International Journal of Engineering Applied Sciences and Technology, 2022
Vol. 7, Issue 3, ISSN No. 2455-2143, Pages 122-128

EXPERIMENTAL AND COMPUTATIONAL ANALYSIS OF A COPPER BASED RADIATOR OF A MOTORCYCLE TO DETERMINE ITS COMPACTNESS BY MODIFICATION OF GEOMETRY OF FINS.

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***Abstract* - In the Internal Combustion Engines, the radiator system plays a vital role in the management of the thermal efficiency. The good conditioned radiator increases the performance of engine by removing the heat effectively. Thus, the present project work is fundamentally based on the investigations of modelling of radiator made of copper, through the experimental and CFD analysis. Further the effects of increased thickness of fin and the perforation on the fin is analyzed. The work is focused on increasing the heat transfer from the copper fin with the perforation (circular hole) to cool the engine using forced convection method effectively for the improved performance of the engine. The radiator is analyzed with mass flow rate and inlet temperature as boundary conditions for hot water flow. Similarly for air flow inlet velocities and temperatures are taken as a boundary conditions. For this purpose, a copper-based radiator is fabricated and tested for four volumetric flow rates of the hot water. The performance of this radiator is evaluated in terms of outlet temperature of water and heat flow. It is predicted and proven that modifications in fin geometry plays a vital role in improving the performance of engine by cooling water circulation effectively. Thus, making the radiator compact.**

***Keywords* - Radiator, Thermal efficiency, CFD, Temperature distribution and Engine cooling.**

I. INTRODUCTION

The majority of IC engines are cooled by air or liquid coolant passing through air fins of radiator. The present work is delt with forced convection heat transfer. Extended surfaces are used to enhance the convective heat transfer in many of the engineering applications. Fins are commonly applied for heat management such as computer power supplies or transformers and other applications include IC engine cooling and fins in the radiator. Fins are used to enhance convective heat transfer in a wide range of engineering applications and offer a practical means for achieving a larger total heat transfer surfaces area without the use of an excessive amount of primary surface area extensions on the finned surfaces is used to increase the surface area of fin. When the surface area increases the more fluid contact to increase the rate of heat transfer from the base surface as compare to fin without the extensions provided to it. The concept of heat transfer through perforated fin array is also one of the methods to improve the heat transfer. In the conventional radiator the Aluminium material is used, and in the present study the Aluminium is replaced by copper to enhance the heat transfer. The rate of heat transfer in perforated fins is compared with conventional fins by increasing the surface areas.

II. LITEARTURE REVIEW

[1] **Shital B Salunkhe, et. al** [1] had Studied the effect of different material coating on the outer surface of finned tubes. The different materials considered for study were Copper, Aluminium with Silver coating and Aluminium with Nickel coating. They had conducted experiment at different air velocities to increase convective heat transfer. It was concluded that copper is the best choice for higher Heat Transfer Coefficient.

[2] **Nitesh Kumar Jha, et. al** [2] had investigated the heat transfer through the fins of various cavities such as rectangular cavity, triangular cavity was considered for the CFD analysis. And these results were Compared with the fin without cavity. There was an improvement of Heat Transfer about 2% to 21%.

[3] **Sunil S, et. al** [3] had computationally investigated Heat Transfer through the extended surface of various perforations and grooves under natural convection Heat Transfer. The Rectangular Fin with 3mm cut out and 20mm perforations

gave 33.79% of Heat Transfer Enhancement compared to other models.

[4**] Ashish Kalra, et. al** [4] had conducted experiment on focused convection heat transfer through motorcycle radiator. He obtained improvement in Heat Transfer Coefficient at higher Fan speed of 1700 rpm compared to a Fan speed of 1200 rpm. Finally, it was concluded that faster cooling can be achieved by increasing a Fan speed in a motorcycle radiator test rig.

[5] **Vishal Bhuria, et. al** [5] had conducted experiment on Automobile Radiator to increase Heat computational analysis of radiator with modified Fin geometry at constant fan speed, in spark ignition engine cooling system will be performed for different fin materials such as Aluminum and Cooper. Transfer Coefficient using Cuo/Water Nano Fluid concentration in the cooling water. The use of "Nano Fluids" have been developed and these fluids offer higher heat transfer properties compared to that of conventional automotive engine coolants. It is also concluded that use of nano fluid in radiator can minimize the pumping power.

III. OBJECTIVE

To analyze the effect of the heat transfer rate of extended surfaces on the Yamaha R15 motorcycle Copper radiator performance and to compare its effect on copper radiator with perforations on fins

IV. EXPERIMENTAL SETUP

As shown in the figure 4.2 the experimental set up used in this project work includes a centrifugal pump, storage tank, heating element, metal gate valve, rotameter, Thermocouple indicator, CPVC pipe and a cross flow automobile radiator with a section fan.

Figure 4.1 shows line diagram of experimental setup used for project work.

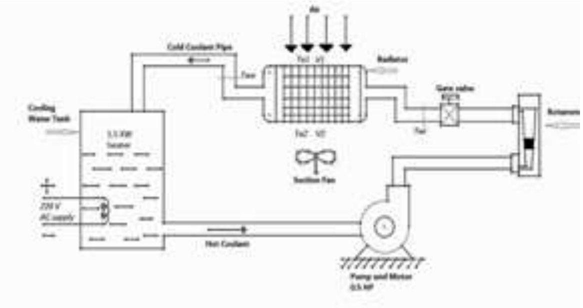


Figure 4.1

Figure 4.2

A. FABRICATED RADIATOR.

This is the manufactured copper radiator as shown in figure 4.3.

Figure 4.3

V. SPECIFICATION

The dimensions of copper radiator is given below :

VI. INSTRUMENTATIONS USED.

A. Pump

½ HP direct drive centrifugal pump is used for pumping hot cooling water as shown in figure 6.1.

Figure 6.1

B. Gate Valve

The Metal gate valve Figure 6.2 is used to control flow rate of cooling water.

Figure 6.2

Figure 6.3

C. Rotameter

The experiment runs in different flow rates of 4,5,6 and 7 lpm. A plastic storage tank is used to store cooling water as we have limited temperature of water up to 70 °C.

Parts	Dimensions
Pipe diameter inlet/outlet	19.05 mm
Thickness of fin	0.33 mm
Width of fin	31 mm
Radiator core height	124 mm
Radiator core length	195 mm
No. of fins in single column	44
No. of fins in columns	13
Total no. of fins	572
Total no. of pipes for hot water	25
Distance between two pipes	10 mm
Distance between two fins	0.4 mm

D. Heater

Figure 6.4 shows an electrical heater with a capacity of 1.5 Kw is deployed in the tank for coolant heating purpose. High temperature thermocouples are used for measuring temperature in the range 20 °C to 80 °C.

E. Anemometer

Figure 6.5 shows an anemometer to measure inlet and outlet air velocities and temperature through the radiator.

Figure 6.5

Thermocouple
Figure 6.6 shows the thermocouple used to measure the inlet temperature of water, outlet temperature of water, and fin base temperature.

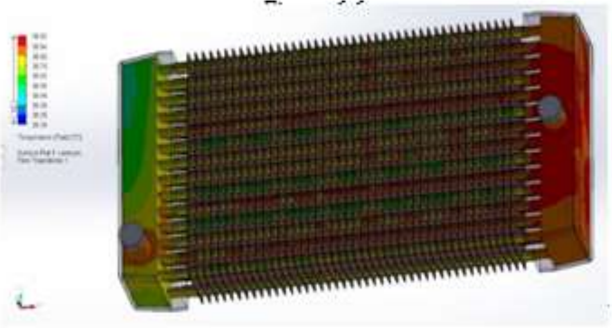


Figure 6.6

VII. EXPERIMENTAL PROCEDURE

The volume of the storage tank was about 10 lit and whole of it was filled with water. The water flows in a closed system. The flow rate for the test section was regulated by adjusting a gate valve as shown in the fig 6.2. The flow rate was 4,5,6 and 7 Lpm. For heating the working fluid, a 1.5 Kw electric heater is used maintain temperature in the range 30 °C to 65 °C. Two thermocouples were implemented on the radiator line to record inlet and outlet temperature of cooling water and two separate thermocouples were also used to note down surface temperature of radiator.

The used heat exchanger was a motorcycle radiator with rectangular shaped Aluminium fins. For cooling the working fluid, a forced fan (1400 rpm) was installed behind the radiator. The air and water had indirect across flow contact.

There was a heat exchange between hot water flowing inside the tube and air cross the tube bundle constant air velocity and temperature of the air are measured Infront of the radiator to investigate the heat transfer. Inlet and outlet air velocities are measured by anemometer.

VIII. CFD INVESTIGATION

The three model are analyzed using Solidworks flow simulation. The models are prepare using Solidworks. The temperature distribution of these models is evaluated at the outlet the outlet of radiator.

IX. METHODOLOGY

Experimental parameters are incorporated as boundary conditions in order to verify the experimental results. The turbulence intensity was kept 2%.

X. TEMPERATURE CONTOURS ON COPPER RADIATOR WITH FIN THICKNESS OF 0.33 MM AT INLET TEMPERATURE 39 ℃:

Figure 10.1 shows the temperature contour along various planes. It is observed from the figure that temperature decreases along the outlet of the radiator. The outlet temperature at the radiator outlet is observe to be 37.03℃. This is due to the cooling from the suction fan.

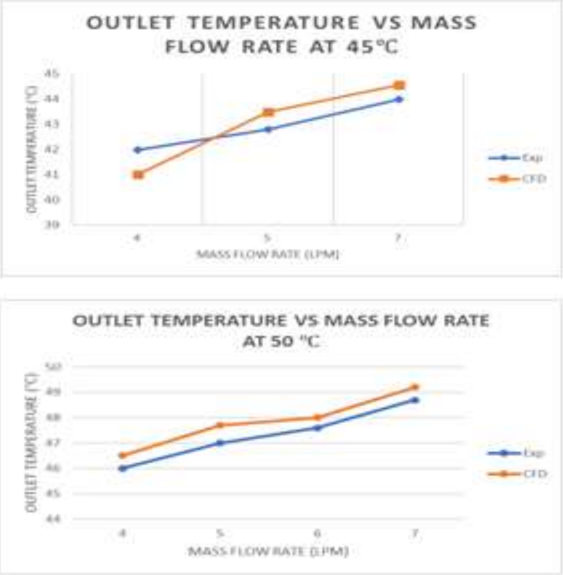


Figure 10.1

XI. TEMPERTURE CONTOUR ON COPPER RADIATOR WITH FIN THICKNESS 1MM WITH 2MM CIRCULAR CAVITY:

Figure 11.1 shows the temperature contour along various planes. It is observed from the figure that temperature decreases along the outlet of the radiator. The outlet temperature at the radiator outlet is observe to be 35.7℃. This is due to the cooling from the suction fan.

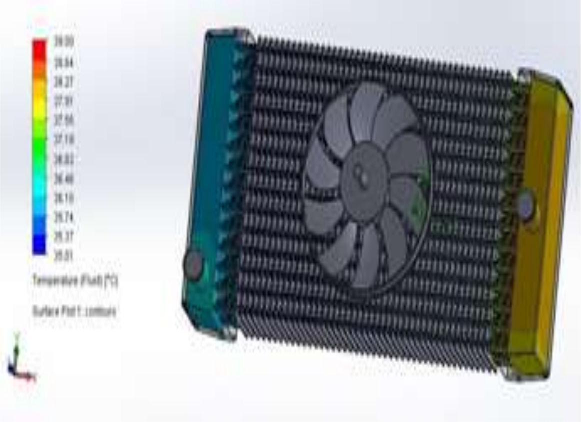
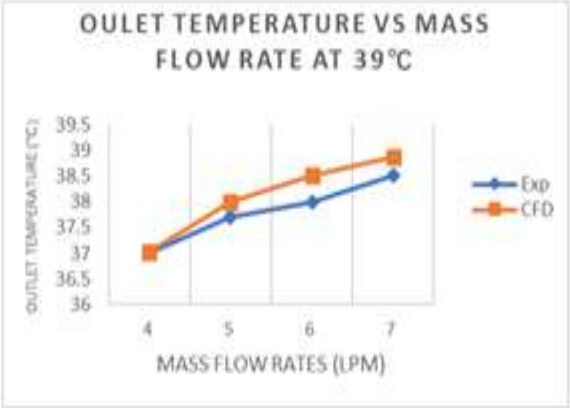


Figure 11.1

XII. RESULTS AND DISCUSSION

A. Comparison of Outlet Temperature of hot water for Experimental and CFD at constant speed of suction fan:



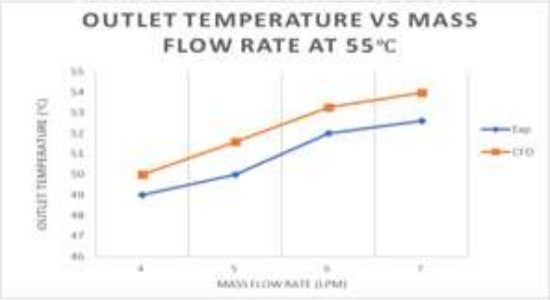


Figure 12.4

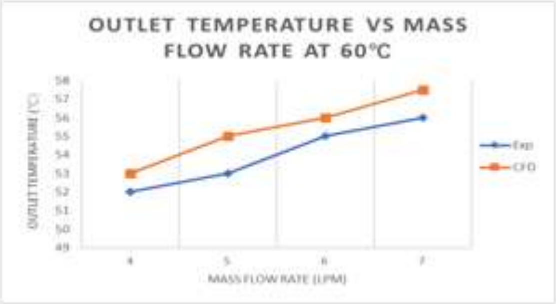


Figure 12.5

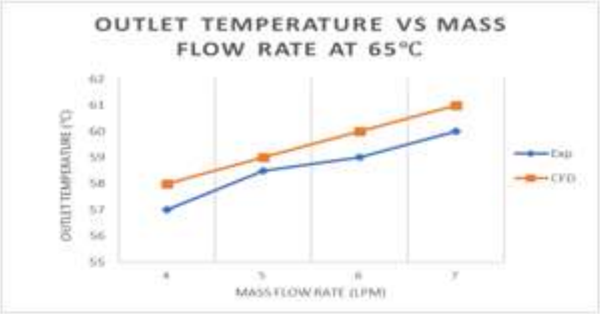


Figure12.6

The above figures show the comparison of outlet temperatures for experimental and CFD at constant suction fan speed. It is found that in copper-based radiator model, CFD values of an outlet temperatures are closely matching with the experimental values with an average percentage error below 20.

B. Comparison of Outlet Temperature of hot water for fin with thickness 1mm and fin with cavity at constant speed of suction fan using CFD:

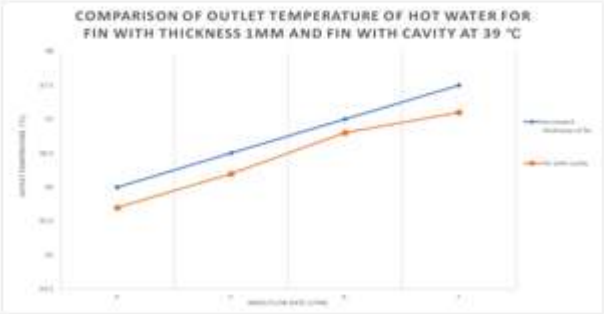


Figure 12.7

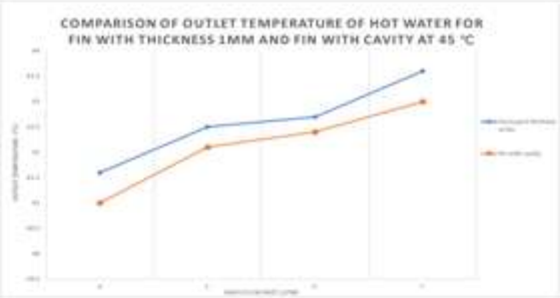


Figure 22.8

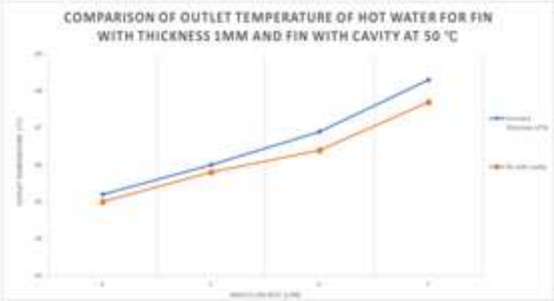


Figure 12.9

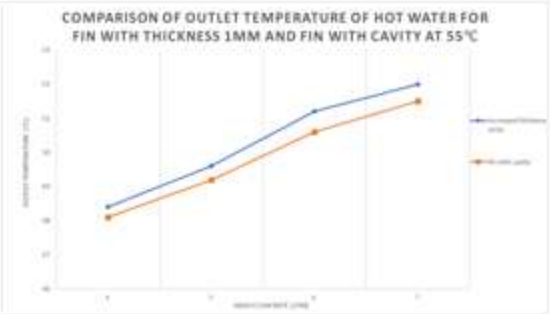


Figure 13

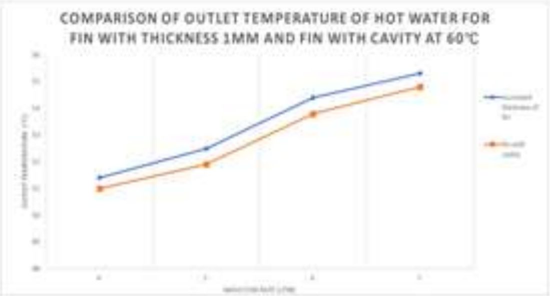


Figure 13.1

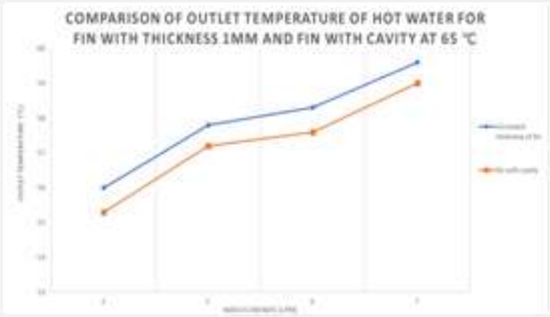


Figure 13.2

The above Figures show the comparison of outlet temperatures for radiator with 1mm thickness and radiator with same thickness having circular cavity for different mass flow using CFD at constant suction fan speed. It is observed that the outlet temperatures are lower in radiator with circular cavity.

XIII. CONCLUSION

A. Experimental Analysis:

The test on copper-based radiator is conducted on a test rig. Experiments are carried out at four different volumetric flow rates keeping speed of the fan constant. Each reading is taken two times and average readings are taken in order to mitigate the experimental errors. The findings of the work are enlisted below:

- The temperature distribution and heat flow rate are studied on a copper-based radiator fabricated model used for motorcycle engine by varying thickness and having circular perforation on the fins.

B. Computational Analysis:

- The CFD results are validated with the experimental results on base model. For comparison, experimental and computational values of outlet hot water temperature and mass flow rates are plotted against corresponding experimental values at different inlet temperatures.
- It is found that CFD values are closely matching with experimental values.
- The lower outlet temperatures and higher heat rates are achieved by using radiator with 1mm thickness having 2mm circular cavity. This results in increased fin efficiency, cooling performance thus making the radiator compact.
- Fin having perforation gives higher surface area and therefore the radiator can be made compact. Thus, saving material of construction.
- Though the cost is little higher but certainly copper based model will give better mechanical strength and heat transfer characteristics over Aluminium.

XIV. REFERENCES

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