Performance Evaluation of Evaporative Engine Cooling Using VCR System

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Abstract-*An internal combustion engine produces power burning by fuel within the cylinders; however, only about 30% of the heat is converted to useful power. Thirty to thirty five per cent of the heat produced in the combustion chambers by the burning fuel is dissipated by the cooling system along with the lubrication and fuel system. If this heat were not removed quickly, overheating and extensive damage would result. Valves would burn and warp, lubricating oil would break down, pistons and bearing would overheat and seize, and the engine would soon stop. Most internal combustion engines are cooled using either air or a liquid coolant run through a heat exchanger (radiator) cooled by air. In air cooling system, heat is carried away by the air flowing over and around the cylinder. In water-cooling system of cooling engines, the cylinder walls and heads are provided with jacket through which the cooling liquid can circulate. The above two system explain are widely used in cooling of IC engine of all types of automobiles vehicles. These systems provide constant cooling effect which is a major limitation. Because of constant cooling rate they give lower cooling effects at High speed and load condition, while at lower speed they give high cooling which is also not desirable. Here in this project we are going too analysed and proposed a new cooling system which has cooling effect based on speed and load condition experimentally.*

Keywords:-Coefficient of performance, Compressor power consumption, Cooling system, Internal combustion engine, Vapour compression.

I. INTRODUCTION

Generally cooling system used in all type of automobiles are water cooled, air cooled and oil cooled system Conventional cooling system used in automobile gives satisfactory performance at normal speed and load condition .But, when vehicle is derived continuously at high speed and load .These system does not give proper cooling effect. Again ,all air conditioned car have a condenser located infront of the radiator .here, the atmosphere air is pass over condenser tube and heat is added to air ,then this air flows over radiator tube which cools the coolant flowing through engine block. This condenser location at in front of the radiator reduces the cooling efficiency of system. Again this has adverse effect on Coefficient of Performance of (COP) car air conditioning system. In this paper we are introducing a new cooling system which will maintain the engine temperature under maximum efficiency condition. We are also trying to improve the Cop of the car air conditioning system. The set up consist of a vapour compression refrigeration system which will provide combine engine cooling and air conditioning of car. The main objective of this project is to test and determine total cooling rate of system, The coefficient of performance, compressor power consumption, pressures and temperatures of refrigerant at each component (inlet and outlet) are measured and analysed with the variation of speed and load.

II.LITERATURE REVIEW

Goncalves F.J., et.al. [1]it analyzed that The actual cooling systems are not the most efficiency, far away from that, the cooling capacity was not always enough to cool the engine and also some times the cooling capacity is higher than the needs.

Iskandar M.A., et.al.[2]it analysed that the results described in the specialized technical literature, as well as experience in the MWM International Motors and tests made in the context of this work, allow us to predict that the use of a cooling system with electronically controlled engine, tends to reduce both energy consumption, the temperature of the cylinder wall and the temperature fluctuations in order to reduce the thermal stresses and stabilizing the temperature of the oil film that reduces friction in the sliding component.
Sharma V.,[3] it analysed that a savings of 12-18 % of surface area can be seen by use of Nano fluids. As the load on the engine and the speed of the engine increases the percentage savings of surface area also increases. The thermal conductivity of Nano fluid was temperature dependent. As the temperature increases at higher load and speeds the heat carrying capacity of Nano fluids increases. This was advantageous when engine was running at high speed and load. At higher air velocity the % savings in surface area is more. It means that at higher vehicle speed the use of Nano fluid has a lot of advantage.

Krakowski R.,[4] it was analyzed that the original cooling system operating at elevated pressure coolant was developed, built and tested. With an average overpressure 0.3 MPa in the cooling system, due to evaporation of cooling water, the water temperature at the outlet of the cylinder head, was achieved at 120°C.

Reddy A.K., et.al. [5] it was analyzed that this advanced engine cooling system consists of micro controller to control the quantity of coolant into the engine cylinder block. The thermal efficiency of the internal combustion engine was increased remarkably by using this type of engine cooling system.

III.PROBLEM RELATING TO CONVENTIONAL ENGINE COOLING SYSTEM

As already stated that in air conditioning system of automobile the condenser unit is located in front of radiator, for condensation of refrigerant used in the system at least 5 ˚c temperature difference is necessary. Air from outside first passes over the condenser tube and then to radiator, this increases the temperature of inlet air to be passed over the radiator. As the heat removing rate is directly proportional to temperature difference this reduces the cooling efficiency of the system.

Amount of heat removed in radiator is given by,

$Q_{radiator}=A_s h_c(T_{cm} - T_a)$

Where,

T_{cm}= mean coolant temperature,

T_a =temperature of inlet air.

Thus increase in air temperature reduces the heat transfer capacity of radiator. It is found that 5˚C increase in air temperature reduces the heat flow from 4 kj/sec to 6kj/sec. This heat is results in adverse performance of the engine at high speed and load condition. Again the conventional cooling systems have constant cooling effect, due to there is possibility of high cooling at low load condition. High cooling is also not important as it lowers the thermal efficiency of engine and lower the brake power output. So it is important to use a cooling system which gives cooling effect as per load and temperature of coolant.

IV. EVAPORATIVE ENGINE COOLING SYSTEM

In evaporative engine cooling (ECS) we are using two evaporators one for car air conditioning and another for engine. The evaporator for air conditioning performs its usual function, while the extra evaporator is located in front of condenser of the refrigerating system for engine cooling purpose.

Following are the main objectives of the ECS System,

a) To maintain engine temperature in such range in which engine operate at optimum efficiency.
b) To reduce engine power loss due to overheating.
c) To avoid failure and damaging of engine parts at high load and speed condition.
d) To increase COP of air conditioning system in car.

Principles of ECS System:

Air coming from outside first passes over the evaporator tube, then to condenser tube and finally on radiator tube. First the incoming air is cooled by evaporator tube and then passed over the condenser tube. Here the air absorbs the heat from vapour refrigerant and there is slight increase in air temperature. This air is then passed over the radiator tube to absorb the engine heat. As condenser tube is subjected to low temperature air, there is sub cooling of refrigerant. As per laws of refrigeration and air conditioning sub cooling always results in higher refrigerating effect and lower compressor requirement. This ultimately increases the COP of the system. Hence using ECS one can achieve combine engine cooling and car AC. This is the principle on which ECS system is based.

V. HEAT LOAD CALCULATIONS

The total quantity of heat generated in the engine that is lost to the cooling water as in equation

$$Q_{engine}= mC_p\Delta T \quad (1)$$

Since, there is a constant cooling air mass flow through the engine, radiator, fan and vehicle, from Energy Conservation or Continuity :

$$Q_{engine} = Q_{radiator} \quad (2)$$

Heat lost in Radiator :

Determining the Heat Transfer Area

Temperature drop in radiator is given by,

$$\left(\frac{T_i - T_o}{2}\right) - T_a \quad (3)$$

Other considerations for effective heat dissipation are the number of tube rows and arrangement, coolant velocity and air velocity . Coolant velocity above 1.8 m/s can lead to waste of energy.

$$Q_{radiator} = A_s h_c (T_{cm} - T_a)$$

This gives the cooling surface heat transfer area, *As*
For this first heat transfer coefficient (h_c) is required to be determine byNusselt equation $h_c$is given by ,

$$h_c = 1.155(1+1.24Cm)(P^2T_m)^{0.67}$$

Heat rejection in radiator (without condenser):
Heat rejected in radiator is given by,

$$Q=UA\Delta T_{lm}$$

Overall heat transfer coefficient is given by,

$$U = \frac{1}{\frac{1}{h_a} + \frac{A_t}{A_w} * \frac{1}{h_w} + \frac{A_t}{A_w} * \frac{x}{k}}$$

Total amount of heat load is the addition of engine heat and cabin heat present in car

VI. EXPERIMENTAL SETUP:

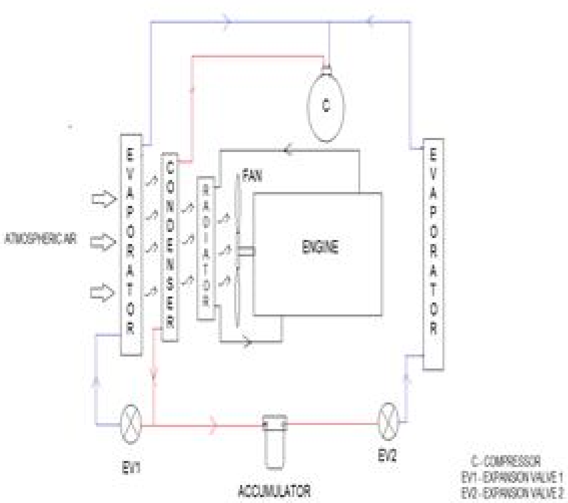

Figure No.1

Component To Be Used In Evaporative Cooling System**:**

1. Heating chamber
2. hermetic compressor
3. condenser
4. evaporator
5. expansion valve
6. pressure and temperature sensor
7. pressure and temperature indicator

VII. RESULT OF THE CALCULATION:

i. Engine heat load:

Table No.1

Sr.No.	Parameter	
1	Coolant inlet temperature	350 K
2	Coolant outlet temperature	410 K
3	Mass flow rate of coolant	0.347 Kg/sec
4	Specific heat of water	4.18 KJ/KgK
5	Theoretical heat carried by cooling water	67.18 KW
6	Density of water	1000 Kg/m^3
7	Heat transfer co-efficient	1200 W/m^2K
8	Surface area of radiator	0.88 m^2
9	Actual heat carried by cooling water	52.27 KW
10	Velocity of water in radiator tube	1.8 m/sec
11	Heat carried with condenser in front of radiator	47.40 KW

ii. Cabin heat load:

Table No.2

Sr.No.	Parameter	
1	Heat flow through walls	0.822 KJ/sec
2	Heat load due to solar radiation	2.87 KJ/sec
3	Occupant heat load	0.488 KJ/sec
4	Heat received from electronic and lightening devices	0.1277 KJ/sec
5	Metabolic heat load	0.564 KJ/sec
6	Direct radiation load	0.748 KJ/sec
7	Defused radiation load	0.14 KJ/sec
8	Ambient load	0.16 KJ/sec
9	Exhaust load	0.08 KJ/sec
10	Ventilation load	0.06 KJ/sec
11	Total load	2.9 KW

iii. Design calculation:

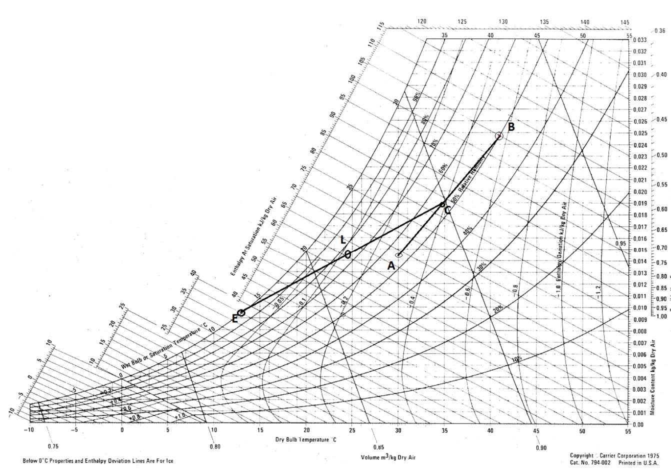

Table No. 3

Sr.No.	Parameter	
1	Inlet air condition	40◦C DBT,50% RH
2	Cabin air condition	30◦C DBT,55% RH
3	Enthalpy of inlet air	102 KJ/Kg
4	Enthalpy of recirculated air	70 KJ/Kg
5	Enthalpy of mixture	82 KJ/Kg
6	Temperature of mixture	34◦C
7	ADP of evaporator coil	13◦C
8	Condenser temperature (outlet)	45◦C
9	Mass flow rate of fresh air supply	0.092 Kg/Sec
10	Mass flow rate of reciculated air	0.138 Kg/Sec
11	Refrigerant	R134a
12	Mass flow rate of refrigerant	0.0496 Kg/Sec

From above calculation following results are obtained

1. Heat to be removed by the system also called as refrigerating effect (RE) is 6.449 KJ/sec.
2. Work required for compressor 2.2 KJ/sec.
3. Hence COP of the system is given by

$$COP = \frac{RE}{COMPRESSOR\ WORK}$$

$$COP = \frac{6.449}{2.2.}$$

COP = 2.8

VIII. CONCULSION

- Study of previous research papers shows that auto mobiles with current cooling system gives satisfactory performance at normal speed and load condition.But this system are not capable to maintain engine temperature in the range of maximum efficiency condition.
- The result of calculation shows that it is possible to run the engine under the temp. rangein which maximum efficiency can be obtained.
- Due to sub-cooling effect the C.O.P of system is found to be increased by considerable amount.
- There is a provision to avoid low temp cooling as well as over heating of engine.

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