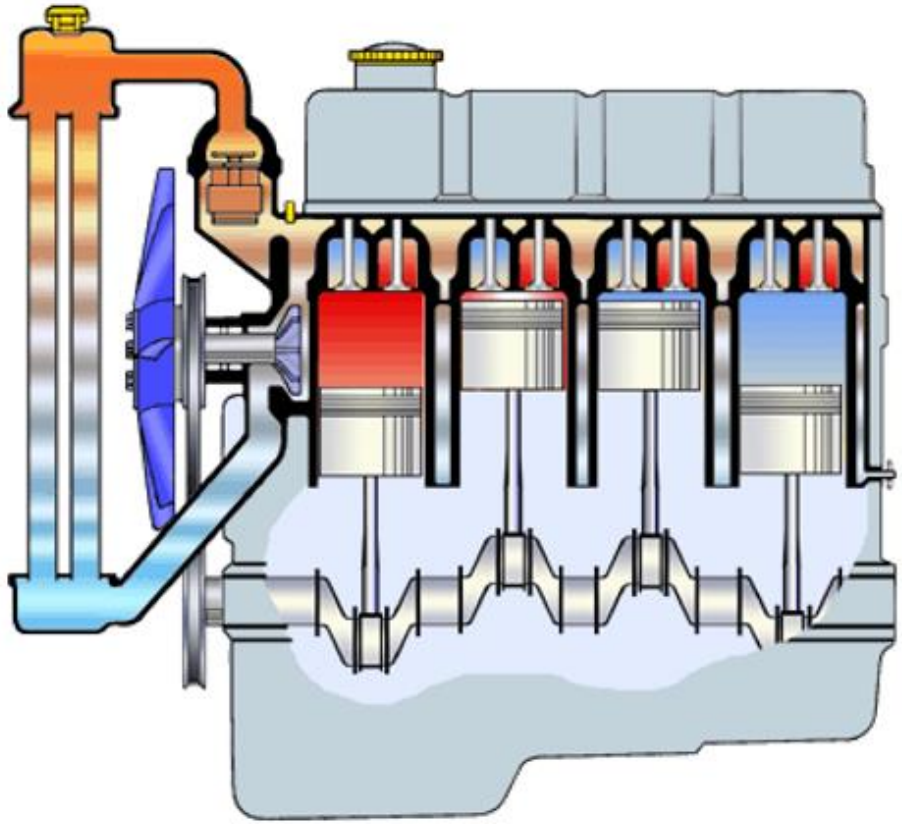
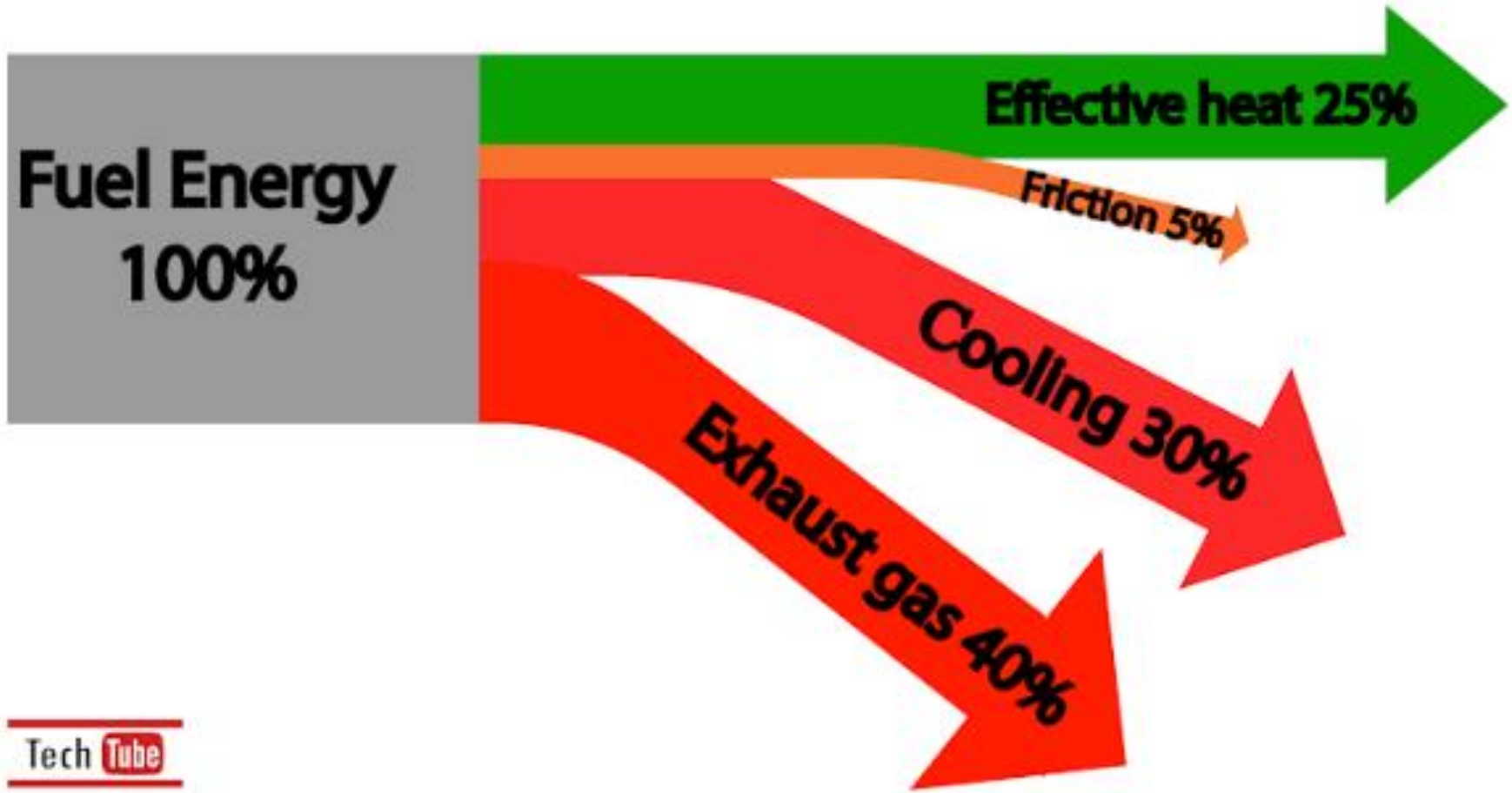
ENGINE COOLING SYSTEM

PURPOSE

•Get the engine up to optimum operating Temperature as quickly as possible and maintains it at that temperature.

•Controls the heat produced in combustion chamber, so that the engine parts are not damaged & the oil does not break down.




Fuel Energy
100%
Effective heat 25%
Friction 5%
Cooling 30%
Exhaust gas 40%
Tech Tube

INTRODUCTION

We know that in case of Internal Combustion engines, combustion of air and fuel takes place inside the engine cylinder and hot gases are generated. The temperature of gases will be around 2300-2500°C. This is a very high temperature and may result into burning of oil film between the moving parts and may result into seizing or welding of the same. So, this temperature must be reduced to about 150-200°C at which the engine will work most efficiently. Too much cooling is also not desirable since it reduces the thermal efficiency. So, the object of cooling system is to keep the engine running at its most efficient operating temperature.

It is to be noted that the engine is quite inefficient when it is cold and hence the cooling system is designed in such a way that it prevents cooling when the engine is warming up and till it attains to maximum efficient operating temperature, then it starts cooling.

TYPES

- AIR COOLED (FOR SMALL ENGINES)

A. NATURAL FLOW:

- Have metal FINS on the outer perimeter of the engine.
- Heat is transferred from the engine, through these fins, into the atmosphere.

B. FORCED CONVECTION

- Uses a fan
- For enclosed engines

- LIQUID COOLED (FOR LARGE ENGINES)
  - A liquid (**coolant)** is circulated around the cylinders and absorb heat from the cylinder walls and cylinder head.

TYPES OF COOLING SYSTEM

There are two types of cooling systems:

(i) Air cooling system and

(ii) Water-cooling system.

AIR COOLING SYSTEM

In this type of cooling system, the heat, which is conducted to the outer parts of the engine, is radiated and conducted away by the stream of air, which is obtained from the atmosphere. In order to have efficient cooling by means of air, providing fins around the cylinder and cylinder head increases the contact area. The fins are metallic ridges, which are formed during the casting of the cylinder and cylinder head

The amount of heat carried off by the air-cooling depends upon the following factors:

(i) The total area of the fin surfaces,

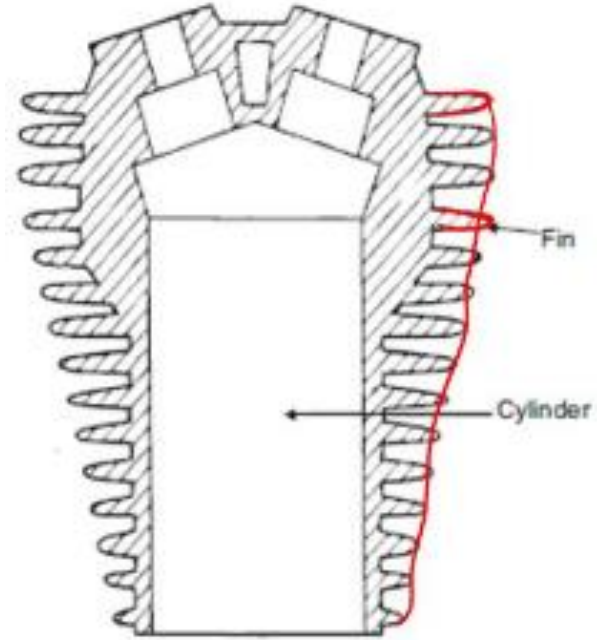
(ii) The velocity and amount of the cooling air and

(iii) The temperature of the fins and of the cooling air.

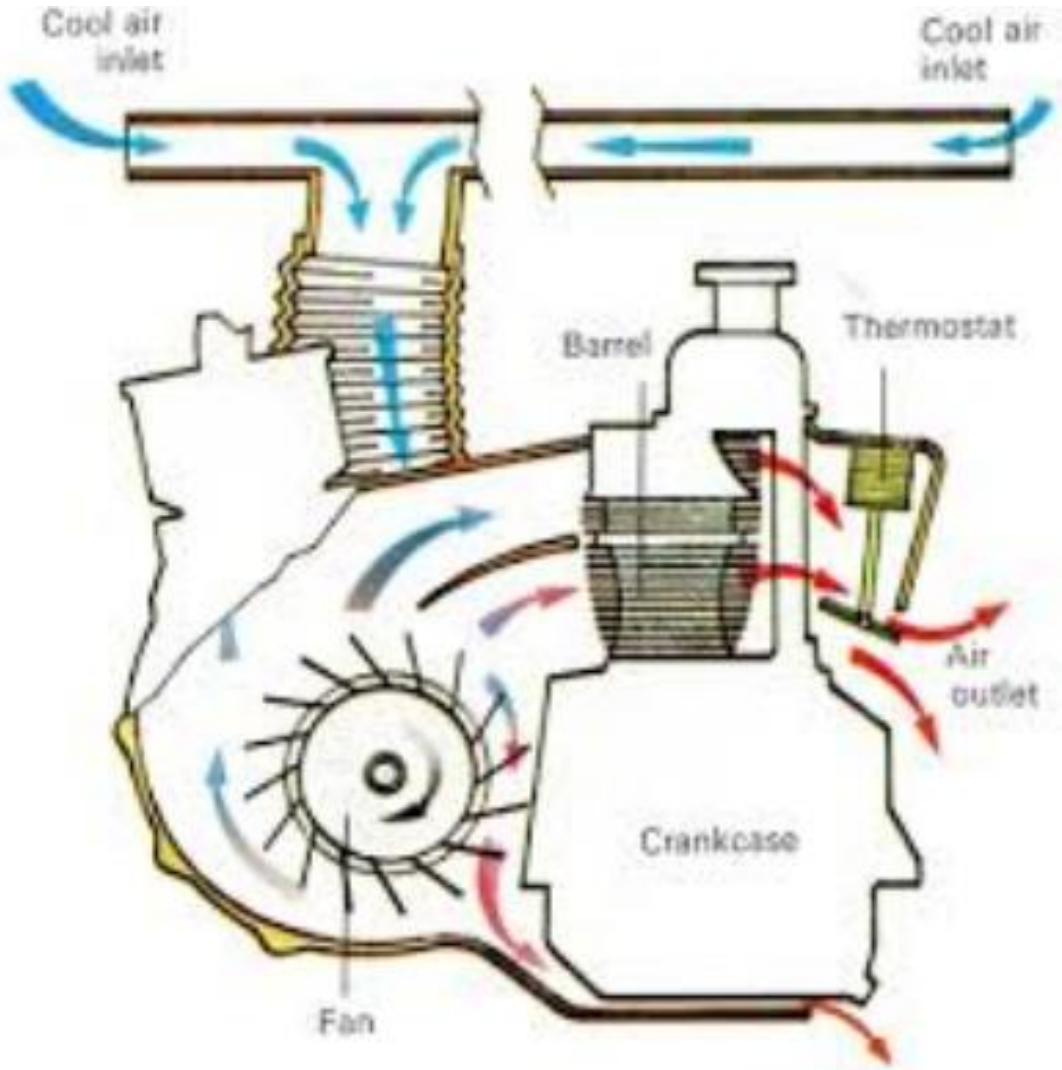
Air-cooling is mostly tractors of less horsepower, motorcycles, scooters, small cars and small aircraft engines where the forward motion of the machine gives good velocity to cool the engine. Air-cooling is also provided in some small industrial engines. In this system, individual cylinders are generally employed to provide ample cooling area by providing fins. A blower is used to provide air.

AIR COOLED TYPE

Finned Engine Cylinder



Air Cooling: Vw Beetle Air Cooling System



Advantages of Air Cooled Engines

Air cooled engines have the following advantages:

1. Its design of air-cooled engine is simple.
2. It is lighter in weight than water-cooled engines due to the absence of water jackets, radiator, circulating pump and the weight of the cooling water.
3. It is cheaper to manufacture.
4. It needs less care and maintenance.
5. This system of cooling is particularly advantageous where there are extreme climatic conditions in the arctic or where there is scarcity of water as in deserts.
6. No risk of damage from frost, such as cracking of cylinder jackets or radiator water tubes.

Disadvantages of Air Cooled System

(a) Comparatively it is less efficient.

(b) It is used in aero planes and motorcycle engines where the engines are exposed to air directly

WATER COOLING SYSTEM

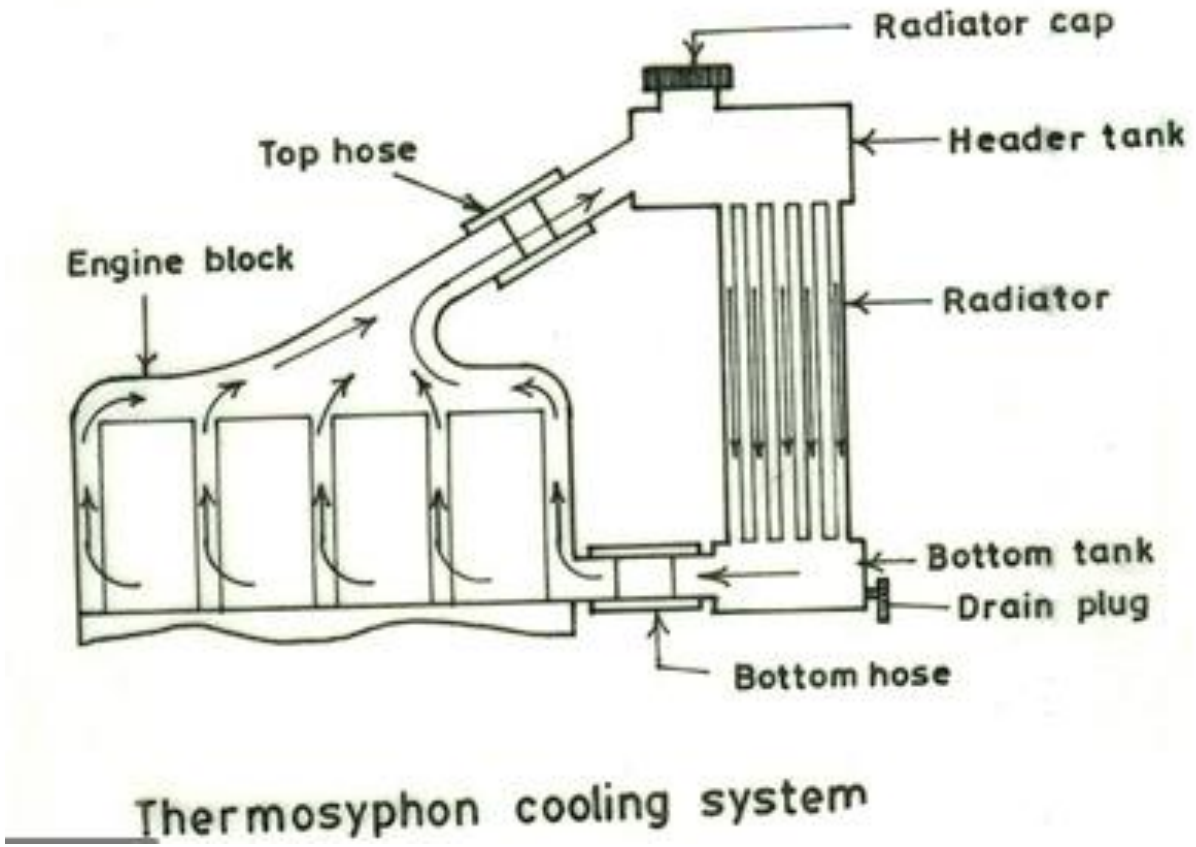
In this method, cooling water jackets are provided around the cylinder, cylinder head, valve seats etc. The water when circulated through the jackets, it absorbs heat of combustion. This hot water will then be cooling in the radiator partially by a fan and partially by the flow developed by the forward motion of the vehicle. The cooled water is again recirculated through the water jackets.

There are two types of water cooling system.

1. Thermosyphon
2. Pump circulation system

LIQUID COOLING SYSTEM

- THERMOSYPHON SYSTEM



Thermosyphon cooling system

Thermo Siphon System

In this system the circulation of water is due to difference in temperature (i.e. difference in densities) of water. So in this system pump is not required but water is circulated because of density difference only.

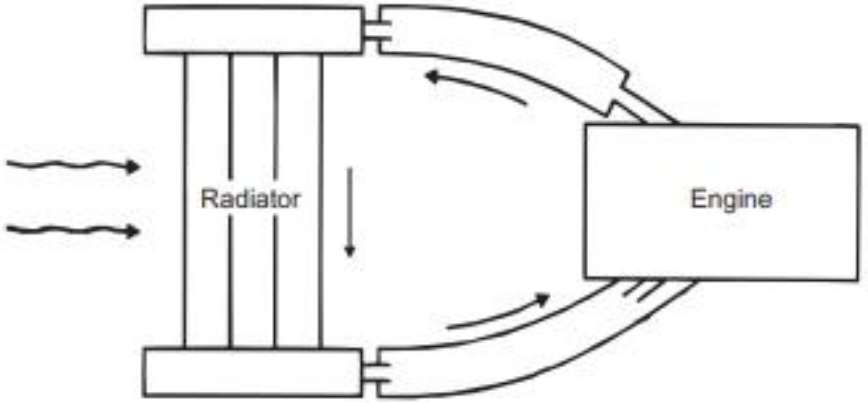


Figure 5.2 : Thermo Siphon System of Cooling

Thermo-Syphone Water Cooling System

This system works on the principle that hot water being lighter rises up and the cold water being heavier goes down. In this system the radiator is placed at a higher level than the engine for the easy flow of water towards the engine. Heat is conducted to the water jackets from where it is taken away due to convection by the circulating water. As the water jacket becomes hot, it rises to the top of the radiator. Cold water from the radiator takes the place of the rising hot water and in this way a circulation of water is set up m the system. This helps in keeping the engine at working temperature.

Disadvantages of Thermo-Syphone System

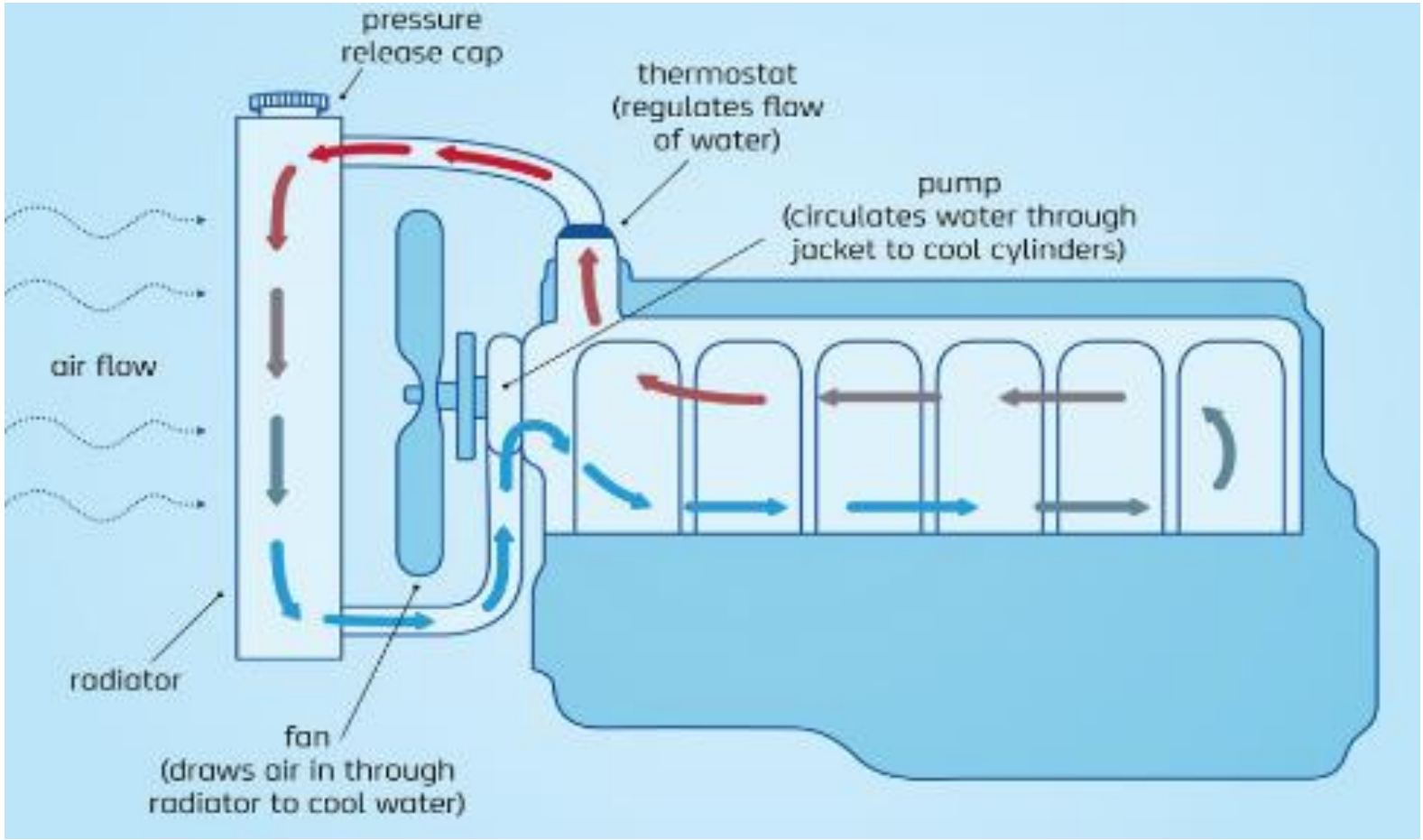
1 Rate of circulation is too slow.

2. Circulation commences only when there is a marked difference in temperature.

3. Circulation stops as the level of water falls below the top of the delivery pipe of the radiator. For these reasons this system has become obsolete and is no more in use.

LIQUID COOLING SYSTEM

Forced Circulation system



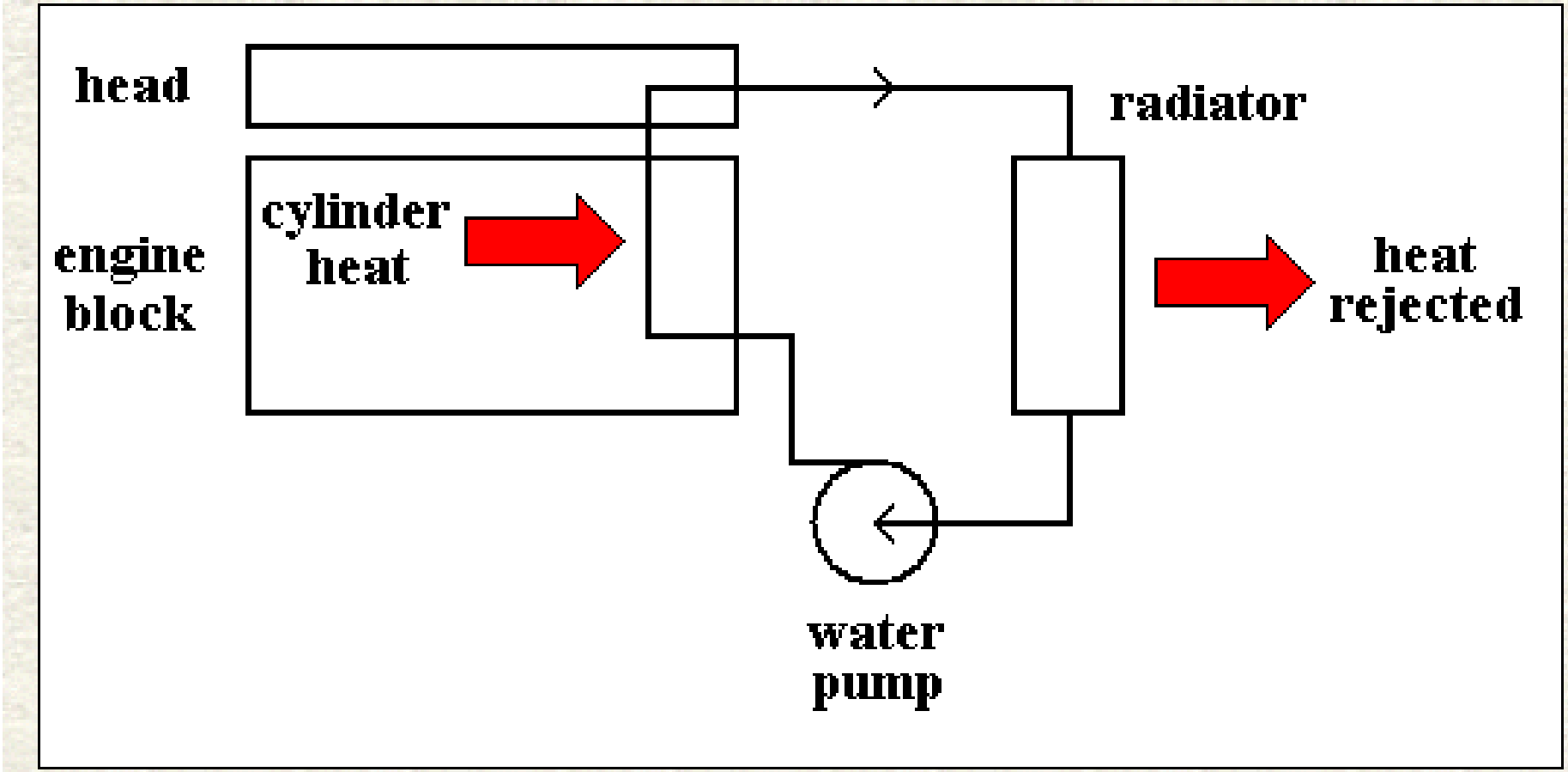


Figure 18. Cooling System Loop

In this cooling system, the circulation of water is done by providing a centrifugal pump.

Due to this pump, the rate of flow of water is more.

Here radiator may be fitted at any place convenient to the designer.

The pump is driven by a belt from a crankshaft.
In this system, the direction of cooling water flow is upward from the cylinder head to the top tank of the radiator, then down through the radiator core to the bottom tank.

From the bottom tank, it moves through the lower radiator hose to the cylinder block water jackets by the help of the water pump, which circulates the water.

Water enters the engine at the center of the inlet side of the pump.

The circulating pump is driven by a belt from the crankshaft.

As engine speed increases, the flow of coolant increases.

SYSTEM COMPONENTS

COOLANT is a mixture of antifreeze (*Ethylene Glycol)* and Water (*some Aluminum radiators have special antifreeze)*

- Coolant absorbs heat as it passes through the engine and also lubricates the water pump.
- Hot coolant enters the radiator in which the heat is transferred to air that is flowing through the radiator.
- Prevents rust and corrosion from the water jackets.
- Cooling system flush is recommended every two years in order to remove any rust or contaminants.

The ideal antifreeze solutions should have the following properties :

(a) It should dissolve in water easily.

(b) It should not evaporate.

(c) It should not deposit any foreign matter in cooling system.

(d) It should not have any harmful effect on any part of cooling system.

(e) It should be cheap and easily available.

(f) It should not corrode the system.

No single antifreeze satisfies all the requirements. Normally following are used as antifreeze solutions :

(a) Methyl, ethyl and isopropyl alcohols.

(b) A solution of alcohol and water.

(c) Ethylene Glycol.

(d) A solution of water and Ethylene Glycol.

(e) Glycerin along with water, etc.

Water Jackets

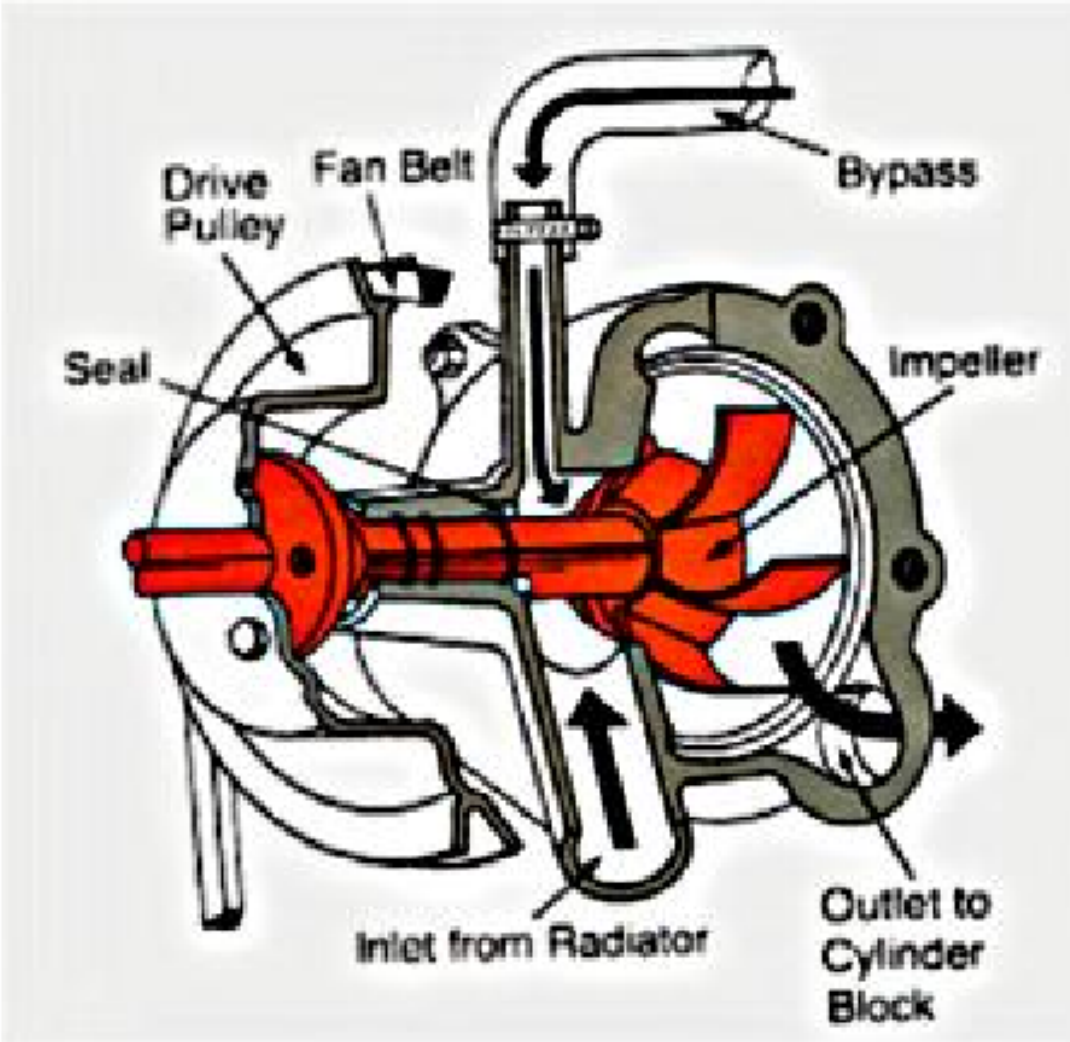
- Designed to keep engine block and cylinder head cool.
- Open spaces between the outside of cylinder and inside of cylinder block and head.
- When engine is running at normal operating temperature, the coolant is forced through the water jackets in the engine block, through the head gasket, into the head, and back to the radiator.

Cooling System Components

Water Pump (Non Positive displacement - Impeller Type)

•Draws the coolant from radiator, through the lower radiator hose, and then forces it through the water jackets, back into the radiator.

•Water pumps gasket is placed between the water pump and the engine block to prevent leakage (if left loose it might leak and if tightened too much it might crack).



Cooling Fan

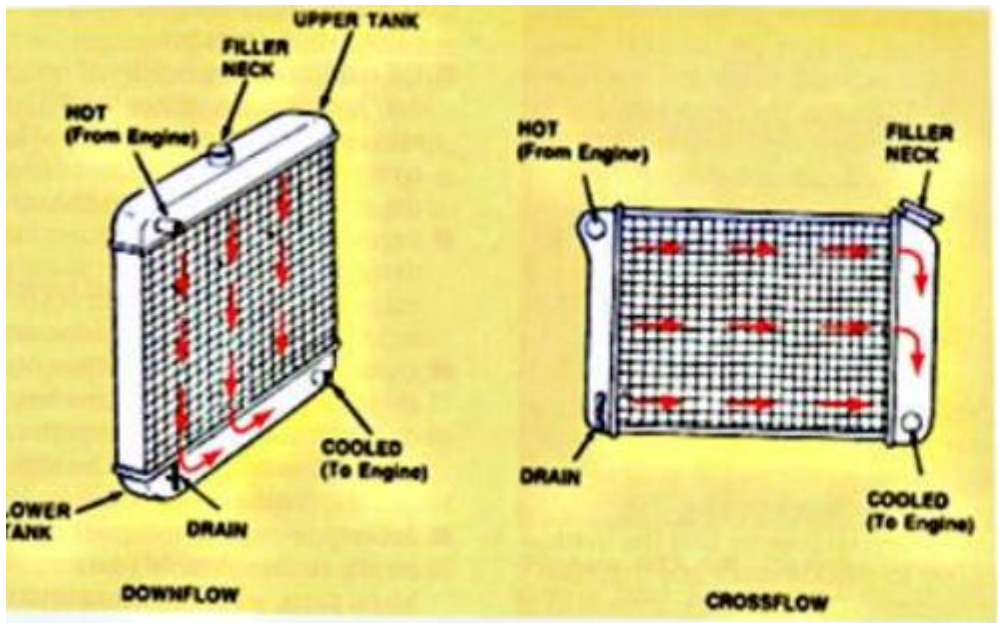
- Provides air flow when vehicle is stationery
- Provides increased air flow at low RPM or vehicle speeds

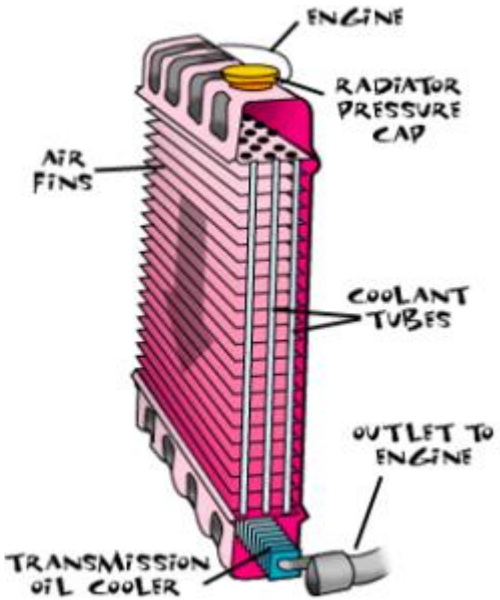
Electric fan is mounted on the radiator
and is operated by battery power.

- Is controlled by the thermostat switch.
- Is located on Thermostat housing, Block, or Radiator.
- Some modern cars have the range between
  193° to 207° F (89 to 97° C)
- On AC equipped cars, a second fan is mounted,
  and it runs any time AC is turned on.

Radiator

- Heat Exhanger which transfers heat from coolant to the atmosphere
- Two types – Vertical & cross flow
- Vehicles equipped with automatic transmission have transmission cooler build into the radiator.
- Aluminum, brass, copper core; brass, copper or plastic tanks
- Air movement through radiator created by a mechanical fan or/and by vehicle movement dissipates heat



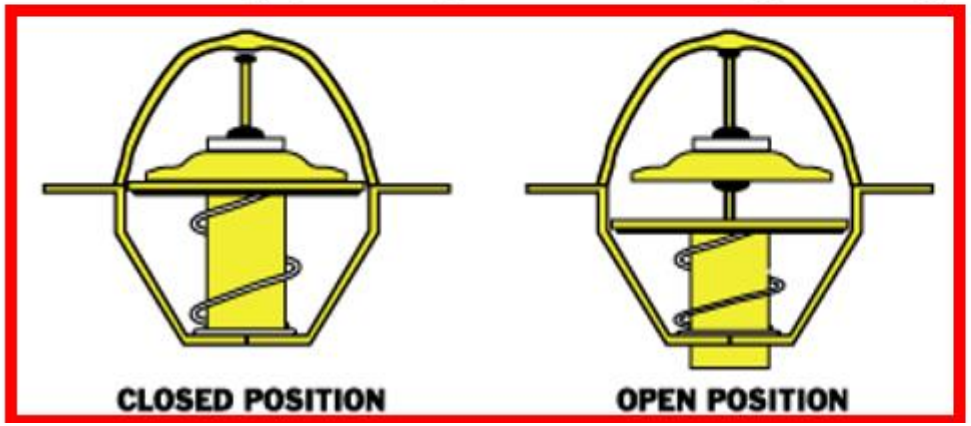


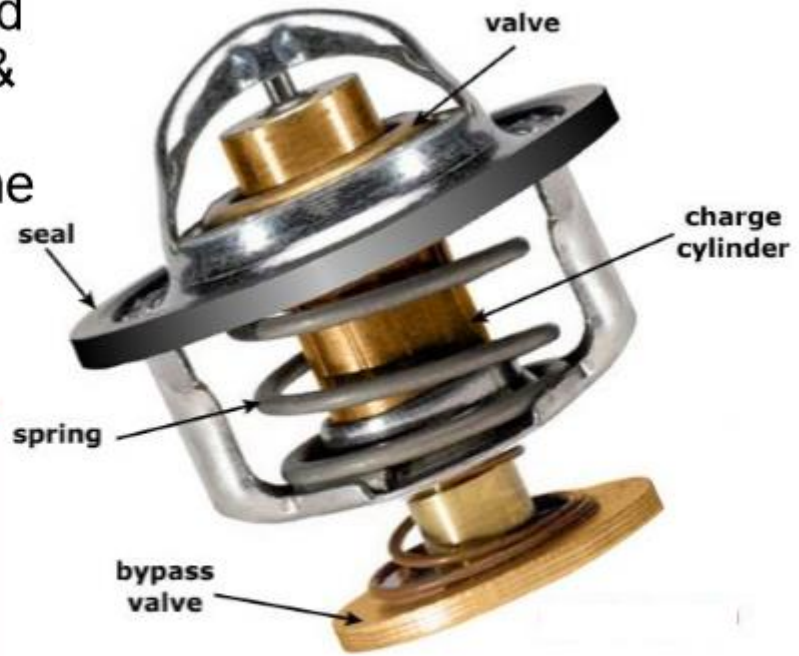
Thermostat

- Placed between the cylinder head and top radiator hose.
- Regulates engine coolant temperature
- The temperature that the thermostat opens is called ***thermostat rating***. (85-90^0 C most common)
- Solid Expansion design – wax pellet expands as temp increases, valve begins opening at rating & is completely open within 10 degrees

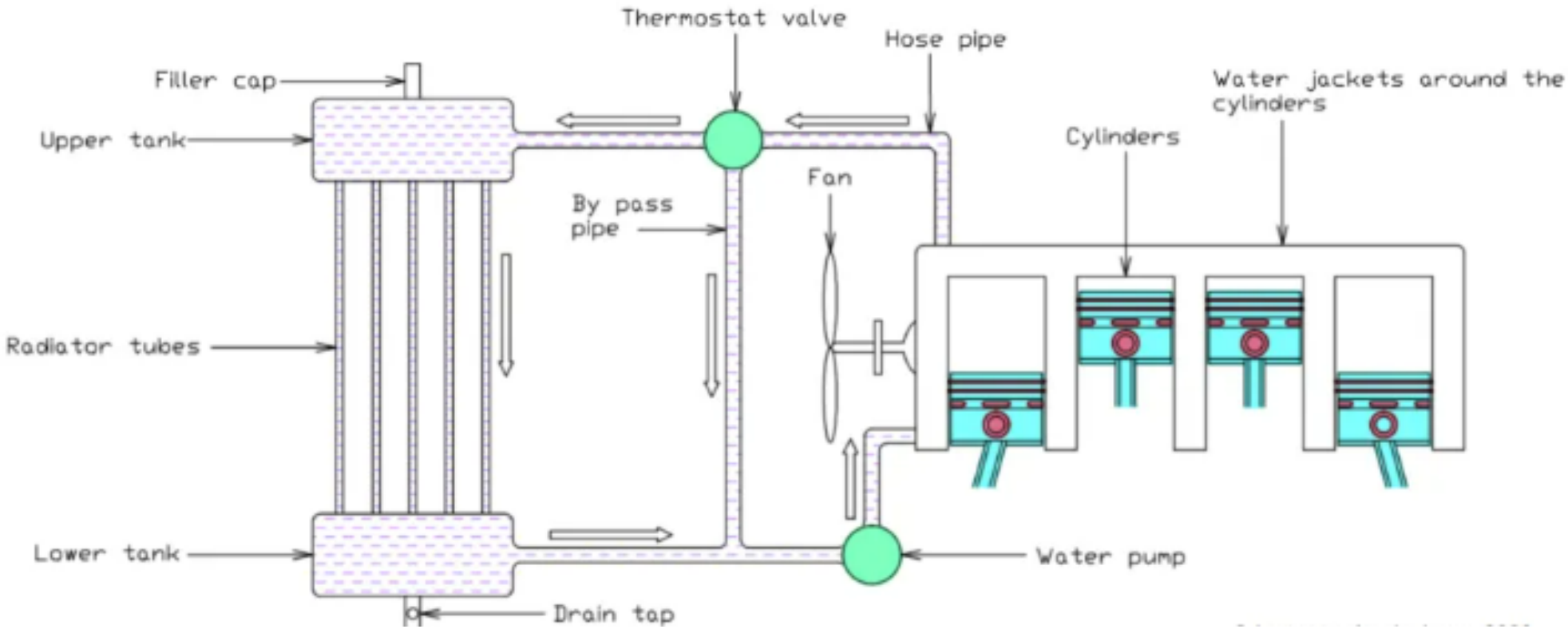
If it fails in open position, engine runs cold resulting in poor mileage and high wear & tear.

If it fails closed, creates temperature in the engine well beyond normal limits. Many types of damage may occur. (Can be checked by placing in the boiling water)

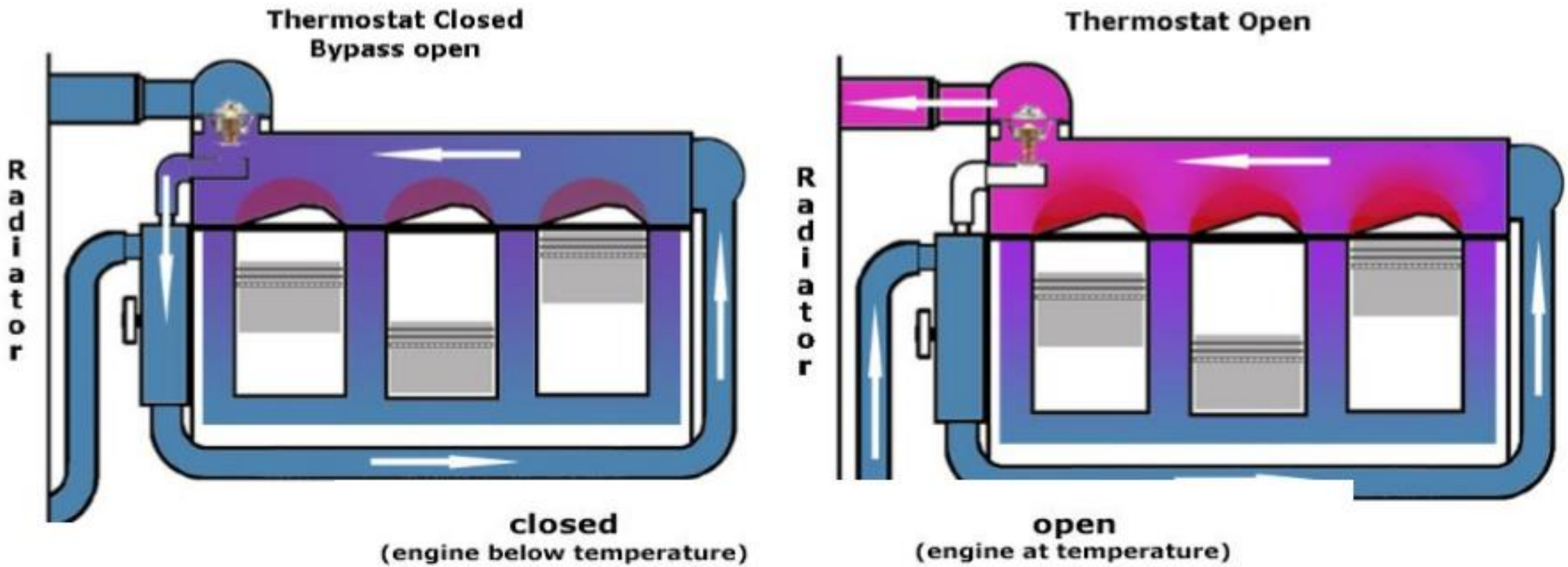




The function of this valve is to restrict the flow of water from the engine to the radiator. This valve design as when the water temperature inside the engine cylinder exceeds a certain value (Generally 70-degree centigrade) then the valve allows the flow of water, if the temperature of the water inside the cylinder is below 70-degree centigrade then the valve restrict the flow of water.



Working of Thermostat



Hoses

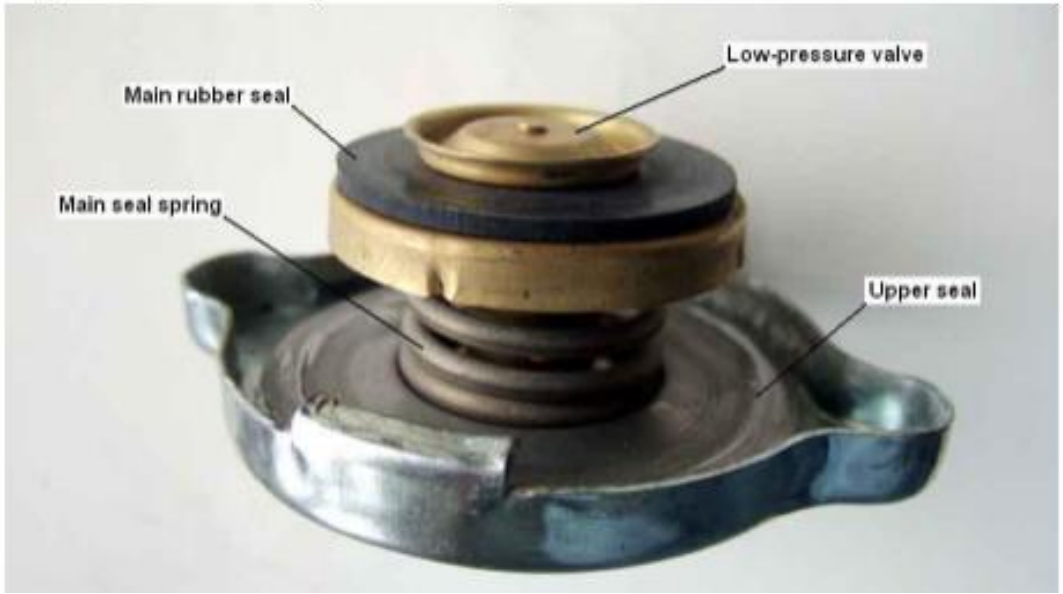
Top Radiator hose brings the coolant back to the radiator and are molded Specifically for individual make and model.

Lower radiator hose draws the coolant into the engine, from the radiator and is attached to the water pump

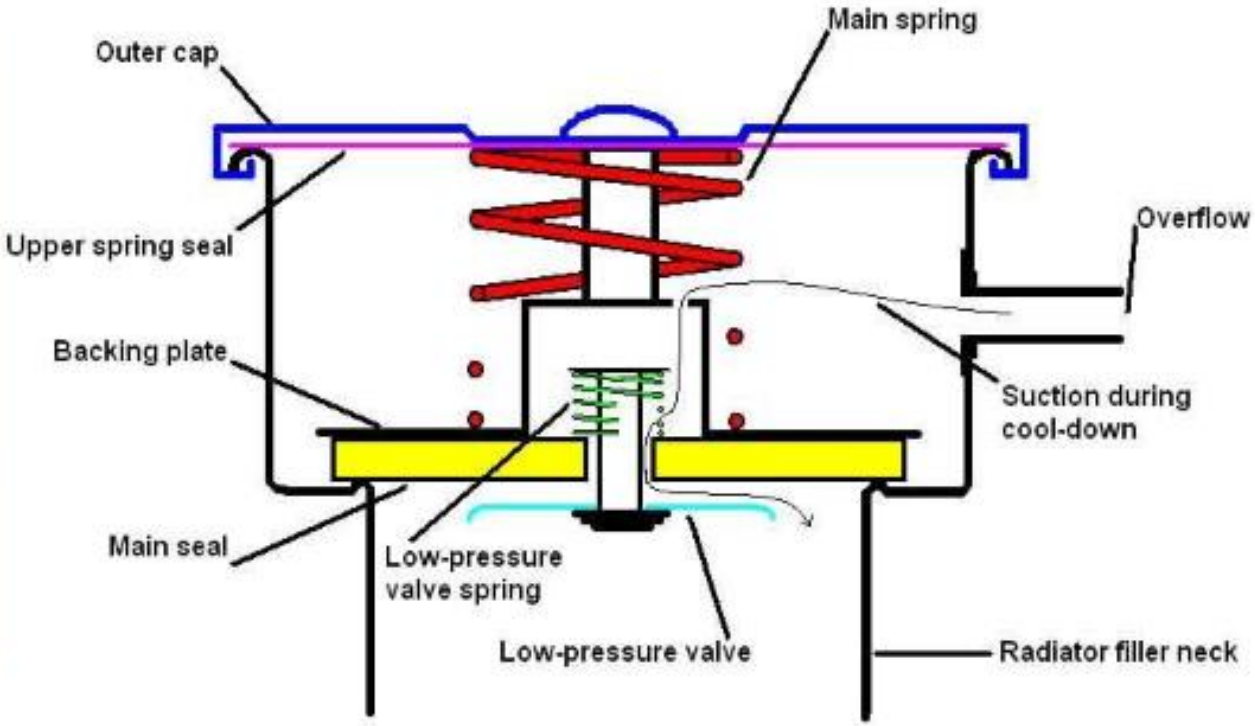
Radiator Pressure cap seals the cooling system and pressurizes it.

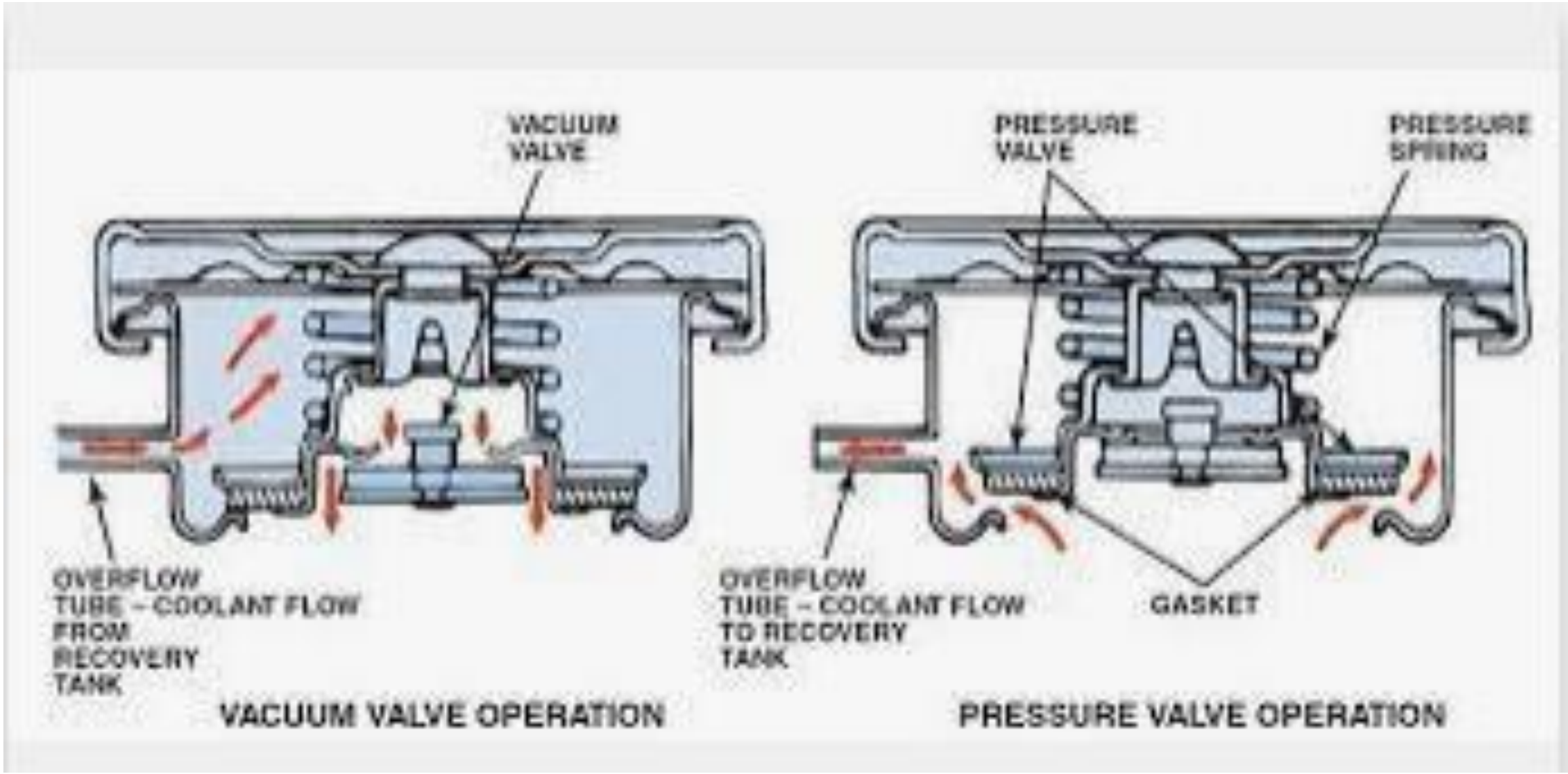
- Most caps exert 10-16 psi (0.7-1.1 kg/sqcm) of pressure
- Each psi of pressure inserted increases the boiling point of coolant by 1.8° C (3° F)
- Built in pressure relief valve prevents excessive pressure build-up by sending excess coolant to the expansion (Recovery) tank
- Vacuum vent valve allows the coolant to re-enters the system (when engine is shut off and cools)

CAUTION: Radiator cap should never be opened when the engine is hot (if the top radiator hose is hard)



Working of Radiator cap valves




VACUUM VALVE
OVERFLOW TUBE – COOLANT FLOW FROM RECOVERY TANK
VACUUM VALVE OPERATION
PRESSURE VALVE
PRESSURE SPRING
OVERFLOW TUBE – COOLANT FLOW TO RECOVERY TANK
GASKET
PRESSURE VALVE OPERATION

As the engine's coolant heats, it expands, increasing pressure inside the closed coolant system. The radiator cap controls this expansion and provides constant pressure on the system. The caps pressure rating varies by engine application anywhere from 13 – 16 psi. High-performance caps range from 19 – 32 psi. Water boils at 212° F, increasing the pressure in a closed system increases the boiling point. This allows manufacturers to manufacture engines with higher operating temperatures.

The radiator cap also allows the engine's coolant to expand and contract without allowing air to enter the cooling system. The upper seal seals and protects the system at all times. After the engine warms and system pressure reaches the caps rated pressure, the pressure spring compresses and pressurized coolant flows into the reservoir or coolant overflow tank. It allows for the expansion of the heated fluid.

The radiator cap also allows the coolant to flow back into the radiator as the engine cools. It also contains a vacuum valve. As temperatures drop and the coolant contracts, a vacuum is created in the engine's cooling system. The vacuum valve opens and allows coolant to flow from the overflow tank back into the radiator. This valve allows for contraction as the fluid cools.

Coolant Recovery Tank

- Keeps the coolant level full in the system at all times.
- Works in conjunction with the radiator cap.
- When the engine heats up the coolant expands and flows to the recovery tank.
- When the engine cools the coolant contracts and creates a vacuum and draws the fluid back into the radiator.
- Reduces air in system
- Reduces rust
- Less need to open radiator

Cooling System Inspection

- Check coolant level.
- Check anti-freeze protection.
- Check coolant condition.
- Check coolant pH.
- Leak check system.
- Check radiator cap.
- Check belt tension.
- Check belt condition.
- Check hose condition.
- Blow out radiator fins.
- Check thermostat.
- Check radiator fan.
- Check water pump.

Advantages of Water Cooling System:

These are some advantages of Water Cooling System:

- In these types of cooling, we see a high heat transfer rate.
- This type of cooling system is used where the size or power of the engine is more.
- Thermal Conductivity is more
- Water is easily available
- Liquid has a high enthalpy of vapourization so that e=the efficiency of water cooling is more.

Disadvantages of Water Cooling System:

The disadvantages of Water Cooling System is mentioned below:

- Some time corrosion occurs inside the radiator or pipe or storage.
- Due to scaling heat transfer rate is goes down after the long run, so it needs regular cleaning and maintenance.

Examples of Water Cooled Engine:

- All the modern engines (Cars, Bus, Trucks, etc.) are nowadays use this type of cooling system.