Experimental Investigation of Heat Transfer By Using Fins of Different Material In Free 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 in pin fin apparatus. There are different shapes of fins generally used in practical applications. Aluminum 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, Aluminum. 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 of materials.

Keywords- Thermal conductivity, Rayleigh number, Nusselt number, Heat transfer rate, Heat transfer coefficient, Fin efficiency, Temperature distribution, natural convection.

I. INTRODUCTION

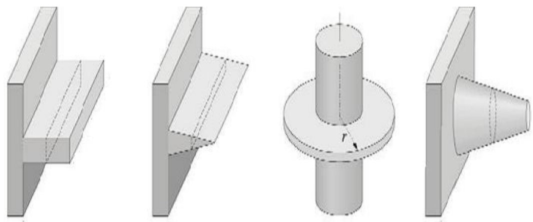
In modern engineering applications like air conditioning, cooling of nuclear reactor fuels internal combustion engines as well as in electronic devices & solar energy applications, heat dissipation has been a major problem & a challenge to thermal engineers. Modern portable electronics have seen component heat loads increasing, while the space available for heat dissipation has decreased. These factors have forced thermal engineers to develop and optimize devices that not only perform better, but also are at the same or lower cost than previous generations. Extended surfaces have played an important role in heat dissipation & have found themselves in most of the applications. Though extended surfaces & fins have been efficient, they remain a very good subject of research as the heat transfer rate from the fins depends on a variety of factors. The studies have shown that the convective heat transfer rate from fin arrays depends on geometric parameters, fin material, base to ambient temperature difference & approach velocity.

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

FINS:

- Fins serve as a heat removal mechanism from the heat sources where the presence of additional components such as pumps, fans and blowers are not feasible due to product design.
- Numerous studies had been performed on the investigation for the optimal fin designs, fin arrangement.
- The most popular fin configurations are pin fins (circular cross-section) and plate fins (rectangular cross-sections).
- In the fin arrangement, the surface area that is available for heat transfer play a critical area in the overall heat transfer rate.
- Another important factor is the flow turbulence in the vicinity of the fins. If flow turbulence is higher, it would result in higher heat transfer rate. So, the fin arrangement should be preferred in such a way that higher flow turbulence is created.



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

Fig: Different Shape of fins

II. 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.

III. DIFFERENT TYPES OF MATERIALS USED:

1. ALUMINUM

Aluminum fin

The three main properties on which the application of aluminum is based are its low density of approximately 2.7, the high mechanical strength achieved by suitable alloying and heat treatments, and the relatively high corrosion resistance of the pure metal. Other valuable properties include its high thermal and electrical conductance, its reflectivity, its high ductility and resultant low working cost, magnetic neutrality, high scrap-value, and the non-poisonous and colorless nature of its corrosion products which facilitates its use in the chemical and food-processing industries.

Still further valuable features are obtained by various treatments of the metal; these will be considered when the applications of aluminum and its finishes are considered. In its pure state, aluminum is, however, a relatively soft metal with a yield strength of only 34.5 N/rrnn2 (5,000 lb/in2) and a tensile strength of 90 N/mm2 (13,000 lb/in2). Through the development of a wide range of alloys, however, very varied strengths

2. BRASS

Brass fin

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Brass is the most common alloy of Cu. It's an alloy with Zn Brass has higher ductility than copper or zinc. Easy to cast - Relatively low melting point and high fluidity Properties can be tailored by varying Zn content. Some of the common brasses are yellow, naval. Brass is frequently used to make musical instruments. Copper alloys containing tin, lead, aluminum, silicon and nickel are classified as bronzes. Cu-Sn Bronze is one of the earliest alloy to be discovered as Cu ores invariably contain Sn. Stronger than brasses with good corrosion and tensile properties; can be cast, hot worked and cold worked. Wide range of applications: ancient Chinese cast artifacts, skateboard ball bearings, surgical and dental instruments.

IV. WORKING OF EXPERIMENTAL SETUP:

1. Insert the required fin and make proper connections.
2. Switch on the main supply
3. Start heating the fin by switching ON the heater
4. Adjust dimmer stat voltage equal to 80 volts.
5. Wait for 20 minutes and adjust the voltage to 60 volts.
6. Wait to obtain the steady state condition.
7. Note down the thermocouple readings (1) to (4) at a time interval of 5-10 minutes.
8. When the steady state is reached, record the final reading (1) to (4).
9. Repeat the same experiment with different air flow readings.
10. Remove the fin when it is cooled

V. RESULT AND ANALYSIS

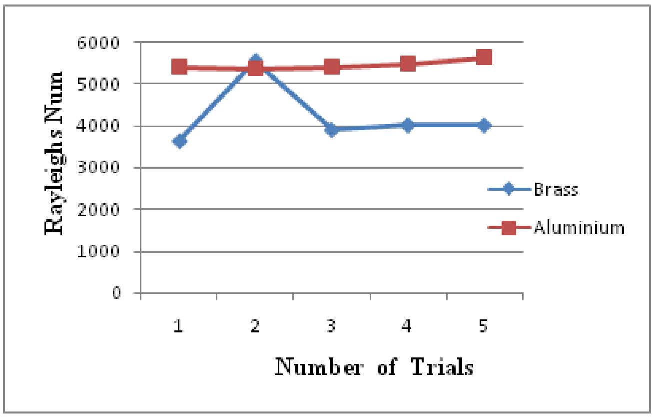
Readings of brass material

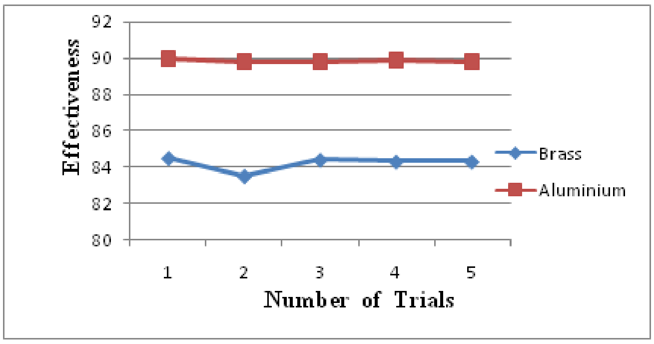
Sl No	T_1	T_2	T_3	T_4	T_5	T_6	HTC h	Q	€	N_U	$R_a \times 10^3$
1	73	68.9	61.7	60.1	58.3	37.4	8.81	1.423	84.57%	3.96	3.628
2	75	70.6	63.3	61.7	59.8	37.8	9.56	1.61	83.5%	4.29	5.542
3	76.1	71.7	64.2	62.7	60.6	37.9	8.94	1.56	84.4%	4.02	3.89
4	77.6	73	65.6	63.7	61.8	38.3	8.98	1.61	84.3%	4.04	4.006
5	78.9	74	66.4	64.4	64.4	38.7	9.01	1.64	84.3%	4.05	4.05

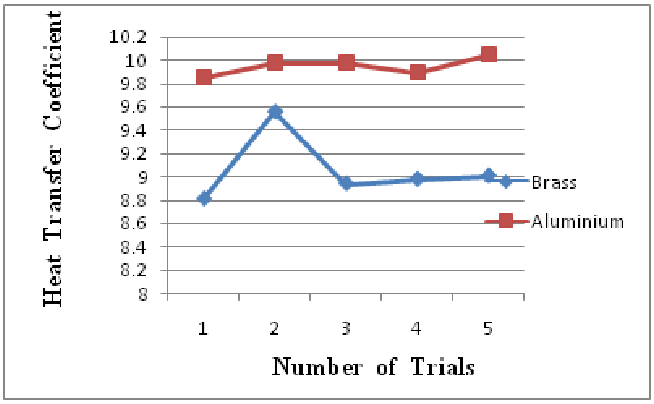
Readings of Aluminum material

Sl No	T_1	T_2	T_3	T_4	T_5	T_6	HTC h	Q	€	N_U	$R_a \times 10^3$
1	100	95	94	86	91	39	9.85	3.19	90%	4.27	5.39
2	105	100	99	90	96	40	9.97	3.45	89.8%	4.27	5.36
3	106	102	100	91	97	41	9.97	3.47	89.8%	4.27	5.38
4	107	102	101	92	98	41	9.89	3.52	89.9%	4.28	5.47
5	108	103	102	93	98	40	10.04	3.64	89.8%	4.3	5.62

T_1 to T_5 =Surface Temperature Readings
T_6 = Ambient Temp
h =Heat Transfer Coefficient
Q =Heat Transfer Rate
€ =Effectiveness
N_U = Nusselt Number
R_a = Rayleigh's Number







VII. CONCLUSION

From the experimental analysis in this project the enhancement of heat transfer of fin for different materials is analyzed and we can conclude that

- As Rayleigh's Number increases, the efficiency of pin fin decreases.
- Heat transfer coefficient for Aluminum fin is more than Brass.
- Nusselt Number remains almost same for all materials fin.
- As Rayleigh's Number decreases, heat transfer coefficient also decreases for all materials fin.
- As heat transfer coefficient decreases, Efficiency increases for all materials fin.
- While material wise Aluminum is the most efficient material.

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