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Thermal Analysis to Determine Temperature Distribution and Heat Flow Using Ansys by Computational Fluid Dynamics Method

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ABSTRACT

The present work aims at using the computational fluid dynamics as a tool with the help of ANSYS software for determining the temperature distribution and heat flow at different nodes in the rectangular slab and net heat flux subjected to boundary condition. The behavior of composite wall under thermal loading, it is required to predict the accurate temperature distribution within the wall. These composite wall structure which can be implemented to many applications such as thermal ventilations, insulators, metallic multiwall thermal protection systems, etc. In this study we are going to analyze the thermal behavior of composite wall. For finding heat flux and heat flow rate the finite element difference ANSYS is used.

Keywords: Computational fluid dynamics, Thermal conductivity, Composite wall, Heat flux, Finite element difference, Heat Flow Rate.

1. INTRODUCTION

Nowadays, due to the advent of computational fluid dynamics as a tool to analyze fluid flow and thermal temperature distribution can be done more conveniently when compared to conventional methods of conducting experiments. Now in this paper we have attempted to analyze the temperature distribution in a composite wall which finds the necessity in various applications such as thermal ventilations, insulators, metallic multiwall thermal protection systems, etc.

Composite wall- A composite wall is a unidirectional arrangement of slabs of materials with different thermal properties (primarily thermal conductivity). Such arrangements are used mostly in labs to substantiate conductive laws for 1D heat transfer. Their practical application could be in furnaces with masonry structure, etc.

Heat transfer- Heat is a form of energy in transit due to temperature difference. Heat transfer is transmission of energy from one region to another region as a result of temperature difference between them. Whenever there is temperature difference in mediums or within a media, heat transfer must occur. The amount of heat transferred per unit time is called heat transfer rate and is denoted by Q. The heat transfer rate has unit J/s which is equivalent to Watt. When the rate of heat transfer Q is available, then total amount of heat energy transferred ΔU during a time interval Δt can be obtained from $\Delta U = Qdt = \int Q\mathrm{d}t$ (Joule). The rate of heat transfer per unit area normal to the direction of heat flow is called heat flux and is expressed as q= QA

Steady and unsteady state heat transfer- For analysis of heat transfer problems, two types of heat transfer are considered-steady state and unsteady state. In case of steady state heat transfer, the temperature at any location on the system does not vary with time. The temperature is a function of space coordinates only, but it is independent of time mathematically, for rectangular coordinate system; $T = f\ (x,\ y,\ z)$. During steady state conditions, the heat transfer rate is constant and there is no change of internal energy of the system. For example, the heat transfer in coolers, heat exchangers, heat transfer from large furnaces etc.

Conduction rate equation- Conduction is the heat transfer from one end to the other end, it is important for calculating about the heat transfer rate. This can be expressed as

$Q = -KA\ dT/\ dx$

Where

Q is heat transfer rate,

W A is cross-sectional area,

m^2K is the thermal conductivity of the material
W/m k dT/dx is the temperature gradient

2. GOVERNING EQUATIONS AND NUMERICAL PROCEDURE

2.1Continuity equation

Physical principle: Law of conservation of mass.

$$\frac{\partial}{\partial t}\iiint_{\upsilon}\rho \, d\upsilon + \iint_{S}\rho \, VdS = 0 \ldots\ldots \quad (1)$$

$$\frac{D}{Dt}\iiint_{\upsilon}\rho \, d\upsilon = 0 \ldots\ldots \quad (2)$$

ρ - density, v-volume, S – surface area

Momentum equation

$$\rho\frac{Du}{Dt} = -\frac{\partial p}{\partial x +}\frac{\partial \tau_{xx}}{\partial x} + \frac{\partial \tau_{yx}}{\partial y} + \frac{\partial \tau_{zx}}{\partial z} + \rho f_x \ldots\ldots \quad (4)$$

$$\rho\frac{Dv}{Dt} = -\frac{\partial p}{\partial y +}\frac{\partial \tau_{xy}}{\partial x} + \frac{\partial \tau_{yy}}{\partial y} + \frac{\partial \tau_{zy}}{\partial z} + \rho f_y \ldots\ldots \quad (5)$$

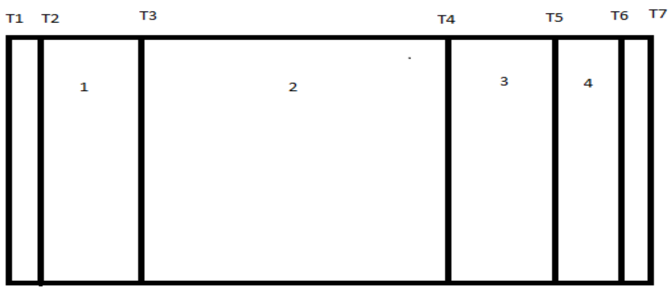
u,v- components of velocity, τ_{xy} -viscous stress , ρf_x -body force, p –pressure

2.2 GENERAL HEAT EQUATION

$$\frac{\partial}{\partial x}\left(k\frac{\partial T}{\partial x}\right) + \frac{\partial}{\partial y}\left(k\frac{\partial T}{\partial y}\right) + \frac{\partial}{\partial z}\left(k\frac{\partial T}{\partial z}\right) + \dot{q} = \rho \cdot c_p \frac{\partial T}{\partial t}$$

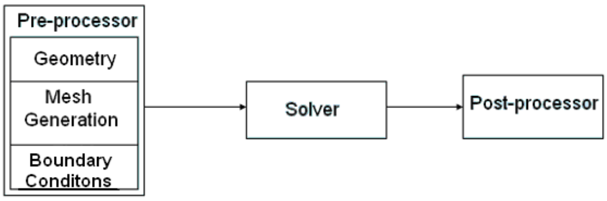
3. PROBLEM DEFINITION

A composite wall slab consisting of four conducting material of thermal conductivity 1} 0.176 (W/m °C) 2} 0.036 (W/m °C) 3} 0.115 (W/m °C) 4} 0.215 (W/m °C) of length 12mm, 75mm, 20mm and 20mm. This wall is subjected to differential temperatures of air having convective heat transfer coefficient of 6(W/m^2 k) and 10(W/m^2k) of length 1mm each subjected to thermal loading of 20°C and -10°C at both the ends.



4. METHODOLOGY ADOPTED

The general methodology that has been adopted to solve the problem is:



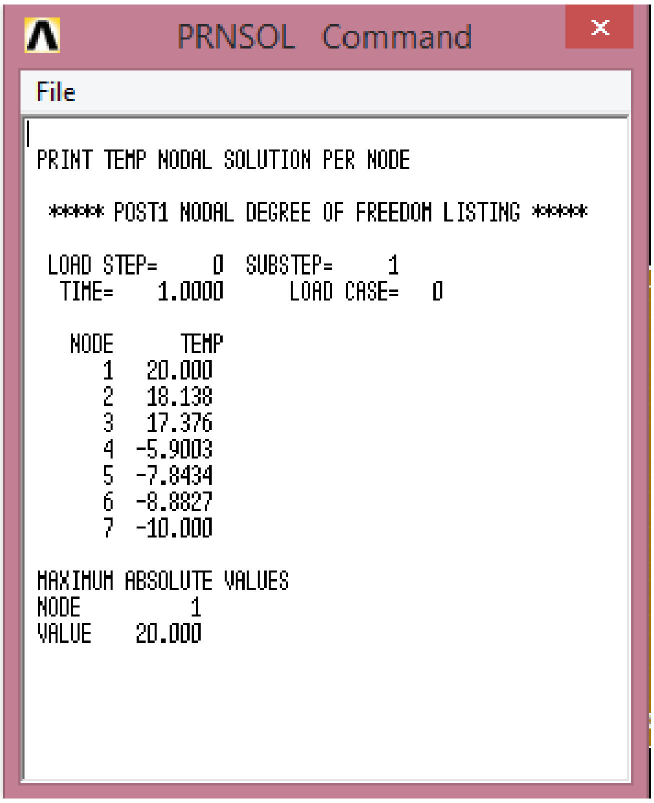
5. SOLUTION

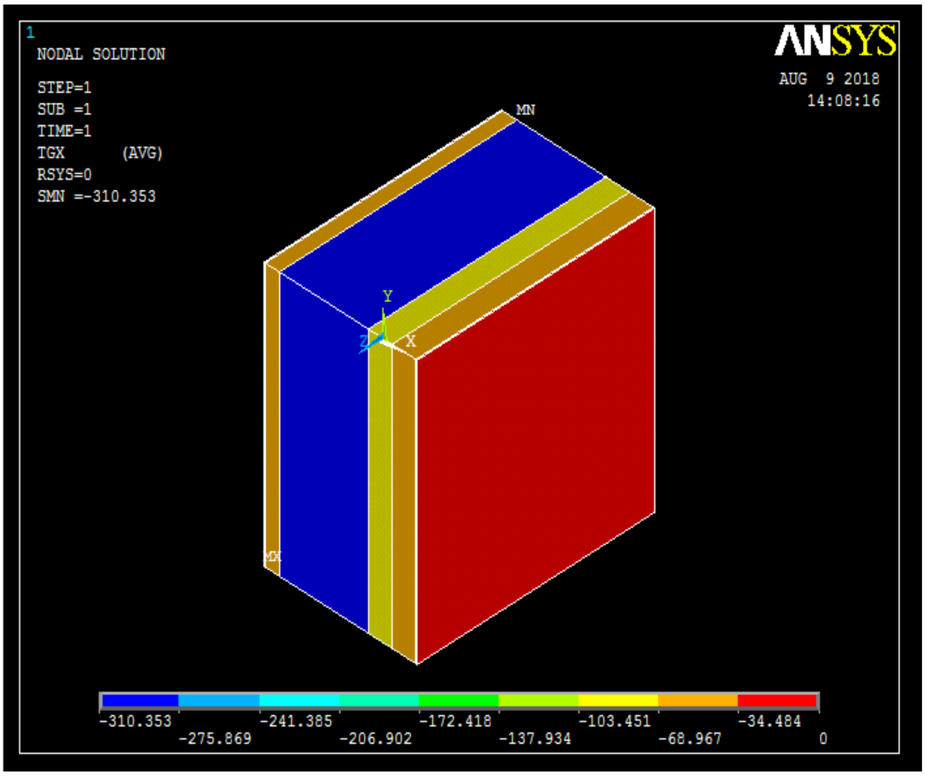
Using ansys software the nodal solution optained for the give composite wall is as shown below

NODE	TEMP(°C)
1	20
2	18.138
3	17.376
4	-5.9003
5	-7.8434
6	-8.8827
7	-10

The net heat flux is 11.173 watt per meter square.

6. RESULT





7. CONCLUSION

After obtaining the nodal solution and the contour plot of the given problem we may conclude that by using ANSYS (computational fluid dynamics method) the nodal temperature and the net heat flux through the composite wall can be determined conveniently over the old conventional methods.

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