UNIT - 5

COOLING SYSTEMS

Introduction:

When the fuel is burnt in the cylinder, only about one-third of heat energy liberated is converted to mechanical energy. The rest of the heat goes to exhaust gases and heating the combustion chamber. This chamber consists of cylinder head, cylinder and piston.

The Necessity of providing Cooling system:

The cooling system is necessary to remove the unwanted heat from the cylinder so as to present:

a. Burning of lubricating oil so as to minimize the wear of the parts.
b. Seizure of the piston because of excessive expansion.
c. Overheating of spark plug and cylinder walls which leads to pre-ignition.
d. Excessive stress in the parts due to unequal temperature.
e. To increase the life of the parts by controlling the temperature.

Disadvantages of Overcooling and Under Cooling:

Engine should be cooled within a particular temperature limits. It should not be too cooled or too heated up. Getting the Engine too much cooled is called overcooling. And if the Engine is over heated it is to under cool. Both under cooling and over cooling have individual disadvantages. Over cooling results in the increase of viscosity of the lubricating oil, which in turn result in the increase of friction between the moving parts.

If the Engine gets warmed up excessively, it should be cooled so as to keep the correct alignment of the Engine. Under cooling also keeps the Engine in correct position and increase the life of the Engine. Evaporation of lubricating oil that lubricates the piston and cylinder wall is also another reason of under cooling. This will result in metal to metal contact of the piston and cylinder wall leading to piston crown. Burning of and warping of exhaust valves setting up of thermal stresses in the cylinder, cylinder head and piston. This may lead to cracking of them.

Methods of Cooling:

There are three methods used for cooling of automobile Engines.

1. Air Cooling
2. Water Cooling

1. Air Cooling System:

In sir cooling system the removal of heat is effected by inducing air to flow around the cylinders and their heads. To increase the surface heat transfer area, metallic fins are cast on the outer surface of cylinder and head. Small capacity Engines obtain adequate circulation of the cooling air by convection. But high capacity Engines require a forced circulation. Forced circulation of air around the Engine is provided by a rotary blower. Revolving with a high speed, the rotor forces the cooling air and remove the heat of Engine. The air cooling system is employed for scooters, motorcycles and aircrafts.

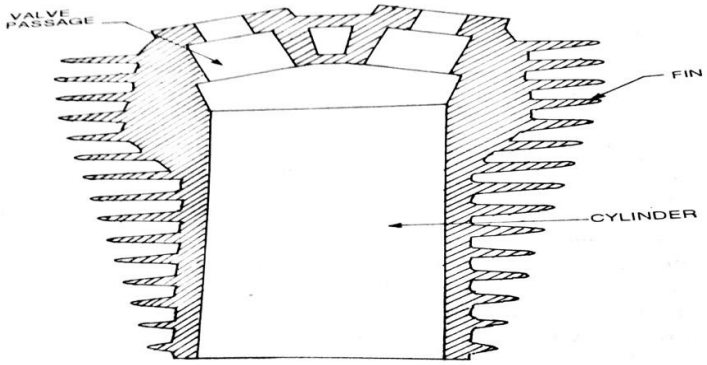

Fig 5.1 Air Cooling System

Advantages & Disadvantages:

1. Design of Engine is simple and no water jackets are required.
2. Absence of radiation makes the system simple.
3. No danger of leakage and freezing of water is cold climate
4. Insufficient cooling effect.

2. Water Cooling System:

In water cooling system, the Engine cylinders are surrounded by water jackets through which the cooling water flows. Heat flows from the cylinder walls into water which goes to the radiator where it loses its heat to the air.

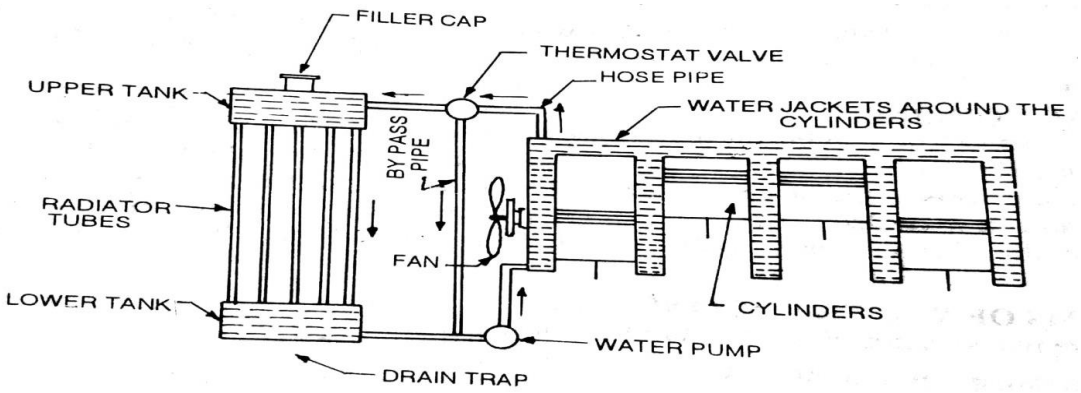

Fig 5.2 Water Cooling System

The system consists a radiator connected to the Engine through flexible hoses. In this system circulation of water is obtained from the differences in densities of hot and cold regions of cooling water. The circulation of water gets heat from the Engine cylinders, thereby cooling the same. The same heat in the water is then dissipated into the atmosphere through the radiator by mainly conduction and convection. The circulating water becomes cold by the time it reaches the collector tank of the radiator. The same water is then circulated through the Engine to collect heat from the cylinders.

In some systems the pump is used for the circulation of cooling water and the most of it is employed to control the air flow.

3. Thermo Syphon Cooling System:

In this system the circulation of water is obtained due to the difference in densities of hot and cold regions of the cooling water. There is no pump. The hot water from the Engine jacket being lighter, rises up in the hose pipe and goes in the radiator from the top side. It is cooled there and goes down at the bottom of the radiator. In this cooling is slow. To maintain continuity of water flow the water must be maintain minimum level. If not cooling system will fail. To avoid this, a thermostat valve is used. It maintain the normal temperature of the Engine parts. When the Engine started from cold, the thermostat valve prevents the flow of water from Engine to radiator so that the Engine readily reaches to its normal working temperature, after which it automatically comes into action. Generally the thermostat valve does not permit the water below 70^0C. There are two types of thermostats used in automobiles. They are bellow type and pellet type thermostat.

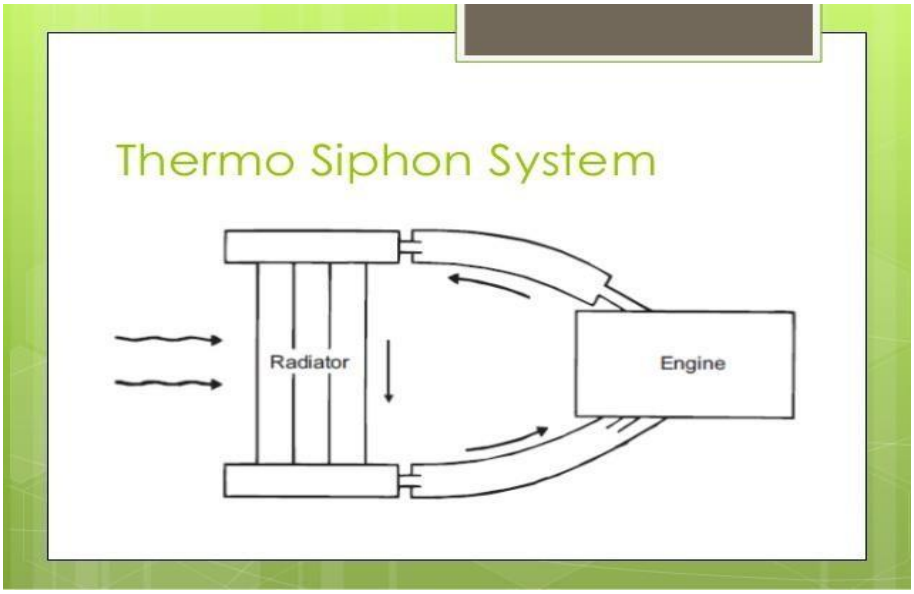

Fig 5.3 Thermo Syphon Cooling System

Radiator:

The function of the radiator is to ensure close contact of the hot water coming out of the Engine with outside air, so as to ensure high rates of heat transfer from the water to air. The radiator consist upper tank or header, core and lower tank or collector. Besides overflow pipe, header tank and drain pipe in lower tank. Filler neck is attached to the upper tank.

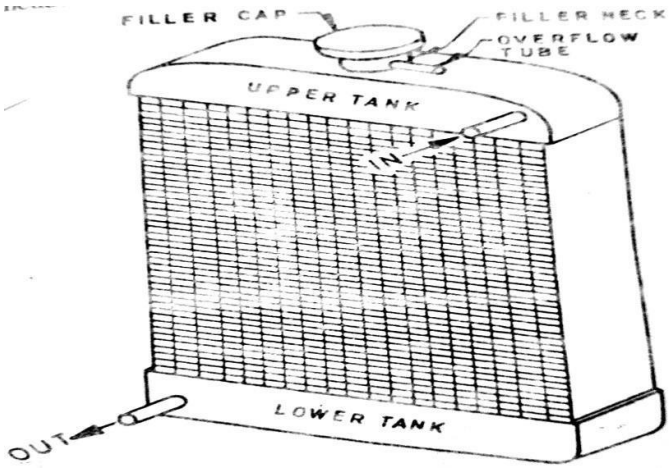

Fig 5.4 Radiator

Hot water from the Engine enters the radiator at the upper tank and is cooled by cross flow air which flowing down the radiator. The cooled water collects in the lower tank. There are two types of cores are used one is tuber type and other is cellular type.

Water Pump

A water pump is necessary for the forced circulation type of Engine cooling system. The pump is mounted at the front end of the Engine and is driven from the crank shaft by means of v-belt. The main parts of the pump are causing shaft mounted impeller having number of vanes and bearings.

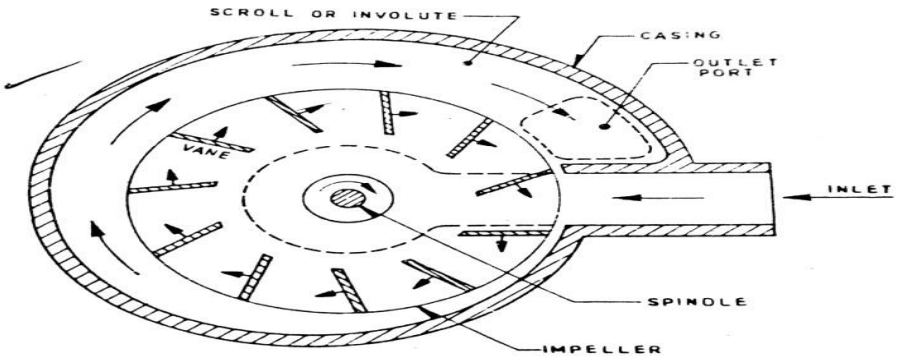

Fig 5.6 Construction of Water Pump

When the impeller rotates the water between the vanes is thrown outward due to centrifugal force. The water forced on periphery of impeller. This water leaving the periphery of the impeller tangentially and having maximum kinetic energy. Then enters the involute or scroll. The enlarging scroll converts the kinetic energy of water to pressure energies. In the way water pressure is created at the pump outlet that forces the coolant through the cooling system.

Anti-freeze solutions & Anti rusting Solutions:

In cold climates there is always a danger that the water in the cooling system may get frozen. Due to this bursting of the radiator core and the cylinder jackets. To avoid this some additives are used. These additives are called anti-freezers and solutions are called antifreeze solutions. The anti-freezers commonly used are wood, alcohol, methyl alcohol, ethyl alcohol, glycerine, ethylene glycol.

Comparison of Air Cooling & Water Cooling System:

S. No	Air Cooling System	Water Cooling System
1.	Due to direct transfer of heat from Engine to air, no water jacket, radiator and water pump are required. Therefore weight is reduced.	Need for pump and radiator increases weight and air resistance of vehicle.
2	Engine is smaller in size and its design much simpler.	Engine has larger dimensions and its design is more complex.
3	Warm-up performance of air-cooled Engine is better. This results in low wear to cylinders.	Warm-up performance is poor and results in greater cylinder wear.
4	Air cooled Engine can take up some degree of damage. A broken fin does not affect the Engine much.	Water cooling system requires more maintenance. A slight leakage of radiator may result in Engine breakdown.
5	Air cooled Engine is less sensitive to climatic conditions. Anti-freeze solution is not needed.	Engine performance is more sensitive to climatic conditions. Cold weather starting requires use of anti-freeze solutions.
6	Air fan is an additional source of noise.	Presence of water passage attenuates the combustion noise.
7	Control of cooling system is much easier.	Control of cooling system is comparatively difficult.

5.8 Thermostat :

A thermostat basically switches the heating system on and off accordingly. It detects by sensing the air temperature, switches on when the heating of air temperature falls below the thermostat setting and switches off when the set temperature has reached.

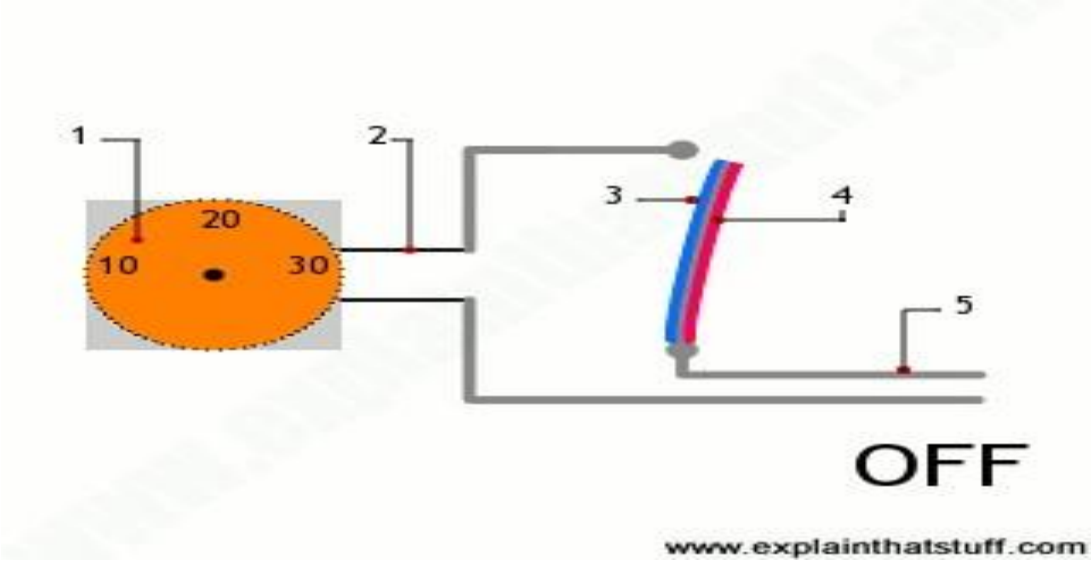

Fig 5.7 Thermostat

Construction & Working:

1. An outer dial enables you to set the temperature at which the thermostat switches on and off.
2. The dial is connected through a circuit to the temperature sensor (a bimetal strip, shown here colored red and blue), which switches an electrical circuit on and off by bending more or less.
3. The bimetal ("two metal") strip is made of two separate metal strips fastened together: a piece of brass (blue) bolted to a piece of iron (red).
4. Iron expands less than brass as it gets hotter, so the bimetal strip curves inward as the temperature rises.
5. The bimetal strip forms part of an electrical circuit (gray path). When the strip is cool, it's straight, so it acts as a bridge through which electricity can flow. The circuit is on and so is the heating. When the strip is hotter, it bends and breaks the circuit, so no electricity can flow. Now the circuit is off.

5.8.1 Types of Thermostats:

There are two types of thermostats usually used in automobiles.

1. Bellows type thermostat
2. Wax pellet type thermostat.

1. Bellows Type Thermostat:

As the liquid in the bellows becomes heated, it will begin to turn to vapour. Because the boiling point of the liquid is lower than that of water, this will happen at less than 100oC, usually somewhere between 80-90^{o}C.

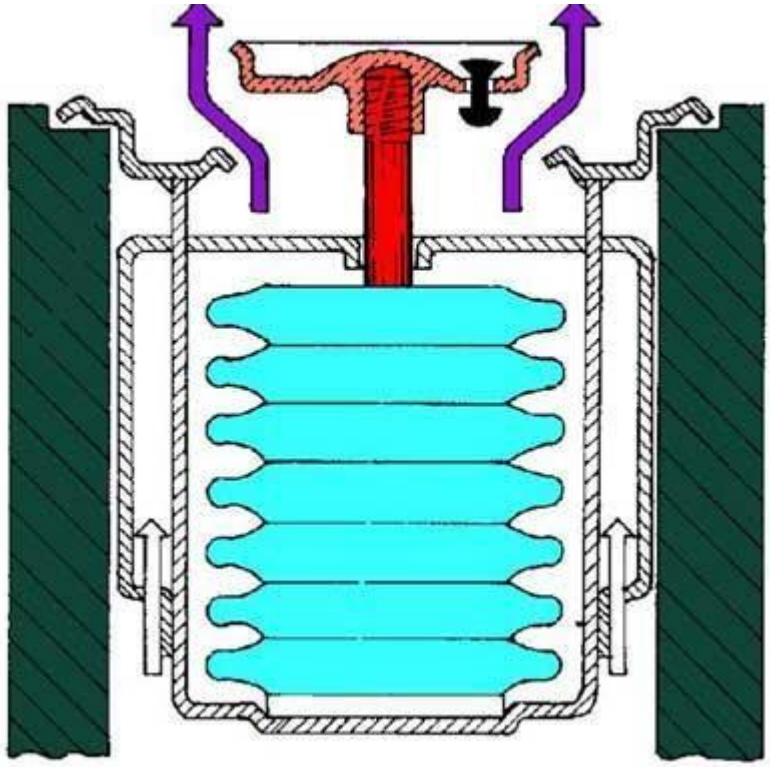

Fig 5.8 Bellow type of thermostat

When this happens, the pressure inside the bellows becomes greater than the pressure outside it. This causes the bellows to expand, thus opening the valve and allowing the hot coolant through and on to the radiator. If the temperature of the coolant drops (say when the engine is running under light load), the pressure in the bellows also drops, causing the thermostat to close. This makes sure the engine is not over-cooled.

2. Wax Pellet Type Thermostat:

The core of the wax thermostat is the motor. Unlike the bellows thermostat, which used an expandable metal bellows filled with alcohol, the wax thermostat uses a rigid brass or copper cup filled with solid wax. Waxes can be blended with any desired temperature range and the motor sized to produce any needed level of force, opening point, and hysteresis. When heated, the wax melts and rapidly expands, acting against a rubber diaphragm, which in turn transmits force to the pin. The pin is pushed out of the cup and reacts against the pin retainer, forcing the entire wax motor backwards. Wax motors in automotive thermostats typically have a stroke of 8mm.

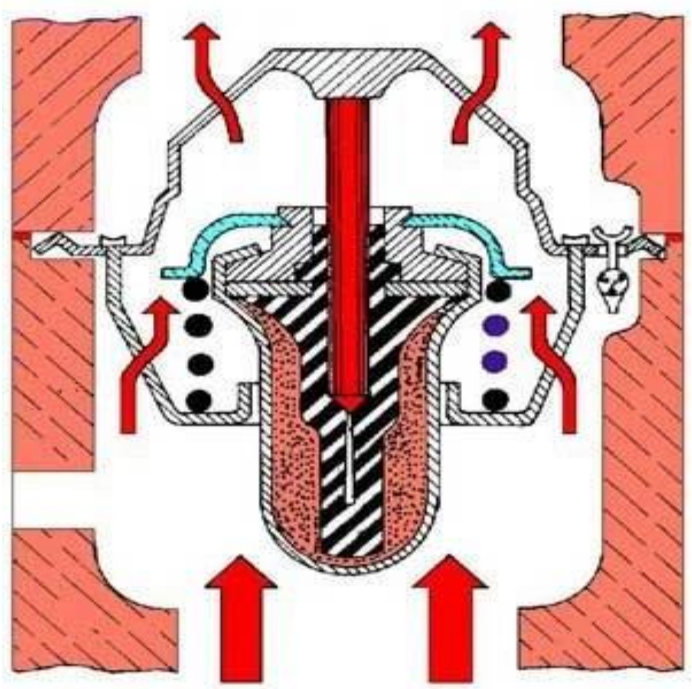

Fig 5.9 Wax Pellet Type Thermostat

Short Answer Questions

1. Write the necessity of providing cooling system for an automobile.
2. Write disadvantages of over cooling & under cooling.
3. Write the advantages and disadvantages of air cooling system.
4. What is the need of anti- freeze & anti- rusting solutions are used for an automobile.

Long Answer Questions

1. Explain the water cooling system with a neat sketch.
2. Explain the thermo syphon cooling system with neat sketch.
3. Explain the below parts used in cooling system.
    a. Radiator.
    b. Water pump
4. Write the comparison between air cooling & water cooling system.