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

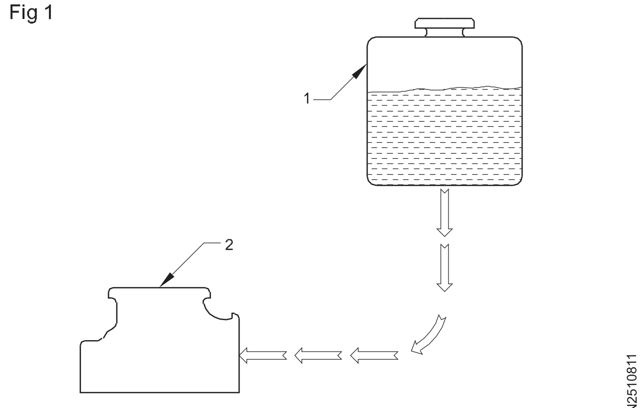
There are three types of fuel feed systems.

- 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

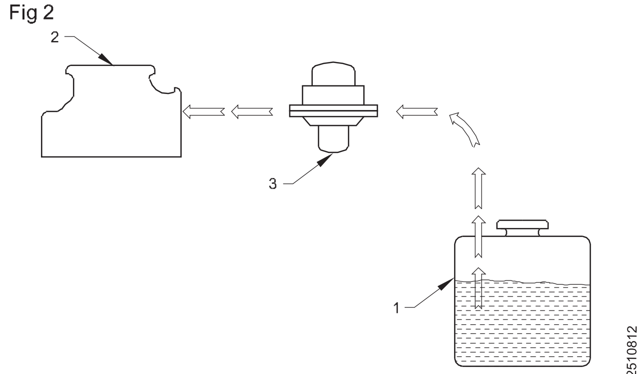
Vacuum feed system

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.

Fig 2



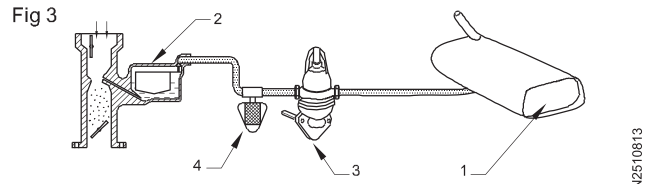
FORCED FEED SYSTEM

This system is used in almost all the vehicles, except two wheelers.

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

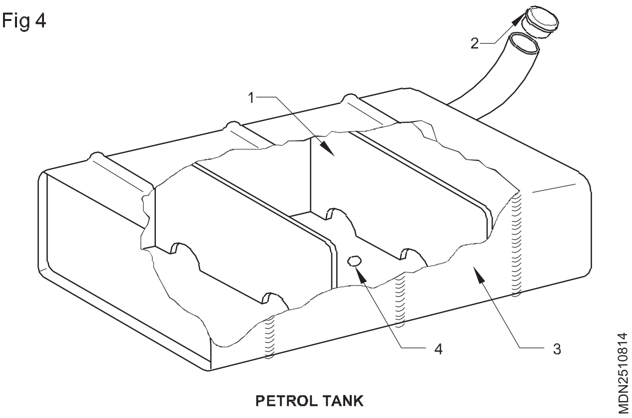
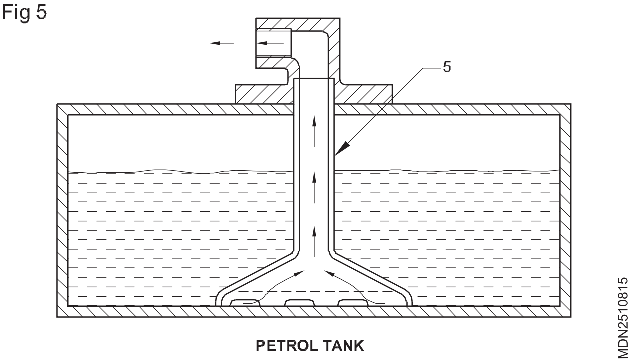


Fig 5



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)

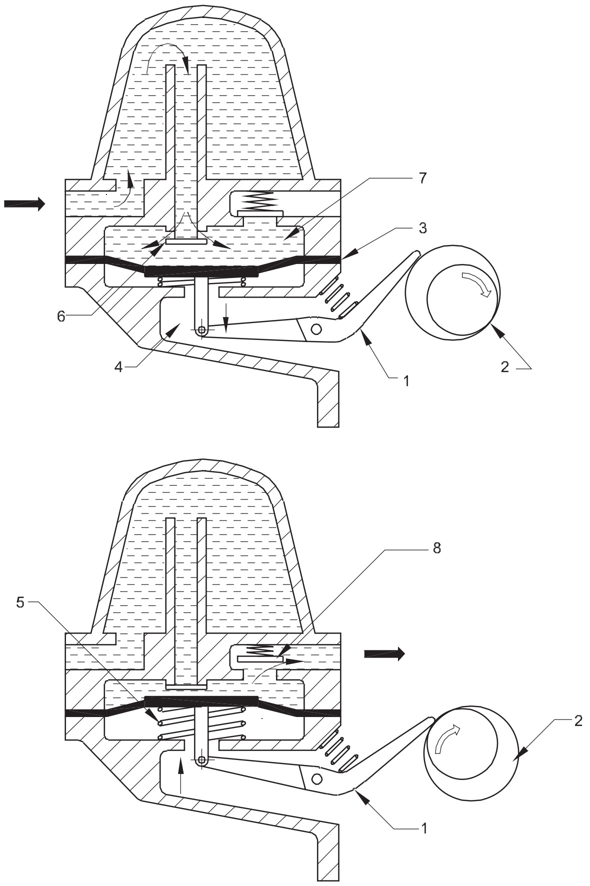
The rocker arm (1) is actuated by the camshaft (2) and moves to and fro. This makes the diaphragm (3) to move up and down along with the spindle (4) and the spring (5). During the downward motion of the diaphragm, a partial vacuum is created and the inlet valve (6) opens, allowing the fuel to be sucked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

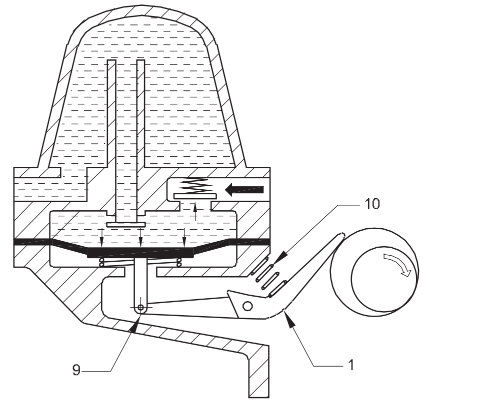
When the carburettor float chamber is full, the pumping action has to be stopped, to avoid flooding of the carburettor. At this condition the needle value in the float chamber remains closed and a back pressure develops in the pipeline. This pressure keeps the diaphragm depressed and the link (9) remains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

Fig 1



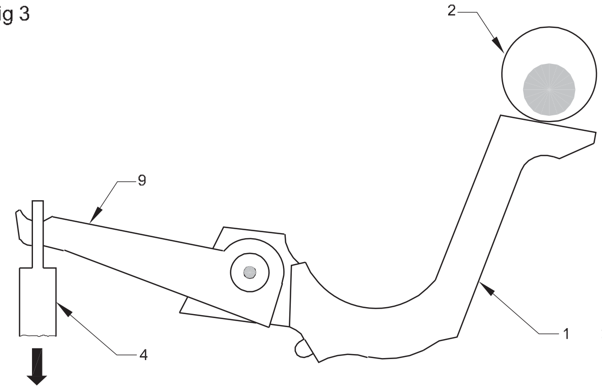
OPERATION OF FEED PUMP

Fig 2



IDLING ACTION

Fig 3



IDLING ACTION

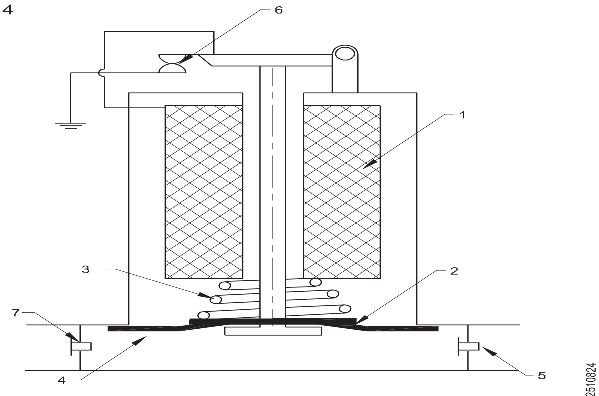
A spring (10) is provided between the rocker arm (1) and the pump body to avoid any rattling noise of the rocker arm (1) during the idling operation.

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

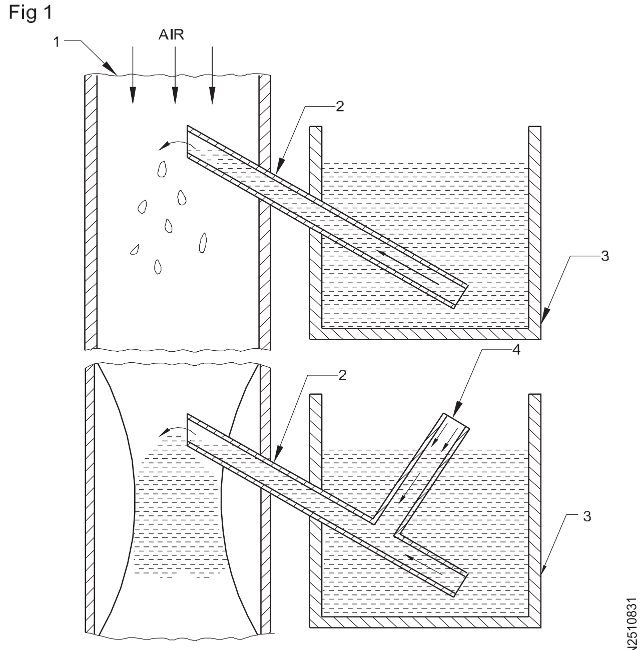
Objectives: At the end of this lesson you shall be able to
- **state the principle of carburettor**
- **list out the different types of carburettors**
- **state the various circuits in the carburettor**
- **state the function of various circuits in a solex carburettor.**

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.

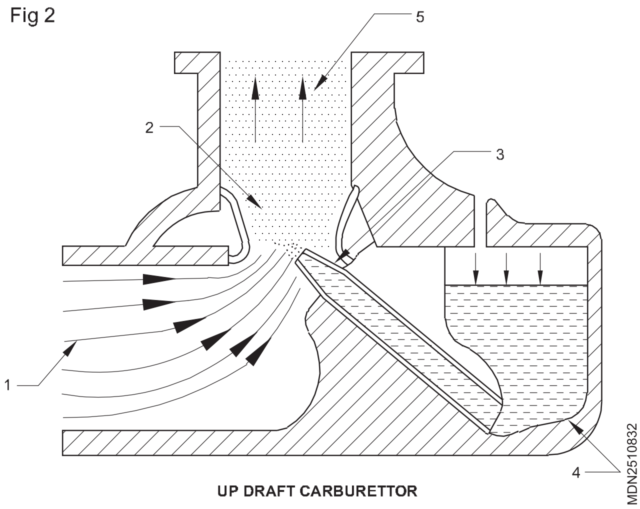
As per venturi arrangement

- 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

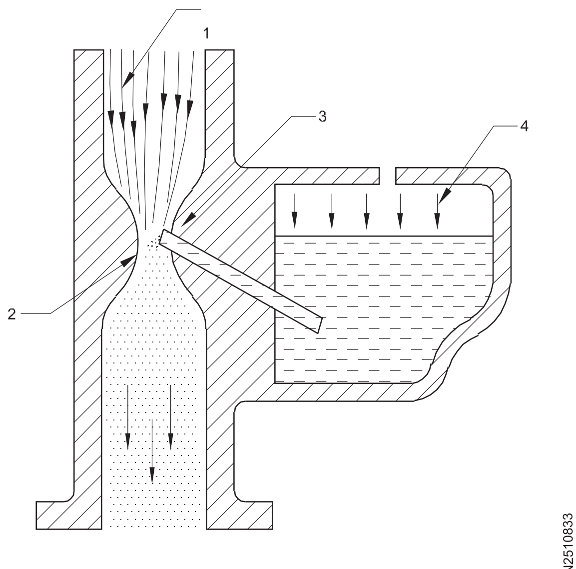


UP DRAFT CARBURETTOR

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

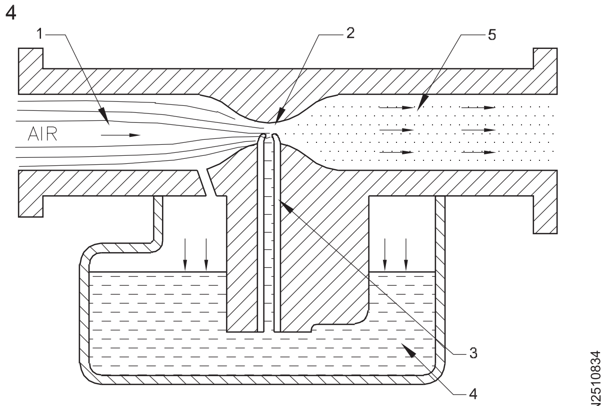


DOWN DRAFT

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.

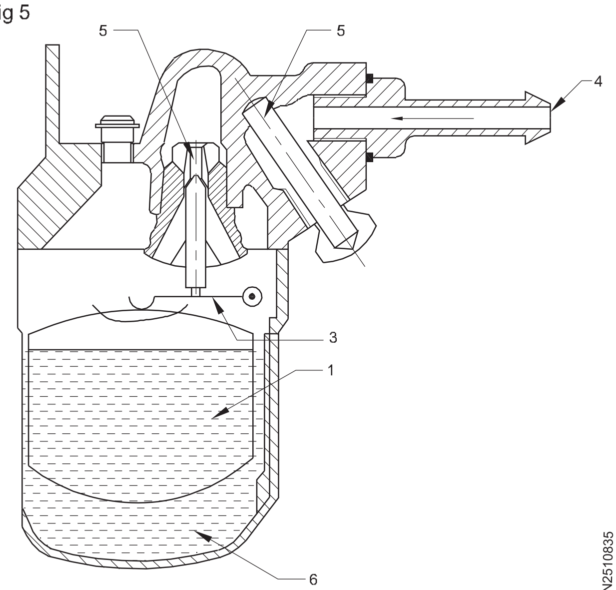
- Float circuit
- Starting circuit
- Idling and low speed circuit
- High speed main circuit
- Accelerator pump circuit
- Power circuit.

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).

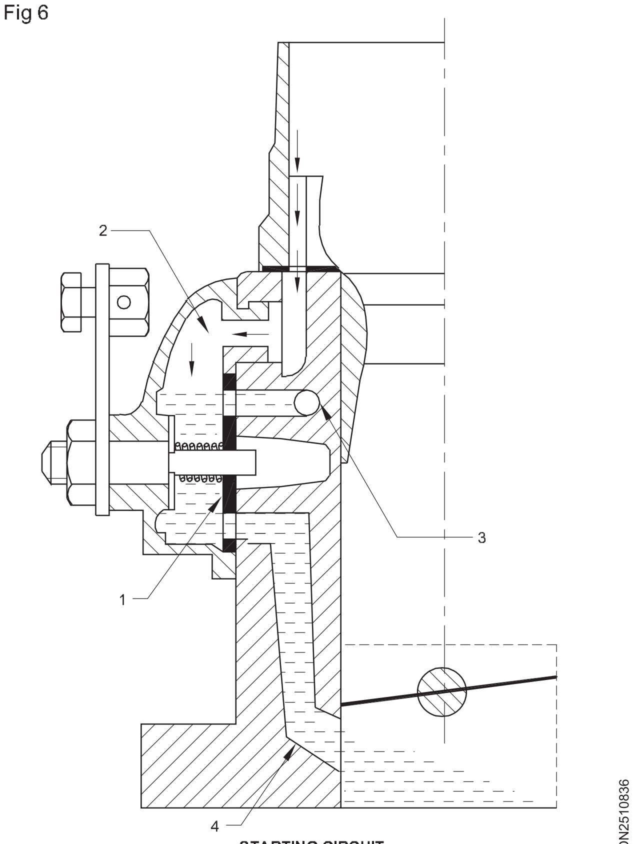
When the fuel level rises in the float chamber ,the float (1) is lifted and it presses the needle valve (2) against the float valve seat and cuts off the flow of fuel to the chamber. When the fuel is consumed, the level in the float chamber drops; the needle valve (2) leaves its seat and fuel flows again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

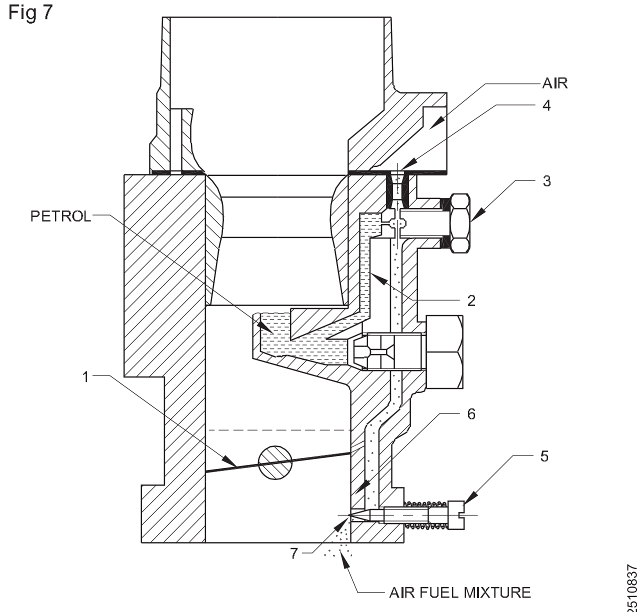
The combined idling and transfer system supply the petrol and air mixture to the engine when the throttle (1) is closed and when the throttle progressively opens for the purpose of driving the vehicle.

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



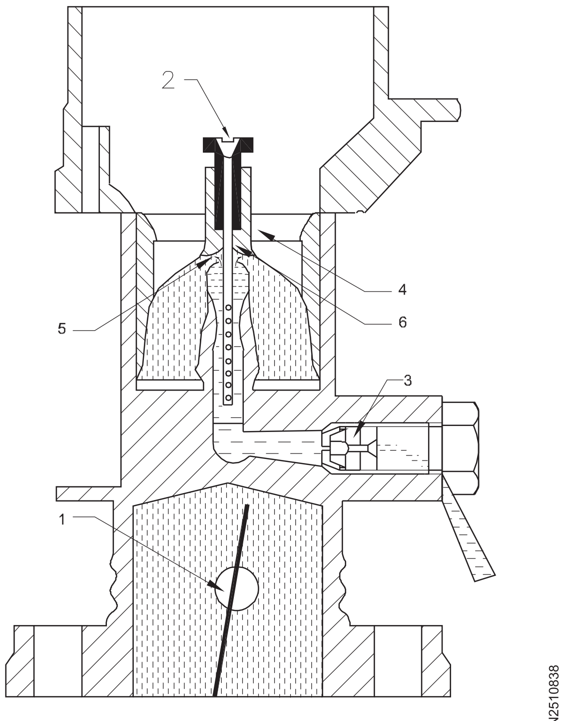
IDLING / SLOW SPEED CIRCUIT

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



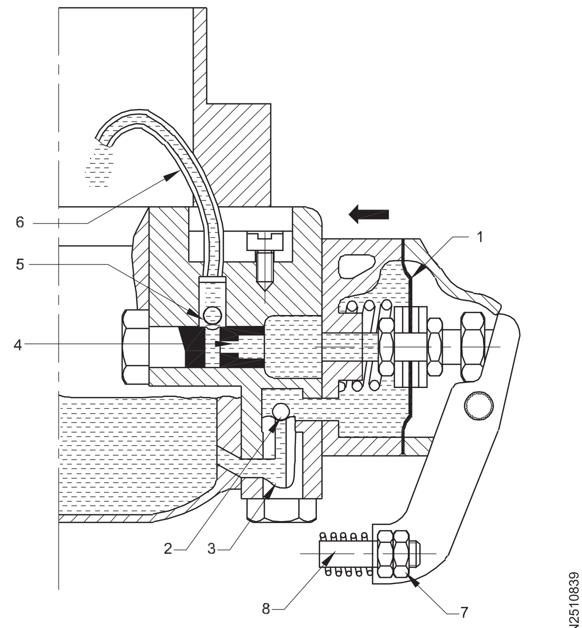
MAIN CIRCUIT / ACCELERATING CIRCUIT

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

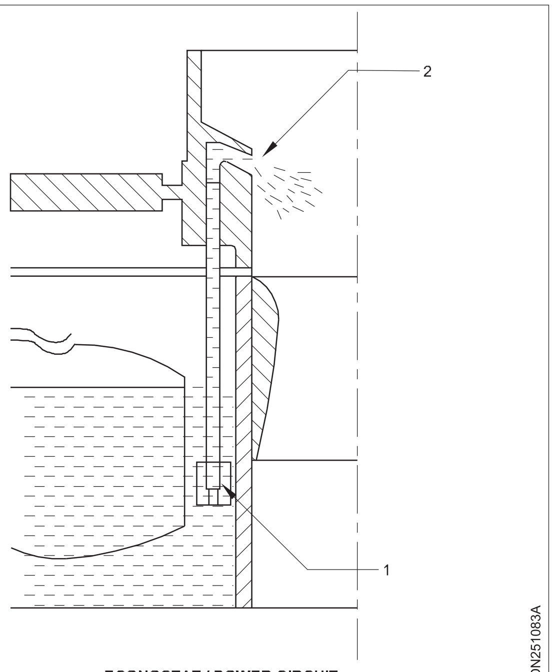


PUMP CIRCUIT

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

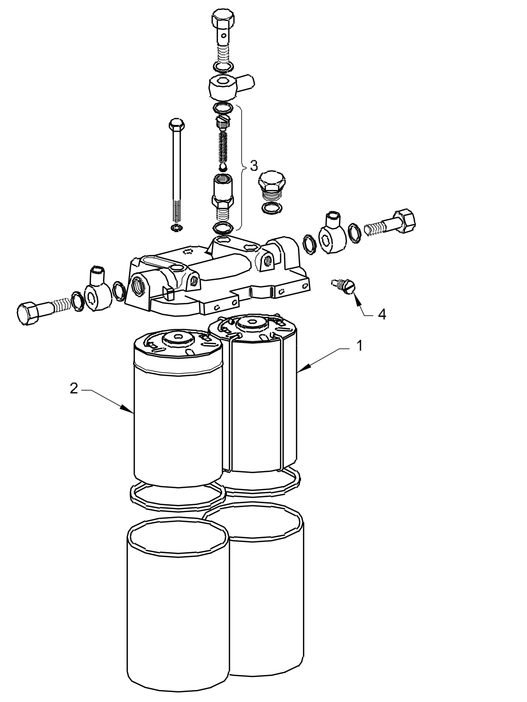
There are two types of fuel filtering system.

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

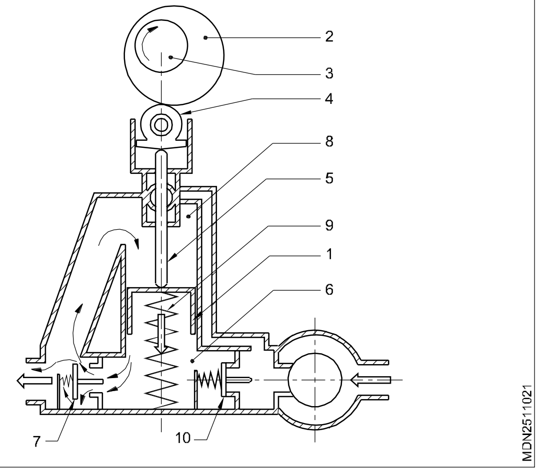
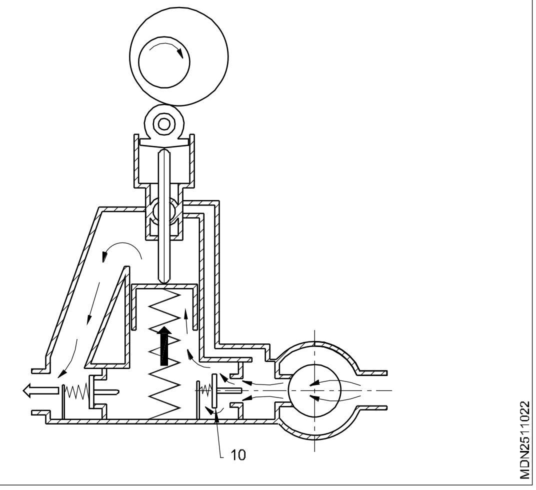


Fig 2



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.

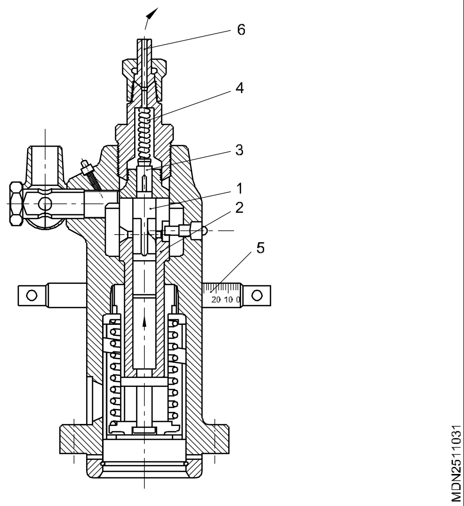
Distributor or rotary type of fuel injection pump has a single pumping element, which supplies fuel to all the cylinders. Distribution to the individual injector is effected by a rotor having a single inlet and delivery, in turn to the appropriate number of outlets. This is done with the help of rotor. 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) .

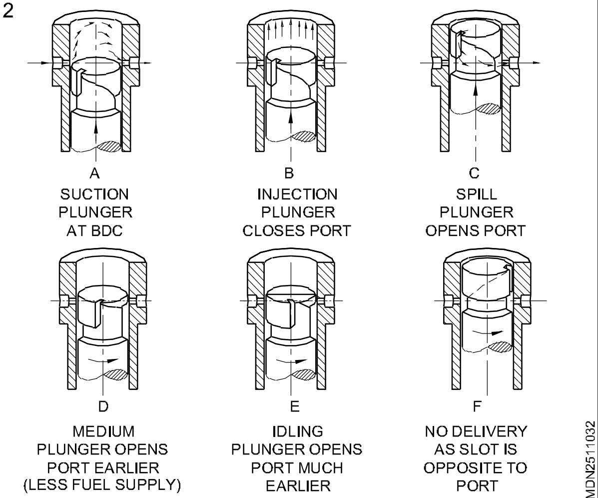
This pressure lifts the fuel delivery valve (3) and the fuel enters the fuel line (6) which is connected to the injector. As the pipe is already full of fuel the extra fuel which is being pumped causes a rise in the pressure throughout the line and lifts the injector valve. This permits the fuel to be 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



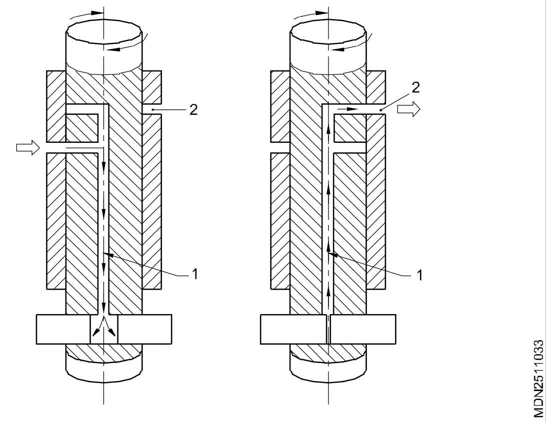
The governor controls all engine speeds upto a maximum, according to pedal pressed by driver. Different positions of the plunger and the fuel flow is given in the figure.

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

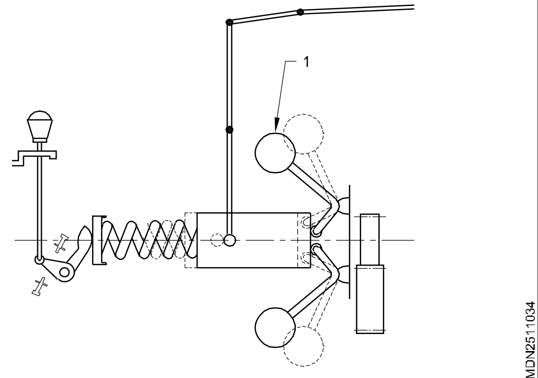
Servo

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

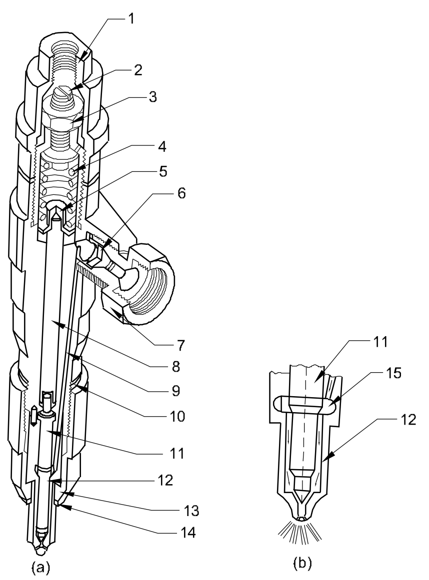
Objectives: At the end of this lesson you shall be able to
- **explain function of injectors**
- **list out different types of injectors**
- **explain special features of various types of nozzles**
- **explain specification of nozzle and nozzle holder.**
- **explain cumming & detrit diesel injection**
- **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.

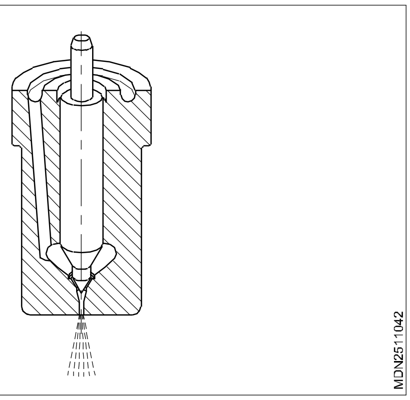
Following types of nozzles are used in engine.

- 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.

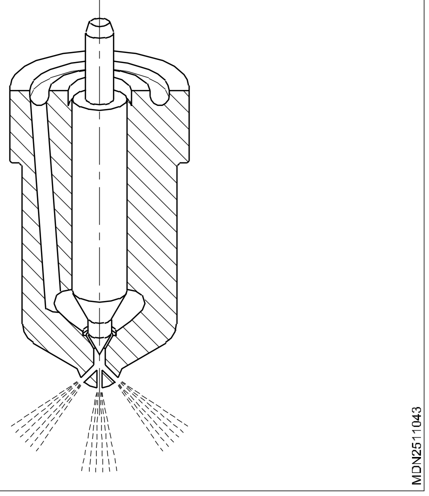
Fig 2



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.

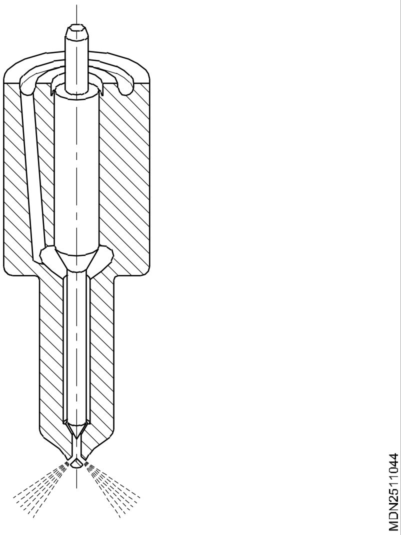
Fig 3



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.

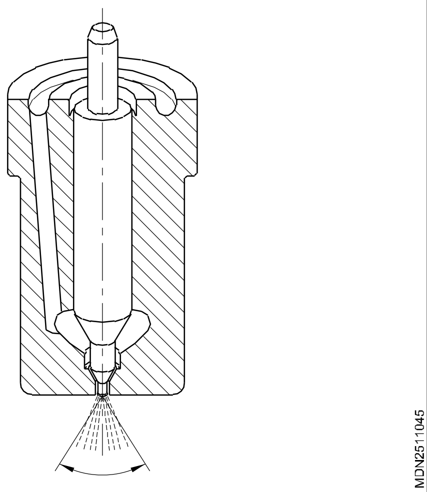
Fig 4



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.

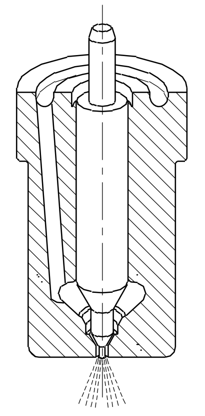


Fig 6

DELAY

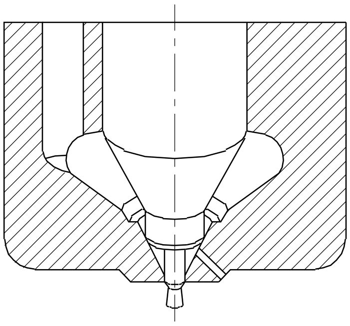


Fig 7

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)

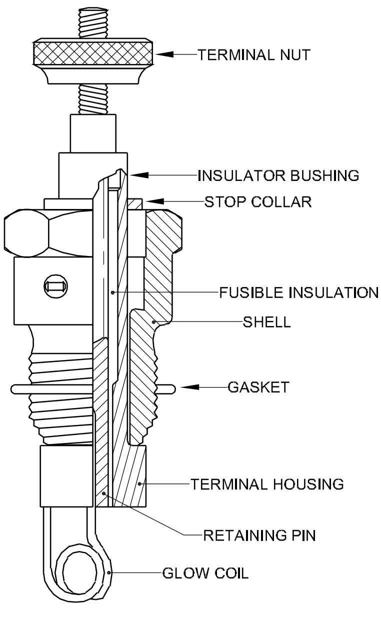


Fig 8

CONSTRUCTION OF THE DUAL - POLE GLOW PLUG

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

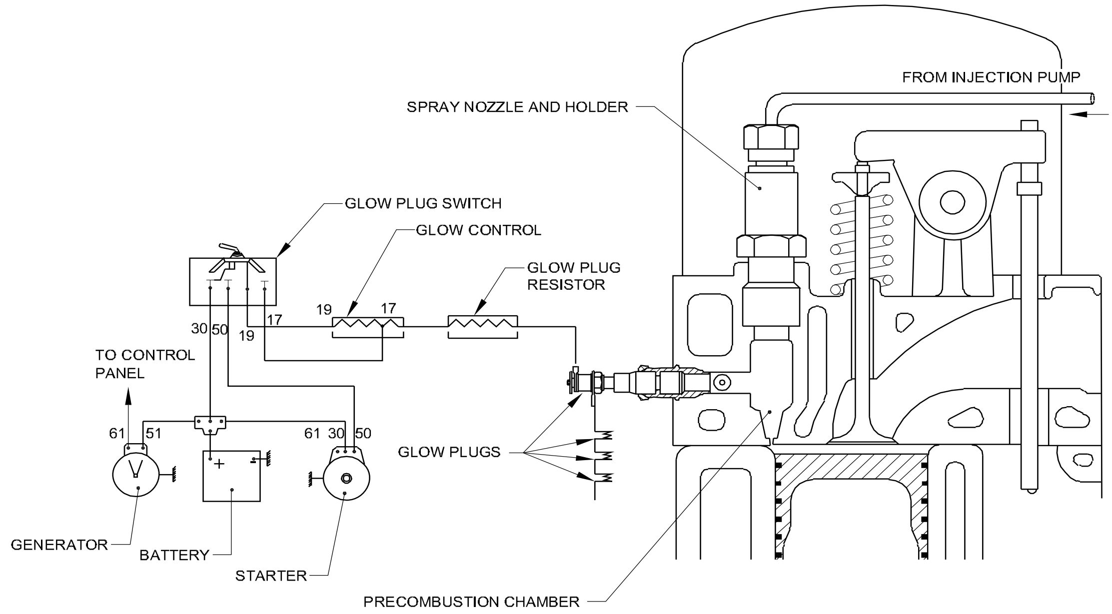
Detroit diesel cummings diesel well known for favouring unit injectors, in which the high-pressure pump is contained within the injector itself. This leads to the development of the modern unit injector.

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
Engine speed sender CKP
Hall sender CMP
Accelerator pedal position APP
Air mass meter HFM
Intake air temperature IAT
Coolant temperature ECT
Radiator outlet coolant temperature
Charge pressure sender G31
Fuel temperature sender
Fuel pressure sender
Exhaust gas recirculation potentiometer
Lambda probe
Exhaust pressure sender
Cutch position
Throttle valve potentiometer
Brake ligjt switch

→ **ECU** →

Output from ECU
Fuel pump relay
Fuel pump for pre-supply
Injection valves
Valve for fuel dosage
Fuel pressure regulating valve
Solenoid valve for cahrge pressure control
Intake manifold flap motor
Throttle valve module
Exhaust gas recirculation valve
Radiator Fan
Automatic glow period control unit
Lambda probe heater

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.

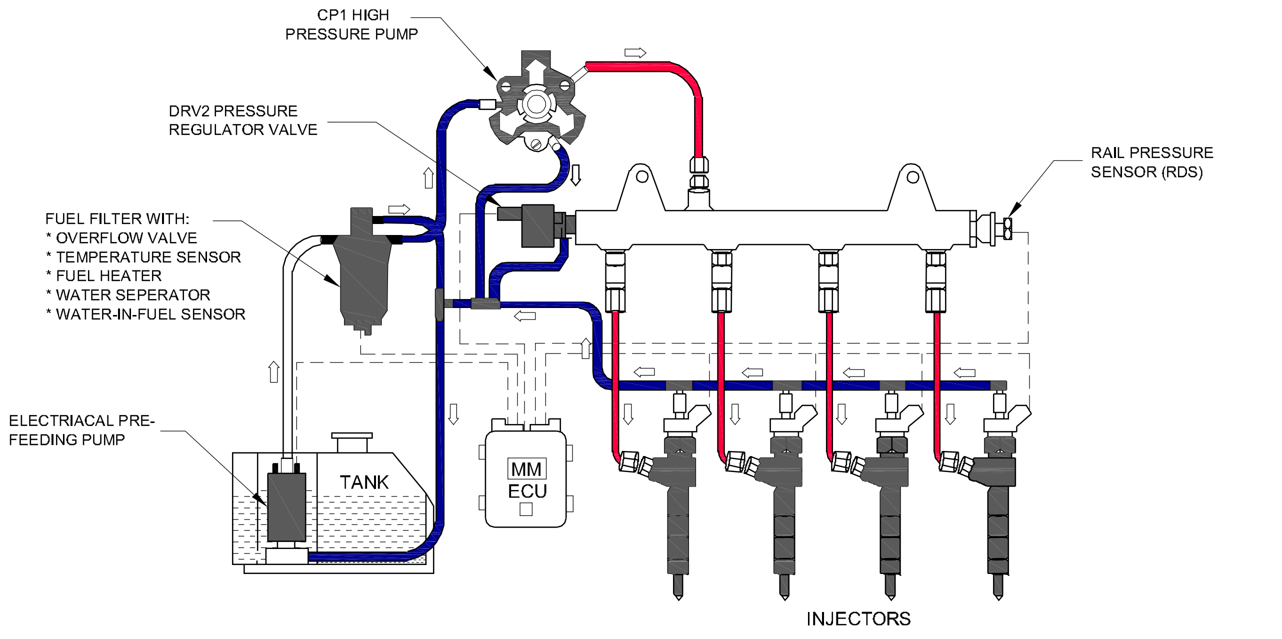
Common rail diesel injection CRDI

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)

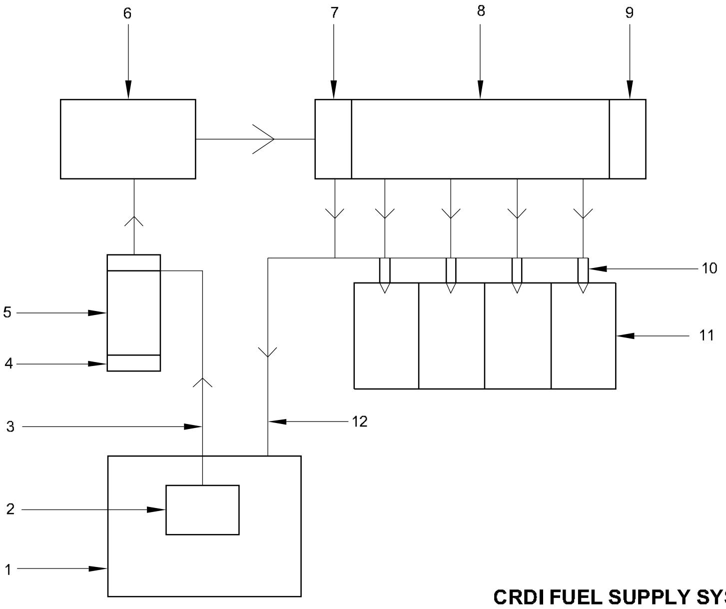
The common rail consists of fuel tank, electrical fuel pump (low pressure) in placed inside the fuel tank, It develops pressure upto 6 bar and supplies to the high pressure fuel pump (CRDI) through fuel filter and water separator. The high pressure fuel pump develops pressure 200 to 2000 bar and supplies 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

Fig 2



1. FUEL TANK
2. ELECTRICAL FUEL PUMP
3. FUEL SUPPLY LINE
4. WATER SEPARATOR
5. FUEL FILTER
6. HIGH PRESSURE FUEL PUMP (CRDI PUMP)
7. FUEL PRESSURE REGULATOR
8. COMMON RAIL
9. FUEL RAIL PRESSURE SENSOR
10. FUEL INJECTOR
11. ENGINE
12.FUEL RETURN LINE

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.

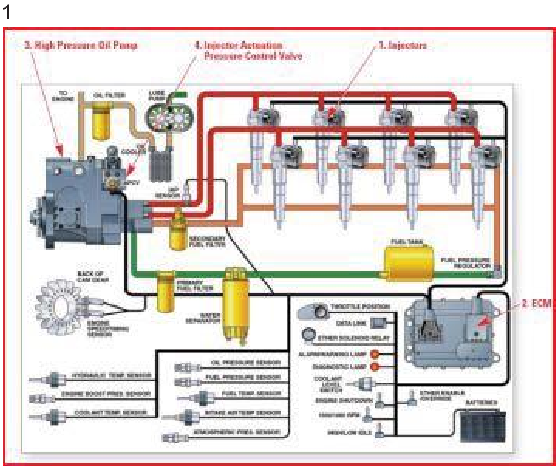
Optimum performance The control of fuel delivered during ignition delay and main injection, known as rate shaping, is made possible by the HEUI's ability to operate independent of engine speed. Rate shaping modifies engine heat release characteristics, which also helps reduce emission and noise levels. 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



MDN2511431

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

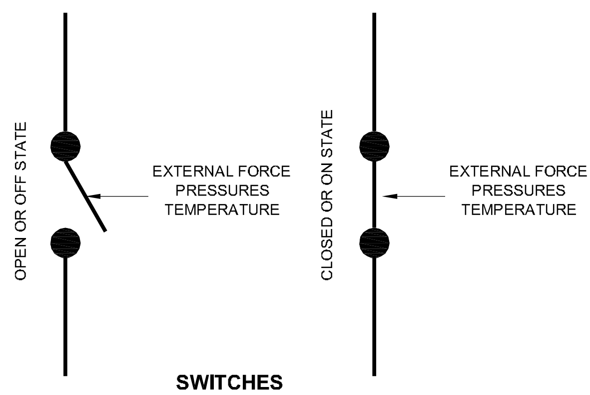
Hot film air mass meter

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



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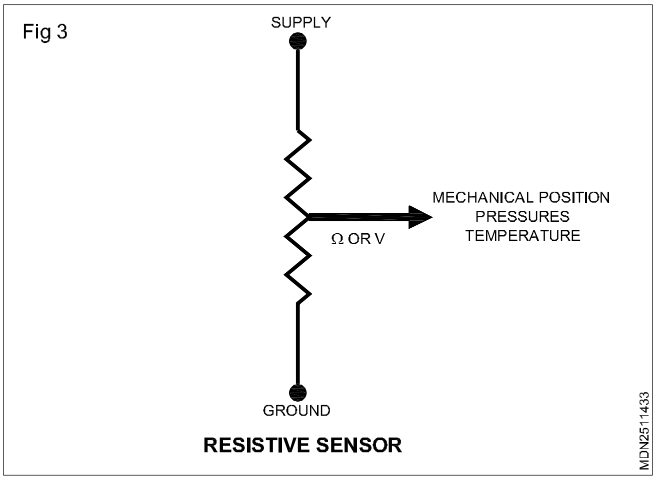
Resistive sensor (Fig 3)

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

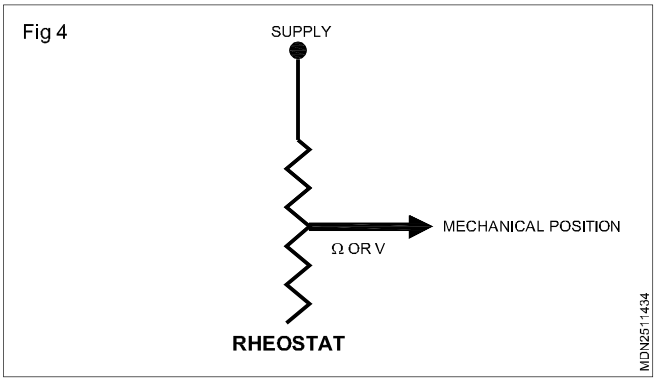


Types of resistive sensor

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

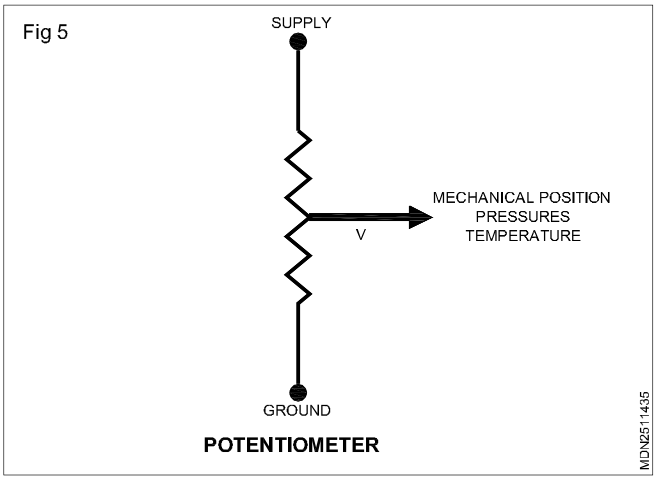
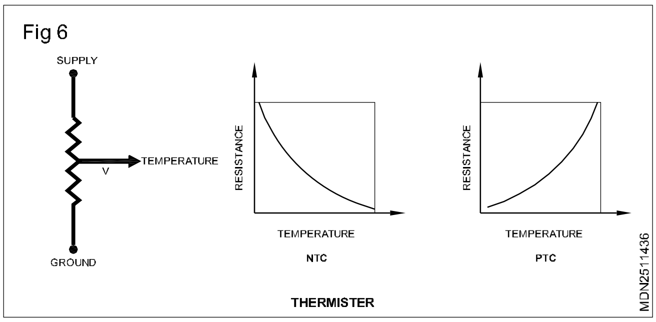


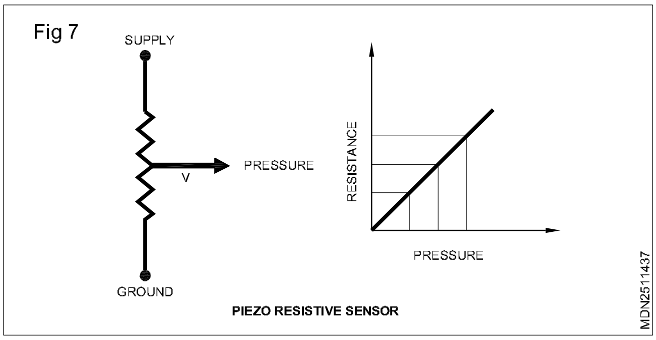
Fig 6



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.

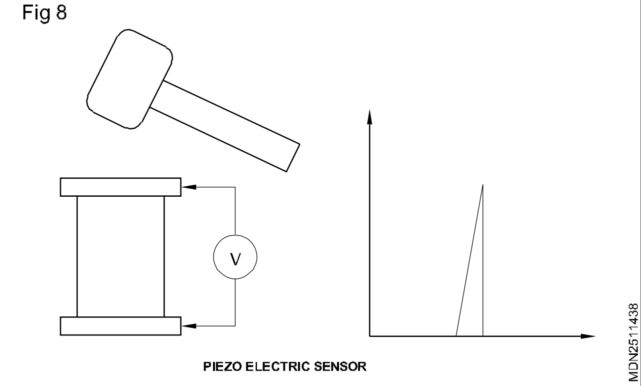
1 Piezo electric sensor

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

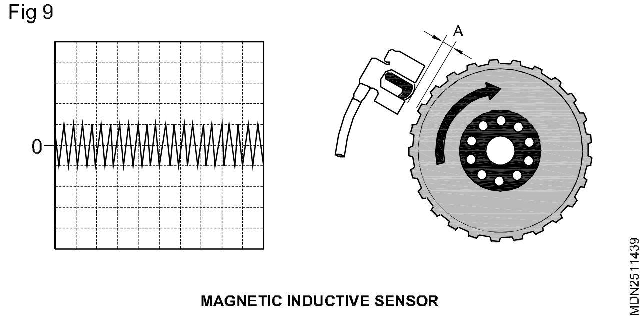


PIEZO ELECTRIC SENSOR

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

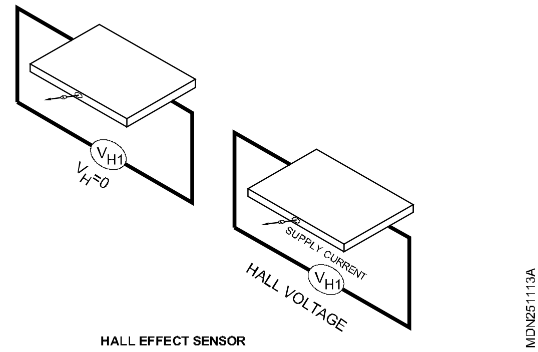


MAGNETIC INDUCTIVE SENSOR

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

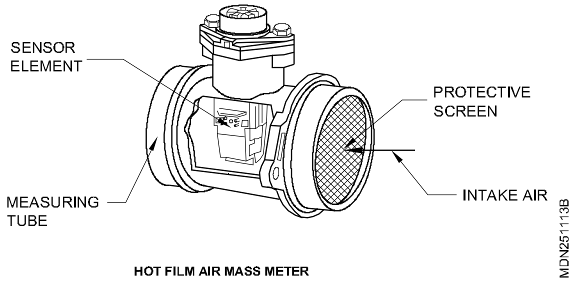


HALL EFFECT SENSOR

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

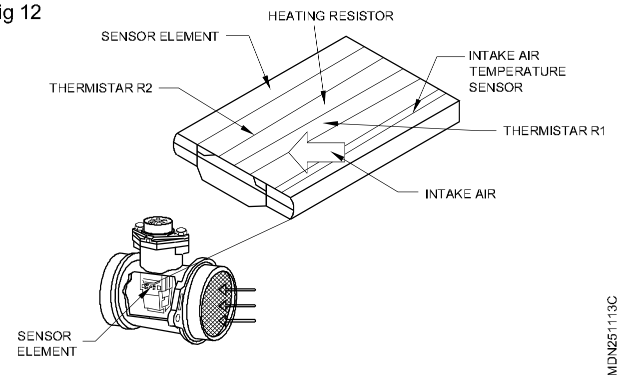


HOT FILM AIR MASS METER

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.

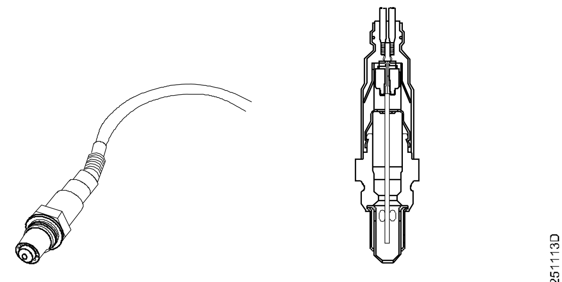
Fig 12



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

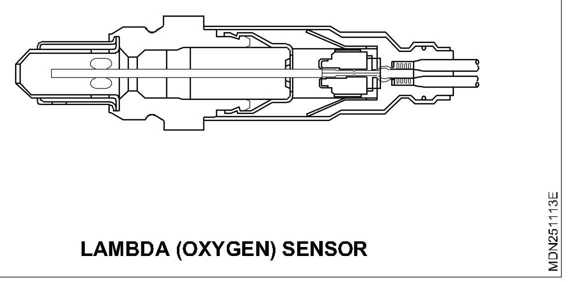


LAMBDA (OXYGEN) SENSOR

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

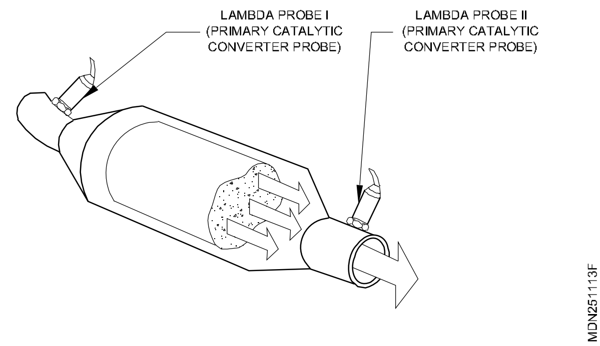


LAMBDA (OXYGEN) SENSOR

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



Actuators

1 Injectors

2 Powerwindows

3 Wiper motos

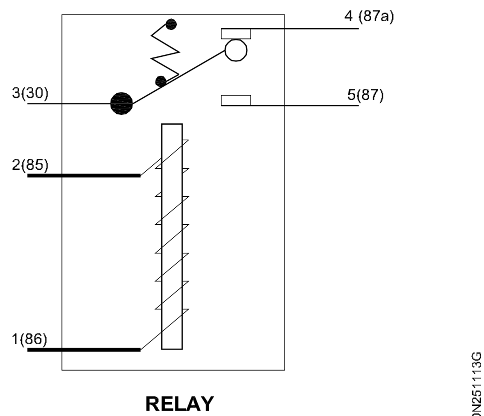
4 Relays etc

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

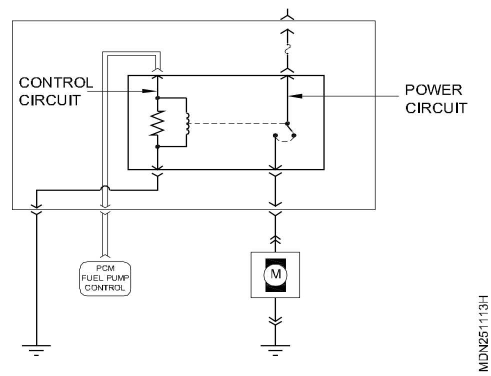


RELAY

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)

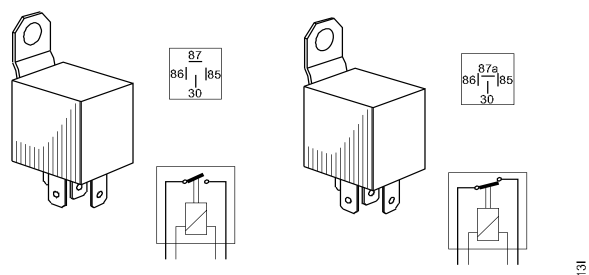
Fig 17



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

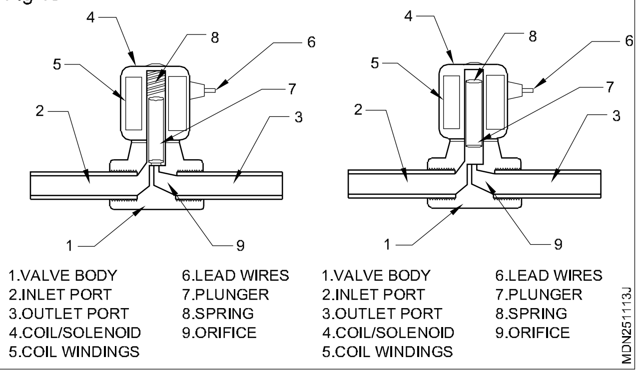
Working principles of acturators

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