Experimental Study of Extended Surfaces (Fins) With Forced Convection

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Abstract--*Extended Surfaces (Fins) are widely used in the engineering for getting better heat transfer by providing additional area. In many applications like heat exchangers, for cooling reactor core, electrical transformer, rectifier, etc fins are used for better heat transfer. This work is carried out for find out which material and which cross sectional fin is best suited for the better heat transfer.*

In this experiment we carried study to find out the heat transfer coefficients for copper, aluminium and steel. We also find out the heat transfer coefficients for same surface area (i.e. A_s = 0.0056 m^2) and different cross section like circular, rectangular and trapezoidal of same material copper. And the heat transfer coefficients are also compared on the basis of different air flow rate. After performing this experiment we observed that heat transfer rate is higher in copper rod than aluminium and steel rod. And for different cross section trapezoidal rod has high heat transfer than that of circular and rectangular rod as it has more surface area near the base where the difference in temperature is high. Graphs of surface temperature distribution along the length of rod and heat transfer coefficient V/S heat input explains the relationship of the parameter of different configuration of heat input.

1. INTRODUCTION

Extended Surfaces (Fins) are widely used in the engineering for getting better heat transfer by providing additional area. In many applications like heat exchangers, for cooling reactor core, electrical transformer, rectifier, etc fins are used for better heat transfer. This work is carried out for find out which material and which cross sectional fin is best suited for the better heat transfer.

Extended surfaces are made of different materials and different cross sections. For the proper heat transfer, we have to decide which type of extended surface is best suited for the engineering purpose. For this we are considering different factors which are affecting to the heat transfer coefficient. In our experiment, the flow rate of air is considered as a variable factor. And heat transfer co-efficient for different cross section and for different materials at same flow rate of air is compared.

2. EXPERIMENTAL PROGRAM

2.1 Experimental Set-up

The experiment set up is used to find out the heat transfer coefficient under force convection heat transfer of fin rods. The experiment set-up is in the lab of Mechanical Engineering Department. The schematic diagram of the experiment set-up is as shown in the figure.

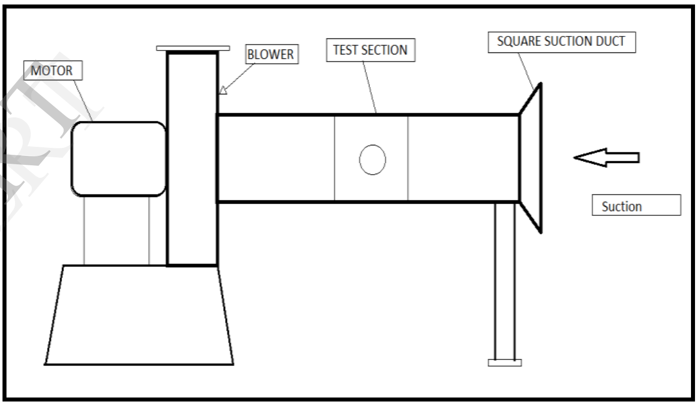

Fig -1: Schematic Diagram of Experiment set up

Fig -2: Experimental Set-up

2.2 Description of Test Section

The test section of experiment set-up is rectangular with a cross section of 10cm×15cm. In test section one hole is provided for inserting the assembly of fin rod and heater. And another small hole is provided above the test section for carrying out the thermocouples. The test section is as shown in figure below.

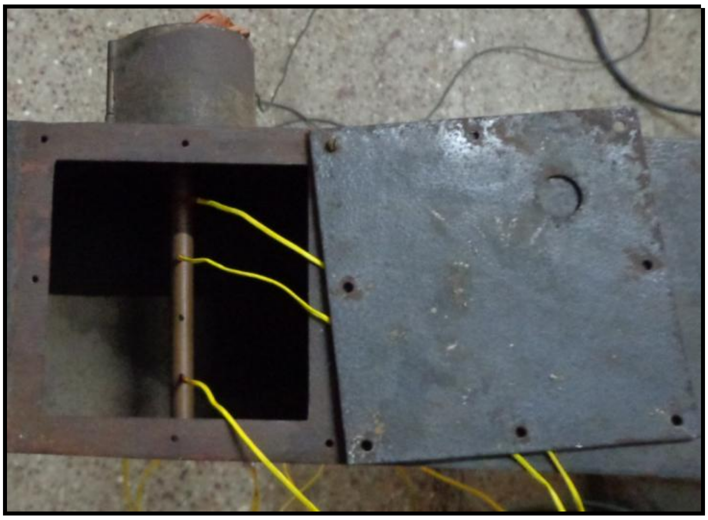

Fig -3: Test Section of Experiment Set-up

2.3 Description of Measurement

In the experiment, six k type thermocouples are used to take the readings. Thermocouples are attached to two different ends. One of the ends is grounded to the fin rod in the test section from where air is passes. The second one was connected to a Digital Multi-voltmeter directly. The readings were thus obtained from it in terms of mV which was then converted into temperature in ^{o}C using standard data tables available for the K-type ungrounded thermocouples.

3. RESULTS

The experiments were carried out by varying the mass flow rate of air to investigate the effect of cross sectional area and materials on heat transfer co-efficient. First, the test is carried out with 200V motor input than with 220V and 240V.

HEAT TRANSFER COEFFICIENT FOR MOTOR INPUT 240 V:

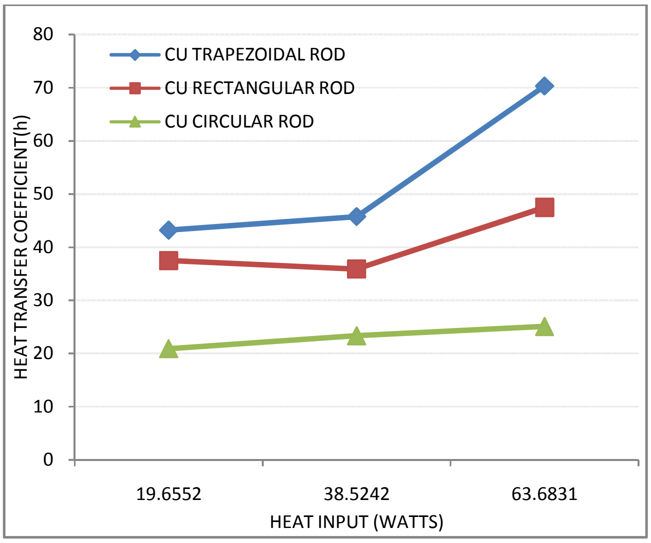

Chart-1: Heat Transfer Coefficient (h) V/S Heat Input for motor input of 240 V for different cross sectional Fin Rods

From the above graph of Heat Transfer Coefficient (h) Vs Heat Input for Motor Input of 240 V, we see that the Heat Transfer Coefficient (h) is higher for the copper trapezoidal rod than that of the copper rectangular and copper circular rod. And as the heat input is increases, Heat Transfer Coefficient (h) is also increases.

HEAT TRANSFER COEFFICIENT FOR MOTOR INPUT 220 V:

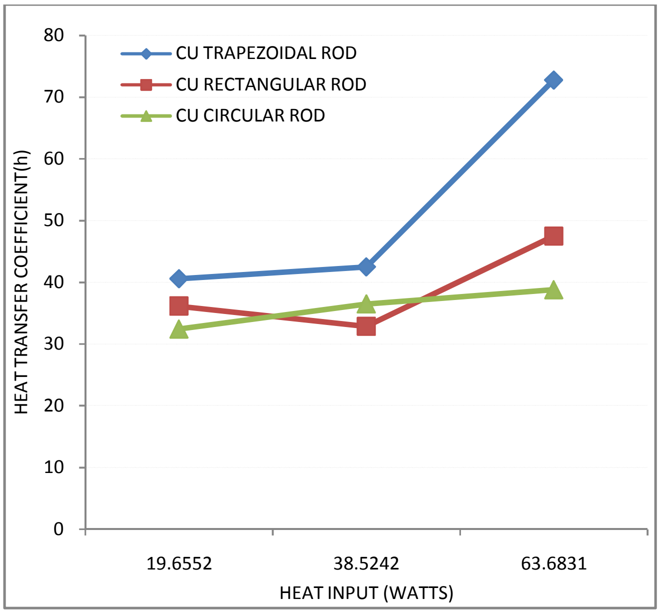

Chart-2: Heat Transfer Coefficient (h) V/S Heat Input for motor input of 220 V for different cross sectional Fin Rods

From the above graph of Heat Transfer Coefficient (h) Vs Heat Input for Motor Input of 220 V, we see that the Heat Transfer Coefficient (h) is higher for the copper trapezoidal rod than that of the copper rectangular and copper circular rod. And as the heat input is increases, Heat Transfer Coefficient (h) is also increases.

HEAT TRANSFER COEFFICIENT FOR MOTOR INPUT 200 V:

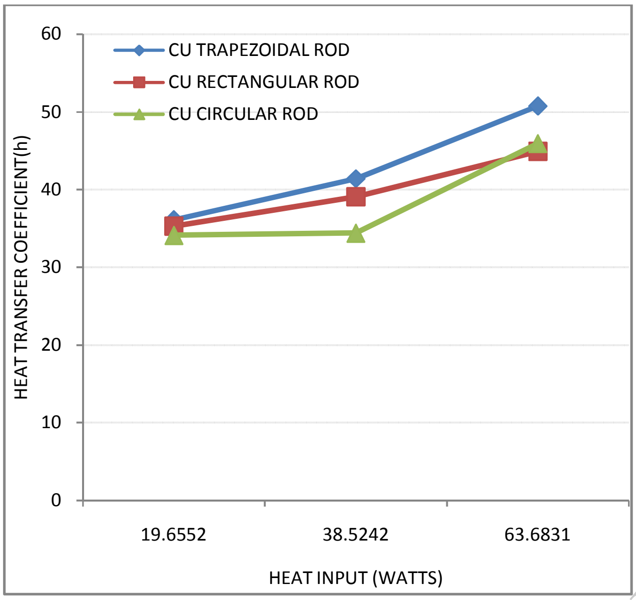

Chart-3: Heat Transfer Coefficient (h) V/S Heat Input for motor input of 200 V for different cross sectional Fin Rods

From the above graph of Heat Transfer Coefficient (h) Vs Heat Input for Motor Input of 220 V, we see that the Heat Transfer Coefficient (h) is higher for the copper trapezoidal rod than that of the copper rectangular and copper circular rod. And as the heat input is increases, Heat Transfer Coefficient (h) is also increases.

MOTOR INPUT 240 V:

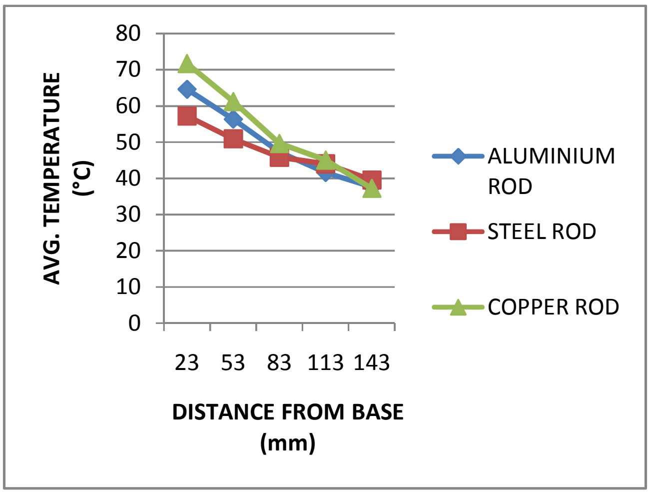

Chart-4: Heat Average temperature Vs. Distance from Base for motor input of 240 V for different material fins

From the above graph of average temperature Vs. Distance from Base for motor input of 240 V, we can see that Average temperature is higher for copper rod than that of aluminium and steel rod of same circular cross sectional area. And it is also observed that heat transfer rate is high in copper than that of aluminium and steel rod.

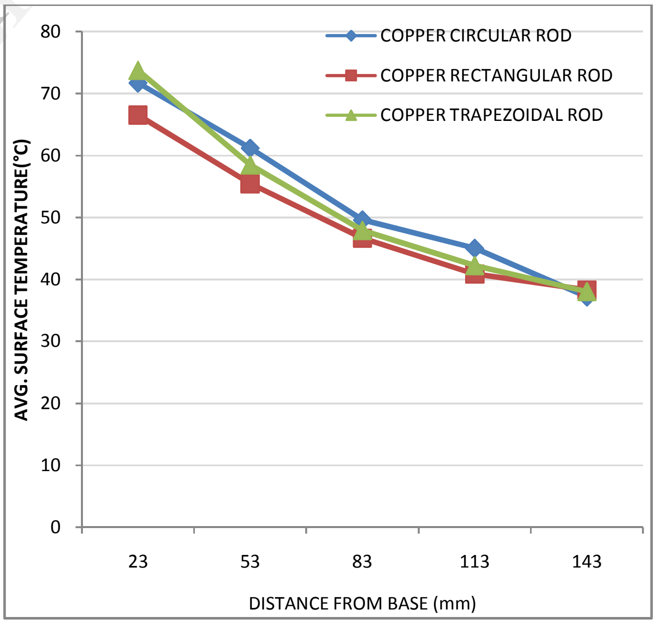

Chart-5: Heat Average temperature Vs. Distance from Base for motor input of 240 V for different cross sectional fins

From the above graph of average temperature Vs. Distance from Base for motor input of 240 V, we can say that the heat transfer rate is higher in copper trapezoidal rod than that of copper rectangular and copper circular rod as the trapezoidal rod has more lateral area at the base.

MOTOR INPUT 220 V:

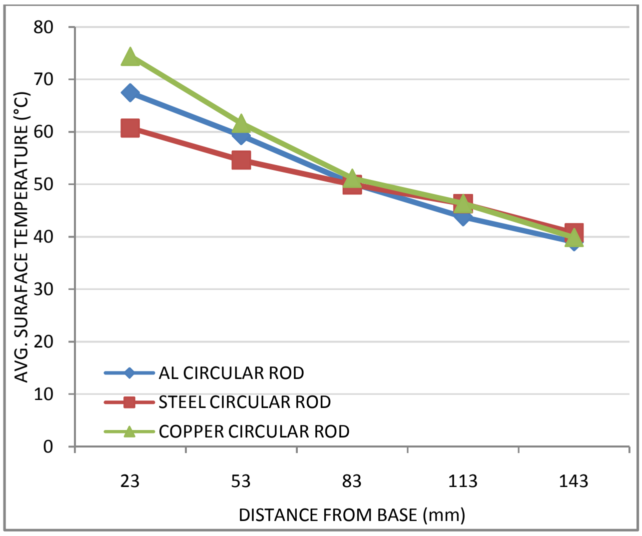

Chart-6: Heat Average temperature Vs. Distance from Base for motor input of 220 V for different material fins

From the above graph of average temperature Vs. Distance from Base for motor input of 220 V, we can see that Average temperature is higher for copper rod than that of aluminium and steel rod of same circular cross sectional area. And it is also observed that heat transfer rate is high in copper than that of aluminium and steel rod.

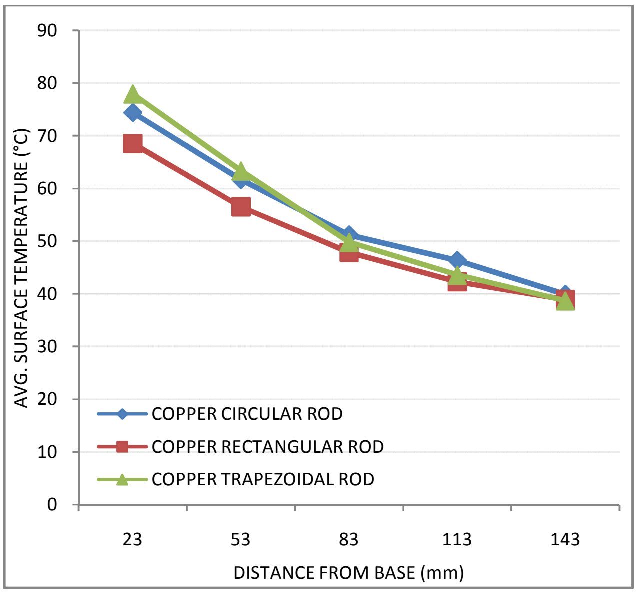

Chart-7: Heat Average temperature Vs. Distance from Base for motor input of 220 V for different cross sectional fins

From the above graph of average temperature Vs. Distance from Base for motor input of 220 V, we can say that the heat transfer rate is higher in copper trapezoidal rod than that of copper rectangular and copper circular rod as the trapezoidal rod has more lateral area at the base.

MOTOR INPUT 200 V:

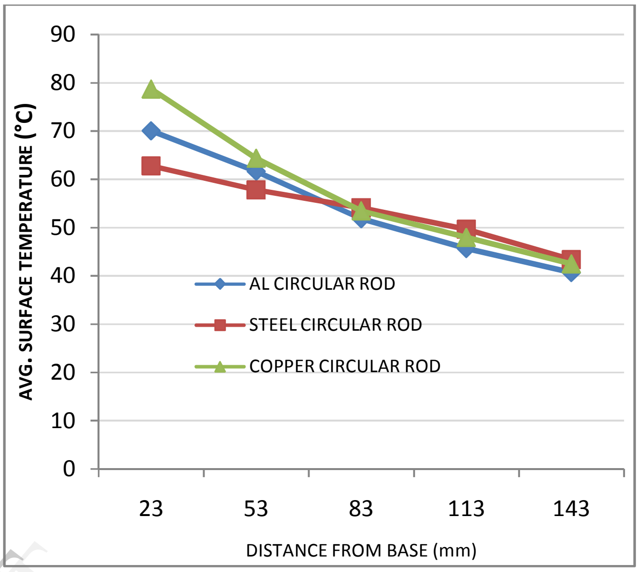

Chart-8: Heat Average temperature Vs. Distance from Base for motor input of 200 V for different material fins

From the above graph of average temperature Vs. Distance from Base for motor input of 200 V, we can see that Average temperature is higher for copper rod than that of aluminium and steel rod of same circular cross sectional area. And it is also observed that heat transfer rate is high in copper than that of aluminium and steel rod.

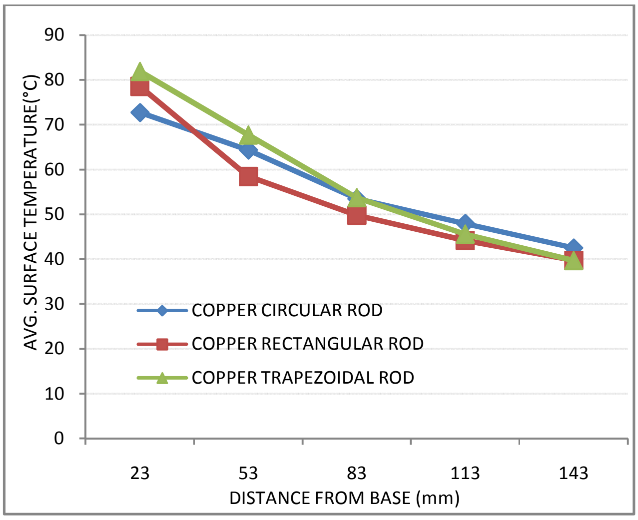

Chart-9: Heat Average temperature Vs. Distance from Base for motor input of 240 V for different cross sectional fins

Chart-9: Heat Average temperature Vs. Distance from Base for motor input of 240 V for different cross sectional fins

From the above graph of average temperature Vs. Distance from Base for motor input of 200 V, we can say that the heat transfer rate is higher in copper trapezoidal rod than that of copper rectangular and copper circular rod as the trapezoidal rod has more lateral area at the base.

CONCLUSIONS

In this experiment, our aim was to find out effect of the different cross section and different metallic rods and which rod (fin) has higher Heat Transfer Coefficient (h). From Experimental results and all the plots of Heat Transfer Coefficient (h) Vs Heat Input, we conclude that the Heat Transfer Coefficient (h) is higher for the copper rod than that of aluminium rod and steel rod.

Another thing observed from experiment is that Heat Transfer Rate for the different cross sectional area of copper rods (i.e., circular, rectangular and trapezoidal) with the same surface area and different motor input (i.e., 240 V, 220 V & 200 V), Heat Transfer rate is higher for the copper trapezoidal rod than that of Circular copper rod and rectangular copper rod as it has more lateral area near its base.

REFERENCES

1. **Alan J. Chapman**, "Heat Transfer", 4th ed., New York, Macmillan Publishing Company, 1989
2. **Ugur Akyol , Kadir Bilen**, "Heat transfer and thermal performance analysis of a surface with hollow rectangular fins", Applied Thermal Engineering 26 (2006) 209–216
3. **Hosni I. Abu-Mulaweh, Donald W. Mueller, Jr**., "Heat Transfer Coefficient Correlation for Circular Fin Rods", Indiana University-Purdue University Fort Wayn Fort Wayne, IN 46805, USA
4. **A. Al-Sarkhi**, "Comparison between variable and constant height shrouded fin array subjected to forced convection heat transfer", International Communications in Heat and Mass Transfer 32 (2005) 548–556
5. **Islam Md. Didarul, Oyakawa Kenyu, Yaga Minoru, Senaha Izuru**, "Study on heat transfer and fluid flow characteristics with short rectangular plate fin of different pattern", Experimental Thermal and Fluid Science 31 (2007) 367–379
6. **C. Schenone, G. Tanda**, "Forced convection heat transfer from shrouded staggered fin arrays", Int. Comm. Heat Mass Transfer, Vol. 17, pp. 747-758, 1990
7. **R. H. Yeh, S. P. Liaw**, "An exact solution for thermal characteristics of fins with power-law Heat Transfer Coefficient", Int. Comm. Heat Mass Transfer, Vol. 17, pp. 317-330, 1990
8. **O. N. Sara, S. Yapici, M. Yilmaz**, "Second Law Analysis of Rectangular Channels with Square Pin-Fins", Int. Comm. Heat Mass Transfer, Vol. 28, No. 5, pp. 617-630, 2001
9. **A. Giri, G.S.V.L. Narasimham, M.V. Krishna Murthy**, "Combined natural convection heat and mass transfer from vertical fin arrays", International Journal of Heat and Fluid Flow 24 (2003) 100–113
10. **Saad A. El-Sayed *, Shamloul M. Mohamed, Ahmed M. Abdel-latif, Abdel-hamid E. Abouda**, "Investigation of turbulent heat transfer and fluid flow in longitudinal rectangular-fin arrays of different geometries and shrouded fin array", Experimental Thermal and Fluid Science 26 (2002) 879–900
11. **Schneider P. J**., "Conduction Heat Transfer", Addison-Wesley, 1955 **Max Jakob**, "Heat transfer", Volume 1, Wiley, 1949

BIOGRAPHIES

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