Process Knowledge Document
Car Cooling System

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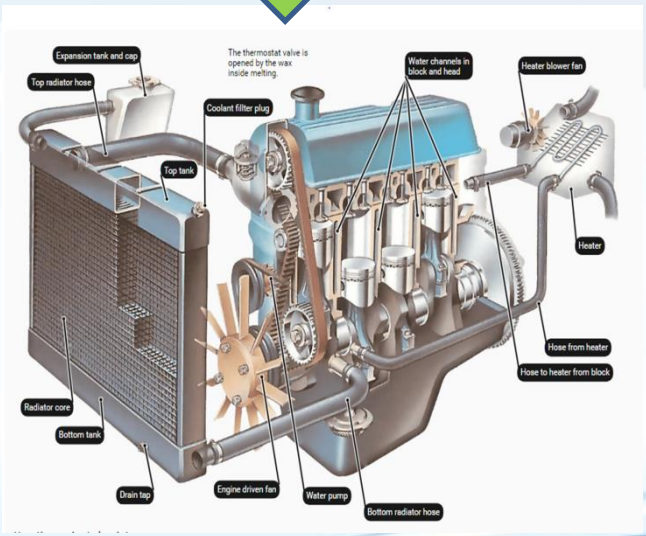
INTRODUCTION

An engine provides mechanical energy from an air/fuel mixture with an efficiency between 20 and 45%. The rest flows in kinetic and heat energy in exhaust gases and in heat energy through metallic bodies due to the frictions.

In this context, the cooling system must allow the engine to give its best performance, ensure the durability of this performance and ensure engine reliability by guaranteeing an acceptable level of thermo-mechanical stresses in any point of the engine. This is done thanks to evacuation of the exceeding calories towards outside atmosphere.

Generally this is done by circulating coolant liquid usually water mixed with an antifreeze solution through special cooling passages. Some engines are cooled by air flowing over finned cylinder casings”



In automotive industry, the main cooling systems are air cooling by natural convection, air cooling by forced convection and liquid water cooling. Natural convection means that cylinder and cylinder heads have fins to ensure efficient convection and conduction, whereas forced convection means that an air turbine and a cooling air housing are installed around the engine. In both cases, the coolant is the air which is the only fluid which evacuates calories. Liquid cooling uses two fluids, air and water. Water evacuates calories from the engine and exchanges them with ambient air in a radiator which is today the most used system in automotive industry.

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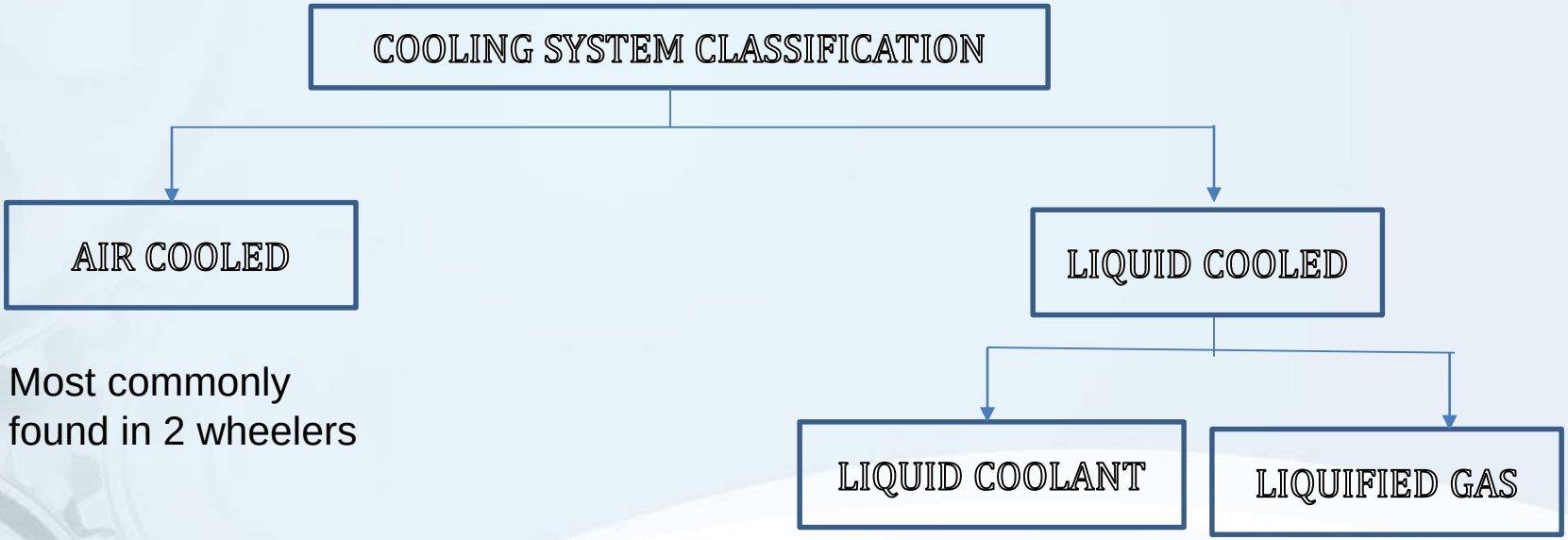
COOLING SYSTEM– TYPES

COOLING SYSTEM CLASSIFICATION

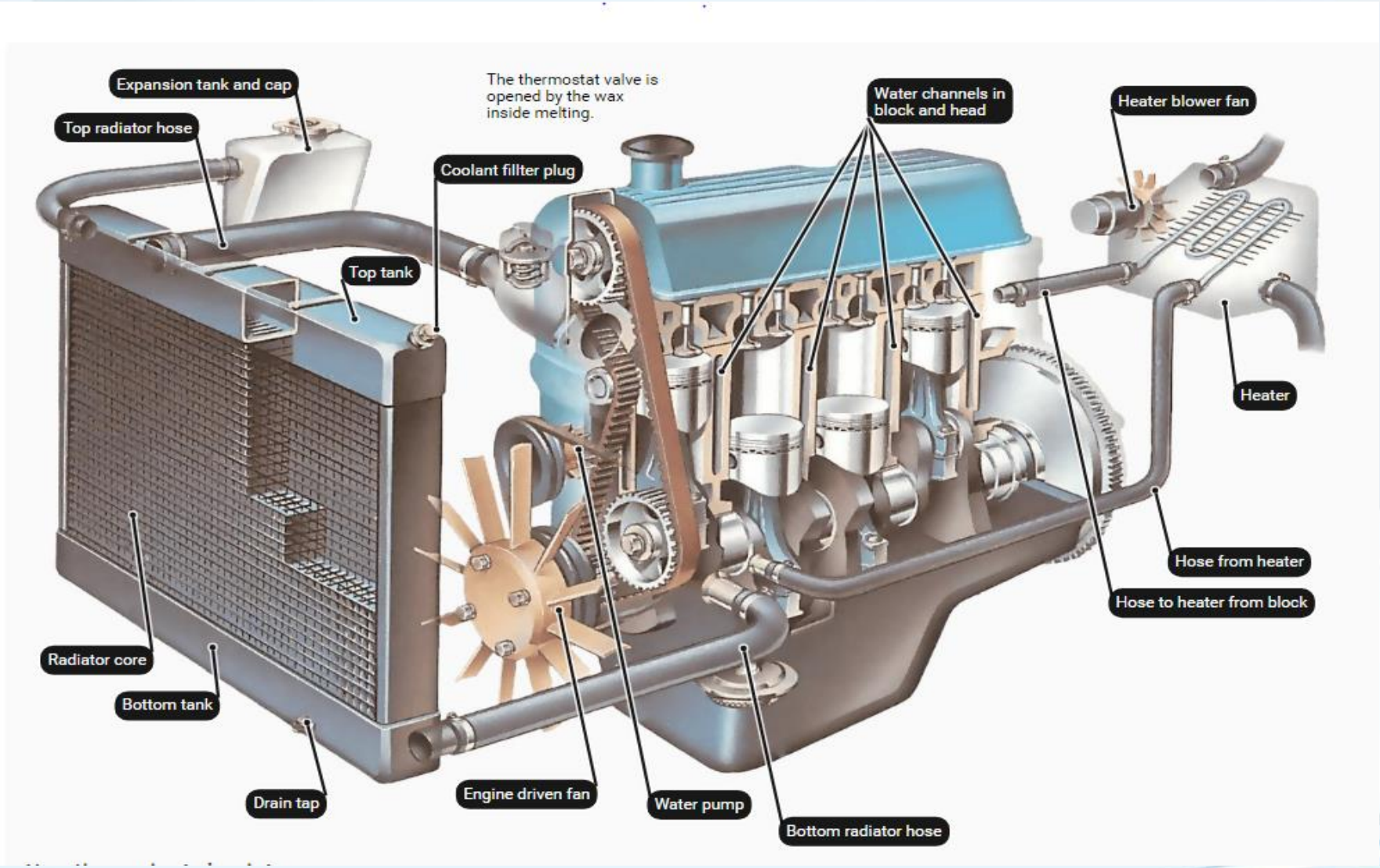


Most commonly found in 2 wheelers

Most commonly found in 4 wheelers and above

COOLING SYSTEM – BUILDING BLOCKS

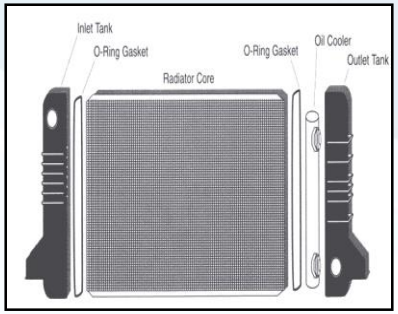
BUILDING BLOCKS OF COOLING SYSTEM(LIQUID COOLED)



BUILDING BLOCKS OF COOLING SYSTEM(LIQUID COOLED)

Water Pump:- This is a centrifugal type pump. It is centrally mounted at the front of the cylinder block and is usually driven by means of a belt. This type of pump consists of the following parts: (i) body or casing, (ii)impeller (rotor), (iii) shaft, (iv) bearings, or bush, (v) water pump seal and (vi) pulley. The bottom of the radiator is connected to the suction side of the pump. The power is transmitted to the pump spindle from a pulley mounted at the end of the crankshaft.

Radiator Fan :- The fan is generally mounted on the water pump pulley, although on some engines it is Attached directly to the crankshaft. It serves two purposes in the cooling system of a engine.
(a) It draws atmospheric air through the radiator and thus increases the efficiency of the radiator in cooling hot water.
(b) It throws fresh air over the outer surface of the engine, which takes away the heat conducted by the engine parts and thus increases the efficiency of the entire cooling system..



Radiator:- The purpose of the radiator is to cool down the water received from the engine. The radiator consists of three main parts: (i) upper tank, (ii) lower tank and (iii) tubes.
Hot water from the upper tank, which comes from the engine, flows downwards through the tubes. The heat contained in the hot water is conducted to the copper fins provided around the tubes. An overflow pipe, connected to the upper1 tank, permits excess water or steam to escape.

Thermostat Valve:- It is a kind of check valve which opens and closes with the effect of temperature. It is fitted in the water outlet of the engine. During the warm-up period, the thermostat is closed and the water pump circulates the water only throughout the cylinder block and cylinder head. When the normal operating temperature is reached, the thermostat valve opens and allows hot water to flow towards the radiator . Standard thermostats are designed to start opening at 70 to 75°C and they fully open at 82°C. High temp. thermostats, with permanent anti-freeze solutions , start opening at 80 to 90°C and fully open at 92°C.

BUILDING BLOCKS OF COOLING SYSTEM(LIQUID COOLED)

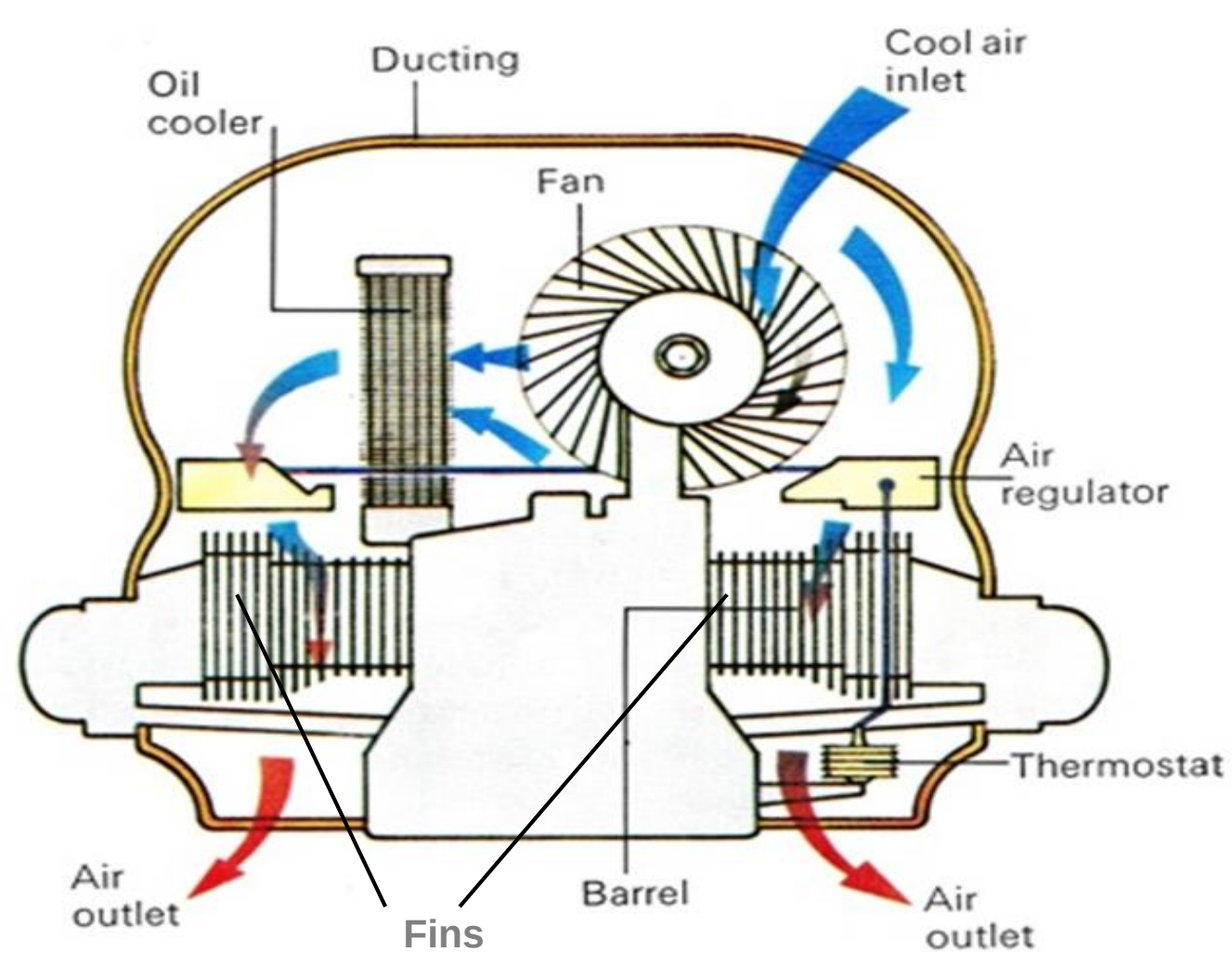
Water Jacket:- these are open surfaces between the cylinder walls and the outside shell of the block and head. Coolant from the shell of the block first flows through the block water jackets . Then the coolant flows up through the cylinder- head water jackets and back to the radiator.

Hoses :- There are several rubber hoses that make up the plumbing to connect the components of the cooling system. The main hoses are called the upper and lower radiator hoses ranging from 2-3 inches.

Pressure Cap :- The radiator pressure cap is a simple device that will maintain pressure in the cooling system up to a certain point. If the pressure builds up higher than the set pressure point, there is a spring loaded valve, calibrated to the correct Pounds per Square Inch (psi), to release the pressure.

Reserve Tank :-A radiator overflow tank collects the expanding coolant that is heated by the engine and recycles it back into the coolant system once it loses enough heat. The radiator overflow tank works in conjunction with the radiator cap to protect the engine and prevent coolant loss due to overflow.

BUILDING BLOCKS OF COOLING SYSTEM(AIR COOLED)

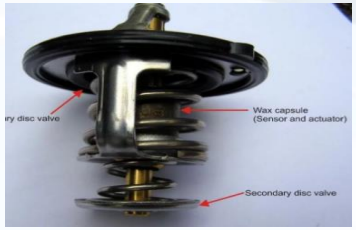


BUILDING BLOCKS OF COOLING SYSTEM(AIR COOLED)

Oil Cooler:- Oil cooler is a kind of heat exchanger for the engine oil to remove the excess heat from an IC engine .The hot engine transfers heat to the oil which then usually passes through a heat-exchanger (oil cooler),typically a type of radiator known as an oil cooler.

Air Cooling Fan :- The forced circulation of air around the engine is generally provided by a centrifugal fan or impeller, which rotates in a spiral shaped housing. This type of fan is capable of overcoming the appreciable resistance offered to the air as it flows around the ducted and finned cylinders and cylinder heads. The fan is driven by a V-belt and pulley system from the engine.

Air Cooling Throttle Valve:- The forced circulation of air around the engine is generally provided by a centrifugal fan or impeller, which rotates in a spiral shaped housing. This type of fan is capable of overcoming the appreciable resistance offered to the air as it flows around the ducted and finned cylinders and cylinder heads. The fan is driven by a V-belt and pulley system from the engine.

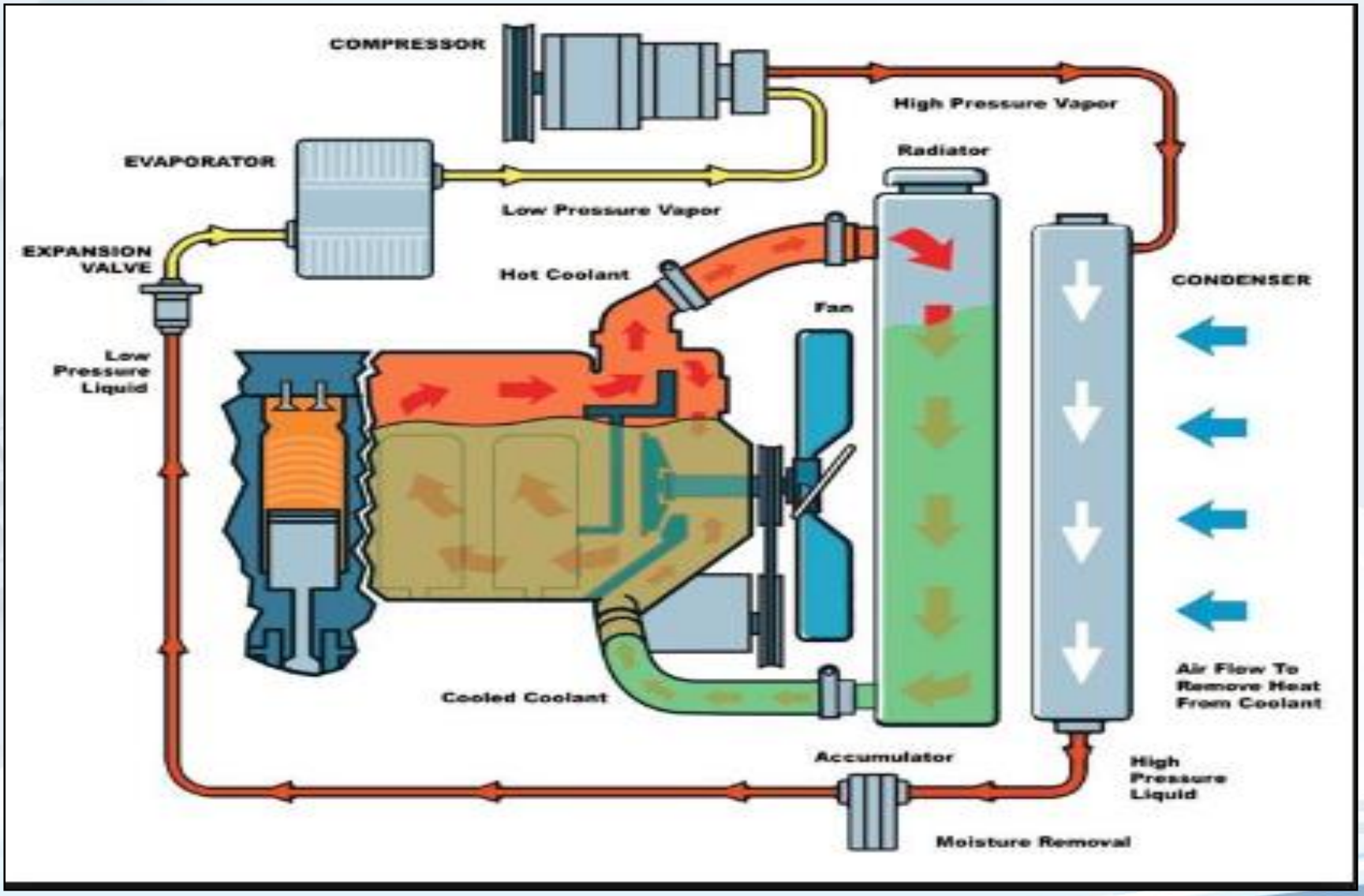


Air Cooling Thermostat Valve:- Automatic operation of the cooling fan throttle valve is effected by a thermostat, which therefore serves to regulate the rate of engine cooling. It is linked mechanically through a simple leverage system to the throttle valve, so that adequate movement is transmitted to the ring within the available working stroke of the unit. The thermostat is generally installed in the hot air duct leading from the lower part of the plenum chamber.

Fins:- The basic use of fins on the engines is to increase the surface area of cylinder of the engine so that air cooling can be done more efficiently. As air is used to remove heat and it has low heat consumption value, more area is provided for air to remain in contact with engine.

COOLING SYSTEM TYPES – WORKING

Liquid Cooling Type :-



Liquid Cooling Type :-

A water-cooled engine block and cylinder head have interconnected coolant channels running through them. At the top of the cylinder head all the channels converge to a single outlet.

A pump, driven by a pulley and belt from the crankshaft, drives hot coolant out of the engine to the radiator, which is a form of heat exchanger.

Unwanted heat is passed from the radiator into the air stream, and the cooled liquid then returns to an inlet at the bottom of the block and flows back into the channels again.

Usually the pump sends coolant up through the engine and down through the radiator, taking advantage of the fact that hot water expands, becomes lighter and rises above cool water when heated. Its natural tendency is to flow upwards, and the pump assists circulation.

The radiator is linked to the engine by rubber hoses, and has a top and bottom tank connected by a core a bank of many fine tubes.

The tubes pass through holes in a stack of thin sheet-metal fins, so that the core has a very large surface area and can lose heat rapidly to the cooler air passing through it.

In an engine at its ordinary working temperature, the coolant is only just below normal boiling point. The risk of boiling is avoided by increasing the pressure in the system, which raises the boiling point.

The extra pressure is limited by the radiator cap, which has a pressure valve in it. Excessive pressure opens the valve, and coolant flows out through an overflow pipe.

In a cooling system of this type there is a continual slight loss of coolant if the engine runs very hot. The system needs topping up from time to time.

Now cars have a sealed system in which any overflow goes into an expansion tank, from which it is sucked back into the engine when the remaining liquid cools.

Liquid Cooling Type :-

Working of Fan:-

The radiator needs a constant flow of air through its core to cool it adequately. When the car is moving, this happens anyway; but when it is stationary a fan is used to help the airflow.

The fan may be driven by the engine, but unless the engine is working hard, it is not always needed while the car is moving, so the energy used in driving it wastes fuel.

To overcome this, some cars have a viscous coupling a fluid clutch worked by a temperature sensitive valve that uncouples the fan until the coolant temperature reaches a set point. Others can have an electric fan, also switched on and off by a temperature sensor.

To let the engine warm up quickly, the radiator is closed off by a thermostat, usually sited above the pump. The thermostat has a valve worked by a chamber filled with wax.

When the engine warms up, the wax melts, expands and pushes the valve open, allowing coolant to flow through the radiator.

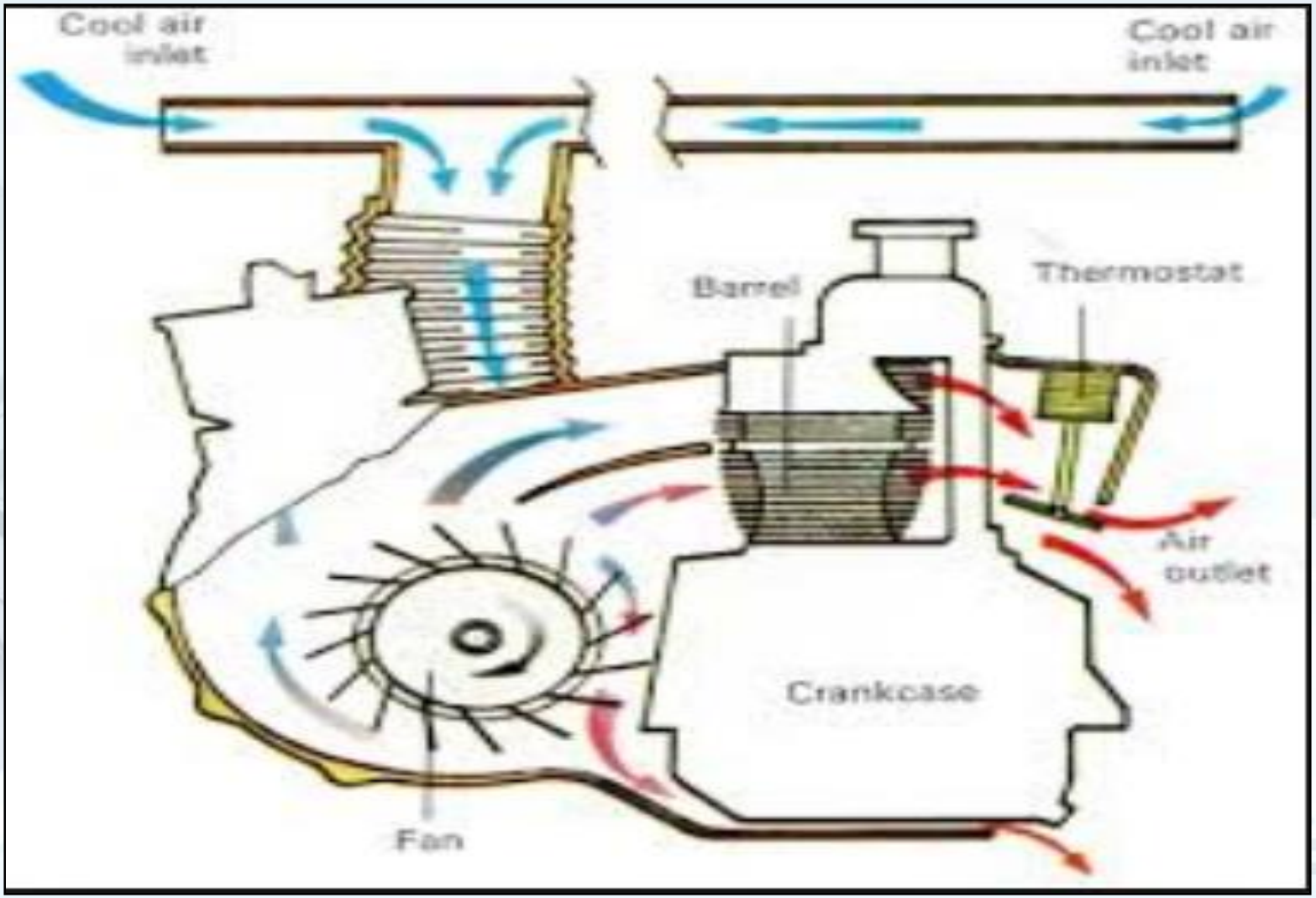
When the engine stops and cools, the valve closes again.

Importance of Anti Freeze-

Water expands when it freezes, and if the water in an engine freezes it can burst the block or radiator. So antifreeze usually ethylene glycol is added to the water to lower its freezing point to a safe level.

Antifreeze should not be drained each summer; it can normally be left in for two or three years.

Air Cooling Type :-



Air Cooling Type :-

Air-cooled system is where the engine block is covered in aluminium fins that conduct the heat away from the cylinder. A powerful fan forces air over these fins, which cools the engine by transferring the heat to the air.

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 reduced by the air-cooling depends upon factors such as ;

a) the total area of the fin surfaces,
b) the velocity / amount of the cooling air
c) the temperature of the fins as well as the cooling air
d) Conductivity of the metal used

Comparison Between Air Cooled and Liquid Cooled System

Air Cooling	Water Cooling
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.
Engine is smaller in size and its design much simpler.	Engine has larger dimensions and its design is more complex.
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.
Volumetric efficiency of air-cooled engine is lower due to higher cylinder head temperatures.	Volumetric efficiency of water-cooled engines is higher.
Air cooling cannot be employed for high specific output engines due to complex nature of fins required.	Since heat transfer coefficient of water is about 350 times that of air, water cooling can be used for high specific output engines.
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.
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.
Air fan is an additional source of noise.	Presence of water passage attenuates the combustion noise.
Control of cooling system is much easier.	Control of cooling system is comparatively difficult.

VEHICLE HEATING DOES NOT WARM UP

Does the heating valve open?

Check the electrical control and/or Bowden cable and valve

Is the heating radiator (heat exchanger) clogged?

Check the temperature at the input and output of the heat exchanger, check the flow rate

Does the flap control work?

Check the flap positions and limit stops, fresh-air and recirculated-air function, air outlet nozzles

Does the interior blower work?

Noise, fan levels

Is the cabin filter soiled or air flow rate decreased?

Check the cabin filter, check the air ducts for false air

General Troubleshooting

ENGINE DOES NOT WARM UP

Is the displayed temperature realistic?

If necessary, check the coolant temperature sensor and indicating instrument

Is the thermostat constantly open?

Record the temperature before and after the thermostat, remove the thermostat and inspect in a water bath if necessary

Does the radiator fan or auxiliary fan work permanently?

Check the switch-on point, thermal switch, fan control unit

General Troubleshooting

ENGINE OVERHEATS

Is the displayed temperature realistic?

If necessary, check the coolant temperature sensor and indicating instrument

Are the radiators or upstream components (condenser) free from contaminants to ensure an unrestricted air flow rate?

If necessary, clean the components

Does the radiator fan or auxiliary fan work?

Check the switch-on point, fuse, thermal switch, fan control unit; check for mechanical damage

Does the thermostat open?

Record the temperature before and after the thermostat, remove the thermostat and inspect in a water bath if necessary

Is the radiator clogged?

Check the temperature at the input and output of the radiator, check the flow rate

ENGINE OVERHEATS

Is the coolant pump working?

Check whether the pump wheel sits firmly on the drive shaft

Are the overpressure and/or under pressure valves of the radiator cover and/or expansion tank working?

If necessary, use the test pump and check whether the seal of the cover is present and/or damaged

THANK YOU

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Are there any Questions?