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 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 charge escapes 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 the engine cylinder	During the suction stroke air alone is sucked in to the cylinder
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 electric spark.	Fuel is ignited due to the heat of the highly compressed air. Combustion takes place at constant pressure.
Spark plug is used	Injector is used.
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

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.

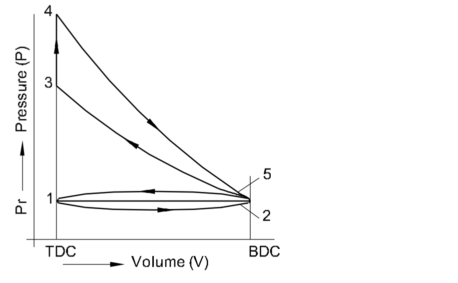
Suction takes place at a pressure below atmospheric pressure when piston moves from TDC to BDC. (1-2)

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.

Fig 8



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

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

Diesel Cycle

1 - 2 - Suction

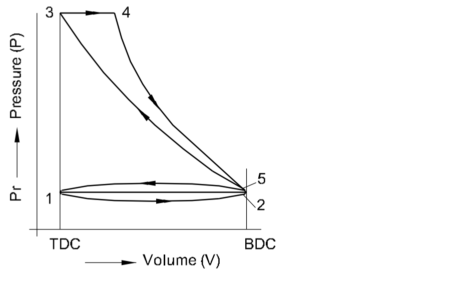
2 - 3 - Compression

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)

Fig 9



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)

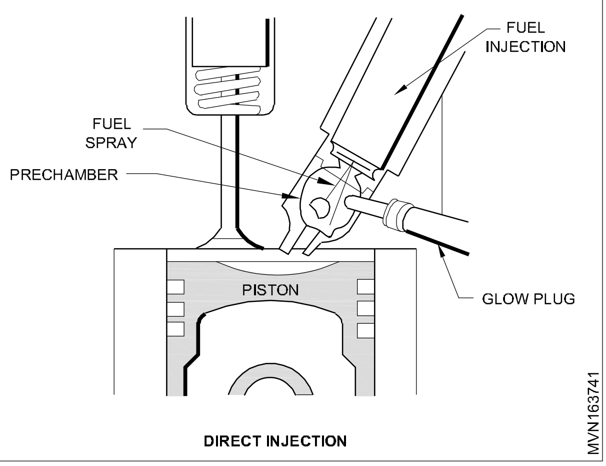
Direct and indirect fuel injection system

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



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.

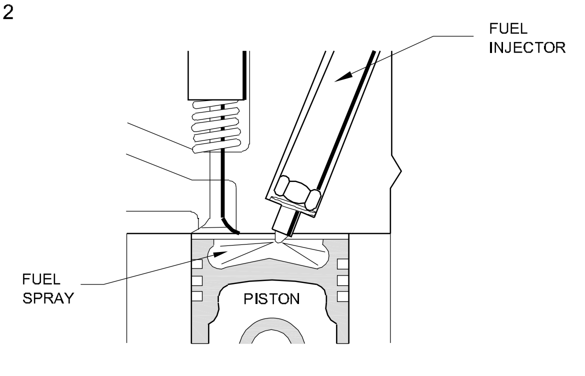
Disadvantages of Direct Fuel Injection

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

Fig 2



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.

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 position 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.

$$IHP = \frac{PLAN}{4500} X K$$

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

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

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 types.

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

Technical 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 injection: nozzle pressure	5 kg/cm^2
Inlet 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
Capacity of cooling system	20 litres
Crankcase oil capacity	Maximum - 14 litres Minimum - 10 litres
Cooling water temperature	75°C - 95°C

Depth max : 223 mm $\left(8\frac{3''}{4}\right)$

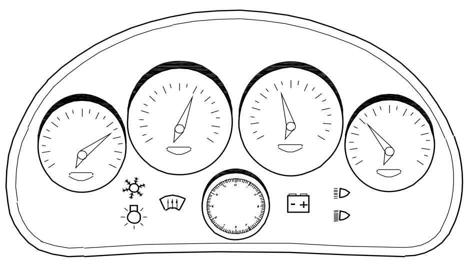
Dashboard gauges, meters and warnings lights

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

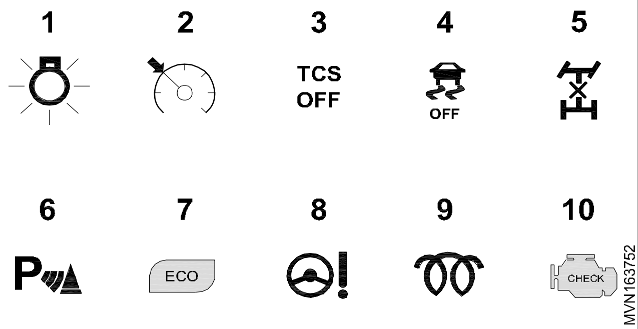
A speedometer or a speed meter is a gauge that measures and displays the instantaneous speed of a vehicle. The unit in which the display shown is in Km/hr. There are both analog and digital meters are available now a days.

Engine RPM meter

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

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

Fig 2



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 combustion champer when you first start it in the morning, glow plugs heat up the fuel coming out of the injectors to give the engine 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:** 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.

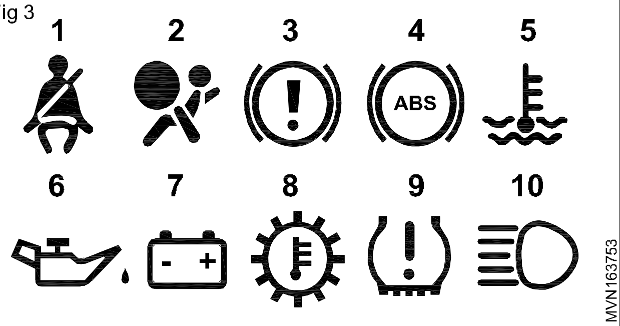
Panel board indicator lights

1 **Seatbelt indicator:** 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.

3 **Brake indicator:** This signals light indicate such as several things. (Fig.3)

Fig 3



a Vehicle parking brake is engaged, so disengage it;

b The parking brake sensor is out of alignment, so have align and fixed it properly.

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 engine 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 one.

10 **High beam indicator:** While not a warning light perse, this bright-icon represents a big danger to other motorists, and it 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

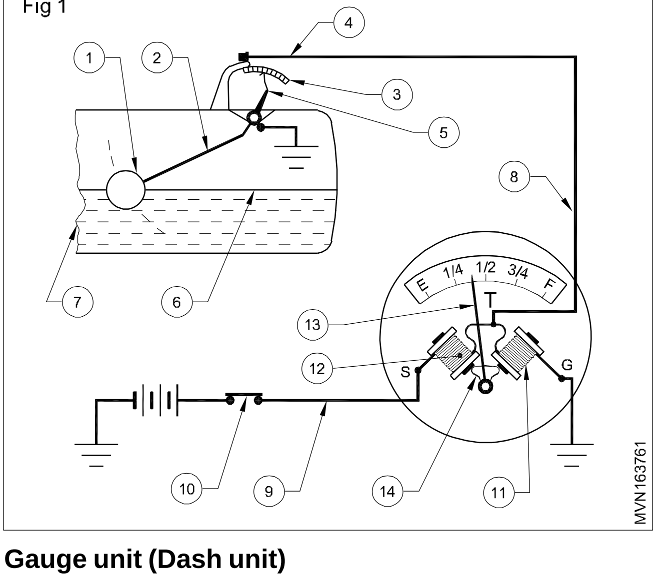
It is used to know the quantity of fuel available in the fuel tank.

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



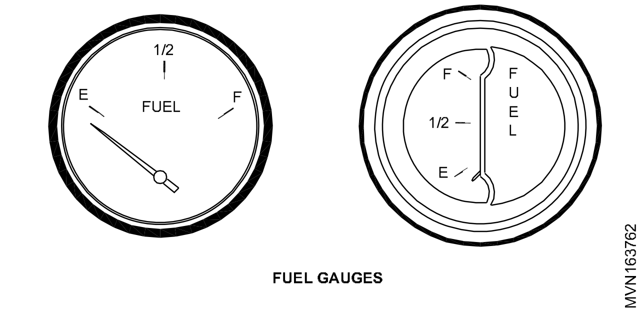
Gauge unit (Dash unit)

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



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.

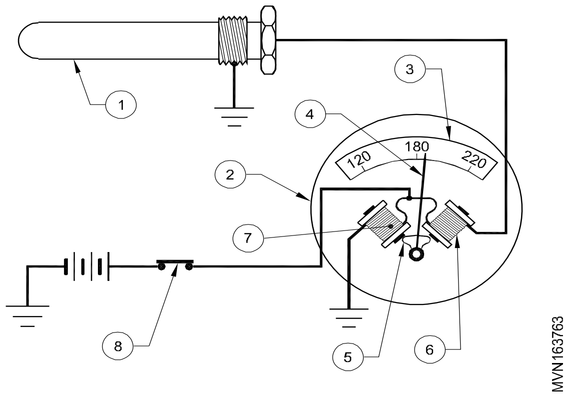
Temperature gauge

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.

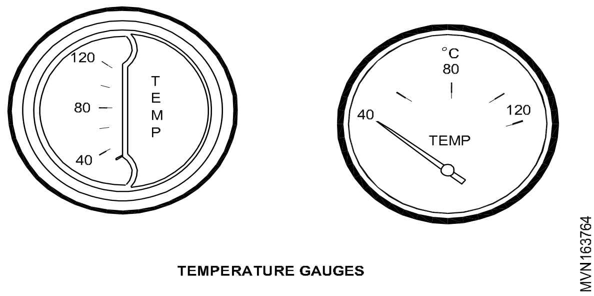
- It consists of an engine unit (1) immersed in the engine coolant in the cylinder head or cylinder block in the form of a pellet. (Fig 3)

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)

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.

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)

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

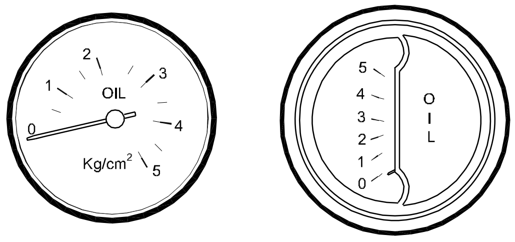
The dash unit consists of two coils (11) & (12) and a pointer (13) with a magnet (14) attached to it. Both coils are connected in series with battery through ignition switch.

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

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

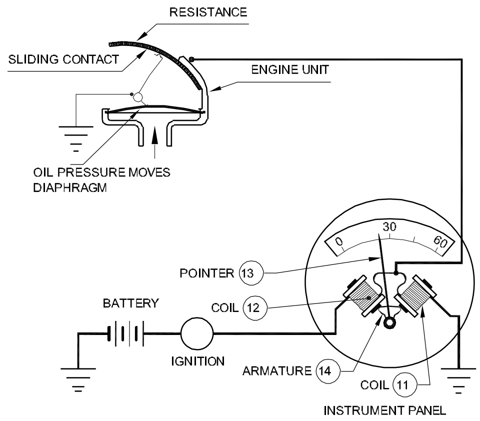
Consequently the armature and the pointer swing towards the right side in indicate higher oil pressure.

Fig 5



OIL PRESSURE GAUGES

Fig 6



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

Starting and stopping methods of engine

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

- **list out different types 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

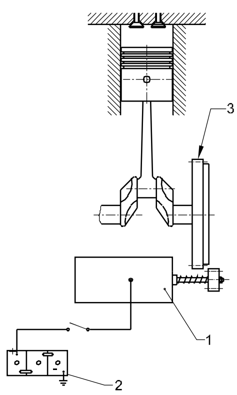
Hand cranking

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)

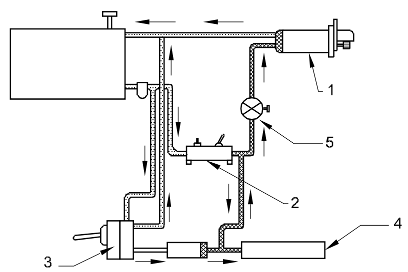
Fig 1



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

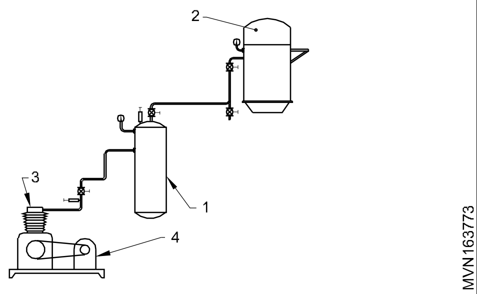
In this method compressed air from the reservoir (1) is admitted through an automatic starting valve in the engine cylinder head when the piston is at the top dead centre at the beginning of the power stroke, at a pressure capable of cranking the engine (2). When the engine is turning fast enough, the 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)

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.

Fig 3



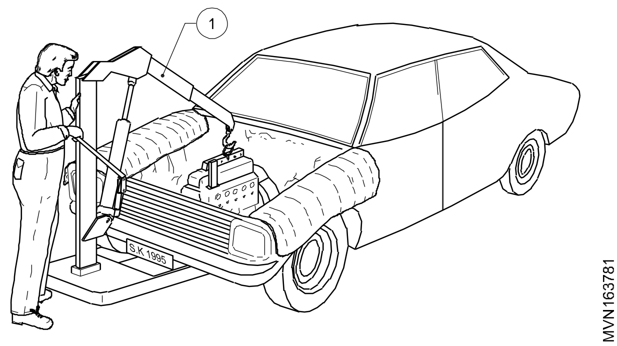
Procedure for dismantling of diesel engine from the vehicle

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 the oil pipe to oil pressure gauge connections (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 connections, 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 not rest on the oil sump.

Petrol engine basics

Objectives: At the end of this lesson you shall be able to
- **explain the characteristics of gasoline fuel**
- **state that engine power transfer**
- **state the engine components.**

Gasoline fuel system

The fuel system is made of the fuel tank, pump, filter and injectors or carburettor and it is responsible for delivering fuel to the engine as needed. Each fuel system components perform easy flow to achieve expected engine performance and reliability.

Fuel system injectors/ carburettor

The fuel injector is a last stop for fuel inside the engine combustion chamber it is basically an electrically operated and injected fuel is enough to run the engine.

Carburators are used for mixing vaporized fuel with air to produce explosive mixture for internal combustion engines.

Cam and camshaft

Most of inline engine camshaft is mounted on lower part of cylinder block and modern engines camshaft is mounted on the cylinder head. Camshaft gets drive from crankshaft and it is operate the valves through operating mechanism.

Engine power transfer

Engine power is transferred through piston, connecting rod, crankshaft, fly wheel and then clutch, gearbox, universal joint, propeller shaft, final drive, differential to wheels. The vehicle wheels move the vehicle.

Counter weights: Counterweights are used for balancing the crank shaft of the engine. It helps to run the engine smoothly at higher RPM. The weight of the piston and connecting rod combination affects the size and placement of the counter weight.

Piston components: Piston is one of the most important parts in a reciprocating engine. Piston helps to convert the heat energy obtained by the combustion of fuel into mechanical energy piston is incorporated with piston rings piston pin, connecting rod and other components to achieve the high compression pressure inside of the cylinder.

EFI air cleaner

Air cleaner contains an air filter in a device composed of fibrous or porous materials which removes solid particulates such as dust, pollens and bacteria from air. Filters containing an absorbent (or) catalyst such a charcoal also remove odors and gaseous pollutants (Ex.volatile organic) Airfilters are used in application where air quality is important, notability in building ventilation in engines. Air compressors tend to use either paper foam or cotton filters, oil bath filters have fallen out of favour. The technology of air intake filters of gas turbine has improvements in the I.C engines air filters). Air enters the engine through the air intake or air induction system. The grit and dust particles in this air must be removed before it enters the engines

Gasoline fuel: Gasoline is the hightest and most volatile liquid by refining the petroleum. The major characteristics of gasoline is as follows.

Velocity: Easy starting, quick warning, good economy smooth acceleration, freedom from vapour lock, freedom from crankcase dilution, volatility bend, indication of volatility. The more volatile of gasoline give more uniform its distribution to the various cylinders and the smoother operation of the engine.

Purity: The gasoline must be free from dirt, grease and trees of chemical and water.

Sulphur content: Too much sulphur is likely to corrode cylinder bores and bearing surfaces.

Gum content: Fuel gun content creates a number of operating difficulties such as carbon deposits, sticking valves and piston rings, clogged carburettor jet. Gasoline should have a minimum amount of gum.

Antiknock quality: The antiknock compound is able to slow down the combustion of fuel and so preventing the knocking.

Calorific value: Fuel must have a high calorific value.

Operating economy: The nature of the fuel is determines kilometres per litre of the fuel.

Viscosity: This is a physical property. This indicates the quality of fuel flow.

Carburattor air cleaner: The atmospheric air enters the air cleaner through the side passage and clean the dust particles. Fine particles are collected by the filter element and then cleaned air is passes via carburettor unit into the inlet manifold. Then air fuel mixture enter into the cylinder during suction stroke.

Inlet manifold: The inlet manifold is used to supply the air fuel mixture in carburettor system and fresh compressed air in EFI system to the intake ports in the cylinder head.

Pressure and vacuum

When an engine is idling there is a vacuum in the intake manifold. This vacuum pulls fuel and increases the effective pressure.

Intake air heating: Heating charge air an important measure to ensure reliable cold starting and to reduce white smoke and unburned hydrocarbon emissions. In take air heating can be provided in cylinder with glow plugs. In some engine glow plugs are provided in air intake system.

Stoichiometeric ratio: The stoichiometric ratio is the exact ratio between air and flammable gas or vapor at which complete combustion takes place. The stoichiometric ration of combustion verify from different types of fuels and oxidizers.

Air density: The density of air is mass per unit volume of earth's atmosphere. Air density like air pressure, decreases with increasing high attitude. It also changes with variation in atmospheric pressure, temperature and humidity.

Electronic fuel injection (Fig.1)

Engine is the heart of a car, then its brain must be the Engine Control Unit (ECU). Also known as a Powertrain Control Module (PCM), the ECU optimizes engine performance by using sensors to decide how to control certain actuators in an engine. A car's ECU is primarily responsible for four tasks. Firstly, the ECU controls the fuel mixture. Secondly, the ECU controls idle speed. Thirdly, the ECU is responsible for ignition timing. Lastly, in some applications, the ECU controls valve timing.

The electric fuel pump usually comes in an in-tank module that consists of a pump, a filter, and a sending unit. The sending unit uses a voltage divider to tell your gas gauge how much fuel you have left in your tank. The pump sends the gasoline through a fuel filter, through fuel lines, and into a fuel rail.

A vacuum-powered fuel pressure regulator at the end of the fuel rail ensures that the fuel pressure in the rail remains constant relative to the intake pressure. For a gasoline engine, fuel pressure is usually on the order of 35-50 psi. Fuel injectors connect to the rail, but their valves remain closed until the ECU decides to send fuel into the cylinders.

Fig.1

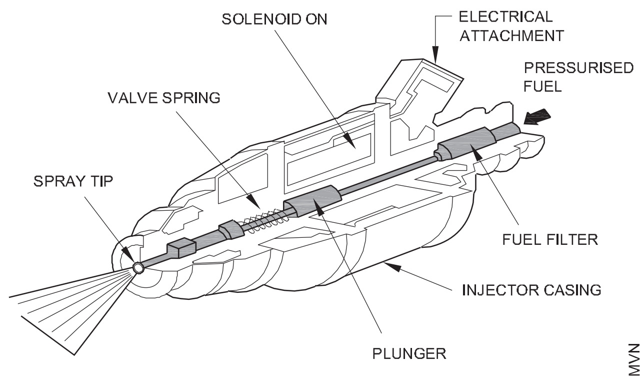
Usually, the injectors have two pins. One pin is connected to the battery through the ignition relay and the other pin goes to the ECU. The ECU sends a pulsing ground to the injector, which closes the circuit, providing the injector's solenoid with current. The magnet on top of the plunger is attracted to the solenoid's magnetic field, opening the valve. Since there is high pressure in the rail, opening the valve sends fuel at a high velocity through the injector's spray tip. The duration that the valve is open- and consequently the amount of fuel sent into the cylinder- depends on the pulse width (i.e. how long the ECU sends the ground signal to the injector).

When the plunger rises, it opens a valve and the injector (Fig.2) sends fuel through the spray tip and into either the intake manifold, just upstream of the intake valve, or directly into the cylinder. The former system is called multiport fuel injection and the latter is direct injection.

When a driver pushes his or her gas pedal, an accelerator pedal position sensor (APP) sends a signal to the ECU, which then commands the throttle to open. The ECU takes information from the throttle position sensor and APP until the throttle has reached the desired position set by the driver.

Either a mass air flow sensor (MAF) or a Manifold Absolute Pressure Sensor (MAP) determines how much air is entering the throttle body and sends the information to the ECU. The ECU uses the information to decide how much

Fig 2



fuel to inject into the cylinders to keep the mixture stoichiometric. The computer continually uses the TPS to check the throttle's position and the MAF or MAP sensor to check how much air is flowing through the intake in order to adjust the pulse sent to the injectors, ensuring that the appropriate amount of fuel gets injected into the incoming air. In addition, the ECU uses the o2 sensors to figure out how much oxygen is in the exhaust. The oxygen content in the exhaust provides an indication of how well the fuel is burning. Between the MAF sensors and the 02 sensor, the computer fine-tunes the pulse that it sends to the injectors.

Controlling idle

Let's talk about idling. Most early fuel injected vehicles utilized a solenoid-based idle air control valve (IAC) to vary air flow into the engine during idle (see the white plug in the above image). Controlled by the ECU, the IAC bypasses the throttle valve and allows the computer to ensure smooth idle when the driver does not activate the accelerator pedal. The IAC is similar to a fuel injector in that they both alter fluid flow via a solenoid actuated pin.

Most new cars don't have IAC valves. With older cable-controlled throttles, the air entering the engine during idle had to go around the throttle plate. Today, that's not that case, as Electronic Throttle Control systems allow the ECU to open and close the butterfly valve via a stepper motor.

The ECU monitors the rotational speed of the engine via a crankshaft position sensor, which is commonly a Hall Effect sensor or optical sensor that reads the rotational speed of the crank pulley, engine flywheel, or the crankshaft itself. The ECU sends fuel to the engine based upon how fast the crankshaft rotates, which is directly related to the load on the engine. Let's say you turn on your air conditioning or shift your vehicle into drive. The speed of your crankshaft will decrease below the threshold speed set by the ECU due to the added load. The crankshaft position sensor will communicate this decreased engine speed to the ECU, which will then open the throttle more and send longer pulses to the injectors, adding more fuel to compensate for the increased engine load. This is the feedback control.

When you initially turn on the vehicle, the ECU checks the engine temperature via a coolant temperature sensor. If it notices that the engine is cold, it sets a higher idle threshold to warm the engine up.

The ECU's tasks of maintaining engine idle speed, as well as maintaining a proper air/fuel mixture, let's talk about ignition timing. To achieve optimum operation, the spark plug must be provided with current at very precise moments, usually about 10 to 40 crankshaft degrees prior to top dead center depending on engine speed. The exact moment that the spark plug fires relative to the piston's position is optimized to facilitate the development of peak pressure. This allows the engine to recover a maximum amount of work from the expanding gas.

Modern vehicles don't use a centrally located ignition coil. Instead, these distributorless ignition systems (DIS) have a coil located on each individual spark plug. Based on input from the crankshaft position sensor, knock sensor, coolant temperature sensor, mass airflow sensor, throttle position sensor, and others, the ECU determines when to trigger a driver transistor, which then energizes the appropriate coil.

The ECU is able to monitor the piston's position via the crankshaft position sensor. The ECU continually receives information from the crankshaft position sensor and uses it to optimize spark timing. If the ECU receives information from the knock sensor (which is nothing more than a small microphone) that the engine has developed a knock (which is often caused by premature spark ignition), the ECU can retard ignition timing so as to alleviate the knock.

Controlling Valve Timing

The fourth major function of the ECU is to adjust valve timing. This applies to vehicles that utilize variable valve timing, which allows engines to achieve optimal efficiency at a multitude of engine speeds.

Scavenging

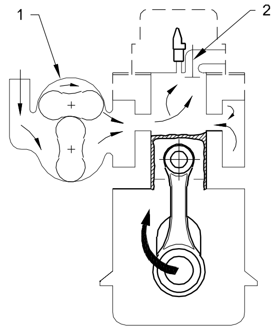
Objective: At the end of this lesson you shall be able to
- **explain the process of scavenging in two stroke diesel engine.**

Scavenging process

The process of driving exhaust gases, out of the cylinder and replacing it with fresh air is called scavenging. In two-stroke diesel engines, all the four process take place in one revolution of the crank shaft or two strokes of the piston.

A series of ports or openings are arranged around the cylinder in such a position that openings are opened when the piston is at the bottom of the stroke. A blower (1) forces air into the cylinder through the opened ports exhaust valve (2) there by filling the cylinder with fresh air. This is called scavenging.

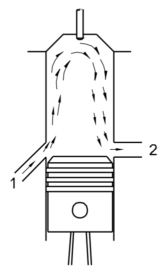
Fig 2



SCAVENGING PROCESS

Loop scavenging

Fig 1



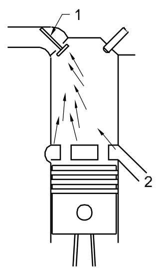
LOOP SCAVENGING

In this type, inlet (1) and exhaust (2) ports are provided on opposite sides of cylinder. Air entering the cylinder drives out burnt gases in the form of a loop.

Following types of scavenging methods are also used in two stroke engines, other that the one's described above.

Uniflow scavenging

Fig 3



UNIFLOW SCAVENGE
G.M.DIESEL

An exhaust valve (1) is provided on top of the cylinder. Air entering into the cylinder through the inlet port (2) drives out burnt gases flowing in the same direction.