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Evaluation Of Thermal Properties On Pin-Fin Material With MATLAB

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ABSTRACT

In the present scenario, Thermal Engineers having a major problem with heat dissipation. In major applications are like refrigeration & air conditioning, lubricating fuels, cooling of internal combustion engines, as well as in electrical, electronic parts, and solar energy applications heat dissipation has been a major problem. This can be minimized only by increasing the surface of the material or with the help of fins. The main aim of the present work is to improve the heat transfer behaviour of the fin and evaluation of the performance of fin efficiency and effectiveness by using the fin of different materials. The performance of pin fin with six different materials (Cu, Brass, Al 3003, Al 1050, Al 6061, Al 6082) is considered for better performance. If Excellency is required, the Cu heat sunk may be used for higher application purpose but Al is used due to their low cost and low weight. In this paper, we mainly focussed on which material shows better performance than the other materials consideration with design parameters on thermal efficiency and effectiveness, which is evaluated by using MAT LAB software.

1. Introduction

In the present day applications such as motherboards in CPU, electronic devices, semiconductor devices, optoelectronic, lasers and LEDs most of the Engineers facing e devices common problem is Heat Dissipation. Over accumulation of heat and temperature effects the life and working condition of these components. To improve the life and function of these devices can be possible by increase its surface area of the components. However, this can be restricted because of its less weight, portability, cost factor and to avoid complexity. Such that the other factor to improve the heat dissipation by selecting suitable material for considering applications as well as increasing its length compared to width and thickness also named as fins. The basic concept of this research is to identify the best material as Fin shows good heat dissipation using Pin Fin apparatus and validate using MATLAB.

2. Experimental Procedure

The pin fin apparatus consists one side open and other side-closed chamber named as duct used to place the fin. The open side of the duct is connected to the blower and outlet of the blower connected to the U tube manometer having orifice through gate valve. The seven thermocouples are placed on the pin fin at an equidistance and eighth thermocouple is placed in the duct and avoid contacting from pin fin. The First thermocouple placed at 10.8 cm from base end of the fin, and all other thermocouples were connected at 12.6 cm, 14.4 cm, 16.2 cm, 18.0 cm, 19.8 cm and 21.6 cm from the base side. The terminals of the thermocouples were connected to the digital temperature indicators to measure the temperature of the fin at the appropriate points. To regulate the heat on the chamber a Dimmer stat is used and can be monitored with the help of voltmeter and ammeter. The readings are noted only when the temperature is stabilized.

Fig1: Experimental setup of pin-fin apparatus

Fig. 2 Used pin fin materials

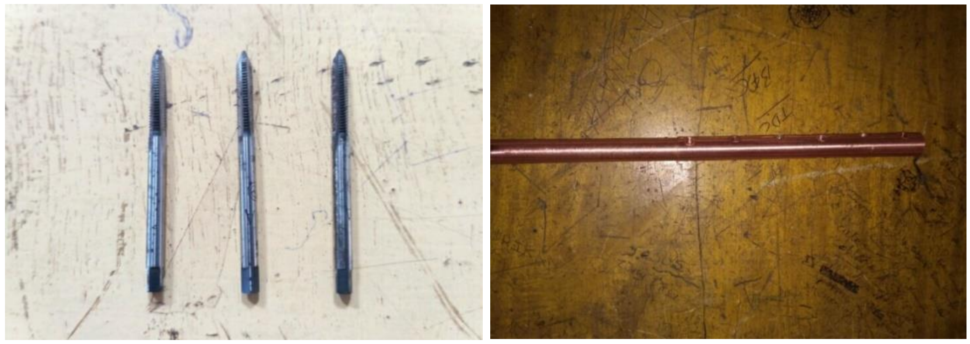

Fig. 3 Fabricated Threaded fins

3. MATLAB Programing:

MATLAB is a high-performance language for technical computing, visualizing, integrating and easy to solve the problems with representing in mathematical notations.
The Ambient temperature To =90;
The final temperature Tf=40;
Heat transfer coefficient h=Vary with the material;
The conductivity of material k= Vary with the material;
The Dia of the material d=0.0012;
The length of the material l=0.2125;
The perimeter p= π*d
The Area a= π*d^2/4

The boundary conditions are
At x=0; $\theta = \theta_0$, $\theta_0 = T_o - T_f$
At x= L, $\frac{d\theta}{dx} = 0$
The Temperature distribution along the fin given by,

$$\frac{\theta}{\theta 0} = \frac{\cosh m\,(L - x)}{coshmL}$$

Where m is calculated as

$$m = \sqrt{hp/kA}$$

At the End of the fin x=L such that

$\frac{\theta}{\theta 0} = \frac{1}{coshmL}$ From this θ will obtained.

In this investigation, we used different types of materials as fins such that the conductivity of material changes so finally the value of m changes with respect to the K. The temperature distribution along the fins changes and can be calculated with the help of mathematical equations as MATLAB program
Differential equation in case of fin is given by

$$\frac{d^2\,\theta}{d\,x^2} - m^2\,\theta = 0$$

For copper rod m value = 3.9807 m^{-1}, For Al 3003 rod m value = 5.4685 m^{-1}, For Al 1050rod m value = 6.4685 m^{-1}, For Al 6061rod m value = 6.053 m^{-1}, For Al 6082 rod m value = 5.704 m^{-1} and For brass rod m value = 6.704 m^{-1}.

Efficiency of the fin can be calculated as $\eta = Tanh\ \lfloor m(L-x)/mL \rfloor$
Effectiveness of the fin as € = $(Ts - Tf)\sqrt{hpkA}$ (tanh mL)/hA$(Ts - Tf)$
Reynolds Number Re= $(L*V_a*\rho_a)/\mu_a$

Where Va=velocity of air in the duct.
ρ_a = density of the air in the duct.
μ_a = viscosity of the air at t ^{0}C.

Prandltl Number $P_r = (C_{pa} \times \mu_a)/ K_a$

Nusselt Number (N_{nu})
For $40<R_e<4000$
$(N_{nu}) = 0.683(R_e) * 0.466(P_r)^{0.333}$
For $1<R_e<4$
$(N_{nu}) = 0.989(R_e)^{0.33} * (P_r)^{0.33}$
For $4<R_e<40$
$(N_{nu}) = 0.911(R_e)^{0.385} * (P_r)^{0.333}$
For $400<R_e<40000$
$(N_{nu}) = 0.913(R_e)^{0.618} * (P_r)^{0.333}$
For $R_e>40000$
$(N_{nu}) = 0.0266(R_e)^{0.805} * (P_r)^{0.333}$

From the experiment the thermal characteristics of tested materials are listed below

Table 1: Thermal Characteristics of tested materials

S No	Type of material	heat transfer coefficient (h) W/m^{2}K	Thermal conductivity (K) W/mK
1	Cu	18.357	386
2	Al 3003	18.323	205
3	Al 1050	17.573	141.2
4	Al 6061	17.592	160
5	Al 6082	17.57	180
6	Brass	14.33	109.0

These equations are helped to generate the program as

```
clc
clear all
close all
To=90;
Tf=40;
h=18.357;
k=386;
d=0.0012;
l=0.2125;
p=pi*d
a=pi*d*d/4
```

```
m=sqrt((h*p)/(k*a))
% copper design%

THETA=dsolve('D2THETA-
15.84*THETA=0','THETA(0)=50,DTHETA(0.2125)=0','x');
pretty(THETA)
ezplot(THETA,[0,0.2125])
hold on
% aluminium design (3303)%
h=18.323;
k=205;
THETA1=dsolve('D2THETA1-
29.90*THETA1=0','THETA1(0)=50,DTHETA1(0.2125)=0','x');
pretty(THETA1)
ezplot(THETA1,[0,0.2125])
hold on

% aluminium design (1050)%
h=17.5733;
k=141.2;

THETA2=dsolve('D2THETA2-
41.733*THETA2=0','THETA2(0)=50,DTHETA2(0.2125)=0','x');
pretty(THETA2)
ezplot(THETA2,[0,0.2125])
hold on
% aluminium design (6061)%
h=17.592;
k=160;
THETA3=dsolve('D2THETA3-
36.63*THETA3=0','THETA3(0)=50,DTHETA3(0.2125)=0','x');
pretty(THETA3)
ezplot(THETA3,[0,0.2125])
hold on
grid on
% aluminium design (6082)%
h=17.57;
k=180;
THETA4=dsolve('D2THETA4-
32.53*THETA4=0','THETA4(0)=50,DTHETA4(0.2125)=0','x');
pretty(THETA4)
ezplot(THETA4,[0,0.2125])
hold on
% Brass design%
h=14.33;
k=109;
```

```
THETA5=dsolve('D2THETA5-
44.89*THETA5=0','THETA5(0)=50,DTHETA5(0.2125)=0','x');
pretty(THETA5)
ezplot(THETA5,[0,0.2125])
hold on
grid on
legend ('COPPER', 'ALUMINIUM-3303','ALUMINIUM-
1050','ALUMINIUM-6061','ALUMINIUM-6082','BRASS');
```

4. Results And Discussions

This study was helped to identify the relation on fin efficiency and effectiveness under various tested materials. The results shows that, aluminium3303 has highest heat transfer rate and efficiency than the other Aluminium grades. The results were taken from the MATLAB and plotted on the graph as shown in fig 4.

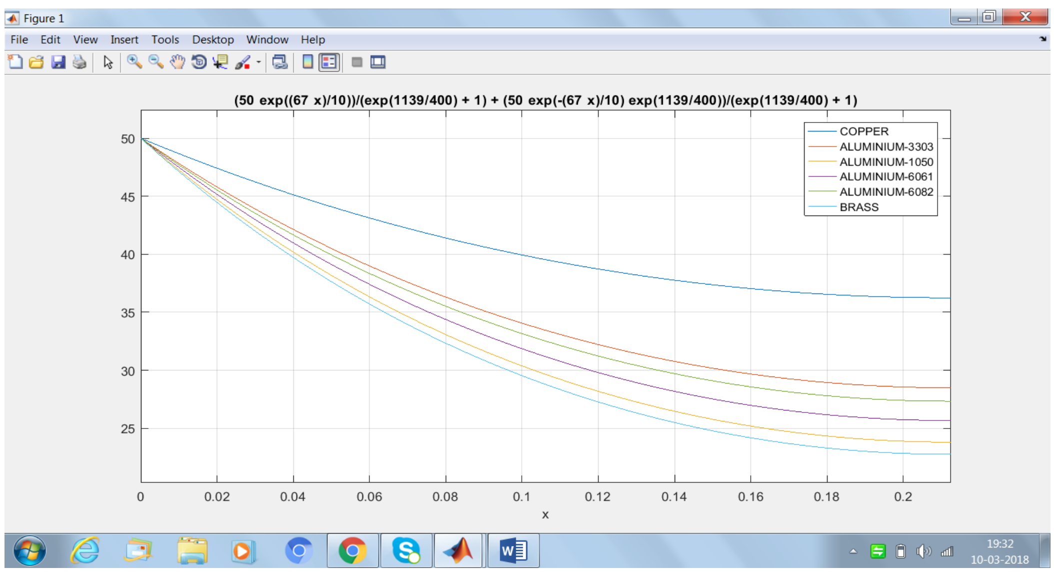

Fig4: Temperature Distribution along the Fin for tested materials

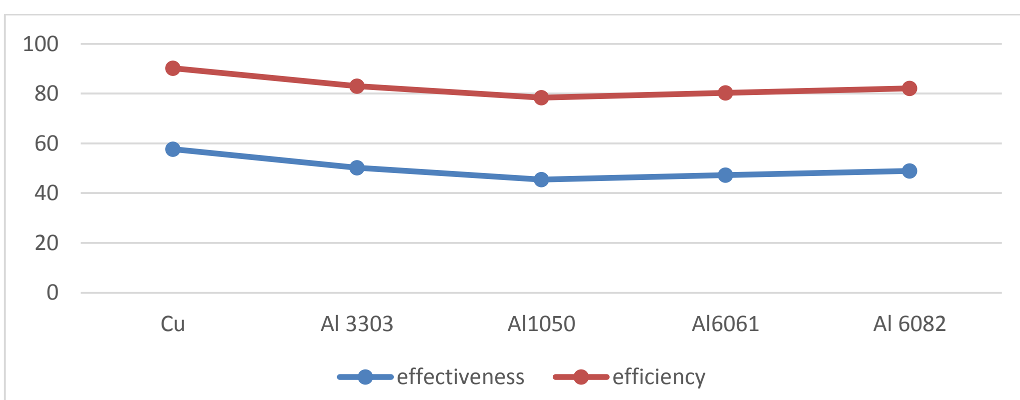

Fig5: Shows the Effectiveness and Efficiency of tested materials

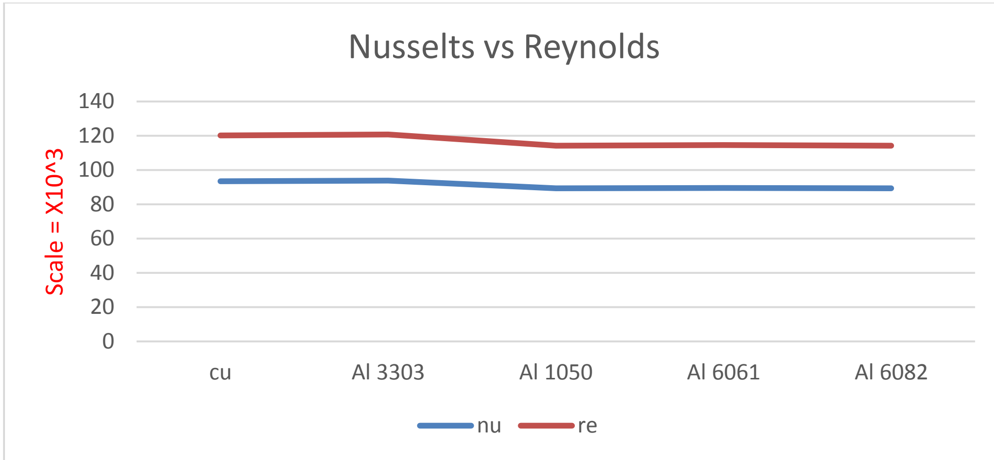

Fig6: Shows the Nusselt and Reynolds Number of tested materials.

5. Conclusion

The heat transfer rate, efficiency and effectiveness of the pin fin for different materials were studied. The deep analysis under temperature distribution along the length of six fin materials (Cu, Brass, Al 3003, Al 1050, Al 6061 and Al 6082) is studied. A mathematical approach for determination of heat transfer rate, efficiency and effectiveness is developed using MATLAB. The experimentation results show that copper having best values but due to its cost, limited for high functional applications. Aluminium3303 has better heat transfer rate, efficiency and effectiveness than the other Aluminium grades with low cost and its availability in industry.

References

Hani et.al, “Enhancement of air jet impingement Heat Transfer Using Pin-Fin Heat Sinks”, IEEE Transactions on Components and Packaging Technology, VOL. 23, No.2.

Pong, “A Comparison of Fin Geometries for Heat sinks in Laminar Forced Convection: Part I – Round, Elliptical, and Plate Fins in Staggered and In-line Configurations. The International Journal of Microcircuits and Electronic Packaging, Volume 24, Number 1, First Quarter, (ISSN 1063-1674).

Sara, “Second law analysis of rectangular channel with square pin-fins”, Int. comm…Heat and mass transfer Vol 28. No. 5.pp 617-630.

Sara, “Performance analysis of rectangular ducts with staggered square pin fins”, Energy Conversion and Management 44:1787-803.

Ali, “Convective heat transfer across a pin fin micro heat sink”, International Journal of Heat and Mass Transfer 48 3615-3627.S.

Sahiti et.al, “Heat transfer enhancement by pin elements”, International Journal of Heat and Mass Transfer 48 4738-4747.