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Thermal Analysis For Various Materials And Alloys

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ABSTRACT

In the present work comparative study of thermal analysis of a rectangular block (1x1x1unit³) is done by taking different material (i.e. Copper, Steel, Brass) for the conduction and convective boundary condition. Best material is selected under the boundary condition, by using FEM based software (ANSYS 11) . Temperature and thermal heat flux contours are plotted for different materials. The result is based on temperature, thermal heat flux variation in the material, contour of temperature distributions and heat flux.

keywords :- FEM, ANSYS11,Thermal behavior.

I.INTRODUCTION

The importance of thermal boundary layer in turbulent Rayleigh –Bernard convection is well documented . The heat flux through the fluid is limited by the thickness of the boundary layers, in which the vertical temperature difference is predominantly concentrated. In addition, eruption of hot and cold fluid from the boundary layers drives the turbulent flow and determines the temperature statistics in the central region of the flow. For these reasons, much can be learned about turbulent convection by studying the properties of the boundary layers[1]. The variations of the heat flux with the Rayleigh number Ra(the non dimensional vertical temperature difference) can be roughly predicted by assuming that the nusselt number Nu(the non dimension heat flux) varies as Ra^{β} with $\beta_3^{1/}$ is not in good agreement with many experiments and this fact has led to the suggestion that interactions of the boundary layer with the temperature or velocity field are significant[2]. Experiments showed that persistent larger –scale flows occur in turbulent thermal convection.

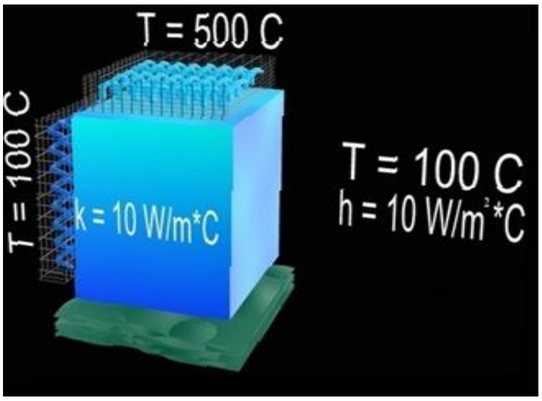


Fig 1: Initial Rectangular Block

These "winds" may play an important role in determining the heat flux, either by modifying the stability condition for δ_b or by adverting heat directly from the boundary layers. Predicted that shearing of the boundary layer by horizontal flows would increase the thickness δ_b at which the boundary layers become unstable, thereby decreasing the heat flux[3]. A somewhat different approach was taken; who predicted that δ_b is governed not by marginal stability, but by a balance between the diffusive heat flux into the boundary layers and the flux adverted from the boundary layer by turbulent flows[1]. Free convection heat transfer from a horizontal, upward facing heated 2-d element of finite size is one of the basic classic natural –convection problems, since it appears, as well as in natural circumstances. Starting from decades of 1990, a large body of research has been performed on this topic, for both condition of uniform wall temperature and uniform heat flux, as witnessed by the wide variety of heat transfer correlations may also differ by ± 50%, or more depending on the investigation method, the boundary conditions, and the occurrence of more or less pronounced three –dimensional edge effects[4].

With the main aim to highlight the conditions under which these correlating equations were obtained, and carry out a comparative survey of their results, so as to help the readers in applications.

In the present work , we have taken a rectangular block (1x1x1 unit^3) of three different materials i.e. copper, steel , brass. And then we analysis the thermal behavior of all the three materials, under the same boundary conditions shown in figure 1.

Boundary condition :

Left Side : 100 °C

Top Side (x-axis) : 500°C

Right Side : 100 °C

Bottom Side : Insulated

And finally compare the temperature distribution and thermal heat flux at the same point (along the length) for all three materials. Then concluded the best material.

II.MODELING AND SIMULATIONS

This section is divided in three parts, in all the three parts we have taken a rectangular box (X x Y=1*1 units) of a particular material. For the analysis of its thermal behavior (temperature distributions and thermal heat flux) along its length at different points(i.e. x= 0.25, 0.50, 0.75, 1.0) at the same boundary condition for all different material with the help of FEM ansys software[5].

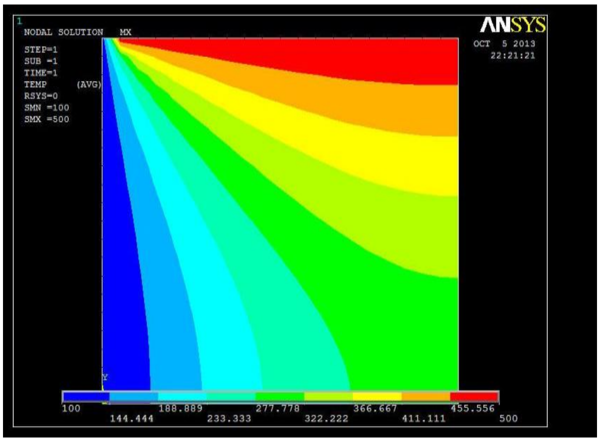
In first part we have taken copper as material and simulated it for different points along its length and noted its thermal behavior (temperature distribution and thermal heat flux) which is listed in table 1 and contours for (temperature and heat flux) is given in figure 2.

Table-1: Thermal behavior of copper.

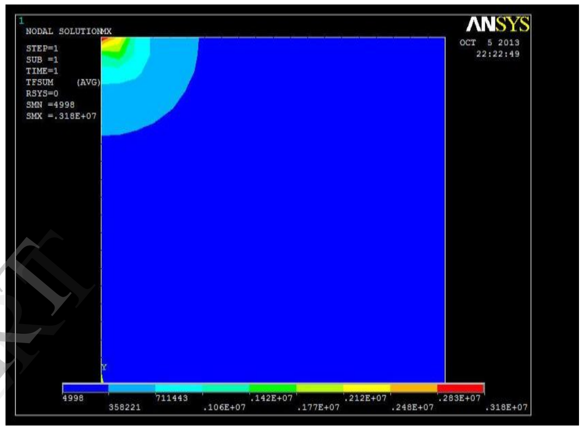
S.no.	X(along length)	Temperature distribution for copper in °k	Thermal heat flux for copper in w/m k
1	0.25	294.77	8883.2
2	0.50	321.18	61224
3	0.75	386.13	109380
4	1	481.73	142160

Table -2: Thermal behavior of Steel.

S.no.	X(along length)	Temperature distribution for steel in °k	Thermal heat flux for steel in w/m k
1	0.25	215.69	1591.5
2	0.50	241.64	3257
3	0.75	311.9	6205.9
4	1	452.16	14205



(a)

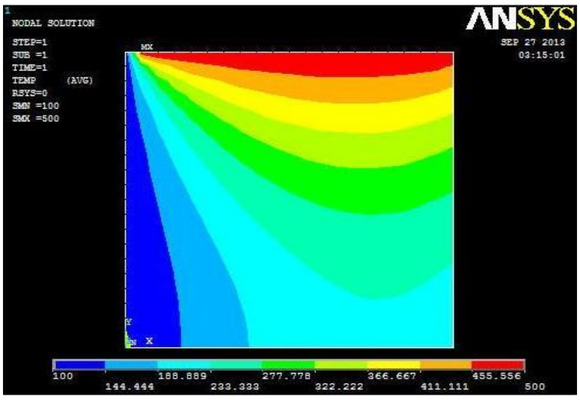


(b)

Fig 2: Contour plots for copper.

(a) Temperature distribution
(b) Thermal heat flux

Now in part second we have taken steel as material and simulated it for different points along its length and noted its thermal behavior (temperature distribution and thermal heat flux) which is listed in table 2. and contours for (temperature and heat flux) is given in figure 3.



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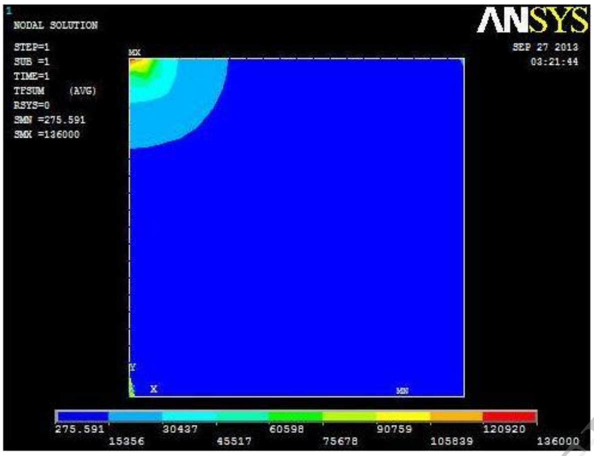


(b)

Fig 3: Contour plots for steel

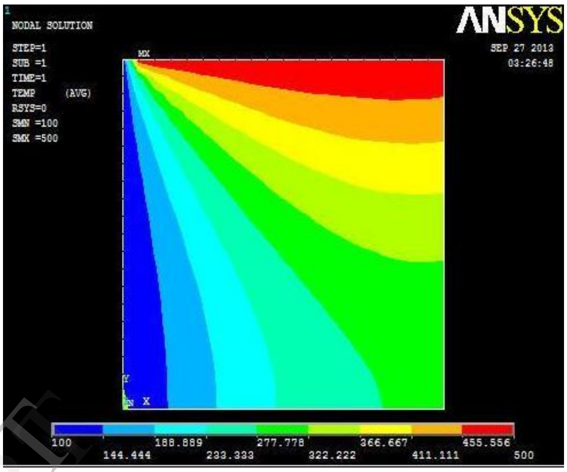
(a) Temperature distribution

(b) Thermal heat flux

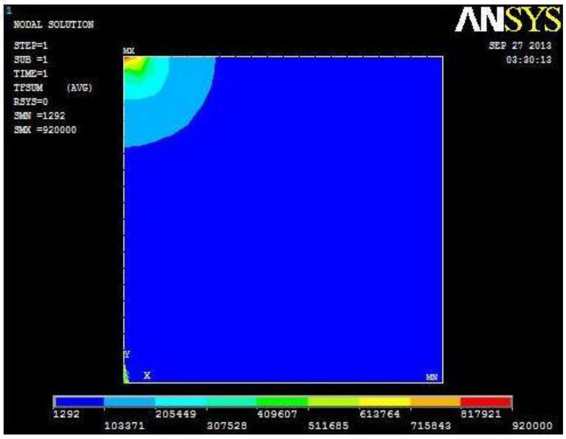
In the last section we have taken Brass as material and simulated it for different points along its length and and noted its thermal behavior (temperature distribution and thermal heat flux) which is listed in table 3. and contours for (temperature and heat flux) is given in figure 4.

Table -3: Thermal behavior of Brass.

S.no.	X(along length)	Temperature distribution for brass in °k	Thermal heat flux for brass in w/m k
1	0.25	282.08	2933.4
2	0.50	308.76	18026
3	0.75	375.27	32909
4	1	477.94	48036



(a)



(b)

Fig 4: Contour plots for Brass

(a) Temperature distribution

(b) Thermal heat flux

Further the comparative study of the materials analysis is given in next section.

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III. RESULTS AND DISCUSSIONS

Temperature Study:

As the temperature study of different material and its alloys (copper, steel, Brass)**,** we analysis the 2-d element(quad-4 nodes) having with different thermal conductivity as per taken the different material, having the same boundary condition of all material. Moreover for better clarification of the results we have also given the comparative table and graphs in table 4 and in fig 5 respectively. Then concluded the result of best material.

TABLE -5: Comparative Temperature Study in °K.

X-axis	COPPER	STEEL	BRASS
0.25	294.77	215.69	282.08
0.50	321.18	241.64	308.76
0.75	386.13	311.9	375.27
1	481.73	452.16	477.94

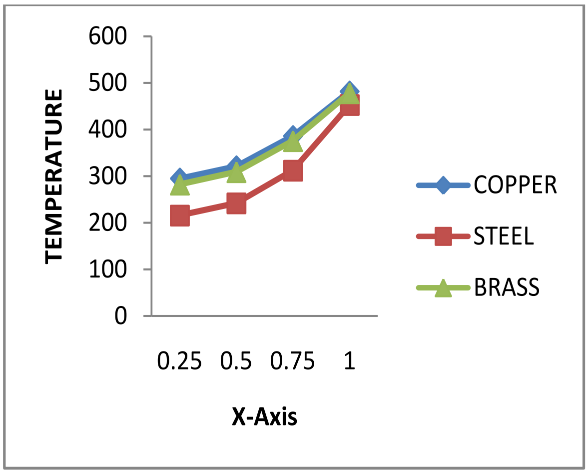

Fig 5): Plot For Comparative Temperature Study.

Thermal Heat Flux : As the thermal heat flux study of different material and its alloys (Copper, Steel, Brass) we analyse the 2-d element(rectangular having with different thermal conductivity as per taken the different material, having the same boundary condition of all material, Moreover for better clarification of the results we have also given the comparative table and graphs in table 5 and in fig 6 respectively. Then concluded the result of best material.

Table 6: Comparative Study Of Thermal Heat Flux.

X-axis	COPPER	STEEL	BRASS
0.25	8883.2	1591.5	2933.4
0.5	61224	3257	18026
0.75	109380	6205.9	32909
1	142160	14205	48036

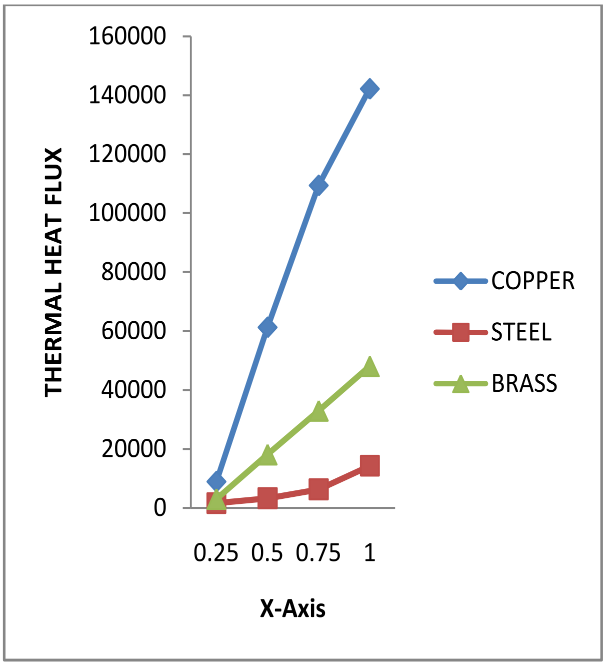

Fig 6: Thermal heat flux vs. x-axis

IV.CONCLUSION

A numerical and computationally study of different Material elements are discussed i.e. copper, steel and Brass are used as working material. From the above result, accurate values of temperature with respect to the varying X-axis are obtained. After comparing Temperature, Heat transfer coefficient analysis, it is observe that heat flow rate in copper is more as compared to other metal and alloys. Principle of separable variables is applied to the heat conduction in a 2-d element (quad-4nodes) that can be used to identify the temperature distribution and heat transfer rate. The temperature distribution falls monotonically along the coordinate x for all various surfaces. For larger the value of thermal conductivity and heat transfer coefficient ,at low temperature with respect to time, the more heat convection on lateral surface and the more thermal energy is efficiently transferred into environment through the surface, also result in heat transfer rate reaches time invariant early. Thus copper metal is more applicable for applications like fins[6], Heat exchanger [7].

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