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Automobile Radiator's Engineering and Analysation

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Abstract: ***The shape of a radiator cover is crucial either in determining the pattern of air flow or in increasing the same through the radiator core thereby increasing the thermal efficiency, thus making it a necessity to understand it. Moreover the parts circumjacent to the core namely the upper tank, lower tank, cooling fan, fins, tubes, etc promote the air flow rate. Also it is to note that the air flow rate of discharge gases from radiator core is one of the prime factors in determining the automobile cooling system.***

Initially factors such as temperature, pressure, air flow rate that affect the performance are obtained in order to derive out the entities of operation. One of the observations that can be made through this paper is that as the volume of the coolant increases, the rate of heat dissipation increases, also parameters like inlet temperature and volume flow rate of coolant, air velocity, temperature drop and drop in pressure of coolant are factors that contribute in radiator performance evidently.

Keywords : Radiator, fins, efficiency, effectiveness

I. INTRODUCTION

Radiators works on the principle of heat transfer briefly, heat exchange takes place between two specific media, specifically for heating and cooling any component or medium. Most of the radiators are used in domains of construction, automobile and electronics. Although the radiator has dual nature of heat transfer, that is cooling the system and heating the environment, on the whole it has a sole purpose of heating the environment. Although the name Radiator implies radiation, the process wont carry out through that, moreover the process that has been employed is Convection but referring the device as convector is scarce. [1] William H. C. and Donald L have started working for making the arrangement to release the considerable amount of heat for avoiding such bigger problem otherwise engine will seize.[2]Randy Rundle has done a lot of research work on different types of materials for the efficient conduction of heat and since copper is having good thermal conductivity of 385watt/m-K, they made a conclusion that it is the best material and can be utilized as a heat exchanger and they made a conclusion for their design namely "COPPER RADIATOR". [3] Ray T. Bohac. Various attempts have been made on numerous kinds of materials and finally came to conclusion that Aluminium can solve our problem, moreover it can be solution for our requirements and objectives.[4]Yunus A. Cengel and Robert H. Turner are said that A clear understanding of the flow pattern inside the radiator cover is essential for optimizing the radiator cover shape to increase the flow through the radiator core, thereby increasing the thermal efficiency of the radiator.[5] S. Vithayasai, T. Kiatsiriroat, A. Nuntaphan; are research on the effect of shape of heat transfer in the radiator. A circular shaped radiator is proposed instead of the conventional rectangular one. [6]K.Y. Leong , R. Saidur , S.N. Kazi , A.H. Mamun; are investigated the effect of nanofluid as a coolant in a radiator and also the heat transfer rate obtained is comparable or slightly higher than that of rectangular radiator.[7] The geometry effects on the performance of a compact louvered heat exchanger are investigated by A. Vaisi , M. Esmaeilpour , H. Taherian; and their aim is, circular shaped radiator gets optimized for maximum heat transfer by modifying the parameters like tube geometry, tank shape etc. [9] Chavan D.K, TasgaonkarG.S; are deals with the design and analysis of the automobile radiator with the help of CAD drawings and deals with the effect of shape of the radiator in heat transfer.

II. TEST SETUP

The working of radiator is demonstrated using an experimental setup. In an engine the heat is carried into the radiator by the coolant, which cools in the radiator and circulates into the walls of cylinder. In a similar manner we made a setup to test the radiator in which we made the changes. Our test setup contains the following components: Frame, Radiator, Cooling Fan, Water Pump, Heaters with Thermostat.

A. Frame

We use a frame made up of iron which includes a water sump. Our frame provides place for fixing cooling fan, motor and radiator including electric switches and wires. We can see in the following figure.

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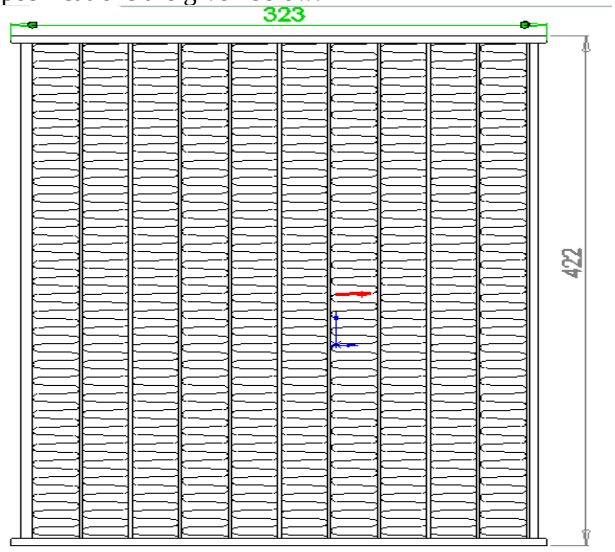
Fig.1 Radiator

B. Radiator

The window angle in the fins of the radiator based on design specifications of MAHINDRA 475 DI. Radiator specifications are given below:



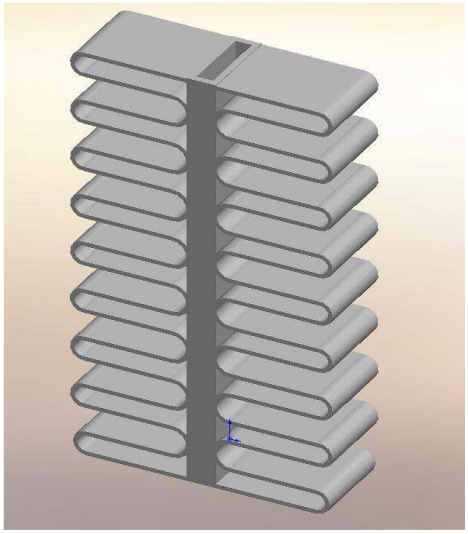


Fig.2 Fins

C. Cooling Fan

We use fan having 5 blades which runs with the help of a cooler motor. Cooling fan blade is of dimension 15 inches. Cooler motor used is of power 95 watts and with a variable speed of 3000-1370 rpm.

Fig.3 Fan and Cooling motor

D. Water Pump and Hoses

We use a water pump to pump water from water sump to the radiator with the help of rubber hoses. Water pump specifications are given below.

Fig. 4 Water pump motor and Hoses

Specifications:

- Power Voltage: 370W / 3,450 RPM
- ½ HP Long Lasting Motor
- Flow Rate Up to: 500GPH
- Dynamic Head up to 131 Ft. 40 M
  Suction Lift Up To 24 Ft.
  Fluid Temperature Up To 80˚C.
  Maximum Ambient Temperature 80˚C
  1" Inlet And 1" Outlet Threaded

We run the pump at constant flow rate of 42 LPM to pump water from water sump to the radiator.

E. Heater with Thermostat

The heater are used to heat water in the water sump as similar to the case of water get heated during working of an engine. We assemble a thermostat to the heater which we can adjust up to a temperature of 85ºC.

Fig.5 Heaters and Thermostats

Here thermostat is used to cut off heating when temperature reaches 85ºC. To check the temperature of inlet and out let we use alcohol thermometer.

III. TEST PROCEDURE

Assumptions for Test Procedure

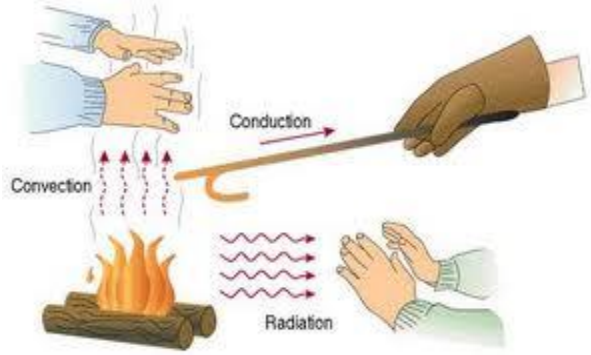
- The temperature and velocity at the beginning of the radiator core on air and coolant sides are constant.
- There is no change in phase i.e condensation or boiling in all fluid streams.
- The rate of fluid flow is constantly distributed along the core in each pass on each side of fluid. In any stream there is no stratification, bypassing of flow or flow leakages occurs. Bulk speed at any type of cross section features the condition of flow.
- At a particular given cross section a single bulk temperature applies to each stream because each fluid's temperature is uniform across every flow cross section
- For a constant fluid mass flow rate over the inner and outside tube surface, between the fluid and the tube material , the heat transfer coefficient is constant.
- The surface effectiveness is considered as uniform and kept constant for the radiator's extended fin.
- The area of Heat transfer is distributed uniformly on each side.
- The tube's both inner and the outer dimensions are assumed to be constant.
- In the axial direction, the thermal conductivity of the tube material is assumed to be constant.
- For thermal energy generation, internal source does not exists.
- For the external to the radiator there is no heat gain or loss and also in the radiator, there is no axial heat conduction.
- Thermal conduction should be equal to zero which is parallel to the flow direction of both the wall and the fluids.
- Wind velocity is 4 km/hr.
- Room temperature is 30.
- Procedure
- Before starting the test we checked weather all the components were properly are not.
- We set thermostat to a temperature of 85 deg centigrade.
- We switch on the heaters and waited for few minutes till the cut off temperature 85 deg centigrade is reached an indication of red light which we attached to the thermostat will put off .
- Then we started water pump to circulate water through the radiator from water .
- We took reading of temperature drop for every 30 seconds under forced convection by starting the cooling fan.
- We repeated the experiment under natural convection and forced convection.
- During natural convection we stopped heaters after reaching 85 deg centigrade since the heat transfer rate is very low during natural convection.

Later on we found the effectiveness and compared input and output temperatures and evaluated them through graphs.

IV. PRACTICAL ANALYSIS

A. Theory

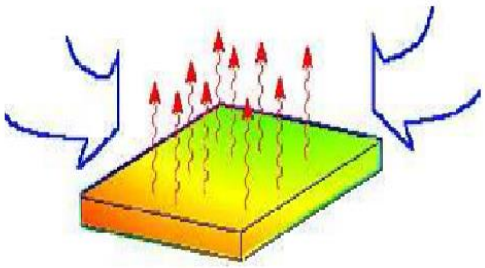
- In the water cooling system the heat transfer takes place by three modes of heat transfer conduction, convection and radiation but the main mode of heat transfer is through convection.
- Following fig might be useful in fixing the concepts of heat conduction, convection and radiation.



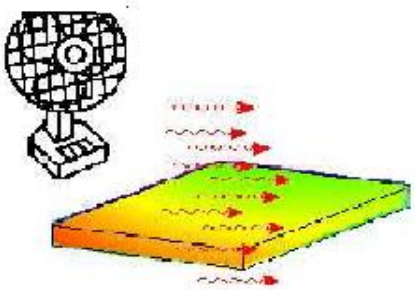
- In convection mode of heat transfer has again two modes forced convection and natural convection.

B. Modes of Convection Heat Transfer

Natural Convection: Because of the differences in the temperature between the solid and the fluid, motion of the fluid which is adjacent to a solid face is caused by buoyancy forces induced by the changes within the density of the fluid. Particles of air adjacent to the face of the plate get warmer, when a hot plate is left to cool down within the air, and hence they move upwards because their density decreases.



Forced Convection:
Over the face of the solid to accelerate the flow of the fluid, an external means like a fan or a pump is employed. The temperature gradient is maximized and over the face of the solid, by the rapid motion of the fluid particles, the rate of heat exchange is increased . Air is forced over a hot plate in the following image.



On the above basic principles any radiator works. Every heat exchanger is based on the above basic convection processes. Newton's law of cooling is obeyed by the rate of heat exchange between the fluid temperature Tf and and a face of a solid of area at temperature Ts ,which can be written as :

$$Q_{convection} = h\,A\,(T_s - T_f)$$

We opted the changes in MAHINDRA 475 DI (tractor) radiator. The radiator is constructed is constructed for the specified engine based on all heat transfer calculations. Also we compared the output temperature with input temperatures and cooling efficiency.

V. CALCULATIONS

The following calculations are used to calculate the effectiveness of the radiator.

$$\text{Effectiveness of radiator } (\varepsilon) = \frac{\text{Actual heat Transfer}}{\text{Maximaum heat transfer}}$$

$$= \frac{mc\,C_{pc}(t_{ci} - t_{co})}{ma\,C_{pa}(t_{ci}/t_{ai})}$$

$$\text{At 1LPM } m_c = \frac{1}{1000\times 60}\ m^3/s = \frac{1000}{1000\times 60}\ \text{(for water)}$$

Where, mc = Coolant mass flow rate in kg/s
ma = air mass flow rate in kg/s
Cpc = coolant Specific heat capacity at constant pressure in kJ/kg K
Cpa = Air Specific heat capacity at constant pressure in kJ/kg K.
tci = Coolant Input temperature
tco = Coolant Ouput temperature
tai = Air Input temperature
We have
Cpc = 4.18 kJ/kg K (for water)
Cpa = 1.005 kJ/kg K
ma = 1.49 kg/sc

VI. READINGS

Following are the experimental readings

Table 1. Forced convection with heating of water

S.No.	Time (Sec)	Inlet Temperature (°C)	Outlet Temperature (°C)
1	30	85	78
2	60	80	73
3	90	74	68
4	120	68	64
5	150	65	63
6	180	63	62
7	210	62	60

Table2. Forced convection with heating suspended

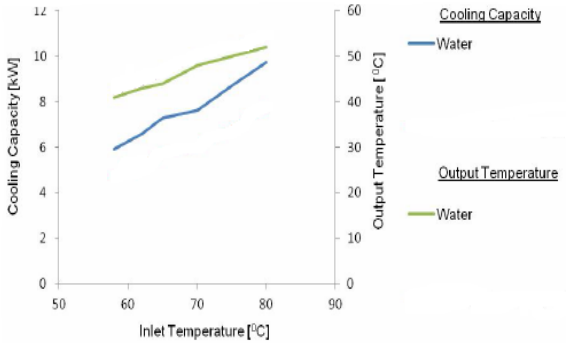
S.No.	Time (Sec)	Inlet temperature (°C)	Outlet temperature (°C)
1	30	85	76
2	60	79	67
3	90	68	59
4	120	59	50
5	150	51	45
6	180	46	40
7	210	40	38

Table3: Natural convection with heating suspended

S.No.	Time (Sec)	Inlet temperature (°C)	Outlet temperature (°C)
1	60	85	81
2	120	83	80
3	180	82	79
4	240	80	77
5	300	78	76
6	360	77	75
7	420	75	73

VII. GRAPHS

The following graphs are plotted according to the readings obtained from practical calculatons:



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VIII. RESULT

It is observed that due to the changes made in the core i.e., due to decrease in the window angle the heat transfer rate is more. It is observed that heat transfer rate is more due to the reason that the air obstructs more and receives more heat through forced convection. Also the cooling capacity is increased.

IX. CONCLUSION

In this study, very clear and in detail presentation of the complete set of various numerical parametric studies on the automotive radiator has been made. For the better improvement and development of more effective and compact radiator, number of recommendations have been provided by a very detailed literature survey. In the future scope section, these recommendations are listed. Changes from the range of geometrical parameters are demanded by all these recommendations. Different parameters which includes mass flow rate of the coolant, coolant temperature at the inlet etc are varied when a radiator is installed into the test setup during the process of evaluation of the performance of a radiator. Then the respective effectiveness and coolant temperature at the outlet values are evaluated.
In 3-axis graphs, all these above evaluated values are plotted and their behavior is analyzed.
In the testing results and discussion section, the formulas are noted which were very helpful while doing the calculations.
Therefore conclusions are made on the basis of the study that:-
The effectiveness and cooling capacity of radiator increases with the increase in the value of inlet coolant temperature since there exists a direct relation between the effectiveness ,cooling capacity and inlet temperature of hot coolant.
Also there exists a direct relation between the mass flow rate of the coolant and effectiveness, cooling capacity. By considering the fan speed at 3000rpm, all the above results have been calculated.
The inlet fluid's maximum temperature is taken as 85 degree centigrade during the testing. Hence at this low temperature, the values of effectiveness are lower. But whereas the experimented value is very much lower than the actual inlet coolant temperature of the radiators. Hence the graphs nature needs to be concentrated on and but not the specific values.
For the other plots also, it is same.

REFERENCES

1. William H. C. and Donald L. A.Automotive Fuel, Lubricating, and Cooling Systems, 1981.
2. Randy Rundle.Automotive Cooling System Basics, 1999.
3. Ray T. BohaczEngine Cooling Systems, 2007.
4. Yunus A. Cengel and Robert H. Turner. Fundamental of Thermal-Fluid Sciences, 2005.
5. S. Vithayasai, T. Kiatsiriroat, A. Nuntaphan; Effect of electric field on heat transfer performance of automobile radiator at low frontal air velocity; Applied thermal engineering; 2006.
6. K.Y. Leong , R. Saidur , S.N. Kazi , A.H. Mamun; Performance investigation of an automotive car radiator operated with nanofluid-based coolants (nanofluid as a coolant in a radiator); Applied Thermal Engineering; 2010, 2685-2692.
7. A.Vaisi , M. Esmaeilpour , H. Taherian; Experimental investigation of geometry effects on the performance of a compact louvered heat exchanger; Applied Thermal Engineering; 2011, 3337-3346.
8. Junjanna G.C, Dr. N. Kulasekharan, Dr. H.R. Purushotham; Performance improvement of a Louver-finned automobile radiator using CFD analysis; International journal of engineering research and technology, Vol. 1, Issue 8, 2012.
9. Chavan D.K, TasgaonkarG.S; Study, analysis and design of automobile radiator proposed with CAD drawings and geometrical model of fan; International journal of mechanical and production engineering research and development; Vol. 3, Issue 2, 2013, 137-146.
10. K.Srividya, Thermo gravimetric analysis of Vetiveria zizanioides/ Jute/ Glass fiber reinforced hybrid polymeric composites, materialstoday: Proceedings, Vol.18, 2019, 5317-5326.