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Experimental Analysis of Heat Transfer Enhancement Using Fins in Pin Fin Apparatus

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Abstract

The aim of the present study is to improve the heat transfer characteristics and to investigate the performance of fin efficiency by using fins of different materials in pin fin apparatus. Here the system follows forced convection as the mode of heat transfer and it is the principle used in it. This experiment accomplished by using blower in the riser tube, which connects to the thermocouple which flows the air to the heater. From the heater the air gets heated and the air transfer to the the pin fin in it. This procedure followed for the fin of different materials, Reynolds number, Nusselts numbers are calculated and heat transfer coefficient and fin efficiencies are analyzed.
***Keywords:** forced convection, heat transfer enhancement, pin fin, etc*

I. INTRODUCTION

The heat conducted through solids, walls or boundaries has to be continuously dissipated to the surroundings or environment to maintain the system in steady state conduction. In many engineering applications large quantities of heat have to be dissipated from small areas. Heat transfer by convection between a surface and the fluid surroundings it can be increased by attaching to the surface thin strips of metals called fins. The fins increase the effective area of the surface thereby increasing the heat transfer by convection. The fins are also referred as "extended surfaces". Fins are manufactured in different geometries, depending up on the practical applications Most of the engineering problems require high performance heat transfer components with progressively less weights, volumes, accommodating shapes and costs. Extended surfaces (fins) are one of the heat exchanging devices that are employed extensively to increase heat transfer rates. The rate of heat transfer depends on the surface area of the fin. It increases the contact surface area, for example a heat sink with fins. The heat transferred through the fins provides the problem of determination of heat flow through a fin requires the knowledge of temperature distribution through it. This can be obtained by regarding the fin as a metallic plate connected at its base to a heated wall and transferring heat to a fluid by convection. The heat flow through the fin is by conduction. Thus the temperature distribution in a fin will depend upon the properties of both the fin material and the surrounding fluid. In this section, we will analyze certain basic forms of fins, with respect to heat rate, temperature distribution and effectiveness. The experiment is conduct to investigate the effect of the pressure loss and heat transfer characteristics in pin-fin channel, where dimples are located on the pin-fins. An aluminum fin of rectangular cross section with various dimple depth is fitted in a long rectangular duct. In the present work aluminum & brass plate were used as a test surface. Variation of Nusselt Number with Reynolds Number is investigated, with various parameter combinations. The experimental results gives heat transfer coefficient & efficiency of aluminum fin is greater than brass fin [1].

Most of the engineering problems require high performance heat transfer components with progressively less weights, volumes, accommodating shapes and costs. Extended surfaces (fins) are one of the heat exchanging devices that are employed extensively to increase heat transfer rates. The rate of heat transfer depends on the surface area of the fin. In this the heat transfer rate and efficiency for circular and elliptical annular fins were analyzed for different environmental conditions [2].

From the experimental study it is found that the heat transfer rate in notched fins is more than the unnotched fins. The average heat transfer coefficient for without notched fin is 8.3887 W/m2K and for 20% notched fins it is 9.8139 W/m2K. Also the copper gives more heat transfer rate than aluminum plate. As the notch area of fin increases the heat transfer rate also increases. Copper plate gives better heat transfer rate than aluminum plate [3]

Heat transfer performance of T-section internal fins in a circular tube has been experimentally investigated. The T-finned tube was heated by electricity and was cooled by fully developed turbulent air. Inside wall temperatures and pressure drop along the axial distance of the test section at steady state condition were measured for different flows having Reynolds number ranging from 2x104 to 5x104 for both smooth and finned tubes. From the measured data, heat transfer coefficient Nusselt number and friction factor were calculated[4] Heat transfer performance of elliptic disc fin has been analyzed using a semi analytical technique .It has been shown that the efficiency of such fin can also be predicted very closely using sector method.

Optimum elliptical fin dissipate heat at higher rate compared to annular fin when space restriction exists on both sides of the fin. Even when the restriction is one side only, the performance of elliptical fin is comparable to that of eccentric annular fin for a wide parametric range [5]

In this paper compiled that obtaining two simple correlation equations which express the optimum heat transfer rate and optimum radii ratio of the fin as a function of the fin volume and Biota Number with uniform thickness [6]

In this paper stated that the variable thickness annular fin mounted on a hot rotating rigid shaft is considered. Thickness of fin varies radically in a continuous variable non liner elliptic form. The heat transfer and deformations in the fins subjected to both centrifugal force and radial temperature gradients [7]

To analyze the effect of fin spacing on four row annular finned tube bundles in staggered and inline arrangements are investigated by 3D numerical study. To investigate the velocity and temperature distribution between fins. The flow behavior of the developing boundary layer, the horse shoe vortex system, and thermal boundary layer developments in the annular finned tube banks will be visualized [8].

It is proved till today that special surface geometry or special fin pattern may enhance heat transfer coefficients. The area selected for investigation is experimental analysis of one of the special fin pattern i.e. staggered fin arrays. They are compared with continuous fin array. From the literature survey, test section and fin arrays under study are designed. Four sets of 38 mm height and four sets of 48 mm height are designed. For each height 33.33 %, 40% and 50% lengthwise staggering is done. Then by performing an experiment, readings of 11 temperatures were recorded for five different heater inputs. From these readings Nusselt number for each array for given range of heater input is calculated. Thus it is concluded that the staggered arrangement enhances the heat transfer rate. In other words it can be concluded that the staggered arrays may be used for augmentation of heat transfer in vertical fins[9]The present study examines heat transfer from a single row of circular pin fins with the row oriented perpendicular to the flow. The configurations studied have span wise spacing to pin diameter ratios of two, four, and eight. Low aspect ratio pin fins were studied whereby the channel height to pin diameter was unity. The experiments are carried out for a Reynolds number range of 5000 to 30,000. Heat transfer measurements are taken on both the pin and on the end wall covering several pin diameters upstream and downstream of the pin row. The results show that the heat transfer augmentation relative to open channel flow is highest for the smallest span wise spacing for the lowest Reynolds number flows. The results also indicate that the pin fin heat transfer is higher than on the end wall [10]

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Pin fin apparatus efficiency is being improved by adding different shape of fins and changing the geometric dimension of fin but they didn't change any materials, in these thesis various material such as copper, aluminum, brass is analyzed, of those material copper had higher thermal efficiency as well as higher heat transfer rate.

II. Experimental Setup

A brass fin of circular cross section in fitted across a long rectangular duct. The other end of the duct is connected to the suction side 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 a 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 a 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.

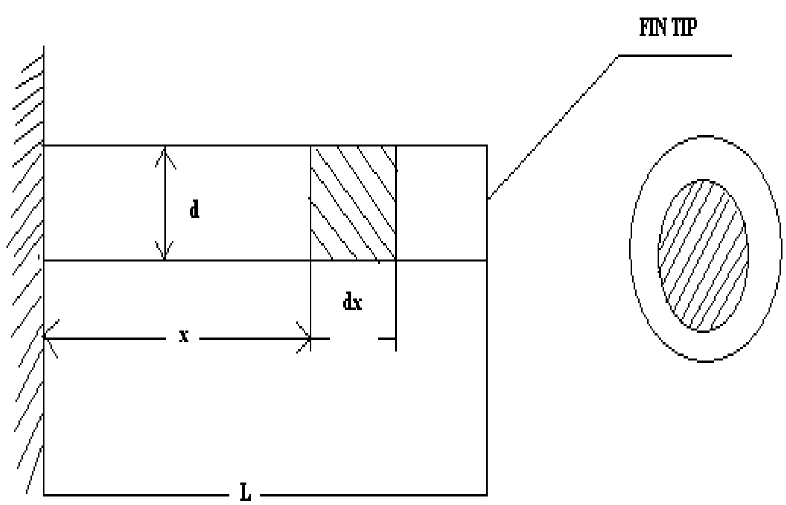

FIGURE 1: Schematic diagram of pin fin apparatus

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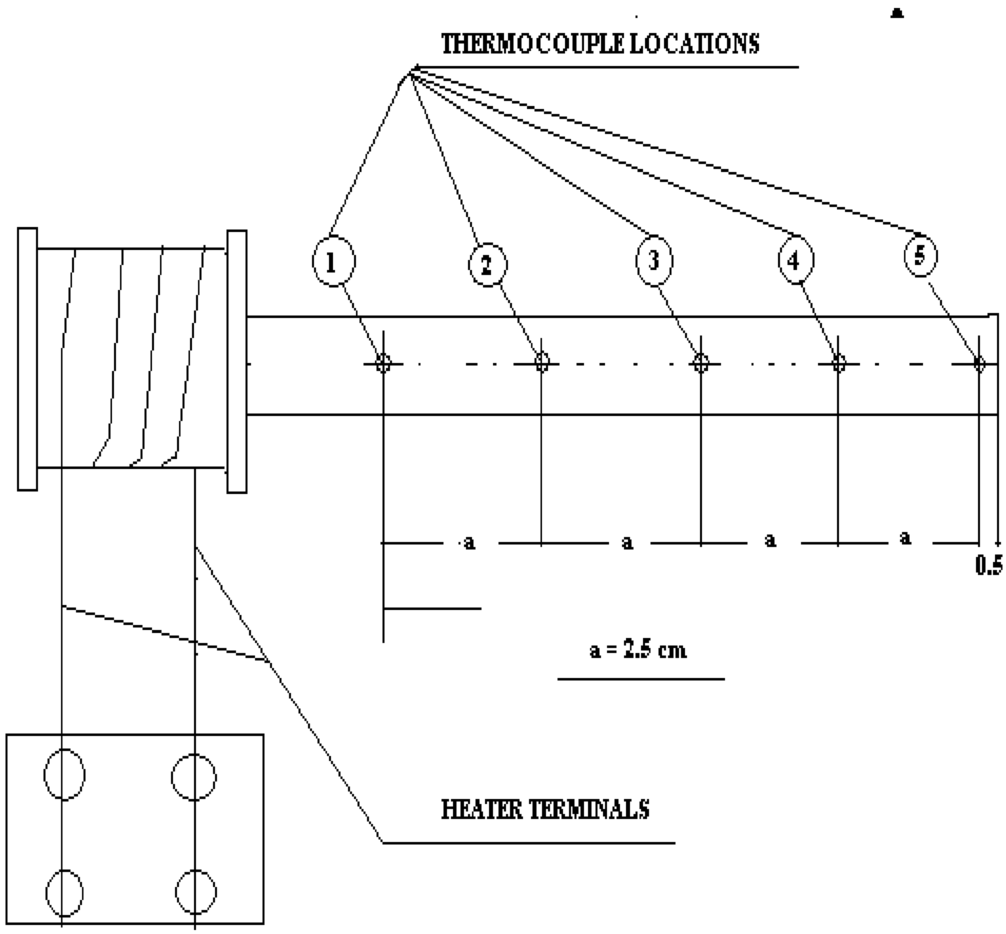

FIGURE 2: Schematic diagram of pin fin apparatus

Extended surfaces of fins are used to increase the heat transfer rate from a surface to a fluid wherever it is not possible to increase the value of the surface heat transfer coefficient or the temperature difference between the surface and the fluid. The use of this is variety of shapes (Refer fig. 1 and 2). Circumferential fins around the cylinder of a motor cycle engine and fins attached to condenser tubes of a refrigerator are a few familiar examples.

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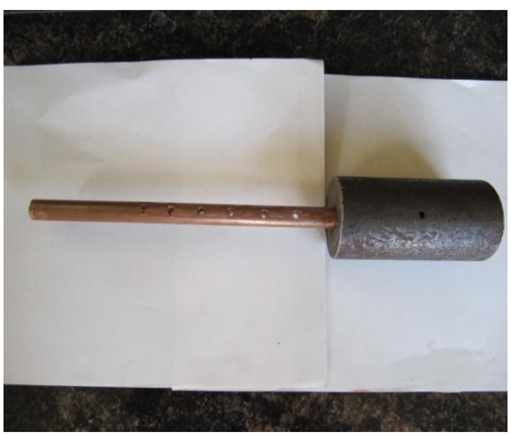
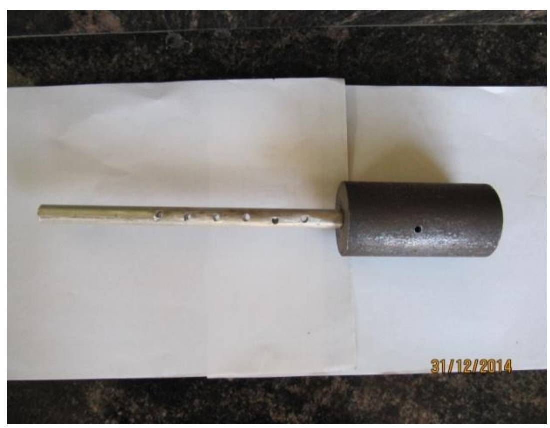
It is obvious that a fin surface sticks out from the primary heat transfer surface. The temperature difference with surrounding fluid will steadily diminish as one move out along the fin. The design of the fins therefore required knowledge of the temperature distribution in the fin. The main objective of this experimental set up is to study temperature distribution in a simple pin fin.

Experimental setup

Brass fin



Copper fin



Aluminum fin

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III. Reading Values

Table 1 Reading for brass:

volts	Amps	T_1	T_2	T_3	T_4	T_5	T_6	T_7	h_1	h_2
40	0.3	38	36	34	29	27	25	22	10	8
45	0.36	42	40	38	36	34	30	28	12	6.2
50	0.42	46	42	40	39	36	33	30	14	7.5

Table 2 reading for copper:

Volts	amps	T_1	T_2	T_3	T_4	T_5	T_6	T_7	h_1	h_2
40	0.3	40	38	36	31	29	28	24	8	5
45	0.36	42	40	39	33	31	31	36	10	6
50	0.42	45	43	41	38	35	35	28	15	8

Table 3 reading for aluminum:

Volts	Amps	T_1	T_2	T_3	T_4	T_5	T_6	T_7	h_1	h_2
40	0.3	38	36	33	28	26	26	22	10	5.6
45	0.36	39	38	35	30	29	28	24	13	6.8
50	0.42	40	38	36	32	28	26	24	16	9.2

Table 4 Comparison of temperature with constant volts

MATERIAL	VOLTS	AMPS	T_1	T_2	T_3	T_4	T_5	T_6	T_7
BRASS	50	0.42	46	42	40	39	36	33	30
ALUMINUM	50	0.42	45	43	41	38	35	35	28
COPPER	50	0.42	50	46	43	42	39	37	35

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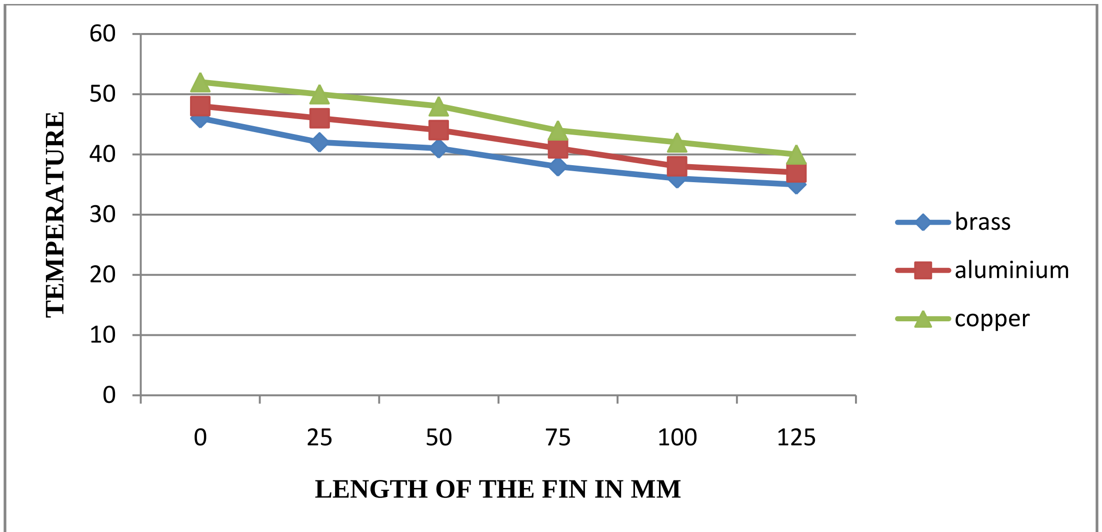
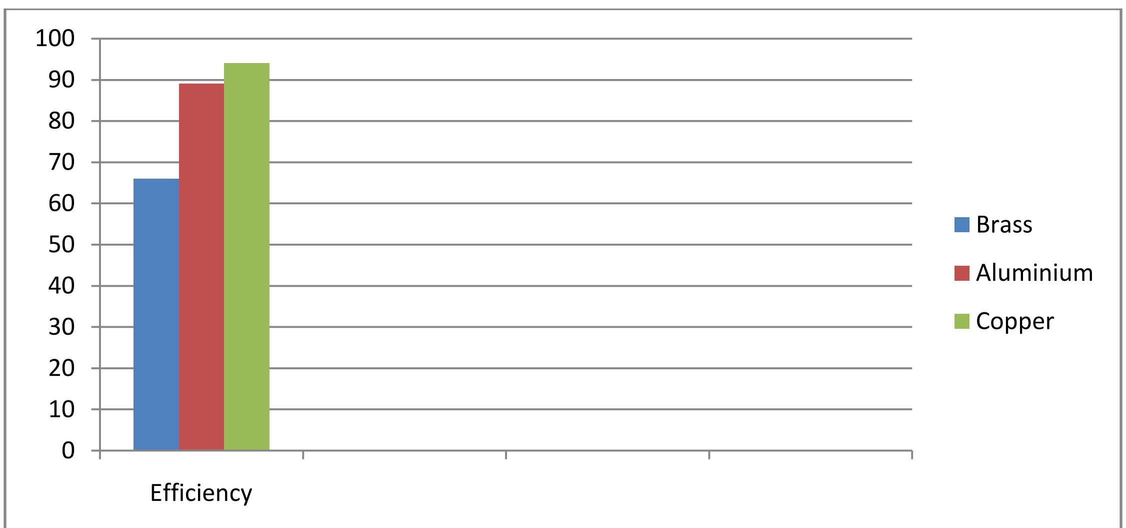


Temperature Distribution Graph



Efficiency Graph

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Table 5 values of materials

Material	Heat transfer coefficient(h)	Nusselt number(Nu)	Reynolds number(Re)	Efficiency
Brass	13.540	0.1784	0.3810	66%
Aluminium	13.630	0.3438	0.6130	91%
Copper	20.460	0.8484	1.2564	94%

IV. Conclusion

From the experimental analysis in this project the enhancement of heat transfer of fin for different materials is analyzed and it can be improved. Fin efficiencies of materials are 66%, 91%, 94% are achieved. And among these materials from the analysis that copper has high thermal conductivity than brass and aluminum.

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