"Comparative Study on Temperature Distribution along Solid Pin fin with Composite Materials under Natural Convection"

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Abstract – *The aim of the present study is to improve the thermal properties and to investigate the performance of fin efficiency by using fins of different materials and composite materials in pin fin apparatus. There are different shapes of fins generally used in practical applications. Aluminium is the basic metal preferred to make fins due to their light weight and cost. In general the heat transfer from fins depends upon different factors, like the material used to make the fin, thermal conductivity of the material, its shape, surface area, mode of heat transfer allowed, size / shape of fin, etc.*

In the present study, an attempt is made to fabricate cylindrical pin fin made Brass, Aluminium, Copper , Mild Steel and composite materials like Aluminium and copper or brass as composite bar and analyzed their performance in terms of temperature distribution along the fin. A constant power is supplied to the heater and the fin is placed horizontally along the axis. Now this time available on different type materials.This paper main objective compare the different type material with composite material.

Keywords: *Composite Pin fin, Thermal conductivity, Heat transfer rate, Heat transfer coefficient, Fin efficiency, Temperature distribution, natural convection.*

1. INTRODUCTION

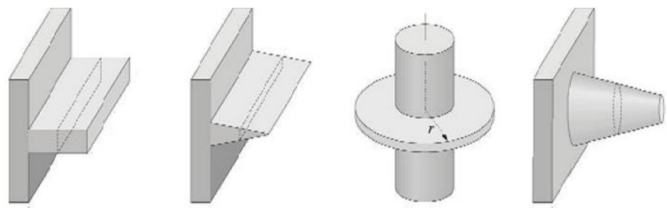
Convection heat transfer between a hot solid surface and the surrounding colder fluid is governed by the Newton's cooling law which states that " the rate of convection heat transfer is directly proportional to the temperature difference between the hot surface and the surrounding fluid and is also directly proportional to the area of contact or exposure between them" Newton's law of cooling can be expressed as

$$Q_{conv} = h\,A\,(T_s - T_\infty)$$

Where, h = Convection heat transfer coefficient
T_s = Hot surface temperature
T_∞ = Fluid temperature
A = Area of contact or exposure

The extended surfaces that enhance the heat transfer rate from the surface by exposing the larger surface area to convection. These extended surfaces are called **fins.** The term extended surface is commonly used in reference to solid that experience energy transfer by the conduction and convection between its boundary and surroundings. A temperature gradient sustains heat transfer by conduction internally, at the same time; there is energy transfer by convection into ambient from its surface. The amount of conduction, convection, or radiation of an object determines the amount of heat it transfers. Increasing the temperature difference between the object and the environment, increasing the convection transfer coefficient or increasing the surface area of the object increases the heat transfer. In most cases, the area of heat transfer is increased by utilizing extended surface in the form of fins attached to walls and surfaces.

In a conventional heat exchanger heat is transferred from one fluid to another through a metallic wall and other things being equal, the rate of heat flow is directly proportional to the extent of the wall surface and to the temperature difference between one fluid and the adjacent surface. If thin strips of metal are attached to the basic surface, extending into one of the fluids, the total surface is thereby increased which results in an enhanced rate of heat flow. These attached heat conducting strips constitute what are generally termed "extended surfaces" or "fins". Fins are of various types, the most common among them being (a) Rectangular (b) Annular (c) Spines.



(a) (b) (c) (d)

Fig: Different Shape of fins

Thermal analysis is the process of finding the values of temperature at different points when the material is in steady state condition. A steady state is the material condition where there is input heat energy equal to output heat energy. The important factors which mainly affect the heat transfer rate are the thermal conductivity of material, size of material etc. Different materials have different thermal conductivity and it affects the rate of heat transfer. By increasing the length and diameter of the pin fin, the heat transfer rate can be improved but the fin faces the difficulty of increased self weight and size.

2. Experimental Setup

The experimental apparatus consists of a simple or circular cross section pin fin which is fitted in a rectangular duct. The other end of the duct is attached to suction end of a blower and the air flows past the fin perpendicular to the axis. One end of the fin projects outside the duct and is heated by an electrical heater. Temperature at five points along the length of the fin. The air flow rate is measured by an orifice meter fitted on the delivery side of the blower. The apparatus consists of a pin fin placed inside an open duct the other end of the duct to connected to suction side of blower the delivery side of a blower is taken on through on orifice meter to atmosphere, the air flow rate can be varied by the blower speed regular and can be measured on the U-tube manometer connected to one end of the pin fin. The panel of the apparatus consists of voltmeter, ammeter and digital temperature indicator, heat regulator in it. Thermocouples are mounted along the length of fin and a thermocouple notes the duct fluid temperature. When top cover the fin is opened and heating started, performance of fin with natural convection can be evaluated and with top cover closed and blower started, fin can be tested in forced convection.

The Experimental set-up consisting of the following parts

1. Main Duct (Rectangular)
2. Heater Unit
3. Middle Portion
4. Data unit

1. Main Duct Rectangular):A rectangular channel constructed by using galvanizing steel of 1mm thickness and 150 X100mm cross section, 1000mm long connected to suction side of blower.

2. Heater Unit: Heater unit (test section) has a diameter of 160mm and with of 20mm which is wound on the cylindrical fin portion the heating unit mainly considered of an electrical heater. The heater input 0 to 230 volt and 2 amps.

3. Middle Portion: On the middle portion of the rectangular duct there is pin fin attach and to heat that pin fin on the middle portion of rectangular duct band heater is wound to heat the pin fin.

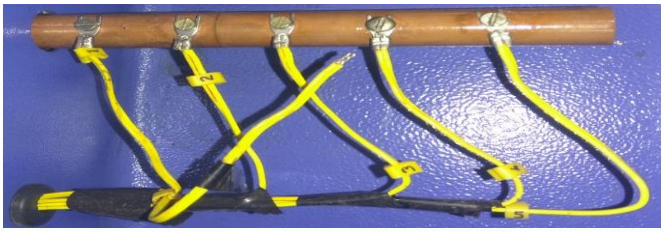
4. Data Unit: It consists of various indicating devices which indicate the reading taken by various components like thermocouples, voltmeter, ammeter, and manometer. There are multichannel digital temperature indicator which shows reading taken by the five thermocouples.

Experimental Setup

Aluminium fin

Brass fin

Mild Steel fin



Copper fin

Brass + Al **Copper + Al**

Table-1: Property of Materials

S. No.	Fin Materials	Thermal Conductivity of fin materials (W/m-K)
1	Brass	110
2	Aluminium	232
3	Copper	398
4	Mild Steel	46
5	Brass + Al	371.28
6	Copper + Al	834.17

Table-2: Comparison of Temperatures Distribution with constant voltage

Materials	T1	T2	T3	T4	T5	T6
Brass	48	44	42	41	38	35
Aluminium	47	44	43	40	36	36
Copper	52	47	44	42	40	36
Mild Steel	54.3	51.6	49.5	47	45	37
Brass + Al	74	68	64	61	58	35
Copper + Al	65	63	59	57	55	34

3. CONCLUSIONS

Now this review paper main objective is compare the thermal conductivity of different materials and temperature distribution along the fin. The temperature dependence of thermal conductivity. Aluminium,Iron and Copper being widely used fin materials; the study of variable thermal conductivity with its resultant impact on the performance of fins becomes imperative. Both increase and decrease of thermal conductivity of metals with temperature occur in practice depending upon the material and the range of temperature involved. Future Experimental investigation and thermal analysis on nano-particle copper coating over aluminium cylindrical pin fin.

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