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IMPROVING CLASSICAL LUMPED MODEL FOR TRANSIENT HEAT CONDUCTION IN SLAB USING HERMITE APPROXIMATION

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ABSTRACT

The present work aims at applying the ideas on the analysis of improved lumped-parameter model for transient heat conduction in a slab with temperature-dependent thermal conductivity. The transient temperature is found to depend on various model parameters, namely, Biot number, heat source parameter and time. Polynomial Approximation Method (PAM) has been possible to derive a unified relation for the transient thermal behaviour of solid (slab and tube) with both internal generation and boundary heat flux. In all the cases, a closed form solution is obtained between temperature, Biot number, heat source parameter and time. An improved lumped parameter model has been adopted through two point Hermite approximations for integrals. For linearly temperature-dependent thermal conductivity, it is shown by comparison with numerical solution of the original distributed parameter model that the higher order lumped model (H1,1/H0,0 Approximations) yields significant improvement of average temperature prediction over the classical lumped model. A unified Biot number limit depending on a single dimensionless parameter is given both for cooling and heating processes. The result of the present analysis has been compared with earlier numerical and analytical results. A good agreement has been obtained between the present prediction and the available results.

KEYWORDS: Hermite approximations, PAM, Temperature-dependent thermal conductivity, lumped model, Nonlinear heat Conduction, Transient heat conduction, Biot number.

INTRODUCTION

Heat goes from a higher temperature zone to lower temperature zone. Hot articles in a cooler room will be cooled to the room temperature. Colder items in a hotter room will heat up to room temperature. Heat exchange is the trading of heat because of a temperature contrast with particular systems: conduction, convection, and radiation. Conduction means heat exchange that happens over a static solid or liquid in which a temperature gradient exists. Convection refers to the heat trade that happens over a dynamic liquid in which a temperature slope exists. Radiation intends to the heat exchange between two surfaces at diverse temperatures isolated by a medium straightforward to the electromagnetic waves discharged by the surfaces

OBJECTIVES OF WORK

Conduction of heat through slabs and walls, originally a topic of physics, has become an area of interest in building services. The reason behind such a trend is the fast development of computer technology which allows large scale problems to be solved with small computers.

Today, architects, engineers, and technicians control total buildings with software. A variety of systems and programs is available for design, maintenance, and control of buildings. Many of them have been implemented to deal with dynamical thermal behaviour of buildings and their structures. Present work deals with the analytical solution of unsteady state one-dimensional heat conduction problems using a software toll Hypermesh. Many researchers have worked on studying the heat conduction problems on different shaped geometries. But a very few work has been done on analysis of heat conduction on different materials. In the present work an attempt has been made to analyze and compare to find the best suitable material for heat conduction through the slabs. Steel

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and Copper have been selected for the present study due to their easy availability and frequent use in similar problems.

METHODOLOGY

FEA utilizes a complex system of points called nodes which make a grid called a mesh. This mesh is programmed to contain the material and basic properties which characterize how the structure will respond to certain loading conditions. Nodes are allocated at a certain density all through the material relying upon the foreseen stress levels of a specific region. Areas which will get a lot of stress typically have a higher node density than those which encounter practically zero stress. Purposes of interest may comprise of: crack purpose of already tested material, filets, corners, complex subtle element, and high stress area. The mesh acts like a spider web in that from every node, there extends a mesh element to each of the adjoining nodes. This web of vectors is the thing that conveys the material properties to the object, making many elements.

An extensive variety of target capacities (variables inside of the framework) are accessible for minimization or maximization:

- Mass, volume, temperature
- Strain energy, stress strain
- Force, displacement, velocity, acceleration
- Synthetic (User defined)

  There are various loading conditions which may be applied to a framework.
- Point, pressure, thermal, gravity, and centrifugal static loads
- Thermal loads from solution of heat transfer analysis
- Enforced displacements
- Heat flux and convection
- Point, pressure and gravity dynamic loads

Each FEA program may come with an element library, or one is developed after some time.Some specimen components are:

- Rod components, Beam components
  - Plate/Shell/Composite components
  - Shear panel
  - Solid components
  - Spring components, Mass components
  - Rigid components, Viscous damping components

Numerous FEA programs likewise are outfitted with the ability to utilize various materials inside of the structure, for example,

- Isotropic, indistinguishable all through
- Orthotropic, indistinguishable at 90 degrees
- General anisotropic, different throughout

RESULT

Heat input of different intensity is provided to the conducting heat flux for measuring the maximum and minimum temperature generated in slab. Eight iterations were performed to calculate maximum and minimum temperature of the slab. Starting with 150 kW to end up with 500 kW,

(i) The figure showing the results of maximum temperature and minimum temperature at 150 kW heat flux for steel (a) and for copper (b).

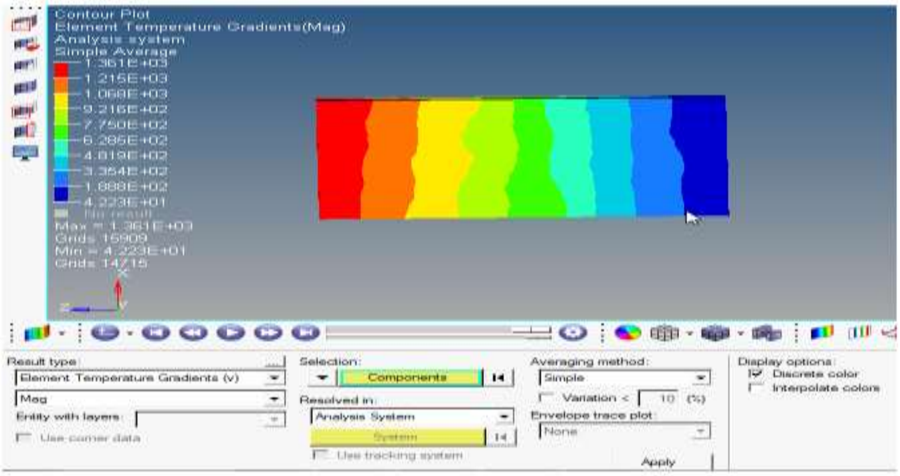

Figure: 1

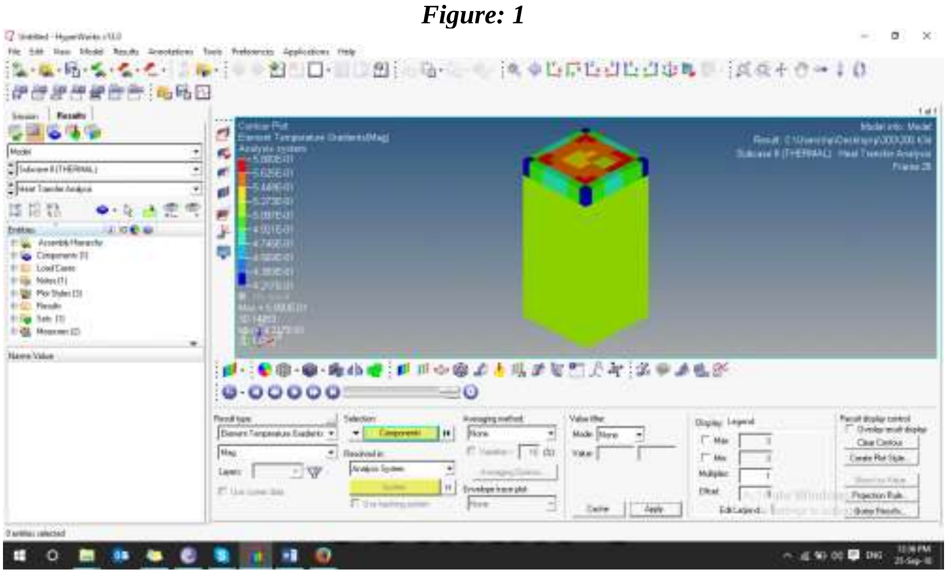

Figure: 2

(ii) The figure showing the results of maximum temperature and minimum temperature at 200 kW heat flux.

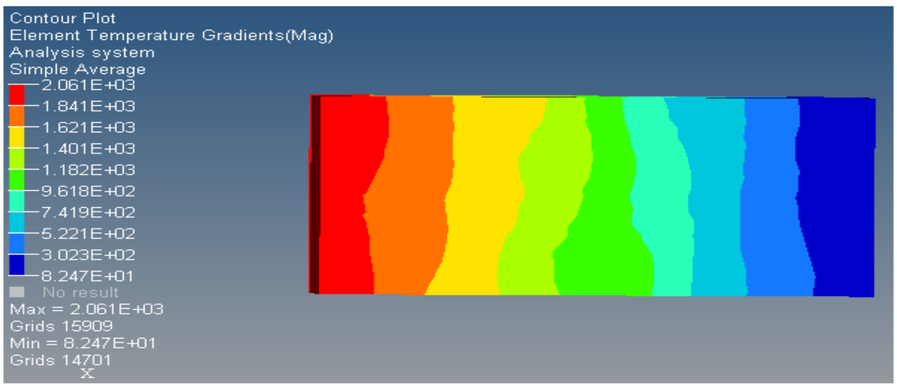

Figure: 3

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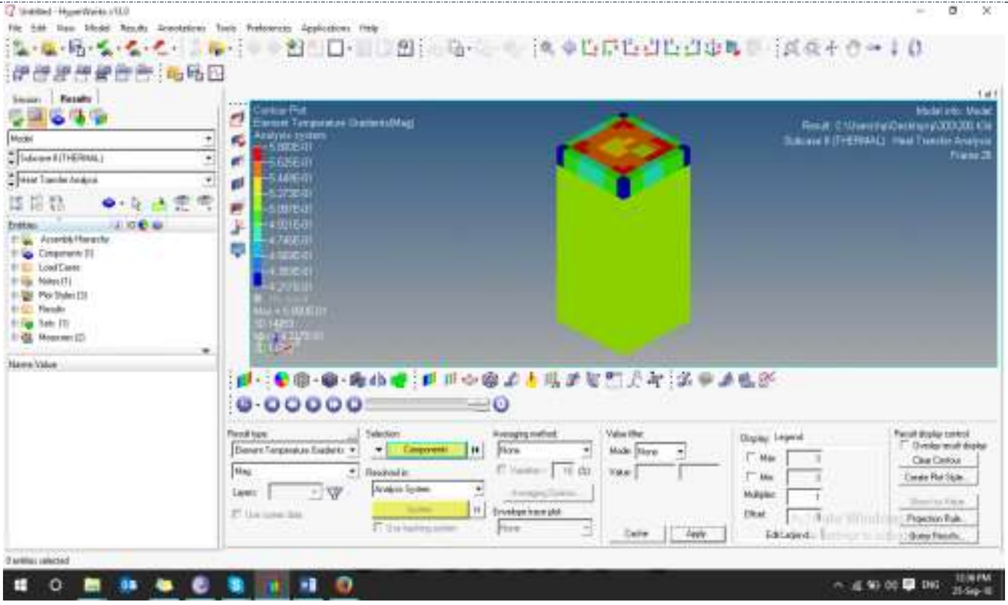

Figure: 4

(iii) The figure showing the results of maximum temperature and minimum temperature a 250 kW heat flux.

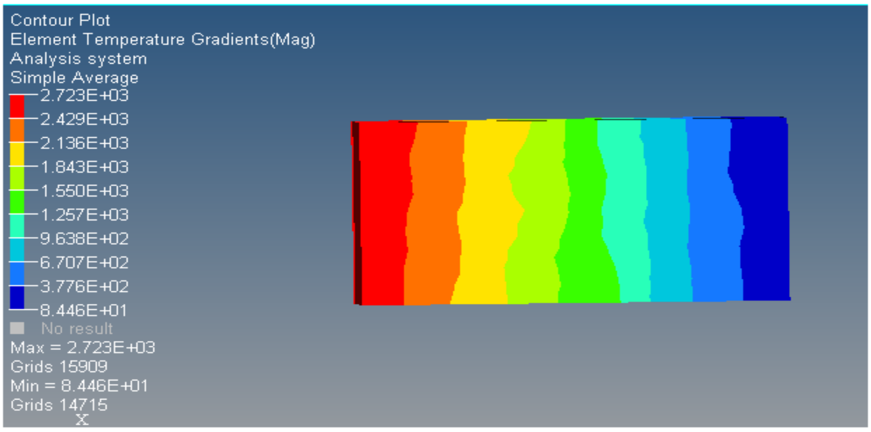

Figure: 5

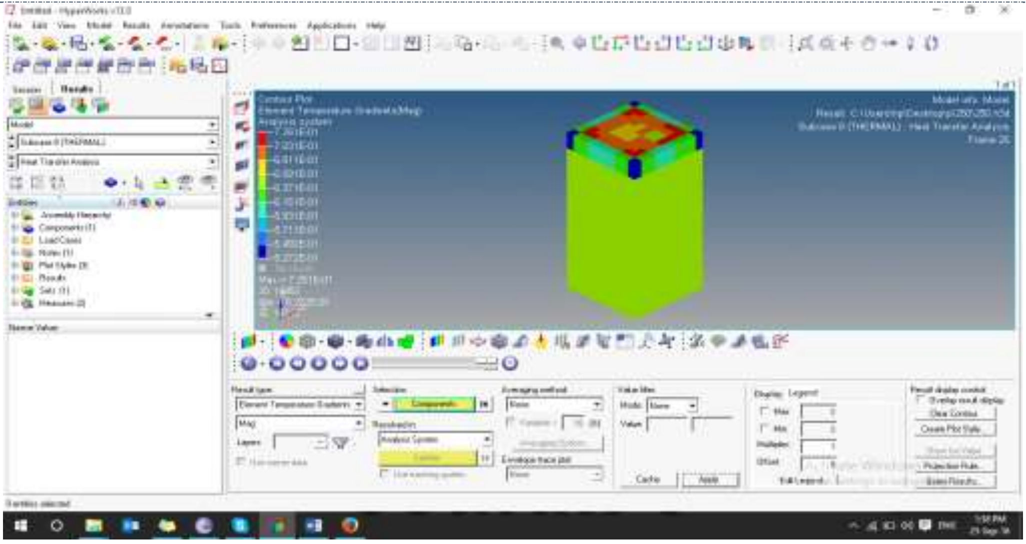

Figure: 6

(iv) The figure showing the results of maximum temperature and minimum temperature at 300 kW heat flux

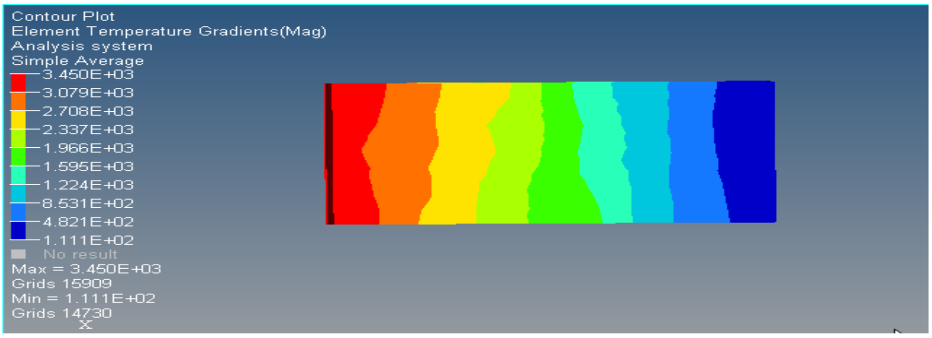

Figure: 7

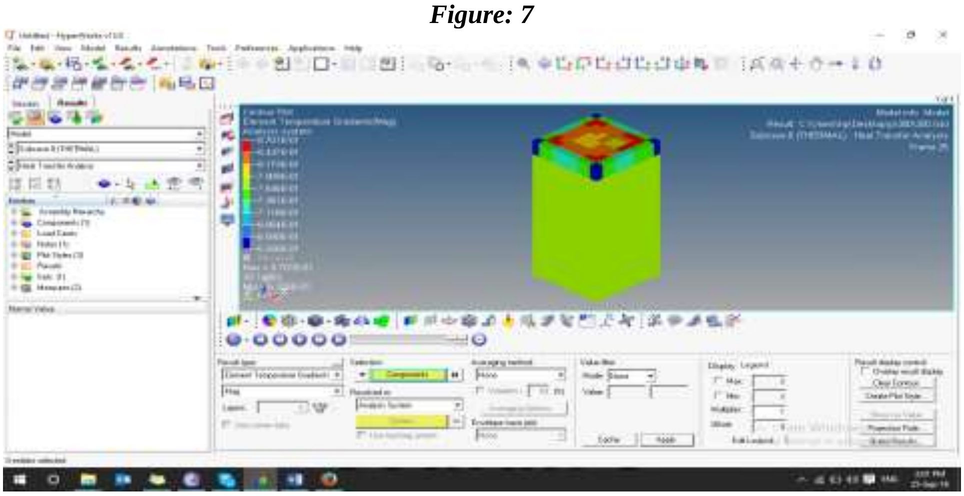

Figure: 8

(v) The figure showing the results of maximum temperature and minimum temperature at 350 kW heat flux.

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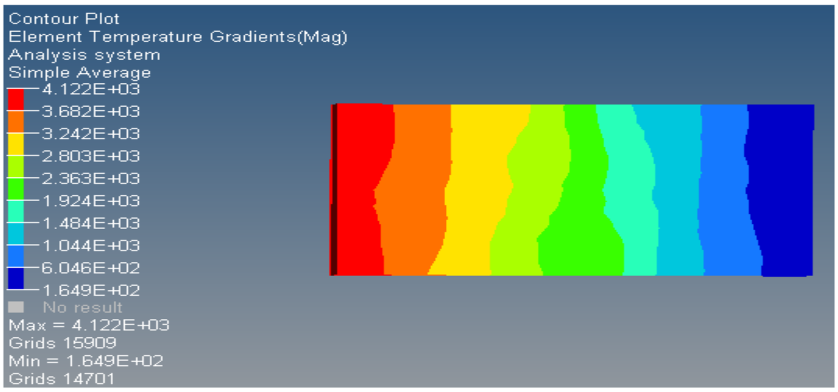

Figure: 9

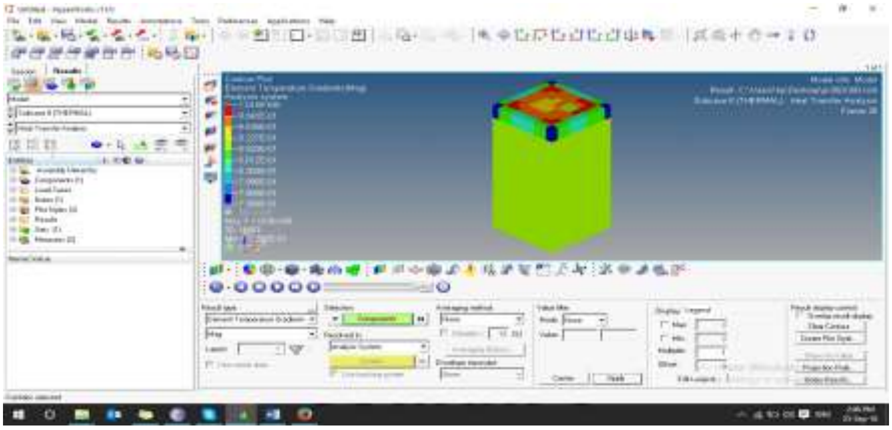

Figure: 10

(vi) The figure showing the results of maximum temperature and minimum temperature at 400 kW heat flux.

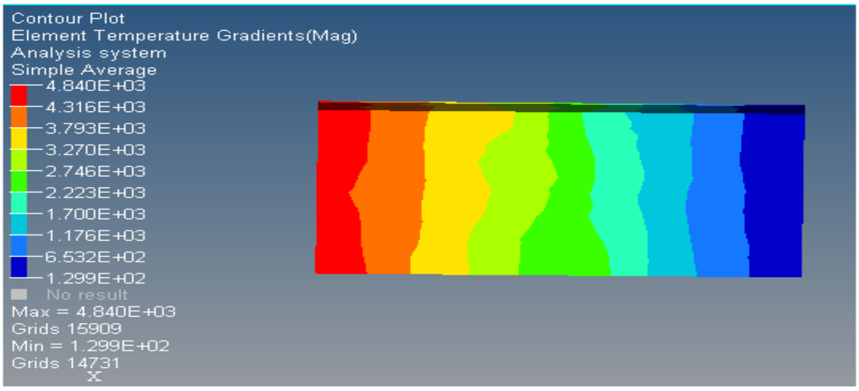

Figure: 11

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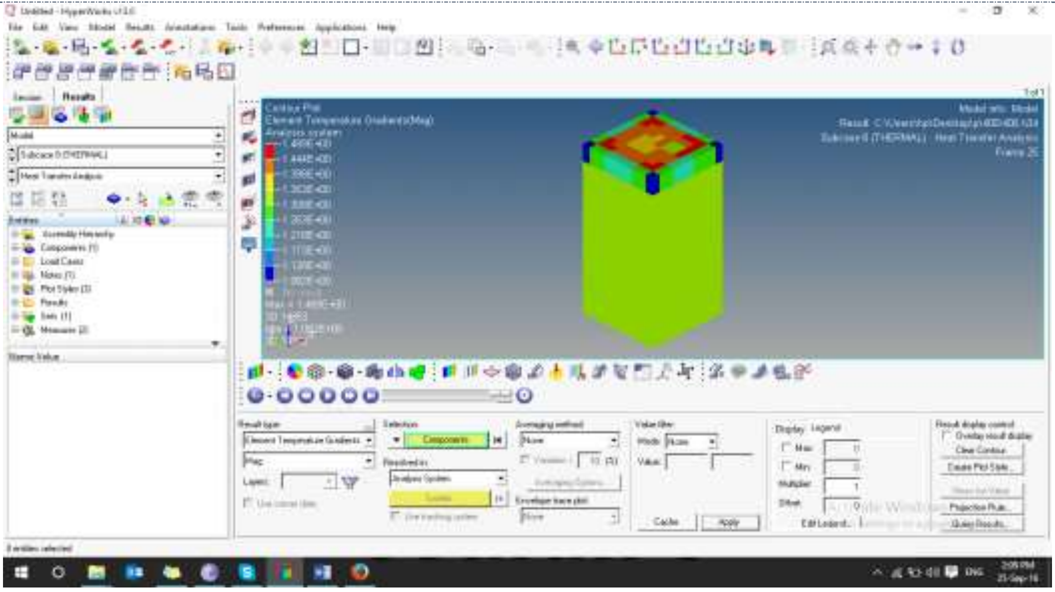

Figure: 12

(vii) The figure showing the results of maximum temperature and minimum temperature at 450 kW heat flux.

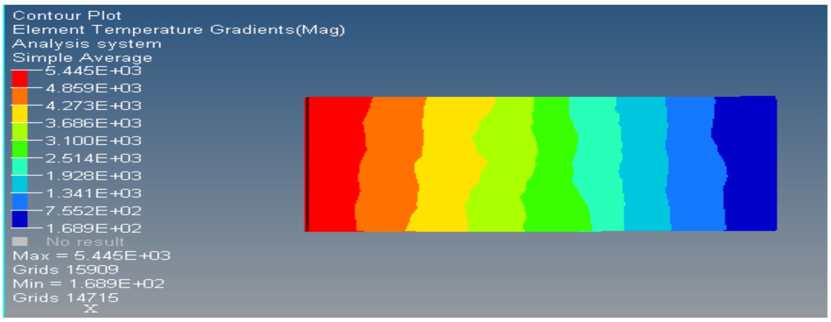

Figure: 13

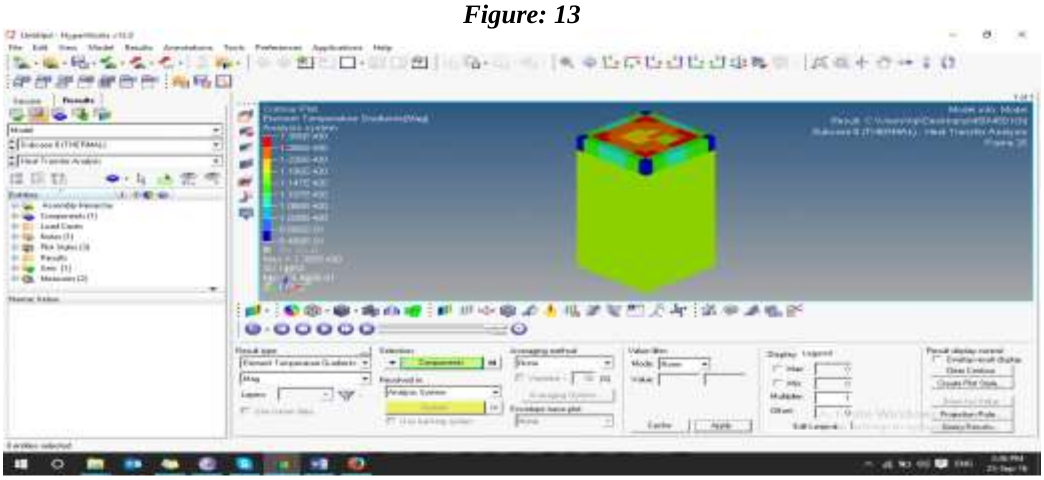

Figure: 14

(viii) The figure showing the results of maximum temperature and minimum temperature at 500 kW heat flux.

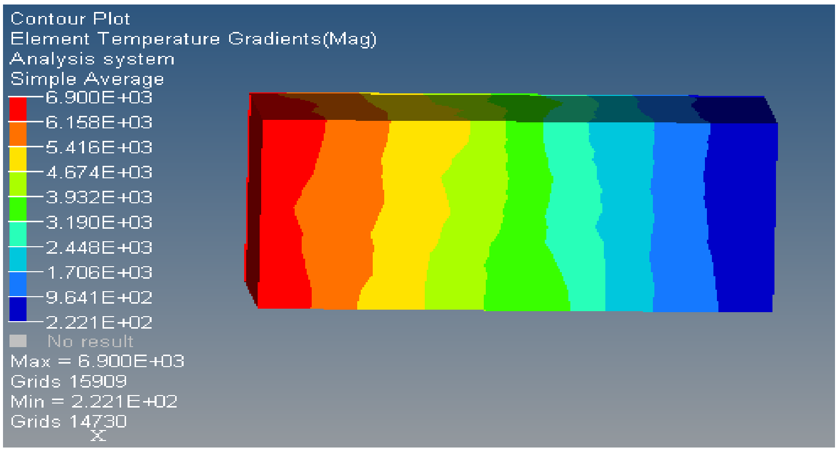

Figure: 15

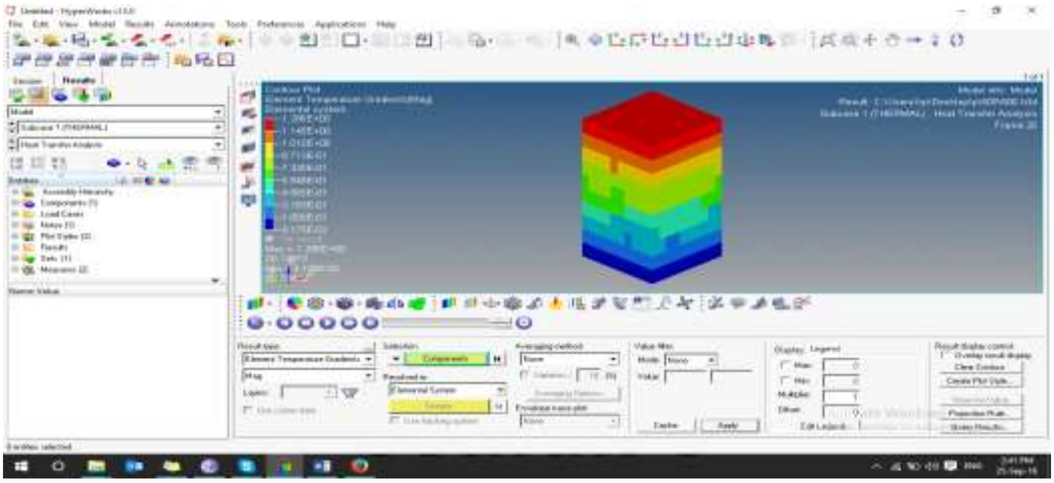

Figure: 16

Table shows Result analysis of heat conduction in a slab and corresponding temperature Obtained in the steel slab

Heat load(Q) (kW)	Maximum Temperature For steel slab	Minimum Temperature For steel slab
150	2061	82
200	2720	84
250	3450	111
300	4122	164
350	4840	166
400	5445	168
450	6141	203
500	6900	222

Obtained in the copper slab

Heat load(Q) (kW)	Maximum Temperature For copper slab	Minimum Temperature For copper slab

	()	)
150	5.8	4.2
200	5.8	4.2
250	7.2	5.2
300	8.7	6.3
350	10.1	7.3
400	14.8	10.8
450	13.5	9.8
500	12.8	4.1

DISCUSSION

When we provided Heat input of different intensity to the conducting heat flux for calculating the maximum and minimum temperature generated in slab. The 9(nine) iterations were performed to calculate maximum and minimum temperature of the slab. The heat flux is applied between 100 kW to 500 kW. In the first iteration, 100 kW heat flux is provided at the one end of slab area, then the higher temperature 1361 ^{0}C is generated and its dropdowns to lower temperature 42 ^{0}C at second end of the slab. Hence we found different phase of heat conduction at contour plot, red color shows higher temperature and green color at lower temperature. Similarly, other eight iteration were found in contour plot for different heat fluxes thus maximum and minimum temperature generated. In this analysis the solid slab of steel material properties for the heat exchanger is being analyze, which is use in power plant to generate the electricity. The solid slab of steel material run error free between 100 kW and 500 kW load it means that this solid slab of steel (dimensions 200*100*100) can be usable anywhere between these heat load. The main objective of this analysis is to selecting right engineering materials to manufacturing of engineering devices using for different industries. In the past the selection or right engineering material by theoretical method is too difficult due to long numerical calculations. This takes more time and gives errors during material property selection, due to this issue the breakdown of engineering devices is found in large amount. Early, to solving this type of problems the Finite Element Method has been developed. In this method the selection of right engineering materials is easily done and gives error free numerical calculations in less time than other methods. Hence our analysis done for solid steel slab for heat exchanger device, the analyses solid slab can be work between 100 kW to 500 kW of heat load. This can be use in power plant industries or any other manufacturing/production industries for given load variations.

CONCLUSION

- In this research work solid slab (Dimensions 200*100*100) of steel AISI1018 and Copper for heat conduction is taken which is used in construction and building engineering and various other mechanical components.
- It was known and also observed that conductivity and heat resistant capability of copper is much higher as compared to AISI steel.
- It was also observed that AISI steel withstand the given temperature and does to allow failure in it.
- On comprising the economic point of view and easy availability AISI Steel is easily available and found on half cost as compared to copper.
- Our analysis done for solid steel slab which is used in construction machineries and heat exchanger device, the analyses suggests that the solid slab can be work between 100 kW to 500 kW of heat load. This much of heat load is chosen based on real life data through various sources.

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