An Experimental Investigation of Forced Convection Heat Transfer Coefficient using Various Pin Fins

Dnyaneshwar Kamble
Assistant Professor
Department of Mechanical Engineering
Zeal College of Engineering & Research, Pune-411041

Pitambar Gadhave
Assistant Professor
Department of Mechanical Engineering
Zeal College of Engineering & Research, Pune-411041

Suraj Gole
B.E Student
Department of Mechanical Engineering
Zeal College of Engineering & Research, Pune-411041

Madhav Gole
B.E Student
Department of Mechanical Engineering
Zeal College of Engineering & Research, Pune-411041

Abstract

The main objective of this experimental study is to quantify and compare the forced convection heat transfer enhancement of pin fin with using different materials. In this study, the steady state heat transfer from the pin fin is measured. The increase in the heat transfer coefficient was achieved with copper pin fin at 100 watt heat input considerably in comparison with that of the other materials pin–fin over the whole range of Reynolds numbers. Pin fin made of steel material had less heat transfer coefficient as compared to other materials.
Keywords: Forced Convection, Heat Transfer Enhancement, Pin Fin, Fin Efficiency, Fin Effectiveness

I. INTRODUCTION

Heat transfer theory provides a direct means of determining the rate of heat transfer in various practical situations. For forced or natural convective heat transfer, empirical correlations are developed with a theoretical basis, Thus, although the correlations can be used for engineering estimates, more exact information is obtained by the construction and testing of a prototype. In this experiment, the temperature distributions for four different pin fins are measured with forced convection.

Heat transfer in pin fin occur due to conduction and convection. the heat transfers by conduction mainly depend on thermal conductivity of material and heat transfer by convection due to air velocity. The term extended surface is commonly used to depict an important special case involving heat transfer by conduction within a solid and heat transfer by convection from the boundaries of the solid. The direction of heat transfer in extended surfaces from the boundaries is perpendicular to the principal direction of heat transfer in the solid. A temperature gradient exists along each fin or pin due to the combination of the conductivity of the material and heat loss to the surroundings. Temperature distribution along the fin pin must be known to determine the heat transfer from the surface to its surroundings. Since radiation and natural convection from the surface occur simultaneously, both of these effects neglected in the analysis.

The heat transfer in convection is given by Newton's law of cooling is given by,

$$q = hAdT$$

To increase the heat transfer rate q, either increase the surface area or increase the heat transfer coefficient. But in some cases it is not possible to increase surface area, in that case the only way is increase the heat transfer coefficient.

The heat transfer can be increased by the following different Augmentation Techniques. They are broadly classified into three different categories:

- Passive Techniques
- Active Techniques
- Compound Techniques.

Pin- Fins are used to increase the heat transfer rate from surface to the surrounding fluid when 'h' value is generally smaller on the surface. In present pin-fins are normally used in different shapes & sizes depending upon its applications. It is obvious that a fin surface sticks out from the primary heat transfer surface. The temperature difference with surrounding fluid will steadily diminish as one move out along the fin.

II. EXPERIMENTAL SETUP

A schematic diagram of the experimental system for the pressure loss and heat transfer measurements for the rectangular duct with pin fin is shown in Figure 1. This experimental setup consists of a Pin Fin with 12 mm O.D & effective length 120 mm with 5 nos. of thermocouple position along the length, made of brass, mild steel, copper and aluminum - one each. Pin Fin is screwed in heater block which is heated by a band heater. Rectangular duct –150*100 mm cross section &1000 mm long connected to suction side of blower. Centrifugal blower with 0.5 HP with orifice having dia. 22 mm and flow control valve on discharge side. Dimmer start is used to control heater input. The air is drawn into the rectangular duct by the blower, and the air mass flow rate is measured by the orifice meter.

Fig. 1: Experimental Setup

III. RESULTS AND DISCUSSION

The graph of Nusselt Number verses Heat Rate for different Fin material as follows,

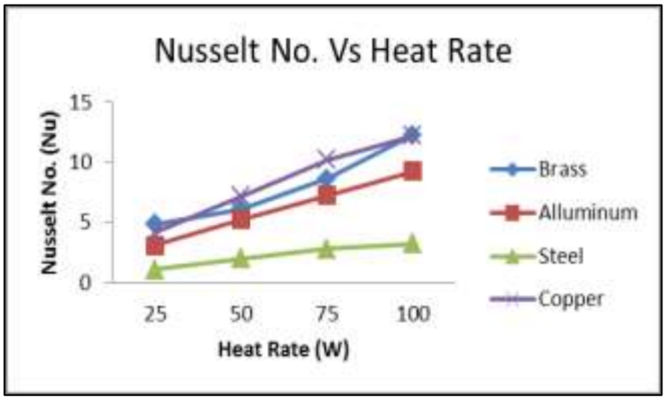

Fig. 2: The graph of Nusselt Number verses Heat Rate for different Fin material

The graph of Reynolds number verses Nusselt Number for different Fin material as follows,

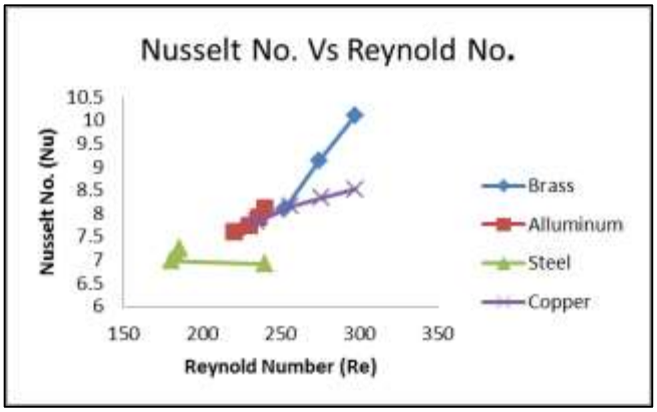

Fig. 3: The graph of Reynolds number verses Nusselt Number for different Fin material

Results of these pin fins are compared with different material fins in terms of excess temperature, heat transfer coefficient, nusselt Number. The effect of or heater input, material of fin and mass flow rate of air.

Higher rate of heat transfer is achieved with copper pin fin at 100 watt heat input considerably in comparison with that of the other materials pin–fin over the whole range of Reynolds numbers. Pin fin made of steel material had less rate heat transfer as compared to other materials.

Nusselt number obtained for copper pin fin at heat input 100W is higher than that of the other materials pin–fin over the whole range of Reynolds numbers. Nusselt number is about 6.9 for steel Pin fin which is less as compared to other materials.

IV. CONCLUSION

The increase in the heat transfer coefficient was achieved with copper pin fin at 100 watt heat input considerably in comparison with that of the other materials pin–fin over the whole range of Reynolds numbers. Pin fin made of steel material had less heat transfer coefficient as compared to other materials.

REFERENCES

[1] R.L. Webb, Principles of Enhanced Heat Transfer, John Wiley & Sons, New York, 1994.
[2] Wilkins J.E., Jr., "Minimizing the Mass of Thin Radiating Fins", J. Aerospace Science, Vol. 27, 1960, 145-146.
[3] S. Sunil Kumar and S.P.Venkateshan, "Optimized Tubular Radiator with Annular Fins on a Non-Isothermal Base, Int. J".
[4] U S Gawai, Mathew V K, Murtuza S D “Experimental Investigation of Heat transfer by PIN FIN” Volume 2, Issue 7, January 2013
[5] K. Park, D.H. Choi, K.S. Lee, Numerical shape optimization for high performance of a heat sink with pin-fins, Numerical Heat Transfer. Part A, Applications 46 (2004) 909–927.
[6] Dong-Kwon Kim, Sung Jin Kim *, Jin-Kwon Bae, "Comparison of thermal performances of plate-.n and pin-.n heat sinks subject to an impinging flow” International Journal of Heat and Mass Transfer 52 (2009) 3510–3517