Finite Element Analysis of Conduction in A Solid Slab With Different Heating Intensity

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Abstract - In this research work the analysis of the pattern of heat flow in a heat conducting solid steel slab is carried out by using the finite element Analysis (FEA) technique. To develop FE model for pre- processing of heat conducting slab, Hypermesh software is used and Radioss bulk data as an implicit solver to solve the conduction equations. The theoretical formation has been taken by Fourier equation of heat conduction and same phenomenon has been adopted in FE model. The Hexa Hedral Element formation has been used for the formation of the conducting slab. The linear first order equation has been used for the formation of diffusion equation. The results of the study are presented in the Hyperview which is post processing solver in which temperature gradient has been observed at every nodal point of the element. This is made conceivable on the use of initial values and boundary conditions that foresee totally the time histories of temperature distribution over the isotherms overlaid through the thickness of the slab.

Key words: Finite Element Method (FEM), Hypermesh, Radioss (bulk data), Hyperview, Heat Conduction.

I. INTRODUCTION OF HEAT TRANSFER

Heat transfer is the exchange of heat due to a temperature difference with distinctive mechanisms: conduction, convection, and radiation. Conduction means heat transfer that occurs across a static solid or fluid in which a temperature gradient exists. Convection refers to the heat exchange that occurs across a dynamic fluid in which a temperature gradient exists. Radiation means to the heat transfer between two surfaces at different temperatures separated by a medium transparent to the electromagnetic waves emitted by the surfaces.

II. HEAT TRANSFER MODES:

Heat transfer modes are of three types: conduction, convection and radiation.

Conduction: This is the transfer of heat from one part of substance to another part of same substance, or from one substance to another is physical contact with it, without appreciable displacement of molecules forming the substance. In solid, the heat is conducted by lattice vibration and transport of free electrons.In case of gases, the mechanism of heat conduction is simple. The kinetic energy of amolecule is a function of temperature. These molecules are in a continuous randommotion exchanging energy and momentum.

In case of liquid, the mechanism of heat is nearer to that gas. However, the molecules aremore closely spaced and intermolecular force comes in to play.In conduction process,Fourier’s law of heat conduction is an empirical law based on observation andstates as, “the rate of flow through a simple homogeneous solid directly proportional to the area of the section at right angles to the direction of heat flow, and to change of temperature with respect to the length of the path of the heat flow”.

Convection: It is the transfer of heat within a fluid by mixing of one portion of fluid with another. Convection can be either forced through for example pushing the flow along the surface or natural/free as that which happens due to buoyancy forces. Natural convection (or free convection):In this the fluid movement iscreated by the warmfluid itself. The density of fluid decrease as it is heated. Thus, hot fluids are lighter than cool fluids. Warm fluid surrounding a hot objects rises and isreplaced by cooler fluid.Forced convection: It uses external means of producing fluid movement. Forced convection is what makes a windy, winter day feel much colder than a calm day with same temperature. The heat loss from your body is increased due to the constant replenishment of cold air by the wind. Natural wind and fans are the two most common sources of forced convection.

Radiation: Occurs where heat energy is transferred by electromagnetic phenomenon, ofwhich the light is a particularly important source. It happens between surfaces at differenttemperature even if there is no medium between them as long as they face each other.

III. RESULTS AND DISCUSSION

Heat input of different intensity are provided to the conducting heat flux for measuring the maximum and minimum temperature generated in slab. 9 iterations were performed to calculate maximum and minimum temperature of the slab. Starting with 100 kW to end up with 500 kW, we have performed the iterations.

(i) The figure3.1 showing the results of maximum temperature and minimum temperature at 100 kW heat flux.

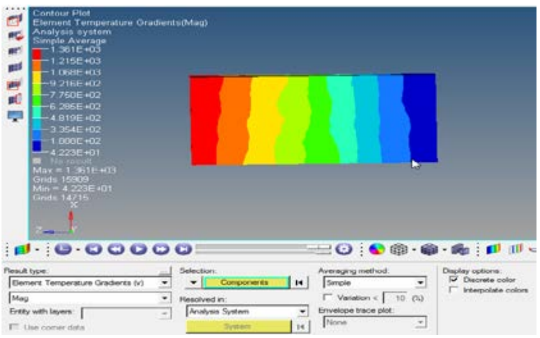


Figure3.1: Hyperview panel for post processing

The area which is in red color shows the maximum temperature and the rest of the area which is shown in blue color shows the minimum temperature. Hence Maximum temperature in a steel slab when we have applied the heat of 100 kW is 1361 ^{0}C and the minimum temperature is 42 ^{0}C.

(ii) The figure3.2 showing the results of maximum temperature and minimum temperature at 150 kW heat flux

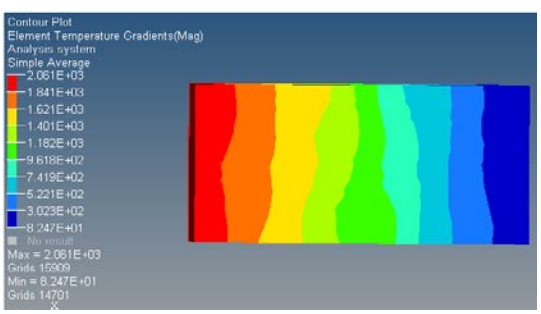


Figure3.2: Contour plot of conduction slab at 150 kW

When 150 kW heat is applied then maximum temperature is 2061 ^{0}Cand minimum temperature is 82 ^{0}C.

(iii) The figure3.3 showing the results of maximum temperature and minimum temperature at 200 kW heat flux.

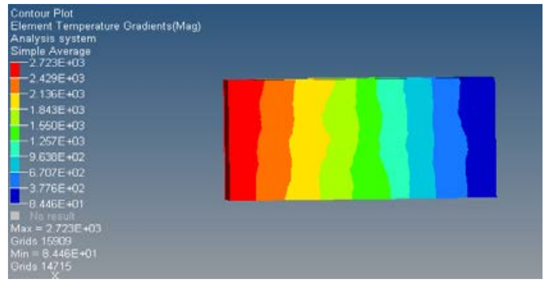


Figure3.3: Contour plot of conduction slab at 200 kW

When 200 KW heat is applied then maximum temperature is 2720 ^{0}Cand minimum temperature is 84 ^{0}C.

(iv) The figure3.4 showing the results of maximum temperature and minimum temperature at 250 kW heat flux

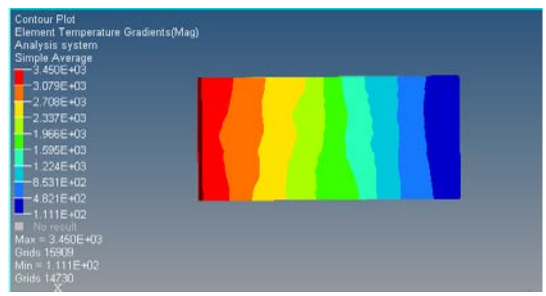


Figure3.4: Contour plot of conduction slab at 250 kW

When 250 kW heat is applied then maximum temperature is 3450 ^{0}Cand minimum temperature is 111 ^{0}C.

(v) The figure3.5 showing the results of maximum temperature and minimum temperature at 300 kW heat flux.

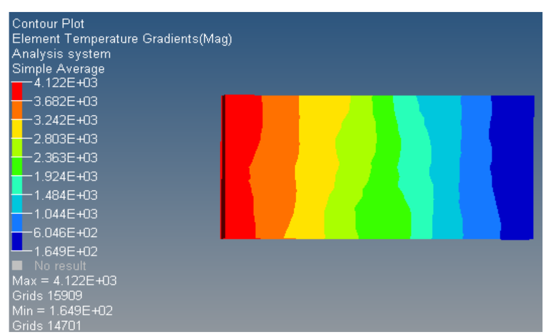


Figure3.5: Contour plot of conduction slab at 300 kW

When 300 KW heat is applied then maximum temperature is 4122 ^{0}Cand minimum temperature is 164 ^{0}C.

(vi) The figure3.6 showing the results of maximum temperature and minimum temperature at 350 kW heat flux.

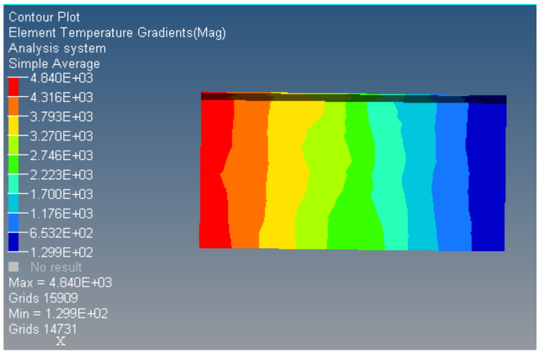


Figure3.6: Contour plot of conduction slab at 350 kW

When 350 kW heat is applied then maximum temperature is 4840^0Cand minimum temperature is 129 ^{0}C

(vii) The figure3.7 showing the results of maximum temperature and minimum temperature at 400 kW heat flux.

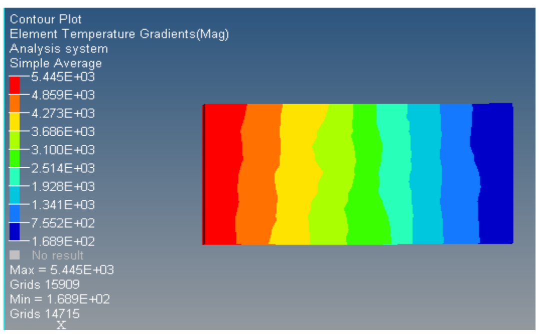


Figure3.7: Contour plot of conduction slab at 400 kW

When 400 kW heat is applied then maximum temperature is 5445 ^{0}Cand minimum temperature is 168 ^{0}C.

(viii) The figure3.8 showing the results of maximum temperature and minimum temperature at 450 kW heat flux

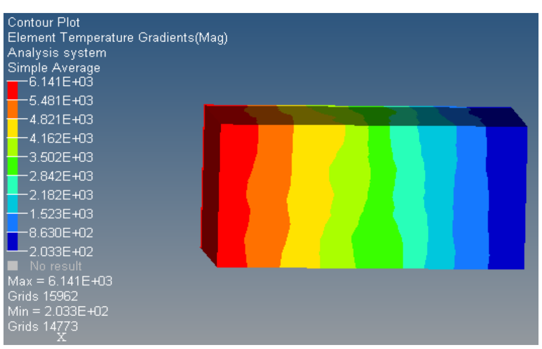


Figure3.8: Contour plot of conduction slab at 450 kW

When 450 kW heat is applied then maximum temperature is 6141 ^{0}Cand minimum temperature is 203 ^{0}C.

(ix) The figure3.9 showing the results of maximum temperature and minimum temperature at 500 kW heat flux.

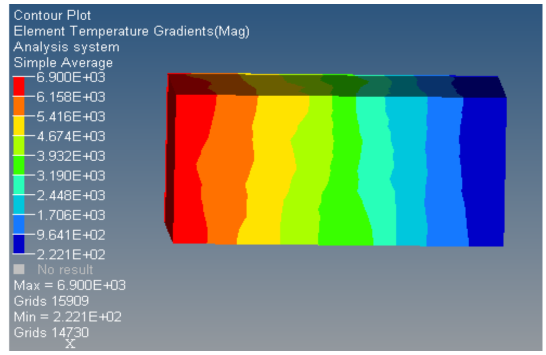
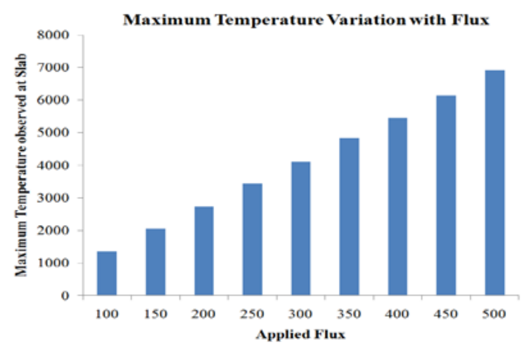


Figure3.5: Contour plot of conduction slab at 500 kW

When 500 kW heat is applied then maximum temperature is 6900 ^{0}C and minimum temperature is 222 ^{0}C



Result Graph

Result Graph:

Line shows the amounts of heat given to the heat flux, and at given different heat load the maximum temperature and minimum temperature variation in slab. The load between 100 to 500 kw and temperature variation between 0 to 8000 ^{0}C.

IV CONCLUSION

In this research work solid slab (Dimensions 200*100*100) of steel AISI1018 or steel AISI material for heat conduction is taken which is used in heat-exchanger. I have analyzed the heat flow pattern in a steel conduction plate. I have performed 9 iterations with different heat source and measured corresponding temperature at different element zone. On the basis of analysis we can assure that if we will use this kind of conduction slab in heat exchanger it can withstand up to given this temperature range.

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