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Experimental Analysis of Heat Transfer of a Fin by using Compressed Graphite Sheet

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ABSTRACT

An experimental investigation of heat transfer from a square fin using graphite sheets is addressed in the present work. The test has been performed on three different thickness of graphite sheet having 1mm,3mm and 6mm thickness placed in the slotted fin. The experimental setup comprises centrifugal blower, test section, heater and test panel. Results are obtained for local fin temperature distribution, rate of heat flux. The local fin temperatures of a fin with graphite sheet are higher than that of a plane square fin due to an increased rate of heat conduction. The rate of heat flux is also increased with the increase in the thickness of graphite sheet. The Effectiveness and Efficiencies of fin with Graphite sheet are also increased

KEYWORDS: Square fin, Graphite sheets, Thermal Conductivity, Effectiveness.

1. INTRODUCTION

Now a day's heat dissipation from electronic and mechanical components is the major problem. Electronic components like LED lights, CPU in computers, different electronic chips, transistors, and some mechanical devices produce heat while it is working. If this heat is not dissipating from the device properly it becomes over heated and system will have damaged and it didn't work properly. So many studies and experiments are done on this problem by using fins, heat sinks with different geometries. Typically, the fin material has a high thermal conductivity. The fin is exposed to a flowing fluid, which cools or heats it, with the high thermal conductivity allowing increased heat being conducted from the wall through the fin. Present work deals with the thermal performance of a square fin using compressed graphite sheets by using the graphite sheets the thermal conductivity of a fin can be increased which intern increases the heat conduction from the fin. Fins are the extended surfaces, which are directly or indirectly attached to the hot body to dissipate the heat by conduction, convection and radiation. Fins are used to increase the heat transfer rate from a surface to a fluid. The heat removed by conduction from body, which it is attached, then by convection and radiation from fin. The use of fins in very common and they are designed in different shapes. Circumferential fins around the cylinder of a motor cycle engine and fins attached to the condenser tubes of refrigerator are a few examples.

Heat sinks are devices that enhance heat dissipation from a hot surface, usually the case of a heat generation component, to a cooler ambient fluid usually air. A heat sink generally consists of a base with different cross-sectional fins attached to it to dissipate heat from the hot body. Thermal performance of heat sink can be improved by having optimum geometric parameters like fin length, fin number, fin height, and height of base. The design of heat sinks such a way that it should remove more heat from device, less in weight, having more thermal conductivity, it occupies less place but having more contact area to dissipate heat and less cost. Generally, heat sinks are made with high thermal conductivity material such as copper, aluminum. Copper has more thermal, electrical conductivity but more cost and weight. Aluminum is less thermal conductivity than copper but it is less cost, light weight, and machining is easy. Thermal conductivity of aluminum increases with increase in temperature. The heat sink removes heat from hot body to cooling medium (air, water, oil or refrigerant). The first heat is conducted from the body to the base. Then the heat further conducted to fins which are attached to the base and from there heat is dissipated through convection and radiation to the surrounding cooling medium. Heat dissipation depends on the heat sink material, fluid properties, flow characteristics and thermal contact resistance between fins and base. In present work single fin is attached to the base which is heated with the help of heater. So, first heat is transfer from base to the fin by conduction. From the fin, heat removed by convection and radiation. Sabarish, R., et al. [1] carried out experimental investigation of heat transfer on cylindrical copper fin coated with Nano graphite. Here cylindrical and square fin of copper and aluminium materials were preferred for analysis. The fins were coated with Nano graphite for all of the above cases and changes in heat transfer through the fin, fin efficiency and effectiveness were studied. It is found that there is a considerable increase in heat transfer and other parameters on Nano coating. Hadi, Ammar M et al [2] experimentally investigated the performance of hot surfaces coated with graphite. This experimental research depicts the role of coating hot surfaces by graphite on the process of heat dissipation from these hot surfaces. The experiments are conducted with four turbulent Reynolds number. The results reveal that the sample coated by grapheme exhibits the best thermal dissipation while the uncoated specimen shows the worst thermal performance. The enhancements of heat transfer coefficient at Re = 12000 are 14 % for graphite nano particles and 4 % for graphite nano particles when compared with uncoated specimen.

2. MATERIALS AND METHODS

A. Materials used:

In the present work square fin made of aluminum, aluminum fin with Graphite sheets of variable thickness i.e., 1mm, 3mm, 6mm is taken for analysis, K-type thermocouples, digital temperature indicator, brass heater are used.

B. Experimental Setup and Procedure

The experimental set-up shown in Fig below. The main components of the experimental setup are duct for air pass, variable speed blower, thermocouples, multipoint temperature indicator, orifice meter attached with differential manometer, voltmeter, ammeter, valve to regulate the various inputs. The set up consists of duct with one end connected with blower, other end of duct is open to atmosphere to flow air into duct. The blower is connected with outlet pipe with orifice plate, manometer and valve to regulate the flow rate of air. Fin with thermocouples is placed inside the duct.

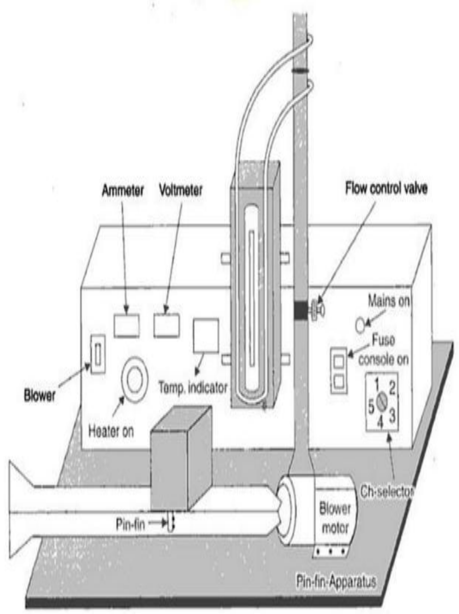

Fig1: Experimental Test Rig Apparatus

The experimental setup as shown in Fig comprises of suction duct of size 1050 mm length, 150 mm wide and 100 mm height connected to a centrifugal blower for air passage. In addition, it consists of heater section, delivery section and test panel.

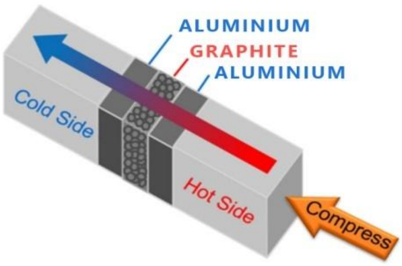

Fig2 : Aluminium with graphite

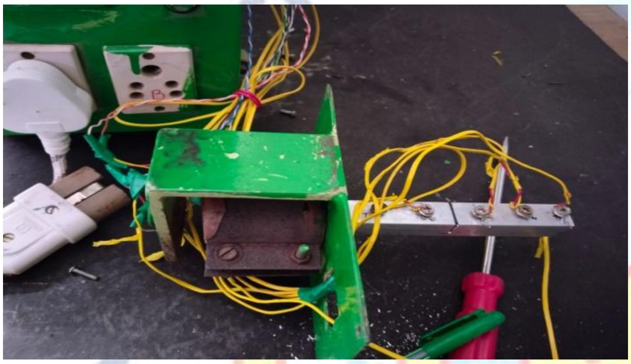

Fig3 : Fin with heater and thermocouples

Specifications:

Duct size = 150 mm x100 mm

Diameter of the orifice plate = 18 mm

Diameter of the delivery pipe = 42 mm

Coefficient of discharge of orifice meter (Cd) = 0.64

Centrifugal blower = 1 hp,

single phase motor Number of thermocouples on fin = 5

Thermal conductivity of fin material = 200 W/m K

Thermal conductivity of graphite = 4180W/m K

Temperature indicator = 0-300 C

Dimmer stat for heat input control = 230 V

2 Amps Voltmeter = 0-100/200 V

Ammeter = 0-2 Amps.

C. Experimental Procedure:

To study the temperature distribution along the length of the pin fin in forced convection the procedure is as follows as initially start heating the fin by switching on the heater and adjust the dimmer stat voltage. Start the blower and adjust the difference of level in the manometer with the help of valve. Note down the thermocouple readings 1 to 5 at equal time interval. When the steady state is reached, record the final readings 1 to 5, and record the ambient temperature reading 6. Repeat the same experiment with different thicknesses of graphite sheets.

D. Calculations:

Discharge of air = $C_d \times \frac{\pi}{4} \times d^2 \times \sqrt{2gh\frac{\rho w}{\rho a}}$

Where C_d = Coefficient of discharge

d= diameter of orifice plate(m)

h = water column height(m)

ρ_w= density of water. (kg/m^3)

ρ_a = density of air. (kg/m^3)

$Velocity\,(V) = \frac{Discharge}{Area\ of\ duct}$

mass flow rate of air $m = \rho AV$.

Fluid properties comprise density (ρ), momentum diffusivity (ν), Prandtl number (Pr), thermal conductivity is to be extracted at mean film temperature. The mean film temperature is the average of average fin temperature and ambient temperature.

Mean film temperature Tmf = (Tavg+Tamb)/2

Where Tmf = mean film temperature.

Tavg = Average Temperature of fin.

T amb = Ambient Temperature.

Properties of air at T mf is taken from heat transfer data book.

Reynolds number (Re) = $\rho \nu L_c/\mu$

Where ρ = density of air. (kg/m^3)

ν = velocity (m/s)

L_c = correction length(m)

μ = dynamic viscosity

Nusselt number (Nu):

Flow across fin:

The present geometry can be described as flow across the cylinder. So, from the heat transfer data book appropriate correlation for calculating Nusselt number has been selected and is given by

$Nu = 0.615 Re^{0.466} Pr^{0.333}$

Heat transfer from fin (Q) = h A (Tavg - Tamb).

Effectiveness of fin (ε) =√PKhA.

Where,

A=Cross-sectional area of fin.

h = Convective heat transfer coefficient.

K = Thermal conductivity of the fin material.

P = Cross-section perimeter.

3.RESULTS AND DISCUSSION

A. Local Temperature of the fin:

The following figure shows the temperature distribution of the fin at different locations on the fin.

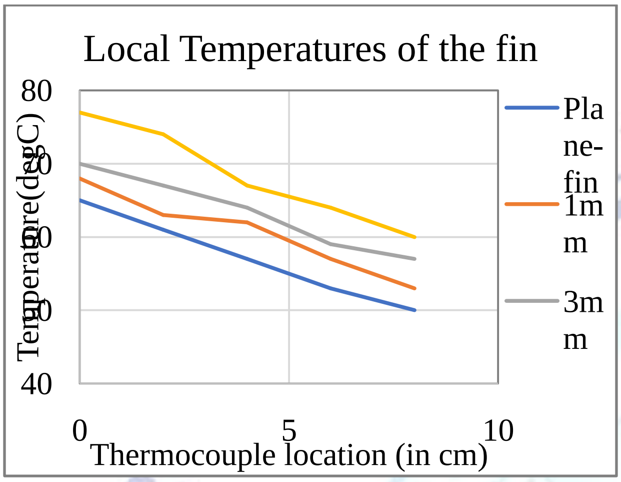

Fig4 : Local temperature of the fin

From the above figure it is seen that the temperature from T1 to T5 is increasing from the plane fin to 1mm, 3mm,6mm thickness graphite fins for the 1mm graphite thickness fin the temperature for the T1 is increased by 4.6% when compared to plane fin at a distance 0 cm. For the 3mm graphite thickness fin the temperature for the T1 is increased by 7.6% when compared to plane fin at a distance 0cm. For the 6mm graphite thickness fin the temperature for the T1 is increased by 18.46% when compared to plane fin at a distance 0cm. For the 1mm graphite thickness fin the temperature for the T2 is increased by 3.27% when compared to plane fin at a distance 2cm. For the 3mm graphite thickness fin the temperature for the T2 is increased by 9.83% when compared to plane fin at a distance 2cm. For the 6mm graphite thickness fin the temperature for the T2 is increased by 21.3% when compared to plane fin at a distance 2cm. For the 1mm graphite thickness fin the temperature for the T3 is increased by 8.7 % when compared to plane fin at a distance 4cm. For the 3mm graphite thickness fin the temperature for the T3 is increased by 12.28% when compared to plane fin at a distance 4cm. For the 6mm graphite thickness fin the temperature for the T3 is increased by 17.54% when compared to plane fin at a distance 4cm. For the 1mm graphite thickness fin the temperature for the T4 is increased by 7.54% when compared to plane fin at a distance 6cm. For the 3mm graphite thickness fin the temperature for the T4 is increased by 11.32% when compared to plane fin at a distance 6cm. For the 6mm graphite thickness fin the temperature for the T4 is increased by 20.75% when compared to plane fin at a distance 6cm. For the 1mm graphite thickness fin the temperature for the T5 is increased by 6%when compared to plane fin at a distance 8cm. For the 3mm graphite thickness the temperature for the T5 is increased by 14% when compared to plane fin at a distance 8cm. For the 6mm graphite thickness fin the temperature for the T5 is increased by 20% when compared to plane fin at a distance 8cm.

B. Heat flux :

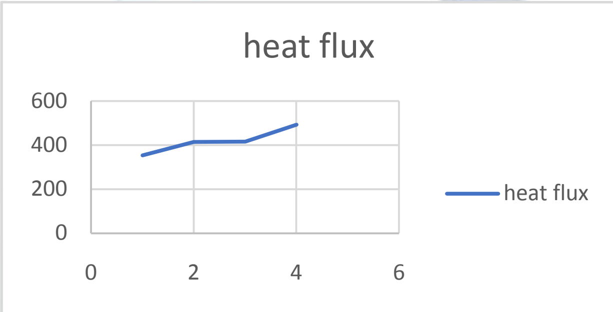

Fig5 : heat flux

The heat flux is maximum for 6mm thickness graphite when compared to1mm, 3mm and plane fin due to the increase in conductivity of the fin with 6mm thickness graphite.

C. Effectiveness of the fin:

The effectiveness of the fin is increasing as thickness of the graphite is increased the trend can be seen from the above table. The effectiveness of the 6mm thick graphite fin is increased by 3.7% due to the increase in conductivity of the fin with graphite material.

D. Effeciency of the fin:

It is observed that the efficiency of the fin with 6mm graphite sheet is more than the plane fin, 1mm, 3mm thick graphite fins due to the more thermal conduction.

4. CONCLUSIONS

Experiments are conducted on square fin using graphite sheets of different thickness Based on the experimental results, the following major conclusions have been drawn:

For the 6mm graphite thickness fin the temperature for the T1 is increased by 18.46% when compared to plane fin at a distance 0cm.

For the 6mm graphite thickness fin the temperature for the T2 is increased by 21.3% when compared to plane fin at a distance 2cm.

For the 6mm graphite thickness fin the temperature for the T3 is increased by 17.54% when compared to plane fin at a distance 4cm.

For the 6mm graphite thickness fin the temperature for the T4 is increased by 20.75% when compared to plane fin at a distance 6cm.

For the 6mm graphite thickness fin the temperature for the T5 is increased by 20% when compared to plane fin at a distance 8cm.

The heat flux is maximum for 6mm thickness graphite when compared to1mm, 3mm and plane fin due to the increase in conductivity of the fin with 6mm thickness graphite.

The effectiveness of the 6mm thick graphite fin is increased by 3.7% due to the increase in conductivity of the fin with graphite material.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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