ALTERNATIVE ENGINE'S COOLING SYSTEM USING REFRIGERANT

VINOTH.B*

ABSTRACT:

The purpose of cooling system is to keep the engine at its most efficient operating temperature at all speeds, and under all operating conditions. During combustion of the air-fuel mixture inside the engine the temperature as high as 220ºC may reached, this level may also increases when the engine speed increases. If there is no provision of any cooling systems the inside temperature heavily affects the cylinder wall, heads, piston and piston rings etc. To minimize this fact every automobile engines comes with cooling system they either natural or artificial. Most the two wheelers comes with air cooling method and four wheelers comes with artificial cooling method sometimes high range two wheelers may also comes with artificial one. Using both methods we will reduce the temperature but it is not sufficient when the atmospheric temperature exceeds more than the normal level. In this situation there is a need of an alternative method. Engine's cooling with refrigerant may solve that fact because it is slightly depends upon the atmospheric temperature than remaining methods of cooling. So we ever get a better result from refrigerant cooling.

KEYWORDS: Internal combustion engine, compressor, condenser, evaporator, expansion device, capillary tube, refrigerant, copper tube.

* Under graduate student, B.E-Mechanical Engineering

E.G.S.Pillay Engineering College (affiliated to Anna University Chennai),

Palpannaichery, Nagapattinam, Tamil nadu, India.

1. IMPORTANCE OF ENGINE COOLING:

The average temperature in the internal vicinity of the cylinder stands at about 1400ºC. If the heat is not dissipated the internal surface of the combustion chamber will become red hot, the cylinder wall will burn and the various parts of the engine will expand excessively resulting seizure of piston and bearings. Cylinder wall temperature must not go higher than about (250 to 260^0C). Temperature higher than this causes the lubricating-oil film to break down and loose its lubricating properties. However, the engine operates best at temperature as close as possible to the limits imposed by oil properties. Removing too much heat through the cylinder walls and the head lowers the thermal efficiency of the engine.

Cooling systems are designed to remove about one-third (30 to 35 percent) of the heat produced in the combustion chamber by burning of air-fuel mixture. One-third of the heat leaves the engine through the exhaust system. Generally, only about one-third of the heat of combustion can be utilized to create pressure on top of the piston for doing useful work.

The engine is very inefficient while cold. Therefore, the cooling system includes devices that prevent normal cooling action during engine warm-up. These devices allow the engine parts to reach their normal operating temperature more quickly. This shortens the efficient cold-operating time. When the engine reaches its normal operating temperature, the cooling system begins to function. The cooling system cools the engine rapidly when it is hot, and slowly or not at all when the engine is cold or warming up.

2. PRESENT TYPES OF COOLING METHODS:

2.1 Air cooling

- Air jacket cooling
- Natural cooling
- Forced air cooling

2.2 Water cooling

- Thermo-siphon cooling
- Pumped circulation cooling

2.1 AIR COOLING:

In air cooling method normal and easily available atmospheric air is used to cool the engine. For getting optimum result of cooling these engines has number of projected surface called as fins. The air takes place between the fins surface and get heat due to their buoyancy effect after they leave from that place then new air takes that pace. This process was done in continuous manner. It is also known as external cooling method.

2.1.1 AIR JACKET COOLING:

In this cooling arrangement, the air is made to pass through the small passages formed in the cylinder block and the cylinder head. The construction is such that a network of passages is made all around the cylinder during its casting. The air is passed through a single or multi-passages, either naturally or by artificial means. If the airflow is natural, an air-duct is provided in front of the engine; and a fan or a blower is used in case of artificial flow of air.

2.1.2 NATURAL COOLING:

In normal cause, larger parts of an engine remain exposed to the atmospheric air. When the vehicles run, the air at certain relative velocity impinges upon the engine and sweeps away its heat. The heat carried-away by the air is due to natural convection, therefore this method is known as natural air-cooling. Engines mounted on 2-wheelers are mostly cooled by natural air.

2.1.3 FORCED AIR COOLING:

It is a well-known fact that the rate of heat transfer due to convection increases with an increase in the velocity of the air flowing over a hot body. This increase may be 55% to 60% when the air velocity is doubled. To utilize gains of this fact, artificial means are adopted to supply air at higher velocity on the engine. A fan or blower is used for this purpose, and the system is then known as fan air-cooling.

2.2 WATER COOLING:

In this water cooling method normal water is used for cooling purpose. Here water jacket arrangement was provided in each and every cylinders outer surface so that the water can easily flow through the area. It is also known as internal cooling method.

2.2.1 THERMO-SIPHON WATER COOLING SYSTEM:

The thermo-siphon cooling system operates on the principle of natural convection caused by variation in density of water, and hence does not use a pump. The heated water expands, due to which the density decreases. When it cools down, its volume decreases and hence density increases. This variation in density sets up convection currents so that circulation of water takes place. All components of water-cooling systems except the circulating pump are used in this case.

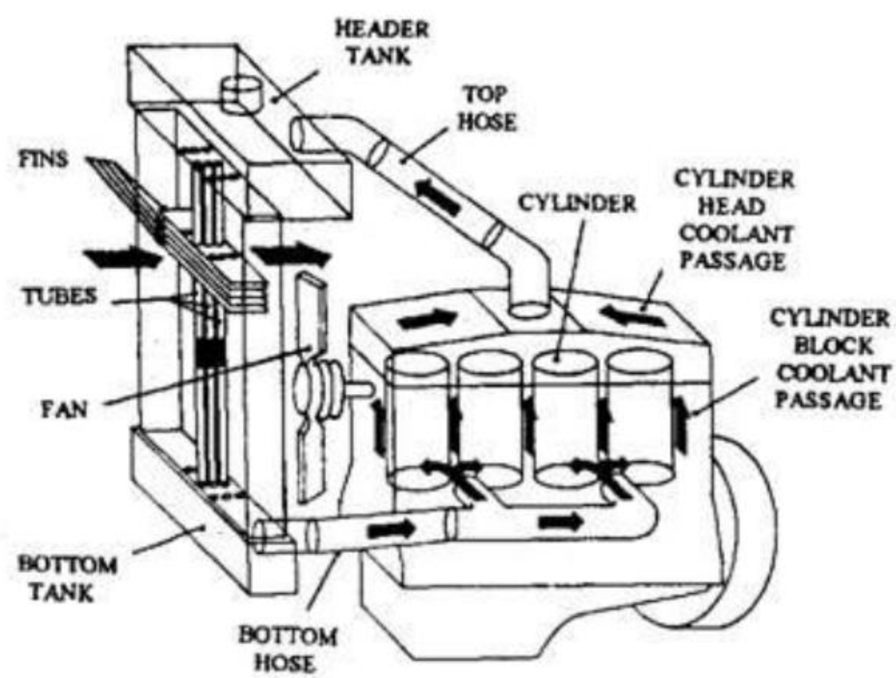

Fig. 2.2.1 Thermo-siphon water cooling system

2.2.2 PUMPED CIRCULATION WATER COOLING SYSTEM:

The water-cooling system has the major components such as water jackets, circulating pump, fan, thermostat, connecting pipes and hoses, radiator and radiator cap. The direction of cooling water flow is upward from the cylinder head to the top tank of the radiator, then downward 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 and then through the water pump, which circulates the water. Water enters the engine at the centre 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.

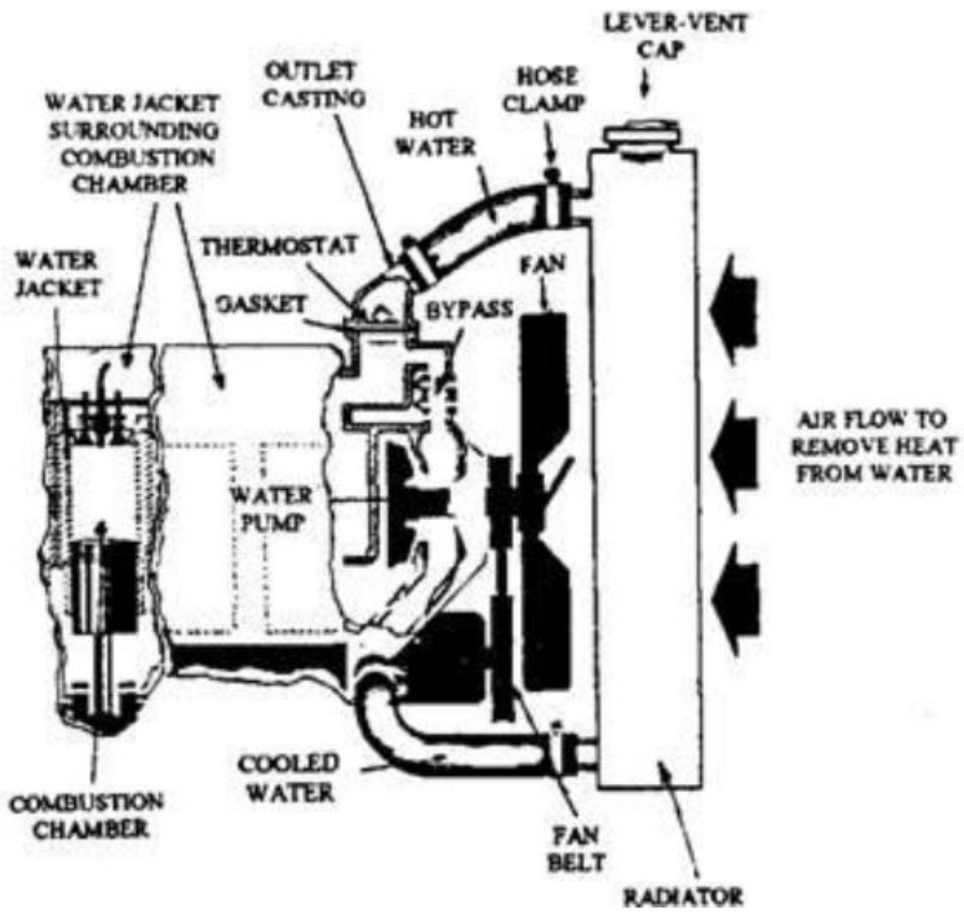

Fig. 2.2.2 Pumped circulation water cooling system

3. ALTERNATIVE COOLING SYSTEM:

In this alternative cooling system there is the variation of coolant, instead of using water the refrigerant is used. The refrigerant may R-12 or R-22 because those kinds of refrigerants are quite harmless and non-flammable. Then the water pump changed into compressor or heat pump.

3.1 REFRIGERANT COOLING SYSTEM:

The refrigerant cooling system also has the same construction of water cooling system but here instead of using water pump compressor is used and the coolant is converted into R-12 refrigerant. At the same when the compressor is switched on the compressor clutch encaged with compressor pulley which is belted with crank pulley. Due to the compressive force on the refrigerant inside the compressor the refrigerant pressure and its temperature increases heavily, then it is passed through the condenser here the temperature gets down slowly so the refrigerants gaseous phase changes into partial liquid, then it is passed through the expansion device or capillary tube here the path is very narrow so the refrigerant make more friction when it cross the tube due this fact its temperature reduces continuously after that the pressure and temperature of the refrigerant accidently reduces and goes to negative value in the outlet of the expansion device. The temperature reduction depends upon the length and diameter of the capillary tube. Here it is fully converted into liquid state with negative heat. This liquid passed through the outer surface of the each cylinder in the engine. Due to the large temperature difference the cooling process done rapidly than the water cooling method.

The compressor ON/OFF process is controlled by the temperature sensor. The temperature sensor continuously sense the engines temperature from its starting and when the estimated temperature is achieved it will turn on the compressor, then the compressor starts its work if the engines temperature may downs its warm up temperature level it will be turned OFF.

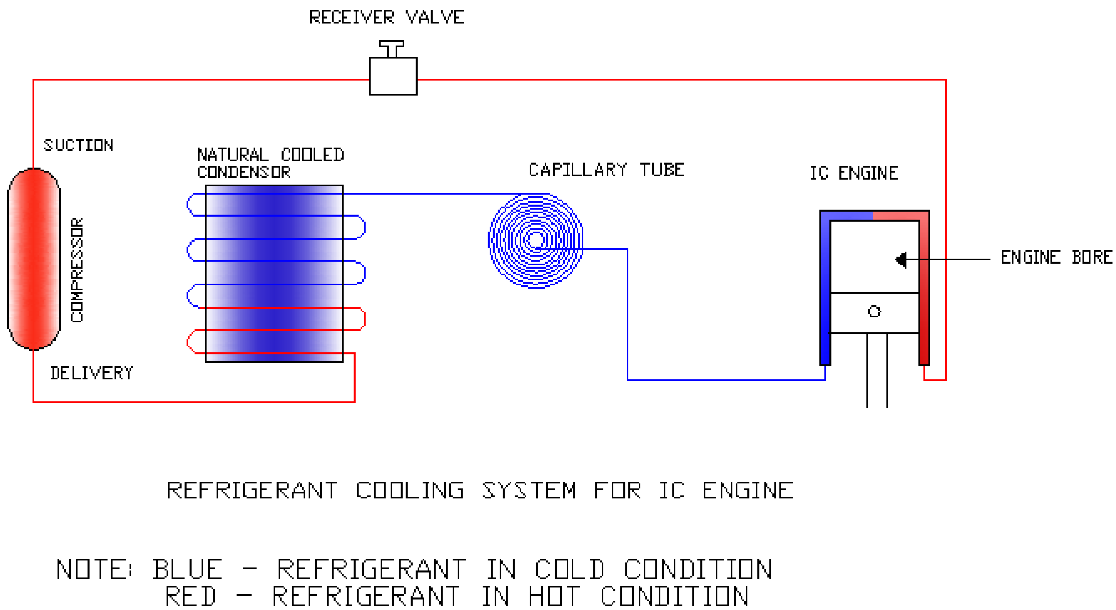

Fig. 3.1 Refrigerant cooling system

The heat transfer from cylinder wall to refrigerant is done by forced convection method. The flow of the refrigerant takes place across the cylinder.

HEAT TRANSFER THROUGH CONVECTION:

Heat transfer through convection $Q_{convec} = h\ A\ (T_s - T_\infty)$ Watts

Here,

Q is convective heat transfer in W

h is heat transfer co-efficient in W/m^2K

A is concentric surface area of the cylinder in m^2

T_s is temperature of the surface in K

T_∞ is temperature of the fluid in K

Here using water as a coolant,

$Q_{convec} = h\ A\ (T_c - T_w)$ W (${T_c}$ cylinder wall temperature, T_w water temperature)

Here the calculations were made for 2 litre engine each cylinder has 500cc, Dia is 0.08m

Area of the cylinder A = $5.027*10^{-3}$ m^2

$T_c = 150^oC = 423$ K

$T_w = 40^oC = 313$ K

The following data's are taken from H.M.T data book New Age International Publication

$Nu_d = [0.35+0.56.Re_d^{0.52}]Pr^{0.333}$ (for liquids) $10^{-1} < Re_d < 10^5$

Nu_d is Nusselt Number base d on the diameter

Re_d is Reynolds Number based on the diameter

Pr is Prandtl Number

Properties of the water at 40ºC is

$\rho = 995$ Kg/m^3, $\nu = 0.657*10^{-6}$ m^2/s, Pr = 4.340, c = 4178 J/Kg K, k = 0.6280 W/m K.

$Re_d = \mu*d/\nu$

$\mu = \rho*\nu = 995*0.657*10^{-6} = 6.54*10^{-4}$ Ns/m^2

$Re_d = (6.54*10^{-4}*0.08)/0.657*10^{-6} = 79.63$ $10^{-1} < 79.63 < 10^5$ (condition satisfied)

$Nu_d = [0.35 + 0.56 * 79.63^{0.52}].4.340^{0.333}$

$Nu_d = 9.47$

$Nu_d = h*d/k$ so $h = Nu_d*k/d = (9.47 * 0.6280)/0.08$

h = 74.35 W/m^2 K

$Q_{convec} = 74.35 * 5.027*10^{-3} * (423 – 313)$

Q_{convec} = 41.12 W is obtained from water cooling system.

Here using refrigerant as a coolant

Initially we fill the refrigerant in to the system in the form of gas when it reaches the engine it is in the form of liquid due to this sudden pressure & temperature drop.

So here we use the same liquid formula for finding Nusselt Number

$Nu_d = [0.35 + 0.56 * Re_d^{0.52}] Pr^{0.333}$ $\quad 10^{-1} < Re_d < 10^5$

$A = 5.027*10^{-3}\ m^2$

$T_c = 150°C = 423\ K$

$T_{ref} = 20°C = 293\ K$

The following data's are taken from H.M.T data book New Age International Publication

Properties of the refrigerant R-12 at 20ºC

$\rho = 1330\ Kg/m^3$, $\nu = 0.198*10^{-6}\ m^2/s$, $Pr = 3.50$, $c = 963\ J/Kg\ K$, $k = 0.0727\ W/m\ K$.

$\mu = \rho*\nu = 1330*0.198*10^{-6} = 263.34*10^{-6}$

$Re_d = (\mu*d)/\nu = (263.34*10^{-6} *0.08)/0.198*10^{-6} = 106.4$

$10^{-1} < 106.4 < 10^5$ (condition satisfied)

$Nu_d = [0.35 + 0.56*106.4^{0.52}]*3.50^{0.333}$

$Nu_d = 10.16$

$h = Nu_d*k/d = 10.16*0.0727/0.08 = 9.23\ W/m^2\ K$

$Q_{convec} = 9.23 * 5.027*10^{-3} * (423 – 293)$

$Q_{convec} = 6.03W$ is obtained from refrigerant cooling system

Form the above two results we conclude when we use refrigerant as coolant we ever get the effective engine cooling.

The above given results are one of the example of the alternative engine cooling system. But sure if we use refrigerant as coolant can get better cooling rate.

REFERENCES:

BOOKS

[1] Auto mobile engineering vol.1 & vol.2 by kirbal singh

[2] Fundamentals of Engineering Heat and Mass Transfer by R.C. Sachdeva

[3] Theory of Machines by R.S. Kurmi & J.K. Guptha

[4] A Text Book of Thermal Engineering by R.S. Kurmi & J.K. Guptha

JOURNALS

[1] IJMIE journal of Integration of EC & IC Engines volume 2, issue 6 in june 2012

[2] International Journal of Engineering & Applied sciences, Design Modification and Analysis of Two wheeler cooling Fins- A Review, volume 5, june 2014.

WEBSITES

[1] http://auto.howstuffworks.com/engine-cooling-system.htm

[2] http://en.wikipedia.org/wiki/Internal_combustion_engine_cooling

[3] http://www.sciencedaily.com/articles/r/refrigerant.htm