UNIT 1

INTRODUCTION TO AUTOMOBILE ENGINEERING

1.1 INTRODUCTION

Automobile engineering is the one of the stream of mechanical engineering. It deals with the various types of automobiles, their mechanism of transmission systems and its applications. Automobiles are the different types of vehicles used for transportation of passengers, goods, etc. Basically all the types of vehicles works on the principle of internal combustion processes or some times the engines are called as internal combustion engines. Different types of fuels are burnt inside the cylinder at higher temperature to get the transmission motion in the vehicles. Most of the automobiles are internal combustion engines vehicles only. Therefore, every mechanical and automobile engineer should have the knowledge of automobile engineering its mechanism and its various applications.

1.2 DEFINITION

Automobile engineering is a branch of engineering which deals with everything about automobiles and practices to propel them. Automobile is a vehicle driven by an internal combustion engine and it is used for transportation of passengers and goods on the ground. Automobile can also be defined as a vehicle which can move by itself.

Examples : Car, jeep, bus, truck, scooter, etc.

1.3 CLASSIFICATION OF VEHICLES

Automobiles or vehicles can be classified on different bases as given below :

On the Basis of Load :

(a) Heavy transport vehicle (HTV) or heavy motor vehicle (HMV),

e.g. trucks, buses, etc.

(b) Light transport vehicle (LTV)

e.g. pickup, station wagon, etc.

(c) Light motor vehicle (LMV),

e.g. cars, jeeps, etc.

On the Basis of Wheels :

(a) Two wheeler vehicle,
for example : Scooter, motorcycle, scooty, etc.

(b) Three wheeler vehicle,
for example : Auto rickshaw, three wheeler scooter and tempo, etc.

(c) Four wheeler vehicle,
for example : Car, jeep, trucks, buses, etc.

(d) Six wheeler vehicle,
for example : Big trucks with two gear axles each having four wheels.

On the Basis of Fuel Used

(a) Petrol vehicle,

e.g. motorcycle, scooter, cars, etc.

(b) Diesel vehicle,

e.g. trucks, buses, etc.

(c) Electric vehicle,

e.g. battery drive

(d) Steam vehicle,

e.g. an engine which uses steam.

(e) Gas vehicle,

e.g. LPG and CNG vehicles, where LPG is liquefied petroleum gas and CNG is compressed natural gas.

On the Basis of Body

On the basis of body, the vehicles are classified as :

(a) Sedan with two doors

(b) Sedan with four doors

(c) Station wagon

(d) Convertible, e.g. jeep, etc.

(e) Van

(f) Special purpose vehicle,

e.g. ambulance, milk van, etc.

Transmission

(a) Conventional vehicles with manual transmission, e.g. car with 5 gears.

(b) Semi-automatic

(c) Automatic : In automatic transmission, gears are not required to be changed manually. It is automatically changes as per speed of the automobile.

Position of Engine

Engine in Front :

Most of the vehicles have engine in the front.

Example : most of the cars, buses, trucks in India.

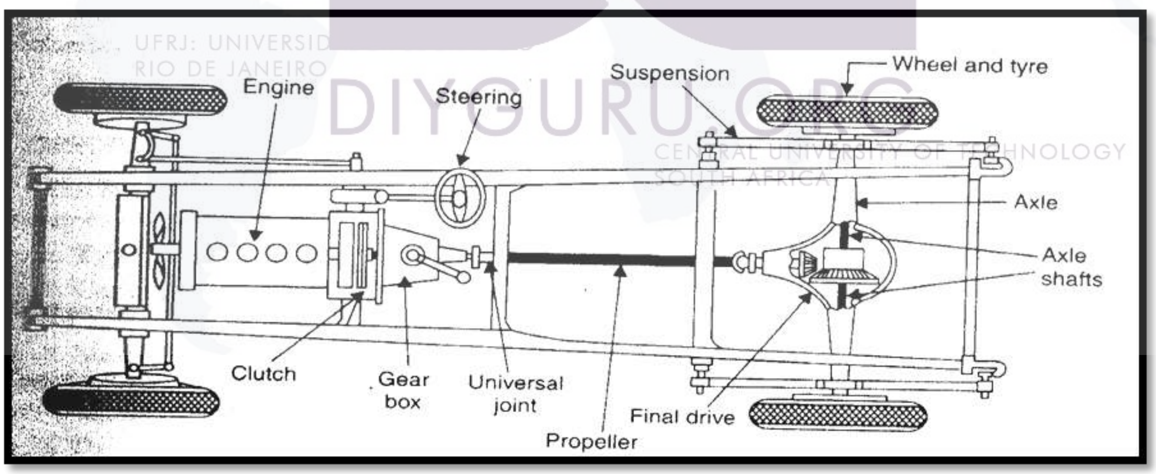
Engine in the Rear Side:

Very few vehicles have engine located in the rear.

Example : Nano car.

1.4 LAYOUT OF AN AUTOMOBILE CHASIS

Layout of an engine chassis is shown below :



It contains the source of power, i.e. engine, the frame, which supports the engine,

wheels, body, transmission, the braking system and the steering. It also gives support to suspension system and springs.

1.5 COMPONENTS OF THE AUTOMOBILE

The automobile can be considered to consist of five basic components :

(a) The Engine or Power Plant : It is source of power.

(b) The Frame and Chassis : It supports the engine, wheels, body, braking system, steering, etc.

(c) The transmission which transmits power from the engine to the car wheels. It consists of clutch, transmission, shaft, axles and differential.

(d) The body fitted on chassis.

(e) Accessories including light, air conditioner/hearer, stereo, wiper, etc.

1.6 FUNCTIONS OF MAJOR COMPONENTS OF AN AUTOMOBILE

Chassis and Frame :

The chasis is formed by the frame with the frame side members and cross members. The frame is usually made of box, tubular and channel members that are welded or riveted together. In addition to this, it comprises of the springs with the axles and wheels, the steering system and the brakes, the fuel tank, the exhaust system, the radiator, the battery and other accessories. Along with this the frame supports the body.

Engine or Power Plant :

The engine is the power plant of the vehicle. In general, internal combustion engine with petrol or diesel fuel is used to run a vehicle. An engine may be either a two-stroke engine or a four-stroke engine.

An engine consists of a cylinder, piston, valves, valve operating mechanism, carburetor (or MPFI in modern cars), fan, fuel feed pump and oil pump, etc.

Besides this, an engine requires ignition system for burning fuel in the engine cylinder.

Transmission System (Clutch and Gear Box):

The power developed by the engine is transferred to the wheels by transmission system. Transmission system must do three jobs :

(a) It must provide varying gear ratios. Number of gear ratio are equal to number of gears in a vehicle.

(b) It must provide a reverse gear for moving vehicle in reverse direction.

(c) It must provide a neutral or disconnecting arrangement so that the engine can be uncoupled from the wheels of the vehicle. In a conventional transmission system, there is a clutch, a manually operated transmission (gear box), a propeller shaft and a differential or final drive.

Clutch :

The purpose of the clutch is to allow the driver to couple or decouple the engine and transmission. When clutch is in engaged position, the engine power flows to the transmission through it (clutch). When gears are to be changed while vehicle is running, the clutch permits temporary decoupling of engine and wheels so that gears can be shifted. In a scooter, the clutch is operated by hand where as in a car the clutch is operated by foot. It is necessary to interrupt the flow of power before gears are changed. Without a clutch, it will by very difficult.

Final Drive

Final drive is the last stage in transferring power from engine to wheels. It reduces the speed of the propeller shaft (drive shaft) to that of wheels. It also turns the drive of the propeller shaft by an angle of 90o to drive the wheels.

The propeller shaft has a small bevel pinion which meshes with crown wheel. The crown wheel gives rotary motion to rear axles. The size of crown wheel in bigger than that of bevel pinion, therefore, the speed of rear axles (or crown wheel) in lower than the speed of pinion. Final drive is of two types, i.e. chain type and gear type.

Braking System

Brakes are used to slow down or stop the vehicle. Hydraulic brakes are generally used in automobiles, where brakes are applied by pressure on a fluid. Mechanical brakes are also used in some vehicles. These brakes are operated by means of leavers, linkages, pedals, cams, etc. Hand brake or parking brake is known usually mechanical brake. These are used for parking the vehicles on sloppy surfaces and also in case of emergency.

Gear Box :

Gear box contain gearing arrangement to get different speeds. Gears are used to get more than one speed ratios. When both mating gears have same number of teeth, both will rotate at same number speed. But when one gear has less teeth than other, the gear with less number of teeth will rotate faster than larger gear. In a typical car, there may be six gears including one reverse gear. First gear gives low speed but high torque. Higher gears give progressively increasing speeds. Gears are engaged and disengaged by a shift lever.

Steering System :

In front wheels can be turned to left and right by steering system so that the vehicle can be steered. The steering wheel is placed in front of driver. It is mechanically linked to the wheels to provide the steering control. The primary function of the steering system is to provide angular motion to front wheels so that vehicle can negotiate a turn. It also provides directional stability to vehicle when the vehicle moves ahead in straight line.

Now-a-days, many vehicles are equipped with power steering which uses pressure of a fluid to reduce steering effort. When driver turns the steering wheel, a hydraulic mechanism comes into play to provide most of the effort needed to turn the wheel.

Front Axle

A part of the weight of vehicle is transmitted to the wheels through this axle. The front axle performs several functions.

It carries the weight of the front of the vehicle and also takes horizontal and vertical loads when vehicle moves on bumpy roads. When brakes are provided on front wheels, it endures bending stresses and torsional stresses. It is generally made from steel drop forging. It is robust in construction.

Suspension System

Suspension system of an automobile separates the wheel and axle assembly of the automobile from its body. Main function of the suspension system is to isolate the body of the vehicle from shocks and vibrations generated due to irregularities on the surface of roads. Shock absorbers are provided in the vehicles for this purpose. It is in the form of spring and damper. The suspension system is provided both on front end and rear end of the vehicle.

A suspension system also maintains the stability of the vehicle in pitching or rolling when vehicle is in motion.

APPLICATION OF I. C. ENGINE :

Road vehicles * Aircraft * Locomotive * Construction Equipment
Pumping set * several Industries

Small Two Stroke Petrol Engine : Used when operation is simple and requirement of low cost of prime mover (scooters, pumping sets etc.)

Small Four Stroke Petrol Engine : Used in automobiles, generators, pumping set.

Two Stroke Diesel Engine : High power, generally used in ship propulsion.

Four Stroke Diesel Engine : Mostly used engine, have diameter 50 to 600 mm, speed ranges from 100 to 4400 rpm, power developed is 1 to 1000 kW. Used in pumping sets, construction machinery, drilling rigs, tractors, diesel electric locomotive, mobile & stationary electric generation plants.

PARTS OF I. C. ENGINE :

1. Cylinder
2. Cylinder Head
3. Piston
4. Piston Rings
5. Gudgen Pin
6. Connecting Rod
7. Crank Shaft

8. Crank

9.Engine Bearing

10. Fly wheel

TERMS CONNECTED WITH I. C. ENGINES :

Bore : The inside diameter of the cylinder is called bore.

Stroke : when the piston reciprocate in the cylinder it has the limiting upper and lower positions beyond which it can not move. The linear distance between the two limiting positions of the cylinder is called Stroke.

Top Dead Centre (TDC) : The top most position of the piston towards top end side is called top dead center. But, in case of Horizontal Engines it is known as inner dead center.

Bottom Dead Center (BDC) : The lowest position of the piston towards crank end side is called Bottom dead center. But, in case of Horizontal Engines it is known as outerdead center.

Clearance Volume : The volume contained in the cylinder above the top of the piston when piston is at the top is called Clearance Volume.

When L = D - Called Square Engines

When L D - Under Square Engine

Swept Volume : The volume swept by piston between between top and bottom dead center is called swept volume / piston displacement.

Compression Ratio : It is ratio of total cylinder volume to clearance Volume.

Compression ratio (r) = Vs + Vc / Vc

Piston Speed : The average speed of the piston is called Piston Speed & = 2LN where L = Stroke of Piston & N = RPM of engine.

Average engine speed of engines is 5 to 15 m/sec. (This speed is kept in this range
Because of – strength of material& noise consideration.

Direct Injection : Fu el injected to the main combustion chamber of an engine.
Indirect Injection : Fuel injected to the secondary combustion chamber of an engine.

Smart Engine : The Engines made with computer controls that regulate operating characteristics such as air-fuel ratio, ignition timings, valve timings, intake tuning and exhaust control.

Air fuel Ratio : It is ratio of the mass of Air to mass of Fuel.

WORKING CYCLES :

I.C.Engines (Four & Two stroke) works on any one of the following cycles –

a. Constant Volume (Otto Cycle)
b. Constant Pressure (Diesel Cycle)
c. Dual Combustion Cycle.

Constant Volume (Otto Cycle):

Heat is supplied at constt. Volume
Petrol & air is mixed in carburator outside the Cylinder.
Fuel in required proportion is drawn in cylinder during Suction Stroke.

Constant Pressure(Diesel Cycle):

The air sucked during suction stroke is compressed during compression stroke and pressure and temp. rises by considerable amount then the measured amount of fuel is finely sprayed in cylinder by fuel injector. Due to very heavy pressure & temperature the fuel ignites and produce hot gases. These gases throw the piston downwards and work is obtained.

FUEL SUPPLY SYSTEM IN SPARK IGNITION ENGINE

The fuel supply system of spark ignition engine consists of

1. Fuel tank

2. Sediment bowl

3. Fuel lift pump

4. Carburetor

5. Fuel pipes

In some spark ignition engines the fuel tank is placed above the level of the carburetor. The fuel flows from fuel tank to the carburetor under the action of gravity. There are one or two filters between fuel tank and carburetor. A transparent sediment bowl is also provided to hold the dust and dirt of the fuel. If the tank is below the level of carburetor, a lift pump is provided in between the tank and the carburetor for forcing fuel from tank to the carburetor of the engine. The fuel comes from fuel tank to sediment bowl and then to the lift pump. From there the fuel goes to the carburetor through suitable pipes. From carburetor the fuel goes to the engine cylinder through inlet manifold of the engine

FUEL SUPPLY SYSTEM IN DIESEL ENGINE

Fuel supply system of diesel engine consists of the following components

1. Fuel tank

2. Fuel lift pump or fuel feed pump

3. Fuel filter

4. Fuel injection pump

5. High pressure pipe

6. Over flow valve

7. Fuel injector

Fuel is drawn from fuel tank by fuel feed pump and forced to injection pump through fuel filter.

The injection pump supplies high pressure fuel to injection nozzles through delivery valves and high pressure pipes.

Fuel is injected into the combustion chamber through injection nozzles. The

fuel that leaks out from the injection nozzles passes out through leakage pipe and returns to the fuel tank through the over flow pipe. Over flow valve installed at the top of the filter keeps the feed pressure under specified limit. If the feed pressure exceeds the specified limit , the over flow valve opens and then the excess fuel returns to fuel tank through over flow pipe.

Fuel tank

It is a storage tank for diesel. A wire gauge strainer is provided under the cap to prevent foreign particles entering the tank

Fuel lift pump

It transfers fuel from fuel tank to inlet gallery of fuel injection pump

Preliminary filter (sediment bowl assembly)

This filter is mostly fitted on fuel lifts pump. It prevents foreign materials from reaching inside the fuel line. It consists of a glass cap with a gasket.

Fuel filter

Mostly two stage filters are used in diesel engines

1. Primary filter 2. Secondary filter

Primary filter removes coarse materials, water and dust. Secondary filter removes fine dust particles.

Fuel Injection Pump

It is a high pressure pump which supplies fuel to the injectors according to the firing order of the engine. It is used to create pressure varying from 120 kg/cm2 to 300 kg/cm2. It supplies the required quantity of fuel to each cylinder at the appropriate time.

Air Venting of Fuel System

When air has entered the fuel lines or suction chamber of the injection pump, venting should be done properly.. Air is removed by the priming pump through the bleeding holes of the injection pump.

Fuel Injector

It is the component which delivers finely atomized fuel under high pressure to combustion chamber of the engine. Modern tractor engines use fuel injectors which have multiple holes.

Main parts of injectors are nozzle body, and needle valve. The needle valve is pressed against a conical seat in the nozzle body by a spring. The injection pressure is adjusted by adjusting a screw. In operation, fuel from injection pump enters the nozzle body through high pressure pipe.

When fuel pressure becomes so high that it exceeds the set spring pressure, the needle valve lifts off its seat. The fuel is forced out of the nozzle spray holes into the combustion

Main types of modern fuel injection systems:

1. Common-rail injection system.

2. Individual pump injection system.

3. Distributor system.

Main Components:

The main components of a fuel injection system are :

(i) Fuel tank.

(ii) Fuel feed pump to supply the fuel from the main fuel tank to the injection pump.

(iii) Fuel filters to prevent dust and abrasive particles from entering the pump and injectors.

(iv) Injection pumps to meter and pressurize the fuel for injection.

(v) Governor to ensure that the amount of fuel is in accordance with variation in load.

(vi) Fuel piping and injectors to take the fuel from the pump and distribute it in the combination chamber by atomizing it in fine droplets.

(vii) Fuel atomizer or injector to inject the fuel

FUEL INJECTOR

Also known as atomizer or fuel valve, a fuel injector is used to inject the fuel in the cylinder in atomized form and in proper quantity. Fuel injectors are available in several designs; one such design is shown in Fig. It consists of an atomizer (or nozzle) 1, valve 2, body 4, spring 6 etc. The nozzle is its main part, which is attached to the nozzle holder. The entry of fuel in the injector is from the fuel injection pump.

To obtain the required degree of pulverization, the fuel is passed at high velocity through a small orifice in the nozzle. An abrupt beginning and end of injection are-attained by means of a special spring-loaded valve. Injection begins when the pressure of fuel supplied by the pump increases so much as to lift the valve. Nozzles provided-with such valve are known as closed-type nozzles.

Each nozzle of the fuel injector has a spring-loaded check Valve that is closed except when high pressure is applied to the fuel. When this happens, the check valve opens, allowing fuel to pass through. The fuel exits from the nozzle tip through small holes. The holes are located so as to send the fuel into the center of the compressed air. The fuel ignites the instant it hits this hot air. When the fuel pressure drops, the check valve closes, so the flow of fuel through the nozzle stops.

Open-type nozzles are designed without valves that shut-off the access of fuel to the pulverizer, and their cavities are in free communication with the combustion chamber. Such nozzles can be employed only when the fuel pump builds-up pressure abruptly, has a small duration of delivery and a sharp cut-off. The pump and nozzle unit used in many types of diesel engines where the high-pressure pump and the nozzle are incorporated in one mechanism may illustrate the case in hand.

The advantage of pump and nozzle units is that they have no high-pressure fuel lines, the elasticity of which makes it difficult to obtain the required fuel pressure, and increase it sharply.

For this reason, pump and nozzle units are used predominantly in diesel engines where the injection pressure is very high (up to or above 300 kgf/cm2). Pump and nozzle units have the drawback that they are difficult to control.

INJECTION NOZZLES

When air injection is employed, the injection nozzles are operated by a cam provided on the camshaft. The mechanically operated injection nozzles are sometimes used with mechanical injection, usually when this is arranged on the common rail system. When the jerk-pump system is used the nozzle operation is automatic. Two types of nozzle are used viz.

1. Closed

2. Open

The distinction being according to whether the injection pressure is controlled by a spring loaded needle valve, or whether a valve is dispensed with. Open nozzles are not much used.

Closed nozzles may have an outlet in the form of one or more holes drilled in the nozzle cap.

Diameter of these holes may be as small as 0.2 mm, and their length/diameter ratio controls the penetration of the spray to some extent. Alternatively the outlet may be in the form of an annular space between a pin (orpintle) at the end of needle valve and a relatively larger hole in the nozzle cap. The pintle has an inverted conical end, which can direct the spray into a cone of 4° to 60° depending on the angle to which the pintle is ground. The ratio pump plunger area/nozzle hole area controls the maximum pressure attained during injection, and also to some extent the duration and degree of atomization of the spray. Rate of rise and fall of the injection pressure greatly affects dribble from the nozzles. A low valve-closing rate being usually accompanied by some dribble is prejudicial to economy.

Types of Nozzles

According to above discussion and also based on some other considerations,

the closed type injection nozzles may be classified into following types.

1. Hole type

   Single hole type & multiple hole type

2. Pintle type

3. Pintaux type

4. Long stem type

5. Delayed action type

6. Throttle type

Carburetor

The earliest form of fuel supply mechanism for modern automobile is carburetor. The primary function of carburetor is to provide the air-fuel mixture to the engine in the required proportion. The goal of a carburetor is to mix just the right amount of gasoline with air so that the engine runs properly. If there is not enough fuel mixed with the air, the engine "runs lean" and either will not run or potentially damages the engine. If there is too much fuel mixed with the air, the engine runs rich and either will not run (it floods), runs very smoky, runs poorly (bogs down, stalls easily), or at the very least wastes fuel. The car is in charge of getting the mixture just right.

Carburetor Basics

A carburetor basically consists of an open pipe, a "barrel" through which the air

passes into the inlet manifold of the engine. The pipe is in the form of a venturi: it narrows in section and then widens again, causing the airflow to increase in speed in the narrowest part.

Below the venturi is a butterfly valve called the throttle valve — a rotating disc that can be turned end-on to the airflow, so as to hardly restrict the flow at all, or can be rotated so that it (almost) completely blocks the flow of air. This valve controls the flow of air through the carburetor throat and thus the quantity of air/fuel mixture the system will deliver, thereby regulating engine power and speed. The throttle is connected, usually through a cable or a mechanical linkage of rods and joints or rarely by pneumatic link, to the accelerator pedal on a car or the equivalent control on other vehicles or equipment.

Fuel is introduced into the air stream through small holes at the narrowest part of the venturi and at other places where pressure will be lowered when not running on full throttle. Fuel flow is adjusted by means of precisely-calibrated orifices, referred to as jets, in the fuel path.

Parts of carburetor

· A carburetor is essentially a tube.

· There is an adjustable plate across the tube called the throttle plate that controls how much air can flow through the tube.

· At some point in the tube there is a narrowing, called the venturi, and in this narrowing a vacuum is created.

· In this narrowing there is a hole, called a jet, that lets the vacuum draw in fuel.

How carburetors work :

All carburetors work on "the Bernoulli Principle. Bernoulli principle states that as the velocity of an ideal gas increases, the pressure drops. Within a certain range of velocity and pressure, the change in pressure is pretty much linear with velocity-if the velocity doubles the pressure halves.

However, this linear relationship only holds within a certain range. Carburetors work because as air is pulled into the carburetor throat, the venturi. It has to accelerate from rest, to some speed.

How fast depends upon the air flow demanded by the engine speed and the throttle butterfly setting. According to Bernoulli, this air flowing through the throat of the carb will be at a pressure less than atmospheric pressure, and related to the velocity (and hence to how much air is being fed into the engine).

If a small port is drilled into the carb throat in this low pressure region, there will be a pressure difference between the throat side of the port, and the side that is exposed to the atmosphere. If a reservoir of gasoline, the float bowl, is between the inside of the port, and the atmosphere, the pressure difference will pull gasoline through the port, into the air stream. At this point, the port gets the name of a jet in the concept of a carburetor. The more air that the engine pulls through the carburetor throat, the greater the pressure drop across the jet, and the more fuel that gets pulled in.

As noted above, within a range of airflow in the throat, and fuel flow in the jet, the ratio of fuel to air that flows will stay constant. And if the jet is the right size, that ratio will be what the engine wants for best performance.

A venturi/jet arrangement can only meter fuel accurately over a certain range of flow rates and pressures. As flow rates increase, either the venturi or the jet, or both, will begin to choke, that is they reach a point where the flow rate will not increase, no matter how hard the engine tries to pull air through. At the other extreme, when the velocity of the air in the venturi is very low-like at idle or during startup, the pressure drop across the jet becomes vanishingly small. It is this extreme that concerns us with respect to starting, idle and low-speed throttle response.

At idle, the pressure drop in a 32 mm venturi is so small that essentially no fuel will be pulled through the main jets. But the pressure difference across the throttle butterfly (which is almost completely closed) can be as high as 25+ mm Hg. Carb designers take advantage of this situation by placing an extra jet, the "idle jet" notch, just downstream of the throttle butterfly. Because of the very high pressure difference at idle, and the very small amount of fuel required, this jet is tiny. When the throttle is open any significant amount, the amount of fuel that flows through this jet is small, and for all intents and purposes, constant. So its effect on the midrange and up mixture is easily compensated for.

During startup, the amount of air flowing through the carburetor is smaller still. At least till the engine begins to run on it's own. But when it is being turned by the starter or the kicker, rpm is in the sub 100 range sometimes. So the pressure difference across the jets is again in the insignificant range. If the engine is cold, it wants the mixture extra-rich to compensate for the fact that a lot of the fuel that does get mixed with air in the carb precipitates out on the cold walls of the intake port. Bing carburetors, and most bike carburetors, use enrich circuits. All this really is another port or jet from the float bowl to just downstream of the throttle butterfly.

Except that the fuel flow to this jet is regulated by a valve that is built into the carb body. At startup, when the lever is in the full on position, the valve is wide open, and the fuel supply to the cold start jet is more or less unlimited. In this condition, the amount of fuel that flows through the cold start jet is regulated just like the idle jet is. When the throttle is closed, the pressure drop across the jet is high, and lots of fuel flows, resulting in a very rich mixture, just perfect for ignition of a cold motor. If the throttle butterfly is opened, the pressure difference is less, and less fuel flows. This is why R bikes like no throttle at all until the engine catches. However, the mixture quickly gets too rich, and opening the throttle will make things better. Just like the idle jet, this cold start jet is small enough that even when the circuit is wide open, the amount of fuel that can flow is small enough that at large throttle openings, it has little impact on the mixture. This is why you can ride off with the starting circuit on full, and the bike will run pretty well-until you close the throttle for the first time, and the mixture gets so rich the engine stalls.

The valve that controls fuel supply to the cold start jet allows the rider to cut the fuel available through that jet down from full during startup, to none or almost none once the engine is warm.

In most cases, at the intermediate setting, fuel to the cold start jet is cut to the point where the engine will still idle when warm, although very poorly since it is way too rich.

True "chokes" are different. But very aptly named. A choke is simply a plate that can be maneuvered so that it completely (or very nearly) blocks off the carburetor throat at it's entrance ("choking" the carb, just like a killer to a victim in a bad movie). That means that the main, idle, intermediate, etc., jets are all down stream of the choke plate. Then, when the engine tries to pull air through the crab, it can't. The only place that anything at all can come in to the carb venturi is through the various jets. Since there is little or no air coming in, this results in an extremely rich mixture. The effect is maximized if the throttle butterfly (which is downstream of the big main jets and the choke plate) is wide open, not impeding things in any way. If the throttle butterfly is completely closed, the engine does not really know that the choke is there-all the engine "sees" is a closed throttle, so there is little enrichening effect. The engine will pull as much fuel as possible through the idle jet, but that is so small it won't have much effect. So a carb with a choke behaves in exactly the opposite manner as one with an enrichener. During the cranking phase, it is best to have the throttle pegged at WFO so that the most fuel gets pulled in, resulting in a nice rich mixture. But as soon as the motor starts, you want to close the throttle to cut down the effect of the choke. Even that is not enough, and most chokes are designed so that as soon as there is any significant airflow, they automatically open part way. Otherwise the engine would flood. Even "manual" chokes have this feature most of the time.

MPFI

Multi-point fuel injection injects fuel into the intake port just upstream of the cylinder's intake valve, rather than at a central point within an intake manifold. MPFI (or just MPI) systems can be sequential, in which injection is timed to coincide with each cylinder's intake stroke, batched, in which fuel is injected to the cylinders in groups, without precise synchronization to any particular cylinder's intake stroke, or Simultaneous, in which fuel is injected at the same time to all the cylinders.

Many modern EFI systems utilize sequential MPFI; however, it is beginning to be replaced by direct injection systems in newer gasoline engines.

The multi-point injector is an electromechanical device which is fed by a 12 volt supply from either the fuel injection relay or from the Electronic Control Module (ECM).

The voltage in both cases will only be present when the engine is cranking or running, due to both voltage supplies being controlled by a tachometric relay.

The injector is supplied with fuel from a common fuel rail. The length of time that the injector is held open for will depend on the input signals seen by the engine management ECM from its various engine sensors. These input signals will include:-

- The resistance of the coolant temperature.
- The output voltage from the airflow meter (when fitted).
- The resistance of the air temperature sensor.
- The signal from the Manifold Absolute Pressure (MAP) sensor (when fitted).
- The position of the throttle switch / potentiometer.

The held open time or injector duration will vary to compensate for cold engine starting and warm-up periods, i.e. a large duration that decreases the injection time as the engine warms to operating temperature. Duration time will also expand under acceleration and contract under light load conditions.

Depending on the system encountered the injectors can fire either once or twice per cycle. The injectors are wired in parallel with simultaneous injection and will all fire together at the same time. Sequential injection, as with simultaneous, has a common supply to each injector but unlike simultaneous has a separate earth path for each injector. This individual firing allows the system, when used in conjunction with a phase sensor, to deliver the fuel when the inlet valve is open and the incoming air helps to atomize the fuel. It is also common for injectors to be fired in 'banks' on 'V' configured engines. The fuel will be delivered to each bank alternately, because of the frequency of the firing of the injectors, it is expected that a sequential injector will have twice the duration, or opening, than that of a simultaneous pulse. This will however be determined by the injector flow rate.

UNIT-2

COOLING AND LUBRICATION

COOLING SYSTEM

Fuel is burnt inside the cylinder of an internal combustion engine to produce power. The temperature produced on the power stroke of an engine can be as high as 1600 ºC and this is greater than melting point of engine parts.. The best operating temperature of IC engines lie between 140 F and 200 ºF and hence cooling of an IC engine is highly essential. . It is estimated that about 40% of total heat produced is passed to atmosphere via exhaust, 30% is removed by cooling and about 30% is used to produce power.

Purpose of Cooling

1. To maintain optimum temperature of engine for efficient operation under all conditions.

2. To dissipate surplus heat for protection of engine components like cylinder, cylinder head, piston, piston rings, and valves 3. To maintain the lubricating property of oil inside engine.

Methods of Cooling

1. Air cooled system

2. Water cooled system

AIR COOLING SYSTEM

Air cooled engines are those engines in which heat is conducted from the working components of the engine to the atmosphere directly.

Principle of air cooling- The cylinder of an air cooled engine has fins to increase the area of contact of air for speedy cooling. The cylinder is normally enclosed in a sheet metal casing called cowling. The fly wheel has blades projecting from its face, so that it acts like a fan drawing air through a hole in the cowling and directed it around the finned cylinder. For maintenance of air cooled system, passage of air is kept clean by removing grasses etc. by a stiff brush of compressed air.

Advantages of Air Cooled Engine

1. It is simple in design and construction

2. Water jackets, radiators, water pump, thermostat, pipes, hoses are not required.

3. It is more compact

4. Lighter in weight

Disadvantages:

1. There is uneven cooling of engine parts

2. Engine temperature is generally high during working period Air cooled engine

WATER COOLING SYSTEM

Engines using water as cooling medium are called water cooled engines. Water is circulated round the cylinders to absorb heat from the cylinder walls. The heated water is conducted through a radiator to remove the heat and cool the water.

Methods of Water Cooling

1. Open jacket or hopper method

2. Thermo siphon method

3. Forced circulation method

1. Open Jacket Method

There is a hopper or jacket containing water which surrounds the engine cylinder. Solong as the hopper contains water the engine continues to operate satisfactorily. As soon as the water starts boiling it is replaced by cold water.. The hopper is large enough to run for several hours without refilling. A drain plug is provided in a low accessible position for draining water as and when required.

2. Thermo Siphon Method

It consists of a radiator, water jacket, fan, temperature gauge and hose connections. The system is based on the principle that heated water which surrounds the cylinder becomes lighter and it rises upwards in liquid column. Hot water goes to the radiator where it passes through tubes surrounded by air. Circulation of water takes place due to the reason that water jacket and radiator are connected at both sides i.e. at top and bottom. A fan is driven with the help of a V belt to suck air through tubes of the radiator unit, cooling radiator water. The disadvantage of the system is that circulation of water is greatly reduced by accumulation of scale or foreign matter in the passage and consequently causing overheating of the engine.

3. Forced Circulation System

In this method, a water pump is used to force water from radiator to the water jacket of the engine. After circulating the entire run of water jacket, water comes back to the radiatorwhere it loses its heat by the process of radiation. To maintain the correct engine temperature, a thermostat valve is placed at the outer end of cylinder head. Cooling liquid isby-passed through the water jacket of th3e engine until the engine attains the desired temperature. The thermostat valve opens and the by-pass is closed, allowing the water togo to the radiator. The system consists of the following components :

1. Water pump

2. Radiator

3. Fan

4. Fan-belt

5. Water jacket

6. Thermostat valve

7. Temperature gauge

7. Hose pipe

Water Pump

It is a centrifugal pump. It draws the cooled water from bottom of the radiator and delivers it to the water jackets surrounding the engine.

Thermostat Valve :

It is a control valve used in cooling system to control the flow of water when activated by a temperature signal.

Fan

The fan is mounted on the water pump shaft. It is driven by the same belt that drives the pump and dynamo. The purpose of radiator is to provide strong draft of air through the radiator to improve engine cooling

Water jacket -Water jackets are passages cored out around the engine cylinder as well as around the valve opening Forced Circulation cooling system- Water cooled engine

LUBRICATION

IC engine is made of moving parts. Duo to continuous movement of two metallic surfaces over each other, there is wearing of moving parts, generation of heat and loss of power in engine. Lubrication of moving parts is essential to prevent all these harmful effects.

Purpose of lubrication -

1. Reducing frictional effect

2. Cooling effect

3. Sealing effect

4. Cleaning effect

Types of Lubricants :

Lubricants are obtained from animal fat, vegetables and minerals. Vegetable lubricants are obtained from seeds, fruits and plants. Cotton seed oil, olive oil, linseed oil, caster oil are used as lubricants. Mineral lubricants are most popular for engines and machines. It is obtained from crude petroleum found in nature.. Petroleum lubricants are less expensive and suitable for internal combustion engines.

Engine Lubrication System

The lubricating system of an engine is an arrangement of mechanisms which maintains the supply of lubricating oil to the rubbing surfaces of an engine at correct pressure and temperature.

The parts which require lubrication are

1. Cylinder walls and piston

2. Piston pin

3. Crankshaft and connecting rod bearings

4. Camshaft bearings

5. Valve operating mechanism

6. Cooling fan

7. Water pump and

8. Ignition mechanism

Types of Lubricating Systems

1. Splash system

2. Forced feed system

Splash Lubrication

Splash lubrication is a method of applying lubricant, a compound that reduces friction, to parts of a machine. In the splash lubrication of an engine, dippers on the connecting-rod bearing caps are submerged in oil with every rotation. When the dippers emerge from the oil trough, the oil is splashed onto the cylinders and pistons, lubricating them.

Experts agree that splash lubrication is suitable for small engines such as those used in lawnmowers and outboard boat motors, but not for automobile engines.

This is because the amount of oil in the trough has a dramatic impact on how well the engine parts can be lubricated. If there is not enough oil, the amount splashed onto the machinery will be insufficient. Too much oil will cause excessive lubrication, which can also cause problems.

Engines are often lubricated through a combination of splash lubrication and force feeding. In some cases, an oil pump keeps the trough full so that the engine bearings can always splash enough oil onto the other parts of the engine. As the engine speeds up, so does the oil pump, producing a stream of lubricant powerful enough to coat the dippers directly and ensure a sufficient splash. In other cases, the oil pump directs oil to the bearings. Holes drilled in the bearings allow it to flow to the crankshaft and connecting rod bearings, lubricating them in the process.

Combination Splash and Force Feed

In a combination splash and force feed, oil is delivered to some parts by means of splashing and other parts through oil passages under pressure from the oil pump. The oil from the pump enters the oil galleries. From the oil galleries, it flows to the main bearings and camshaft bearings. The main bearings have oil-feed holes or grooves that feed oil into drilled passages in the crankshaft.

The oil flows through these passages to the connecting rod bearings. From there, on some engines, it flows through holes drilled in the connecting rods to the piston-pin bearings. Cylinder walls are lubricated by splashing oil thrown off from the connecting-rod bearings. Some engines use small troughs under each connecting rod that are kept full by small nozzles which deliver oil under pressure from the oil pump. These oil nozzles deliver an increasingly heavy stream as speed increases. At very high speeds these oil streams are powerful enough to strike the dippers directly. This causes a much heavier splash so that adequate lubrication of the pistons and the connecting-rod bearings is provided at higher speeds. If a combination system is used on an overhead valve engine, the upper valve train is lubricated by pressure from the pump.

Force-Feed

A somewhat more complete pressurization of lubrication is achieved in the force-feed lubrication system. Oil is forced by the oil pump from the crankcase to the main bearings and the camshaft bearings. Unlike the combination system the connecting-rod bearings are also fed oil under pressure from the pump. Oil passages are drilled in the crankshaft to lead oil to the connecting-rod bearings. The passages deliver oil from the main bearing journals to the rod bearing journals.

In some engines, these opening are holes that line up once for every crankshaft revolution. In other engines, there are annular grooves in the main bearings through which oil can feed constantly into the hole in the crankshaft. The pressurized oil that lubricates the connecting-rod bearings goes on to lubricate the pistons and walls by squirting out through strategically drilled holes. This lubrication system is used in virtually all engines that are equipped with semi floating piston pins.

Full Force Feed

In a full force-feed lubrication system, the main bearings, rod bearings, camshaft bearings, and the complete valve mechanism are lubricated by oil under pressure. In addition, the full force-feed lubrication system provides lubrication under pressure to the pistons and the piston pins.

This is accomplished by holes drilled the length of the connecting rod, creating an oil passage from the connecting rod bearing to the piston pin bearing. This passage not only feeds the piston pin bearings but also provides lubrication for the pistons and cylinder walls. This system is used in virtually all engines that are equipped with full-floating piston pins.

Need of Lubrication System

Lubrication is the admittance of oil between two surfaces having relative motion. The objects of lubrication may be one or more of the following:

1. To reduce motion between the parts having relative motion.

2. To reduce wear of the moving part.

3. To cool the surfaces by carrying away heat generated due to friction.

4. To seal a space adjoining the surfaces.

5. To absorb shocks between bearings and other parts and consequently reduce noise.

6. To remove dirt and grit that might have crept between the rubbing parts.

Additives in lubricating oil

In addition to the viscosity index improvers, motor oil manufacturers often include other additives such as detergents and dispersants to help keep the engine clean by minimizing sludge buildup, corrosion inhibitors, and alkaline additives to neutralize acidic oxidation products of the oil. Most commercial oils have a minimal amount of zinc dialkyldithiophosphate as an anti-wear additive to protect contacting metal surfaces with zinc and other compounds in case of metal to metal contact. The quantity of zinc dialkyldithiophosphate is limited to minimize adverse effect on catalytic converters. Another aspect for after-treatment devices is the deposition of oil ash, which increases the exhaust back pressure and reduces over time the fuel economy. The so-called "chemical box" limits today the concentrations of sulfur, ash and phosphorus (SAP).

There are other additives available commercially which can be added to the oil by the user for purported additional benefit.