM COMPONENTS

The major components of the evaporative emission control system include:

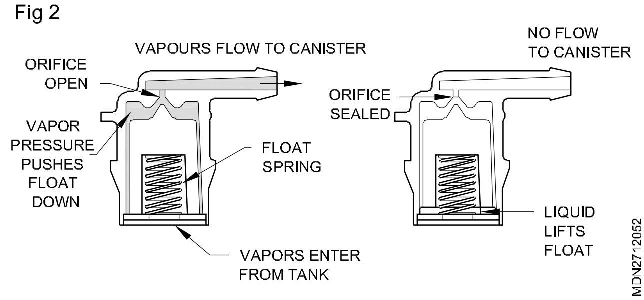
Fuel tank- This has some expansion space at the top so fuel can expand on a hot day without overflowing or forcing the EVAP system to leak.

Gas cap - This contains pressure/vacuum relief valve for venting on older vehicles (pre-OBD II), but is sealed completely (no vents) on newer vehicles (1996 & newer).

Liquid-Vapor Separator - This is located on top of the fuel tank or part of the expansion overflow tank. This device prevents liquid gasoline from entering the vent line to the EVAP canister.

Some liquid-vapor separators use a slightly different approach to keeping liquid fuel out of the canister vent line. A float and needle assembly is mounted inside the separator. If liquid enters the unit, the float rises and seats the needle valve to close the tank vent. (Fig 2)

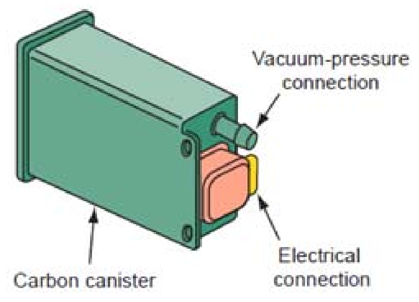
Fig 2



EVAP Canister - This is a small round or rectangular plastic or steel container mounted somewhere in the vehicle. It is usually hidden from view and may be located in a corner of the engine compartment or inside a rear quarter panel. (Fig 3)

The canister is filled with about a kg of activated charcoal. The charcoal acts like a sponge and absorbs and stores fuel vapors. The vapors are stored in the canister until the engine is started, is warm and is being driven. The PCM then opens the canister purge valve, which allows intake vacuum to drain off the fuel vapors into the engine. The charcoal canister is connected to the fuel tank via the tank vent line.

Fig 3



Catalytic converter

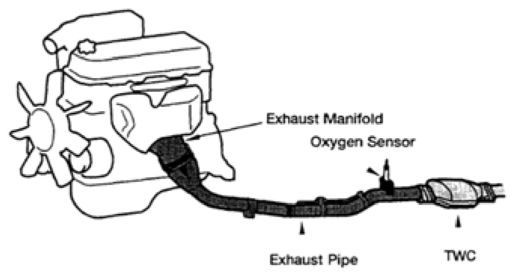
Objectives : At the end of this lesson you shall be able to
- **state the purpose of Catalytic converter**
- **explain the conversion principle of Catalytic converter**
- **describe the EVAP system components.**

Passenger cars and light trucks have been equipped with catalytic converters. A Catalytic converter is located (Fig 1) within the exhaust system and converts to convert harmful emissions as HC, CO, NOx, produced by an internal combustion engine, to less-harmful elements: H2O (Water), CO2(Carbon Dioxide), and N2 (Nitrogen)

Block Diagram of three-way catalytic converters (TWC) (Fig 3)

Modern vehicles are fitted with three-way catalytic converters (TWC). The term 'three-way' is in relation to the three regulated emissions the converter is designed to reduce:

Fig 1

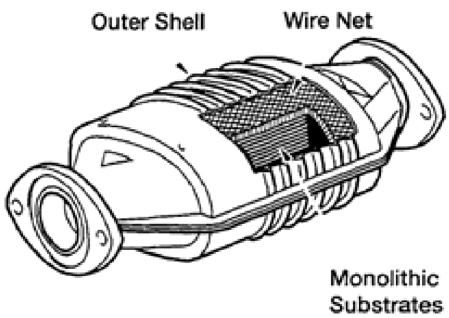


- Unburnt Hydrocarbons are oxidized into water/steam.
- Carbon monoxide is oxidized into carbon Dioxide
- Oxides are converted into Nitrogen and Oxygen

The converter uses two different types of catalysts to reduce the pollutants: a reduction catalyst and an oxidation catalyst.

A honeycomb structure (Fig 2) as either ceramic or metallic is treated with a wash-coat of precious metals usually platinum, palladium and rhodium through which the exhaust gasses flow. The Surface of the honeycomb material has a rough finish such that it allows the maximum contacts are available to the exhaust gasses.

Fig 2



The exhaust gases first pass over the reduction catalyst in the converter. The platinum and rhodium coating helps to reduce the oxides of nitrogen, together known as 'NOX' emissions

The Three-way Catalyst, which is responsible for performing the actual feed gas conversion, formed by coating the internal substrate with the following type materials.

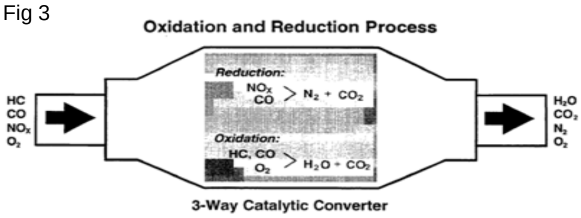
Material	Conversion for
Platinum/palladium	Oxidizing catalysts for HC and CO
Rhodium	Reducing catalyst for NOx
Cerium	Promotes oxygen storage to improve oxidation efficiency

The diagram (Fig 3) below shows the chemical reaction that takes place inside the converter.

The electronic control unit, or ECU, monitors the air-fuel ratio by using an exhaust gas oxygen, or EGO, sensor, also known as a lambda sensor. This sensor tells the engine computer how much oxygen is in the exhaust and uses this information via the ECU to control the fuel injection system.

The ECU can increase or decrease the amount of oxygen in the exhaust by adjusting the air-to-fuel ratio. The system ensures that the engine runs at close to the stoichiometric point in normal driving conditions. It also ensures that there is always sufficient oxygen in the exhaust system to allow the oxidization catalyst to deal with unburned hydrocarbons and carbon monoxide.

Fig 3



Selective catalytic reduction(SCR)

Objectives : At the end of this lesson you shall be able to
- **state the purpose of selective catalytic reduction (SCR)**
- **state the selective catalytic reduction (SCR) system components**
- **describe the working priniciple of selective catalytic reduction (SCR).**

Purpose of selective catalytic reduction (SCR)

selective catalytic reduction (SCR) is the process by which oxides of nitrogen (Nox) contained in diesel exhaust are reduced to nitrogen (N2) and water (H2O)

selective catalytic reduction

Selective : targets NOx in diesel exhaust

Catalytic : reduires a catalyst

Reduction : NOx is reduced to nitrogen (N2) (Fig 1)

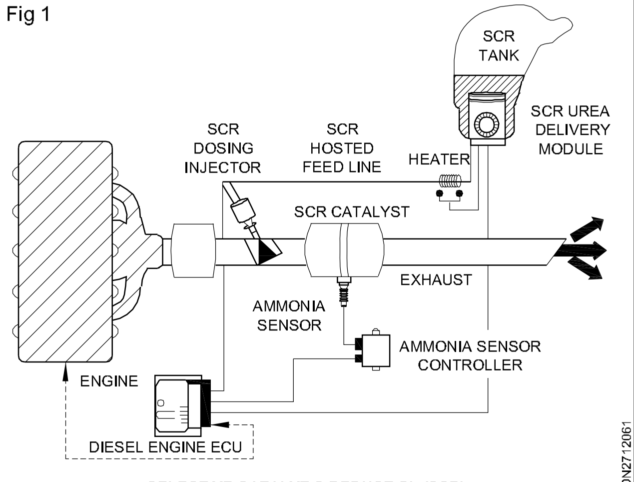
SCR requires diesel exhaust fluid (DEF) - a urea based solution

SCR reduces NOX emissions up to 93%

Selective catalytic reduction (SCR) system components

- Diesel exhaust Fluid (DEF)
- DEF injector
- Mixing tube
- SCR catalyst

Fig 1



SELECTIVE CATALYTIC REDUCTION (SCR)

Working principle of SCR system

SCR works by injecting diesel exhaust fluid (DEF), into the hot exhaust stack. DEF works in conjunction with the hot exhaust gases and catalyst to break NOx into two components of our normal atmosphere wair vapor and nitrogen.

Engine:

The NOx reduction process starts with an efficient CRD engine design CRD engine design that burns clean ultra low sulfur diesel (ULSD) and produces inherently lower exhaust emissions- exhaust that is already much cleaner due to leaner and more complete combustion.

Diesel exhaust fluid (DEF) tank and pump:

Under the direction of the vehicle's onboard computer, Def is delivered in precisely metered spary patterns into the exhaust stream just ahead of the SCR converter.

DEF is a urea based solution,

Composition - 67.5% de-ionized water - 32.5% urea

Urea- Under heat, decomposes to ammonia (NH3) and carbon dioxide(CO2)

Ammonia (NH3) reacts with NOx in the presence of a catalyst

DEF is required for the selective catalytic reduction (SCR) system to function

SCR catalytic converter :

This is where the conversion happens. Exhaust gases and an atomized mist of DEF enter the converter simultaneously. Together with the catalyst inside the converter, the mixture undergoes a chemical that produces nitrogen gas and water vapor.

Control device:

Exhaust gases are moniored via a sensor as they leave the SCR catalyst. Feedback is supplied to the main computer to alter the DEF flow if NOx levels fluctuate beyond acceptable parameters.

EGR Vs SCR

Objective: At the end of this lesson you shall be able to
- **state the different between exhaust gas recirculation (EGR) Vs selective catalytic reduction (SCR).**

EGR Vs SCR

For 2010, the environmental protection agengy (EPA) requires that diesel truck emmissions contain a 97 precent reduction in their sulfer content. Engine manufacurers have come up with two advanced pollution control technology options for cars, trucks, and buses which include:

Exhaust gas reciculation (EGR) is an other way to reduce NOx formation. In an EGR system, engine exhaust is recycled back through the engine to dilute the oxygen. Almost all engine manufacturers use a form of EGR, as it takes both EGR and SCR to achieve near-zero NOx emissions.

While stand alone EGR systems help to reduce NOx, there are some disadvantages:

Selective catalytic reduction (SCR) is an exhaust after treatment system that injects a small amount of a chemical called diesel exhaust fluid (DEF) into the exhaust. DEF is mixed with exhaust in the presence of a catalyst turning NOx (oxides of nitrogen - a harmful pollutant that contributes to smog and acid rain) into harmless nitrogen and water vapor.

Majority of the engine manufacturers have added SCR to their exhaust systems such as; volovo,mack,daimler,and hino to name a few.

EGR	SCR
Reduces overall engine efficiency	More power
Large cooling system	Fuel efficiency
Exhaust back pressure	Larger service intervals
Additional engine components	Reliability and durability
Recirulates 30% exhaust	Uses diesel exhaust fluid
Back pressure sensor	SCR chamber never requires service
No additional fluid	
Increased maintenance cost	

Alternator

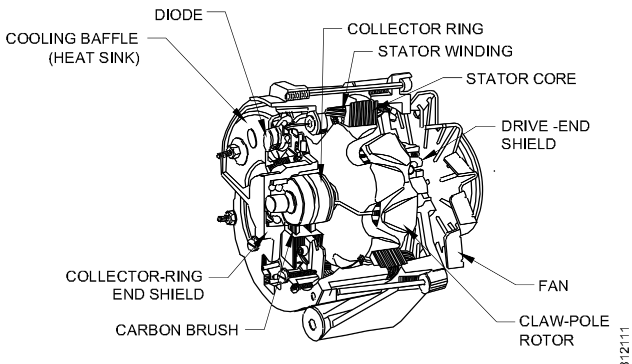
Objectives : At the end of this lesson you shall be able to
- **explain the purpose of an alternator**
- **describe the circuit of the alternator**
- **list out the different parts of the alternator**
- **explain the functions of the various parts of an alternator**
- **explain the working of an alternator.**

Purpose of alternator (Fig 1)

Right from the beginning, vehicles were fitted with dynamos for producing electricity. In present day vehicles the number of electrical accessories used has increased. Thus the demand for higher capacity generators has arisen. This can only be met by increasing the capacity of the generator and also by running it at higher speeds.

The vehicles in large cities have to, often, move at very slow speeds due to heavy traffic. Normally a DC dynamo will not be able to charge the battery at such low speeds. The speed of the dynamo cannot be increased beyond a certain limit. Therefore, an alternator or AC generator is used. An alternator can produce more electricity at low r.p.m.

Fig 1



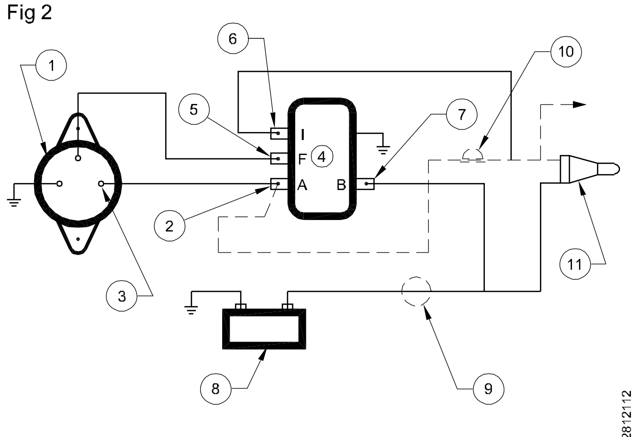
SECTIONAL VIEW OF BOSCH CLAW-POLE ALTERNATOR

Alternator wiring circuit in a vehicle (Fig 2)

The alternator's (1) output terminal (3) is connected to the 'A' terminal (2) of the voltage regulator. The alternators (1) field terminal (5) is connected to the 'F' terminal of the voltage regulator (4). The 'B' terminal of the regulator is connected to the battery (8) via the ammeter (9). The battery's (8) connection is also connected to the 'A' terminal (2) of the regulator (4) via the ignition switch (11) and indicator lamp (10). The terminal I (6) of the voltage regulator (4) is connected to the Ignition terminal (SW).

Description of parts of an alternator

Fig 2



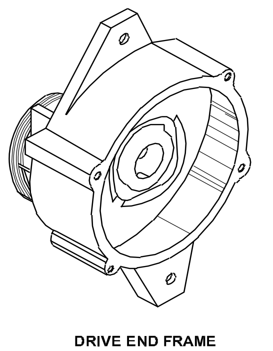
ALTERNATOR WIRING CIRCUIT IN A VEHICLE

Drive end frame (Fig 3)

The drive end frame supports a pre-lubricated sealed bearing in which the drive end of rotor shaft rotates.

The rotor and its shaft is mounted and encased between drive end frame and slip ring end frame.

Fig 3



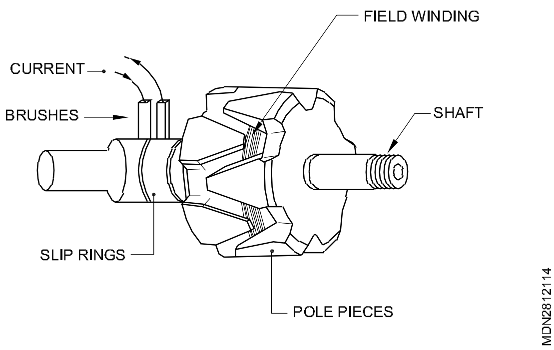
DRIVE END FRAME

The rotor assembly (Fig 4)

This consists of a steel shaft which carries the driving pulley and cooling fan, a cylindrical iron core, and two insulated slip rings. A large number of turns of insulated wire are wound over the core to form the field winding.

Each end of the winding is connected to its own slip ring and spring-loaded brush. The winding is enclosed by two iron pole pieces with eight interlocking fingers which become alternate north and south poles when direct current is passed through the winding via the brushes.

Fig 4



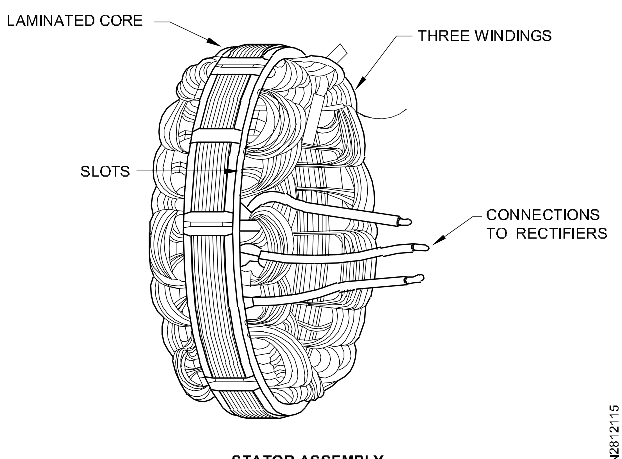
Stator assembly (Fig 5)

It is a stationary part which is held between two end covers. (Figs 1 & 5)

This consists of a laminated, cylindrical, iron core which is slotted to permit the fitting of three sets of insulated windings. In the lighter units these windings are star connected and in the heavier units delta connected. The number of coils depends on the number of poles.

The 'N' pole and 'S' pole of the magnet pass each stator winding and due to interruption of the magnetic flux the current is generated in the stator windings.

Fig 5



STATOR ASSEMBLY

Diodes

The diodes are made of silicon and these allow current to flow in one direction only. They are so connected as to allow the current to flow from the alternator to the battery but not in the opposite direction.

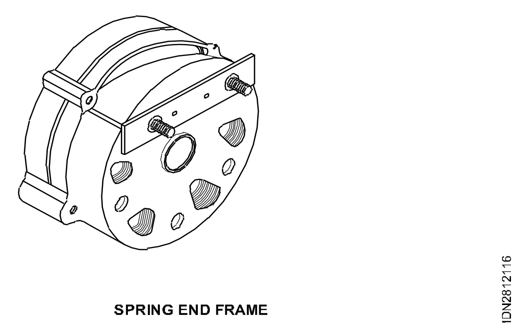
Three diodes on the negative side are connected to the rear end housing and three diodes on the positive side are mounted on an insulated heat sink.

The diodes convert the AC produced by the alternator to DC since the automobile accessories are designed to utilise DC current.

Slip ring end frame (Fig 6)

The slip ring end frame supports the rectifier mounting plates and a pre-lubricated bearing for rotor/shaft rotation. The rectifiers are pressed into the slip ring end head or heat sink and are connected to the stator leads.

Fig 6



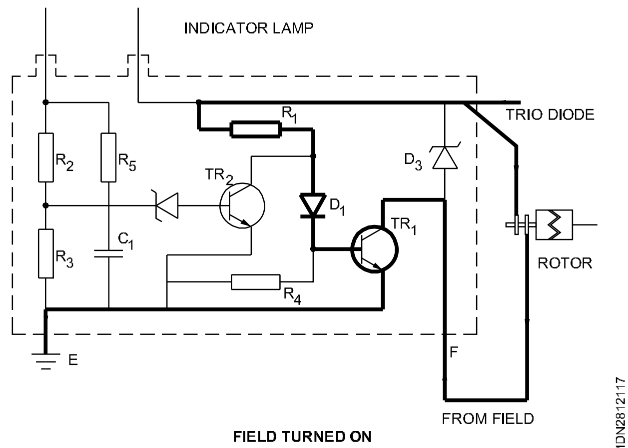
SPRING END FRAME

Electronic regulator (Fig 7 & 8)

To protect the battery and the accessories against high voltage, the alternator voltage must be controlled. This is done by using a voltage regulator which varies the current flow to the rotating field (rotor). The regulator work is done by electronically.

A transistor regulator consists primarily of resistors, capacitors (condensers), diodes and transistors. It is a complete static unit which controls the alternator voltage. It is durable and efficient. It safely allows a high field-current flow, and it has a longer service life than the vibrating contact regulator. An equally important feature is the ease with which it can be tested, adjusted and serviced.

Fig 7



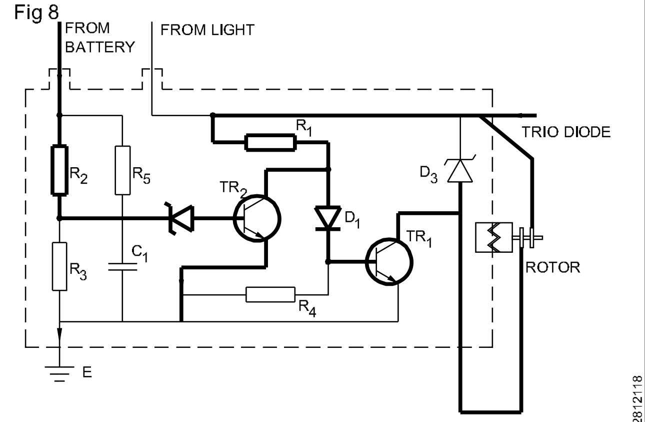
FIELD TURNED ON

When the permanently magnetized rotor rotates, an alternating voltage is induced in the stator winding which is rectified by the three negative and three positive diodes and DC current flows into the battery. The rectified current of each phase winding also flows over diodes D1, D2, D3 into the regulator to resistor R1, to the collector of resistor TR3 and to the resistor R3 to ground. The transistor TR3 is not switched on because the low voltage allows zener diode D6 and diode D5 to block the base circuit. However, transistors TR2 and TR1 are switched on because current can now flow over both emitter bases to ground.

With both transistors switched on, current from the output terminal of the alternator supplies current to the regulator over resistor R5 to the field coil and transistor TR1 (collector elements) to ground. Output current also flows from resistor R5 to resistors R2 and R4 to ground. As charging voltage increases, the voltage impressed across resistor R4 is also impressed across diode D5 and zener diode D6.

When the breakdown voltage is reached, transistor TR3 switches on because the emitter-base circuit ground is completed. This causes TR2 and TR1 to shut off since current now flows over the lower resistance circuit from resistor R1, transistor TR3 (collector-emitter) to ground, robbing the current flow from transistor TR2. The field current flow stops. As system voltage decreases, diodes D5 and D6 stop conducting current and transistor TR3 shuts off. This cycle repeats many times per second to maintain present alternator voltage. The capacitors C1, C2 and C3 and diode D4 perform the same function.

Fig 8



FIELD TURNED OFF

Operation of alternator (Fig 8)

When the engine is started, the belt drives the rotor (3) assembly.

During rotation the 'S' poles and 'N' poles of the rotor magnet pass through each stator coil (4).

Due to this rotation of the rotor assembly the current is generated in the stator coil (4), alternatively positive and negative.

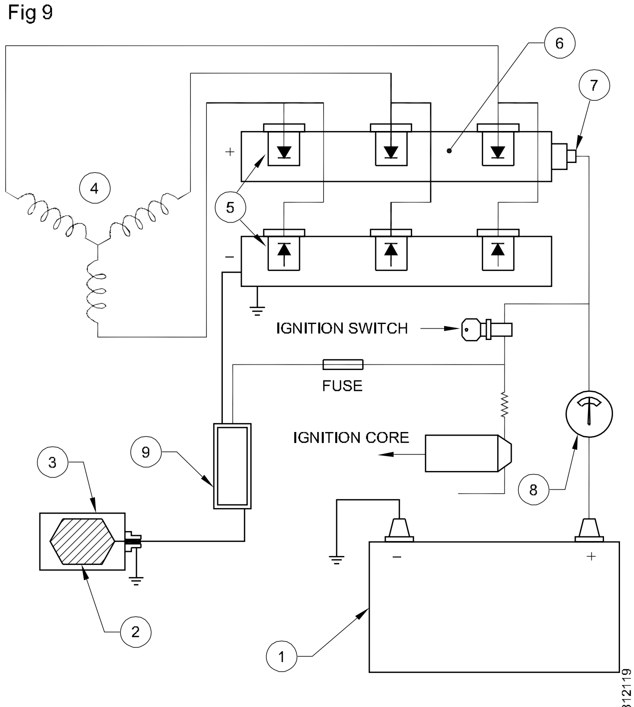
If more rotor magnets pass through each stator coil (4) in a given time, the generation of current will be more, since they form the ends of metal fingers, each finger acting like a magnet. These fingers interlock but do not touch each other.

The current produced is allowed to pass through silicon diodes (5) mounted on the heat sink (6). The diodes convert the AC to DC.

The heat produced in the diodes is dissipated by the heat sink.

The current passes through the battery terminal (7), the ammeter (8) and to the battery (1) for charging.

Fig 9



ALTERNATOR CHARGING CIRCUIT

Differences Between Alternator And Dynamo

Objectives : At the end of this lesson you shall be able to
- **list out the differences between an alternator and a dynamo**
- **state the precautions to be followed while using alternators**
- **state the common troubles and their remedies in alternators.**

DIFFERENCES BETWEEN ALTERNATOR AND DC GENERATOR/DYNAMO

	Alternator	DC Generator/Dynamo
1	The alternator develops DC current	The generator also develops AC.
2	It produces enough current during idling speeds of the engine (18 to 20 amps).	It produces very little current during idling. (No charging of battery is possible.)
3	No cut out is required in the charging circuit as diodes do not allow return current.	Cut out relay is used in the charging circuit.
4	For the same output the weight of the alternator is less. Ex.12 V - 8 kg	But the weight of the generator is more. Ex.12 V - 12 kg
5	The alternator limits its own current. No current regulator is used.	The generator does not limit its own current. Hence a current regulator is required.
6	Diode rectifiers do not pass the current in the reverse direction.	In the generator charging circuit a cut out relay acts as a reverse current relay.
7	In the alternator the voltage is only to be regulated. regulated to a certain value.	In the generator both voltage and current are to be
8	Alternator can run up to a very high speeds (say 20,000 r.p.m.).	Generator r.p.m. is limited to 9000.
9	Less maintenance due to use of slip ring and brushes.	Frequent maintenance due to use of commutator and carbon bushes.
10	The alternator charges the battery at low engine speeds (Idling r.p.m.).	The generator does not charge the battery at low idle speeds.
11	It has high output weight ratio.	It has low output-weight ratio.
12	The alternator is simple and robust in construction, looks compact.	The generator is not very robust.
13	Due to transformation of mechanical energy to electrical energy, the alternator works with 50% efficiency only.	In the generator transfer losses are very minimum and its efficiency of working is very high.
14	The alternator uses diode rectifiers to rectify AC into DC for charging the battery.	The generator uses commutator and brushes to do the rectification of AC to DC.

Precautions to be followed while handling alternators

- Ensure all connections are tight and clean.
- Ensure that there is no open circuit in the charging circuit.
- Observe correct polarity when refitting battery in the vehicle. Reversed battery connections may damage the rectifier and the vehicle wiring.
- Do not short or ground any of the terminals of the alternator or regulator.
- Do not allow water to seep into the alternator.
- Do not operate the alternator unless it is connected to a load.
- Disconnect the battery, alternator and regulator before carrying out any arc welding on the vehicle.
- The alternator should not be mounted near the exhaust manifold without suitable heat protection.
- Do not attempt to polarise the alternator.
- The field circuit must never be grounded on this system between the alternator and the regulator.
- Maintain belt tension.

Common troubles and remedies in alternator

Objectives : At the end of this lesson you shall be able to

- **state the causes and their remedies for no charge when engine is running**
- **state the causes and their remedies for low output voltage**
- **state the causes and their remedies for excessive output (charging at high rate)**
- **state the causes and their remedies for noisy alternator.**

	Trouble	Causes	Remedy
1	No charge when engine is running.	Blown fuse wire in regulator.	Locate cause and rectify and then replace fuse.
		Drive belt loose.	Adjust belt tension.
		Broken drive belts.	Replace.
		Worn out or sticky brush.	Rectify. Replace.
		Open field circuit.	Rectify.
		Open charging circuit.	Rectify.
		Open circuit in stator winding.	Rectify.
		Open rectifier circuit.	Rectify.
		Defective diodes.	Replace.
		Worn or dirty slip rings.	Replace.
		Loose connections.	Tighten.

Starting motor circuit and constructional details

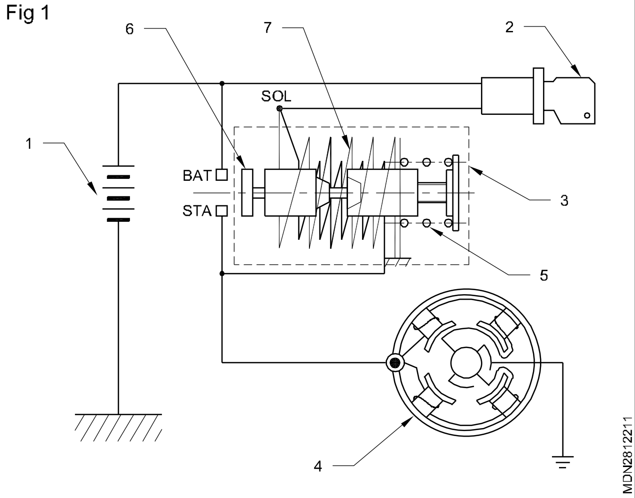
Objectives : At the end of this lesson you shall be able to
- **explain starting circuit**
- **explain the need of starter motors**
- **explain the construction of a starter motor**
- **explain the functions of a starter motor**
- **explain the functions of a starter drive unit**
- **explain the need of a solenoid switch**
- **explain the construction of a solenoid switch**
- **explain the functions of the solenoid switch.**

The starting system is used to start the engine. When the starter switch is pressed/ turned, current flows to the starter motor from the battery and the starter motor's shaft rotates. A drive pinion is connected to the starter motor shaft. The drive pinion turns the engine flywheel till the engine starts.

Description of a starting circuit

The -ve terminal of the battery (1) (Fig 1) is connected to earth. The +ve terminal of the battery (1) is connected to the solenoid switch's (3) battery terminal. From there a wire is connected to the starter switch's (2) input terminal. From the input terminal of the starter switch (2), a wire is connected to the solenoid winding's (7) input terminal. The other end of the winding is connected to earth. From the starter terminal of the solenoid switch a connection is given to the starter motor's (4) input terminal. In a starter motor an internal connection is given to connect the field windings as well as the armature through the brushes and the other end is connected to earth.

Fig 1



When the key switch is turned, a small amount of current flows from the battery (1) to the starter solenoid (3). This current energies the solenoid windings and the plunger (6) moves to connect the battery's and starter motor's terminal in the solenoid switch (3).

Current now flows directly to the motor (4). When the switch is released the current flow stops and the return spring (5) pulls the plunger (6) back, disconnecting the starter motor from the battery.

Starter motor

The engine crankshaft must be rotated at a speed of a minimum 100 r.p.m. to start the engine. This action is called engine cranking. As it is hard to rotate the engine at that speed by hand or with a lever, a starter motor is used to crank the engine.

Location of the starter motor

The starter motor is fixed in the rear side of the engine, when the starter is switched on the starter motor's pinion engages with the flywheel ring gear and rotates the flywheel.

Principle

When a current is passed through an armature coil which is placed between two stationary magnets an e.m.f. is induced and the armature coil starts rotating.

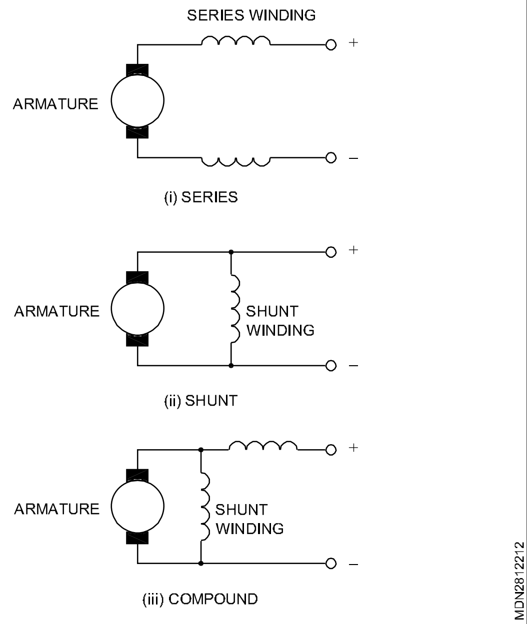
Construction

Three kinds of DC starter motors are used.

- Series (Fig 2)
- Shunt
- Compound

In automobiles the series wound type is generally used. In this the field and armature coils are connected in series. This enables the motor to produce a high starting torque. The armature windings (1) are fixed in slots and their ends are soldered to the commutator segments (2). The pole shoes (3), two or four in number, are screwed to the yoke (4) and they have field windings (5). These windings help to produce the magnetic field. The insulation pieces are placed between the pole shoes (3) and metal yoke (4). Copper segments are provided with mica insulation in between the commutator brushes (6).

Fig 2



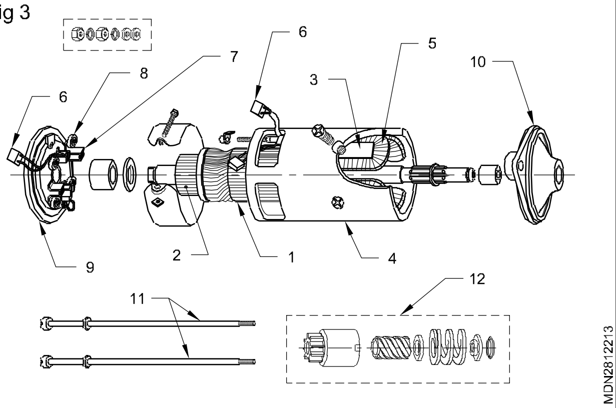
These brushes (6) slide in the brush holders and are kept in contact with the commutator with the help of small springs (8). The brushes (6) are given a curvature at the bottom to have more contact with the commutator (2). The armature is supported either on bushes or coil.

The commutator end is covered by a bracket called commutator end bracket (9). At the drive end, it is covered by the drive end bracket (10). Both the brackets are connected by through bolts (11). At the drive end in the armature shaft, a drive mechanism (12) is fitted.

Operation of starter motor

Current from the battery is supplied to the armature's (1) (Fig 3) coil by two or four stationary brushes (6). These brushes (6) are in contact with the commutator's (2) segments. The same current is also supplied to the field coils (5). Both the field coil (5) and the armature's (1) magnetic field attract and refuse each other and cause the armature to rotate. Each coil of armature (1) is connected to one pair of copper segments of the commutator (2). The brushes come in contact with each coil of the armature (1) by turn, and in the process the armature's speed increases further.

Fig 3



Once the engine starts running under its own power it attains a speed up to 4000 r.p.m. (depending upon the design). Since the flywheel ring to starter pinion ratio is very high, the starter pinion will rotate at a much higher speed than the engine. This speed will damage the starting motor by throwing the windings out of the armature slots and also the commutator segments due to centrifugal force. In order to prevent this it is necessary to disengage the starter pinion from the flywheel ring gear once the engine has started. To achieve this three types of drive mechanisms are used.

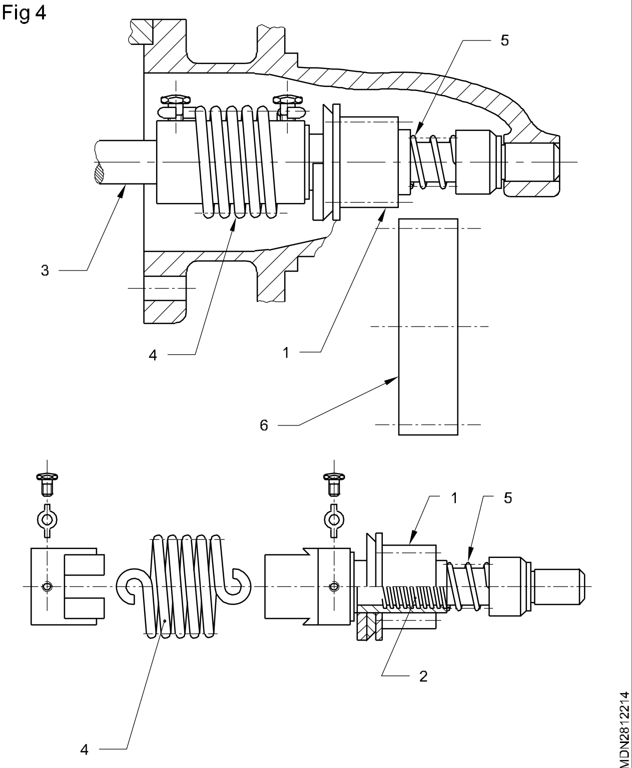
- Bendix drive
- Over-running clutch drive
- Axial or sliding armature type and non-coaxial type

Bendix drive

This is a most commonly used mechanism. It consists of a pinion (1) (Fig 4) which is mounted on a hollow sleeve. The pinion (1) has internal screw threads and is loose fitted on the sleeve (2). The armature shaft (3) is supported by bearings at both the ends. A bendix drive spring (4) is provided to limit the turning of the sleeve on the armature shaft. An anti-drift spring (5) is provided to prevent the pinion from striking the flywheel (6).

When the motor is switched on, the drive head rotates with the armature shaft (3). This motion is transmitted to the sleeve. The pinion (1) rotates along with the sleeve and travels forward to come in mesh with the flywheel ring gear (6). Now the engine's crankshaft rotates and the engine is started. When the engine speed increases the pinion (1) is thrown back to its original position due to inertia.

Fig 4



Over running clutch drive

The shift lever (2) is used by the over-running clutch to slide the pinion along the armature shaft (3) for meshing into or out of the flywheel teeth (4). The shift lever (2) is operated either by a solenoid (5) or by manual linkage. The over-running clutch permits the drive pinion (1) to run faster than the armature for a brief period during which the pinion (1) remains in mesh with the ring gear (4) once the engine has started. This protects the armature from damage due to over-speeding. (Fig 5 & Fig 6)

Fig 5

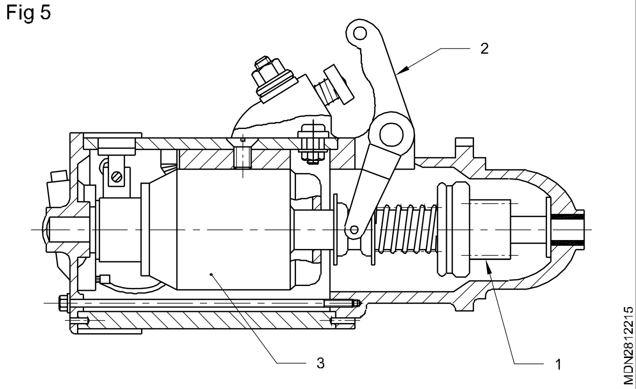
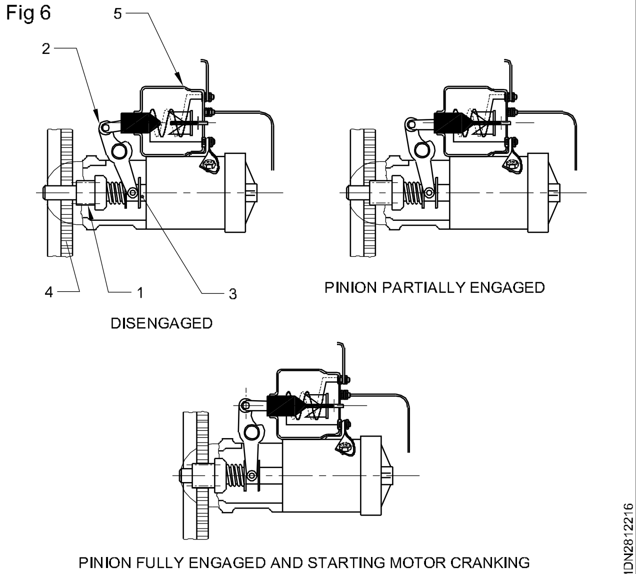


Fig 6

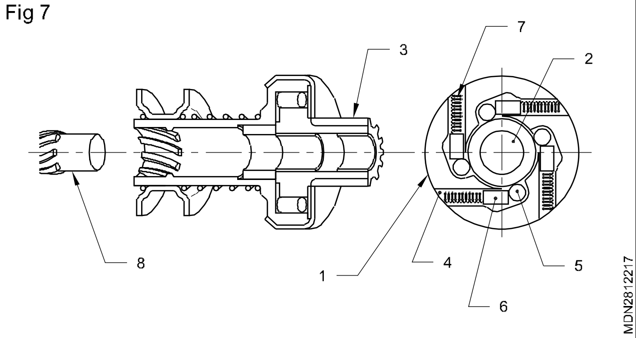


The over-running clutch, (Fig 7) which consists of a shell and a sleeve (1) assembly, is splined to the armature shaft (8), so that the shell is driven by the shaft.

The pinion gear (3) is fastened to a collar (9) which is fitted inside the clutch shell. Four tapered notches (4) cut in the shell contain steel rollers (5). These are held in the small ends of the notches by spring (7) and plunger assemblies so that the rollers contact the collar.

The pinion (3) is forced to rotate with the armature shaft and cranks the engine. When the engine starts its attempts to drive the armature shaft (8) cause the rollers (5) to rotate out of the small ends of the notches. This will release the collar (3) from the shaft. This allows the pinion (3) to rotate at high speed without driving the armature.

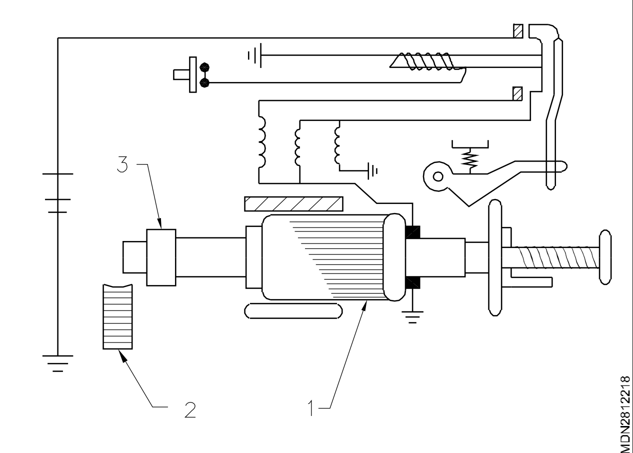
Fig 7



Axial or sliding armature drive

This type of drive allows its armature (1) (Fig 8) to slide in order to enable its pinion to come in mesh with the flywheel ring gear (2).

Fig 8



When the starter switch is operated, the solenoid coil is energised. This completes the circuit of the shunt winding and also of an axillary series field winding. The armature is pulled due to the magnetic field and the pinion (3) engages with the flywheel ring gear (2). A clutch is provided between the armature (1) and pinion (1). When the starter switch is released, the armature returns to its original position by the return spring. Since the pinion (1) is still in mesh with the flywheel (2).

It rotates at very high speed but the clutch prevents the rotation of the armature at the pinion's speed and prevents damage to the armature. The pinion is held in mesh until the starter switch is released by the auxiliary shunt winding. When the engine starts, the current falls down and the magnetic field is reduced. Now the pinion is pulled back to its position by the spring.

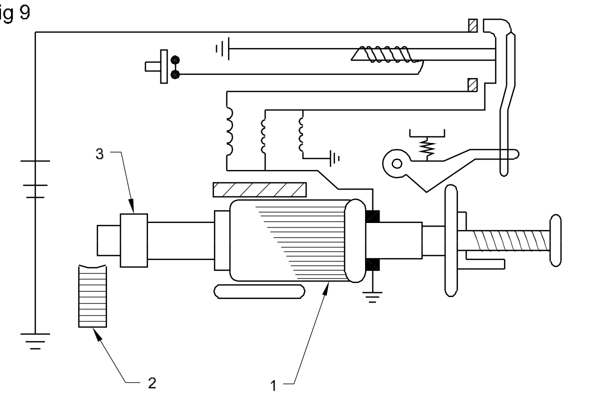
Need of solenoid switch

The solenoid switch is a strong electromagnetic switch. It is used to operate the over-running clutch drive pinion to engage with the flywheel ring gear. It also acts as a relay to close the contacts between the battery and the starting motor.

Construction of solenoid switch (Fig 9)

In a solenoid there are two windings, a pull-in winding (1) and a hold-in winding (2). The pull-in winding (1) is wound with thick wires (series winding) and the hold-in winding (2) is of thin wires (shunt winding). The pull-in winding (1) is connected to the starter switch (3) in the solenoid.

Fig 9



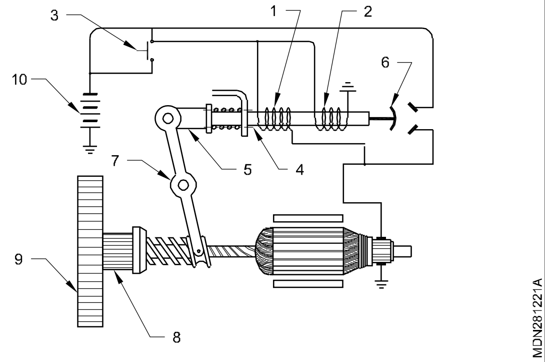
The hold in winding (2) is connected across the switch terminal and ground.The two windings are wound around a hollow core (4). An iron plunger (5) is placed inside the core (4).

The other end of the plunger moves a shift lever (7) to engage the pinion (8) with the flywheel ring gear (9).

Function of solenoid switch (Fig 10)

When the starter switch (3) is turned, current flows from the battery to the solenoid windings (1) and (2). This energises the windings which pull the plunger (5). The plunger (5) operates the shift lever (7) to engage the pinion (8) on the flywheel ring gear (9). Then it closes the circuit between the battery (10) and the starting motor.

Fig 10



Common troubles and remedy in starter circit

Troubles	Remedies
Heavy starter cable terminal worm unit solenoid coil defective sleeve operating lever bend	Replace Replace the solenoid Replace/Replace
Pinion gear teeth wornout	Replace the pinion
Arnature short circuit	Rewinding/Replace
Cummulator wornout	Reground/Replace
Carbon brush wornout	Replace
Carbon brush spring tension week	Replace
Field winding short circuited	Rewinding
Pinion gear returning spring broken	Replace
Starter motor mounting loose connection	tighten
Solenoud plunger jam	Check the fork lever
Plunger contact point pitted /burnt	Clean /Replace

Trouble shooting (causes and remedies)

Objectives : At the end of this lesson you shall be able to
- **causes and remedy for engine does not start**
- **causes and remedy for high fuel consumption**
- **causes and remedy for over heater**
- **causes and remedy for low power generation**
- **causes and remedy for exercise oil consumption**
- **causes and remedy for low oil pressure and high oil pressure**
- **causes and remedy for engine noss**
- **causes and remedy for engine does not start.**

Engine does not start

Probable causes	Remedies
Low fuel in tank	Fill fuel
Choked fuel hose	Replace
Clogged fuel filter	Replace
Air lock in fuel system	Blocked the air lock
Clogged exhaust ports	Clean
Reptured cylinder head gasket	Replace
Worn piston rings	Replace worn piston and rings
Broken valve turning belt/chain	Replace
Poor valve cycasting	Repair
Value seat pitted	Replace
Main fuse is blown off	Replace
Defective starting relay	Repair/Replace
Main ignition switch open circuited	Repair or Replace
Defective brushes in started	Replace
Open in field or armature circuit of starter	Repair/Replace
Loose battery terminal connection	Clean and retighten
Run down battery	Recharge

High fuel consumption

causes	Remedies
Wear compression	Replace pistioning/lime/piston
Fuel leakage in fuel system	Repair or Replace
Idle speed adjusting screw set in correctly	Adjust as prescribed
Clogged /dirty air filter	Replace or clean
Leakage of combustion gases from cyliner head	Retighten or replace head gasket
Value inproper scating	Repair
Value clearance inproper adjustment	adjust as prescribed
Injector defective	Overhand the injector
Inter cooler defective	Repair or Replace
Wrong injection timing	Set proper timing
Defective fuel pump	Overhand

Engine overheating

Causes	Remedies
Excessive carbon deposit in engine	Decarbonise
Loose or broken fan belt	Adjust or replace
Not enough coolant	Clean or top up coolant
Lack of lubrication	Top up engine oil
Erratically working thermostak	Replace
Radiator cores tubes clogged	Repair or Replace
Poor water pump performance	Repair or Replace
Wrong injection timing	Set proper timing
Leaky radiator core tube	Repair
Checked silencer	Clean
Closed radiator shutter	Open
Closed radiator fuel	Straighten the fuel
Clogged oil filter	Replace
Poor perfomance of oil pump	Repair or replace

Low power generation

causes	Remedies
Leaky cylinder head gasket	Replace
Improper valve seating	Repair
Broken value spring	Replace
Worn piston ring/bore	Replace or rebore
Piston rings sized in grooves or broken	Replace
Exhaust port clogged	Clean
Weak compression	Adjust value clearance
Defective fuel feld pump	Repair or Replace
Clogged fuel filter	Replace
Clogged air cleaner	Replace
Wrong injection timing	Set properly
Wrong tappet clearane	Adjust correct clearance
Defective injector	Repair or Replace

High oil consumption

causes	Remedies
External oil leakage	Rectify the leakage
High oil level	Remove excess oil
Value oil seal damaged	Replace oil seal
Piston/rings wornout	Replace piston/rings
Engine oil low viscosity	Replace the oil
Oil reaching in exhaust manifold	Replace exhaust value guides and value stems
Oil reaching to combustion chamber	Replace the piston rings

Low oil pressure

causes	Remedies
Low oil viscosity	Replace oil
Oil strainer blocked	Clean
Wornout oil pump gear	Replace gears
Strainer pipe mounting loose	Lighten
Defective oil pressure gauge	Replace
Defective pressure relief value	Replace
Crank/camshaft bearing wornout	Replace bearing
Low oil level in the sump	Top up

High oil pressure

causes	Remedies
High oil viscosity	Replace oil and use correct viscosity
Defective oil pressure gauge	Replace
Defective pressure relief value	Replace or adjust correct value
Oil passages blocking	Clean the oil passages
High oil level in the sump	Frain and replace at correct level

Engine noise

causes	Remedies
Wornout gudgeon pins	Replace
Wornout piston and rings	Replace
Piston ring broken	Replace
Vehicle over load	Avoid over loading
Tighten wheel bearing	Adjust
Clutch slipping	Adjust or Repair
Big and bearing wornout	Replace