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# ANALYZING THERMAL ANALYSIS IN QUENCHING BY VARYING THICKNESS TO THE PROFILE

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***ABSTRACT - This paper deals with a finite element analysis of the steel quenching process, With reference to the transient temperature field and the thermally lured solid–solid phase transmutation. All the process steps, i.e. holding, cooling and heating, have been treated, modeling both the austenite pattern, decomposition and carrying into account nucleation and growth processes. The final hardness dissemination into the quenched sampling has been predicted according to the rule of mixtures taking into account the chemical configuration of the processing material, the final dissemination of each phase and the local cooling rate. Using Material like Stainless steel C60 steel & Magnesium Alloy. By changing geometry size 15, 30 & 60 mm cross-section of model. Transient analysis conducted from temperature from 720 to 20 deg with time step 1s to 100 sec***

## INTRODUCTION

The main objective of the thesis is to make a quench simulation model of superconductor, supported Finite component methodology (FEM), victimization general business Multi-Physics software system packages, and to validate and compare the model with CERN in-house coding system that was specifically designed for this purpose. Throughout this chapter, we have an inclination to introduce some basic ideas of quenches and quench simulation.

The conclusion is that the method of apace cooling a fabric from heat. As noted within the earlier module, this fast cooling is achieved mistreatment conclusion media.

The thickness of the fabric to be quenched at the side of the speed of cooling needed helps to settle on the conclusion medium. The conclusion medium has got to be chosen fastidiously. If a conclusion medium that cools slower than the specified rate is chosen, the quench isn't effective in manufacturing the specified microstructures and thence properties. On the opposite hand, if a conclusion medium that cools quicker than the specified rate is employed, then that may typically result in defects like distortion and cracking.

There are many different types of quenching: quenching in a fine vapor or mist is known as fog quenching; if quenching is carried out directly from some other heat treatment operation (carburizing for example), it's called direct quenching; if just some parts of a work are quenched, it's called selective ending.

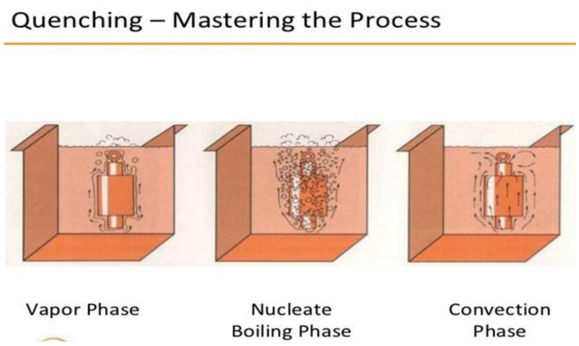


Fig No: 1 Quenching-Mastering the Process

workpiece is quenched, it is known as selective quenching.

## LITERATURE REVIEW

[1]Diego E. Lozano1, Gabriela Martinez-Cazares, Rafael D. Mercado-Solis, Rafael Colas, George E. Totten, FRISA, and México developed a heat transfer model for estimation of transient temperature distribution during quenching via parabolic model. A material-independent model to estimate the transient temperature distribution during a check probe quenched by immersion is

bestowed during this study.

[2] P.Carlone,G.S.Palazzo,R.Pasquino has developed model for finite element analysis of steel quenching process temperature field and solid to solid phase change. This paper deals with a finite element analysis of the steel quenching process; regarding the transient temperature field and the thermally induced solid–solid phase transformations. All the process steps, i.e. heating, holding, and cooling, have been considered, modelling both the austenite formation and decomposition and taking into account nucleation and growth processes

[3]Mohd Abdul Qayum,V.Vasudeva Rao has worked on transient thermal analysis of hot rolled plates under the influence of jet impingement cooling. In hot rolling process the work rolls are subjected to successive heating and cooling cycles with the net effect of heat flux. This nature of heating is likely to cause damage at same time as imperfections in the rolled labs.

[4]F.D. Fischer, W.E.Schreiner, E. A. Werner. C.G. Sendin 2004They mainly focused on the application of the solution for the temperature field of a moving heat source as a logicaland programmable expression allows approximate the temperature field close to the surface layer of a work roll.

[5] Mraudensky, J Horsky and M Pohanka developed an optimization model of roll cooling. The experimental setup was developed to allow full scale measurement on work roll cooling to be carried out.

[6] S.Serajzadeh employed a model for find out temperature distribution in the hot rolling of steels by the effects of rolling parameters. The Raylieght Ritz and the finite element methods (FEM) were implemented to solve the governing equation. In his model, the thermal relationship between rolling metal and rolls was taken into account with the effects of varies parameters such as rolling speed, interface heat transfer coefficient and strip initial temperature were considered in the calculations. His result showed that the rolling speed and interface heat transfer coefficient are important factors. Two-dimensional FEM analyses have been carried out to calculate the temperature profile and the effect of different factors together with the thermal relationships to the roll and the metal strip, and the rolling speed.

## PROBLEMS IN QUENCHING

Theoretical models that specify the physics behind the quench are already developed and documented in the literature, the simulation of quenches could be a Multiphysics drawback. Giant magnets have multi-scale parts from sizes as tiny as ~7 μm to fifteen min length, with extremely non-linear material properties that fluctuate by many orders of magnitude over a variety of solely ten K. Moreover, numerous physical issues are entangled with one another the coupled physical boundary worth issues are:

A) The electrical problem: non-linear current-voltage characteristics of the superconductor; non-linear dependency of the conductor resistance on the sphere, temperature.

B) The magnetic problem: non-linear inductance and eddy-current effects among the coil and in various structural parts.

C) The heat transfer from solid to water: the warmth transfer from the conductor to the water goes through totally different transfer and boiling regimes as operator of temperature, heat flux, and transfer energy.

D) The thermal drawback in solids: Joule losses within the conductor, temperature-dependent thermal conductivity and heat capability.

E) The thermal and fluid-dynamic drawback of water: temperature-dependent consistency, heat capability, density, and thermal conduction.

Among higher than 5 completely different boundary worth issues the thesis project covers C and D. Depend upon the present and field distribution obtained from A and B. Similarly the heat transfer between the conductor and water, C strongly depends upon E.

To make the matter easy the present and field are going to be thought to stay constant throughout the analysis. As a primary step solely D is going to be resolved, i.e, the adiabatic model bestowed in Chapter 4.2.Then C and D will be solved as a coupled problem, i.e, the water-cooled model presented in Chapter 4.3.

Since C and D ar powerfully relied on A, B and E. it's essential to grasp the relation between these issues. Within the following sections we have a tendency to gift the connected topics. In Sections 2.1 and 2.2 we elaborate C and D respectively.

## OHMIC HEATING

Ohmic heating or Joule heating is that the method during which heat is generated in an exceeding conductor because the current passes through it. Assuming $\vec{J}$is the current density vector at a point in the conductor where the temperature-and the field-dependent specific resistivity is $\rho(T,B)$. The Joule heating at the terrible purpose will be expressed as [10]

$$h_{\text{Joule}}(T,B) = \rho(T,B)\vec{J}\cdot\vec{J}. \qquad [\mathrm{Wm}^{-3}] \qquad (2.7)$$

Assuming an Nb-Ti superconducting wire to be a one-dimensional line with constant copper crosswise space of a cut, the Joule heat generated per unit length of the wire will be calculated victimization (2.6) and (2.7) [10],

$$h_{\text{Joule}}(T,B) = \begin{cases} 0 & \text{for } T < T_{\text{cs}} \\ \rho_{\text{cu}}(T,B)\dfrac{(I-I_{\text{c}})^2}{a_{\text{cu}}{}^2} & \text{for } T_{\text{cs}} < T < T_{\text{c}}, \\ \rho_{\text{cu}}(T,B)\dfrac{I^2}{a_{\text{cu}}{}^2} & \text{for } T > T_{\text{c}} \end{cases} \qquad [\mathrm{Wm}^{-3}] \qquad (2.8)$$

Where $\rho_{\text{cu}}$ $(T, B)$ is the resistivity of copper, $T_{\text{cs}}$and $T_{\text{c}}$ are the current-sharing temperature and critical temperature of the superconductor respectively.

**MODEL 1:**

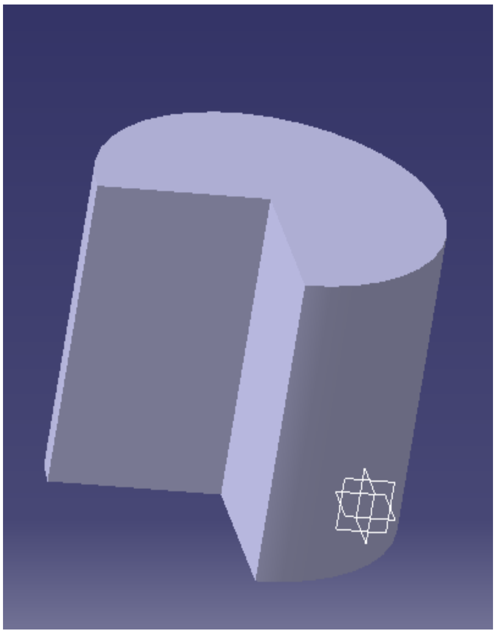


Fig no: 1 60mm thickness 3dcylindricalcross section model

**MODEL 2:**

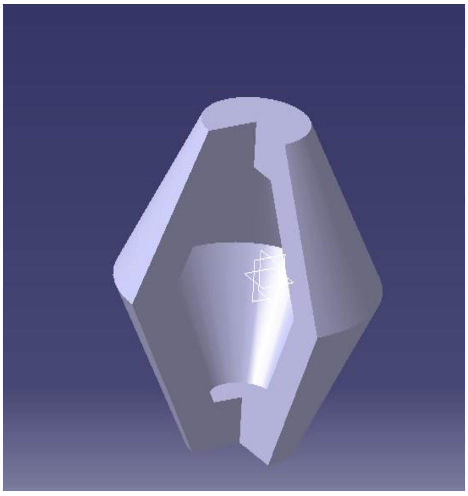


Fig no: 2 15mmthickness 3d hexagonal cross section model

## ANALYSIS

Model Case 1**:** 15 mm thickness rod used for quenching process**.**

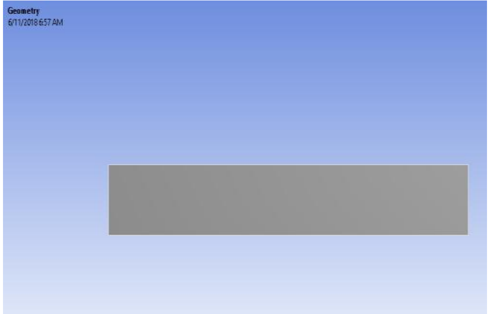


Fig no: 3 Model Geometry made in Ansys thickness of 15 mm

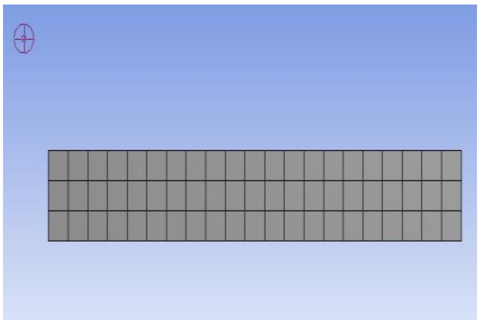
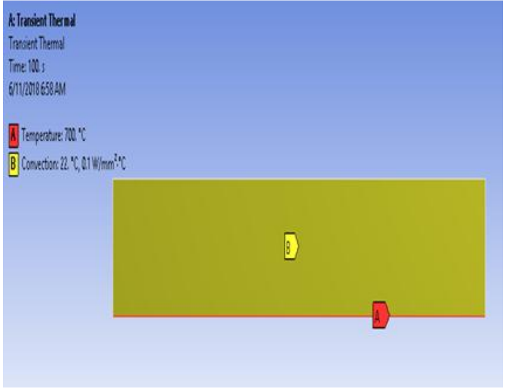


Fig no: 4 Mesh model of 2D elements



A: Transient Thermal
Trancient Thermal
Time: 100. s
6/11/2018 6:58 AM

A Temperature: 700. °C
B Convection: 22. °C, 0.1 W/mm²·°C

Fig no: 5 Load & BC of 15mm model

**Case 1.1: Thickness 15 mm and Material Stainless steel:**

By Transient Time Variant Temperature variation and Analysis done in Transient Analysis in Ansys

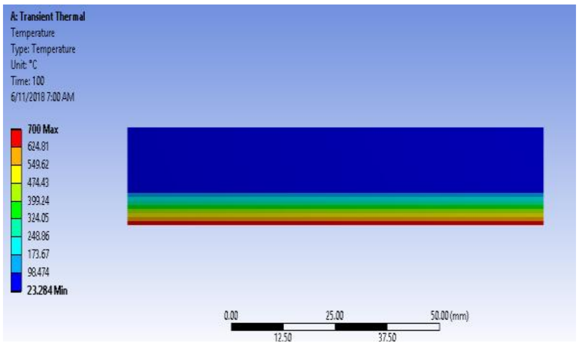


Fig no: 6Temperature Variation after 100 sec time, on outersurface temperature minimum of 23.284 deg.

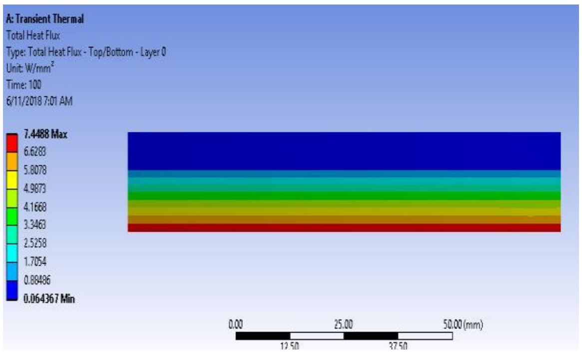


Fig no: 7Heat Flux Variation after 100 sec time, Maximum Heat Flux in the surface is 7.44 W/mm2.

**Case 1.2: Thickness 15 mm and Material C60 steel:**

By Transient Time Variant Temperature variation and Analysis done in Transient Analysis in Ansys

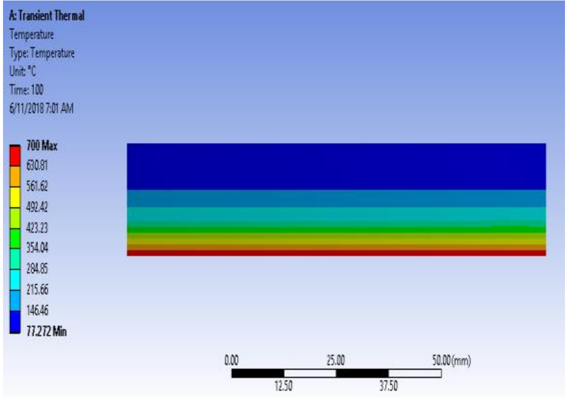


Fig no: 8Temperature Variation after 100 sec time, on outersurface temperature minimum of 77.27 deg.

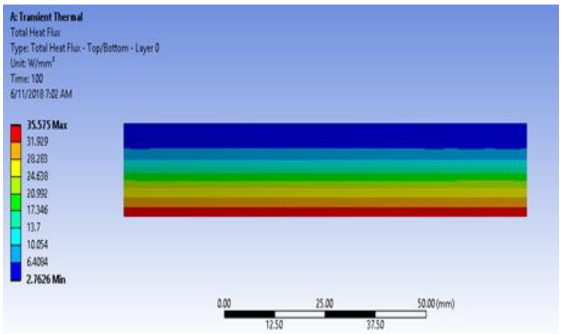


Fig no: 9 Heat Flux Variation after 100 sec time, Maximum Heat Flux in the surface is35.575W/mm2

**Case 1.3: Thickness 15 mm and Material Magnesium Alloy:**

By Transient Time Variant Temperature variation and Analysis done in Transient Analysis in Ansys

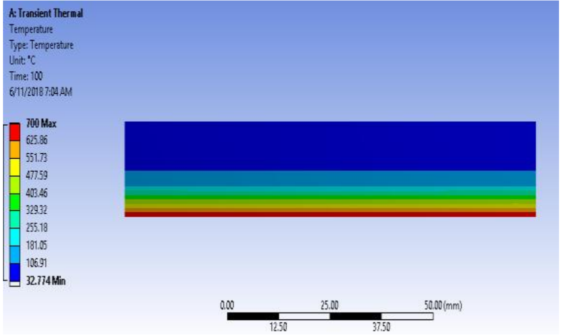


Fig no: 10 Temperature Variation after 100 sec time, on outer surface temperature minimum of 32.77 deg.

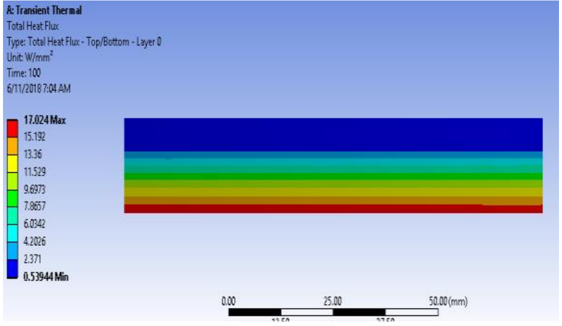


Fig no: 11 Heat Flux Variation after 100 sec time, Maximum Heat Flux in the surface is 17.02W/mm2.

**Case 2.1: Thickness 30 mm and Material Stainless steel:**

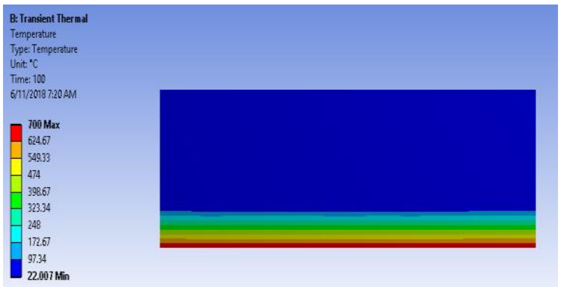


Fig no: 12 Temperature Variation after 100 sec time, on outer surface temperature minimum of 22.00 deg.

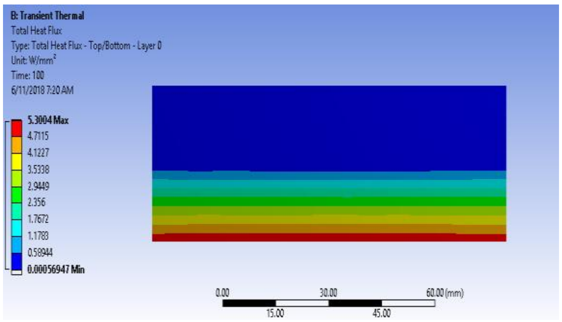


Fig no: 13 Heat Flux Variation after 100 sec time, Maximum Heat Flux in the surface is 5.3 W/mm2.

### Case 2.2: Thickness 30 mm and Material C60 steel:

By Transient Time variant Temperature variation and Analysis done in Transient Analysis in Ansys

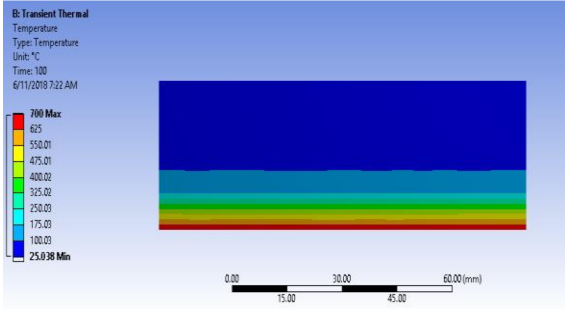


Fig no: 14 Temperature Variation after 100 sec time, on outer surface temperature minimum of 25.03 deg.

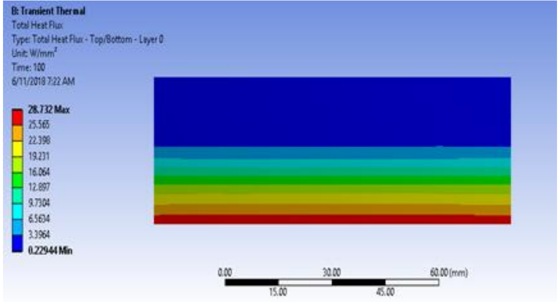


Fig no: 15 Heat Flux Variation after 100 sec time, Maximum Heat Flux in the surface is 28.732W/mm2

### Case 2.3: Thickness 30 mm and Material Magnesium Alloy:

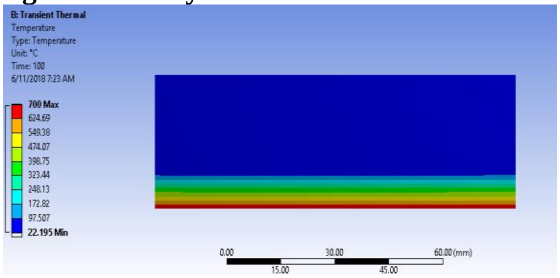


Fig no: 16Temperature Variation after 100 sec time, on outer surface temperature minimum of 22.195 deg.

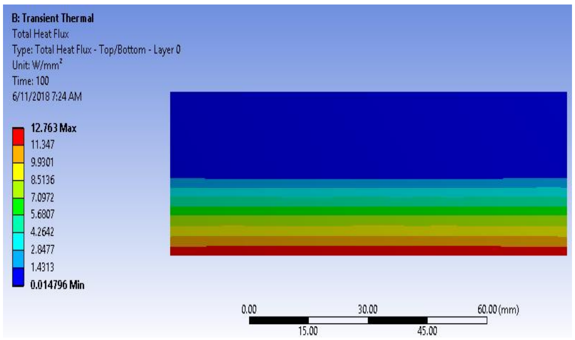


Fig no: 17Heat Flux Variation after 100 sec time, Maximum Heat Flux in the surfaceis12.763W/mm2

### Case 3.1: Thickness 60 mm and Material Stainless steel:

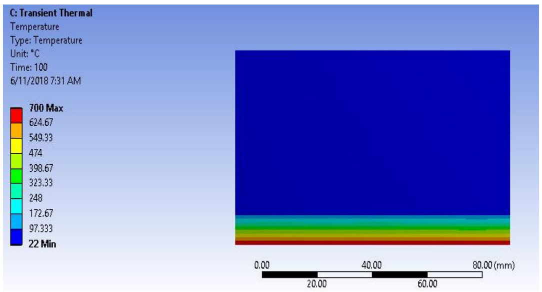


Fig no; 18 Temperature Variation after 100 sec time, on outersurface temperature minimum of 22.00 deg.

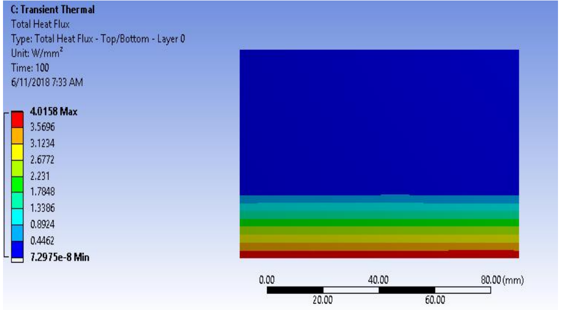


Fig no: 19 Heat Flux Variation after 100 sec time, Maximum Heat Flux in the surface is 4.01 W/mm2

### Case 3.2: Thickness 60 mm and Material C60 steel

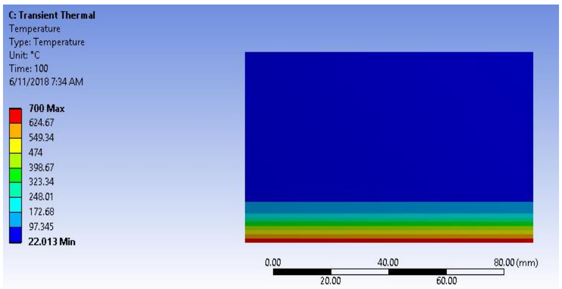


Fig no: 20Temperature Variation after 100 sec time, on outersurface temperature minimum of 22.013 deg.

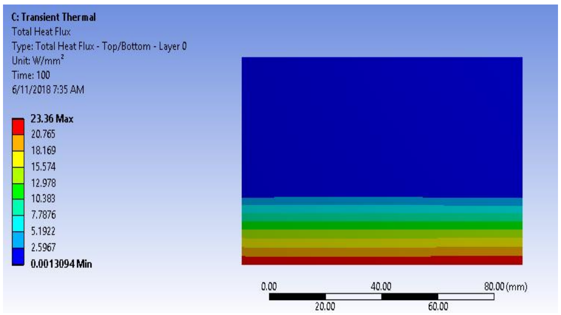


Fig no: 21Heat Flux Variation after 100 sec time, Maximum Heat Flux in the surface is 23.36W/mm2

### Case 3.3: Thickness 60 mm and Material Magnesium Alloy

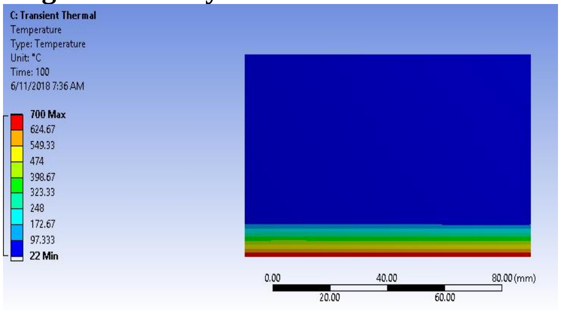


Fig no: 22Temperature Variation after 100 sec time, on outer surface temperature minimum of 22 deg.

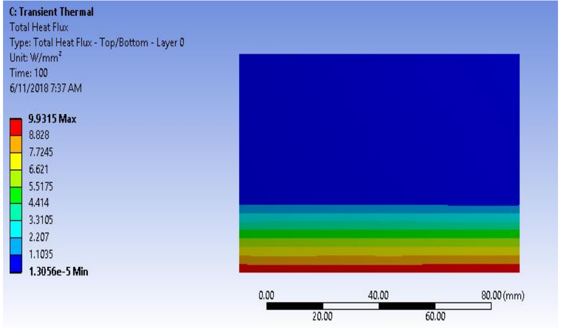


Fig no: 23Heat Flux Variation after 100 sec time, Maximum Heat Flux in the surface is 9.9315W/mm2.

### Model Case 4: 15mm thickness Hexagonal shape geometry used for quenching process.

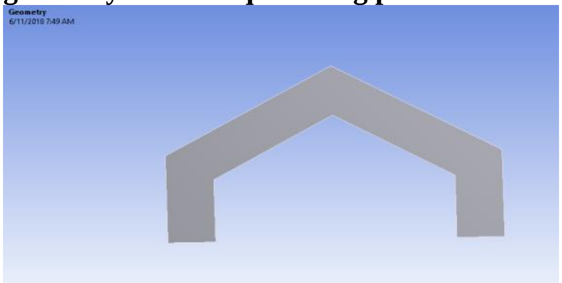


Fig no: 24Model Geometry made in Ansys thickness of 15 mm

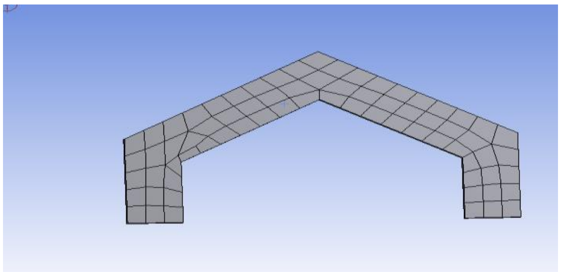


Fig no: 25Mesh model of 2D elements

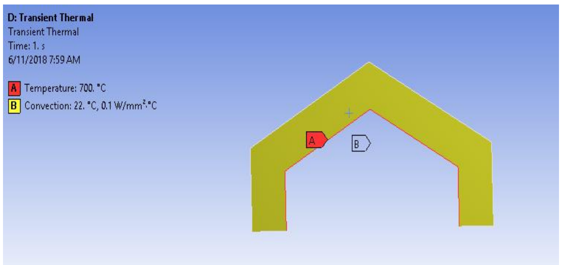


Fig no: 26Load & BC of 15mm model

### Output Results from Ansys:

### Case 4.1: Thickness 15 mm and Material Stainless steel:

By Transient Time variant Temperature variation and Analysis done in Transient Analysis in Ansys

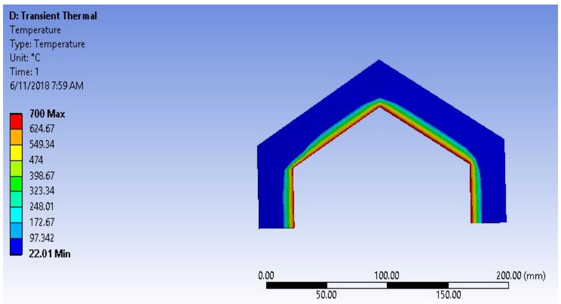


Fig no: 27Temperature Variation after 100 sec time, on outersurface temperature minium of 22.01 deg.

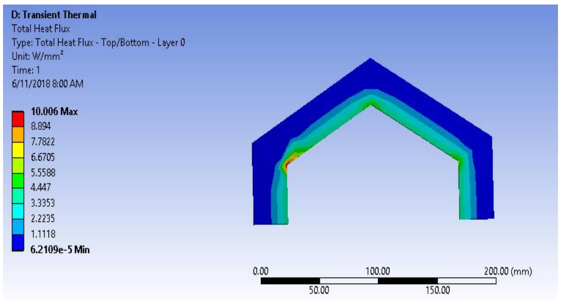


Fig no: 28Heat Flux Variation after 100 sec time, Maximum Heat Flux in the surface is 10.00W/mm2

## RESULTS AND DISCUSSIONS:

**TABLE NO: 1** HEAT FLOW VS THICKNESS

| HEAT FLOW FOR 15,30&60 MM CYLINDRICAL CROSS SECTION THICKNESS PROFILE | | | | |
|---|---|---|---|---|
| s.no. | MATERIAL | HEATFLOW(DEG) 15MM | HEATFLOW(DEG) 30MM | HEATFLOW(DEG) 60MM |
| 1 | Stainless steel | 23.28 | 22 | 22 |
| 2 | C60 steel | 77.27 | 25.03 | 22.01 |
| 3 | Magnesium Alloy | 32.77 | 22.19 | 22 |

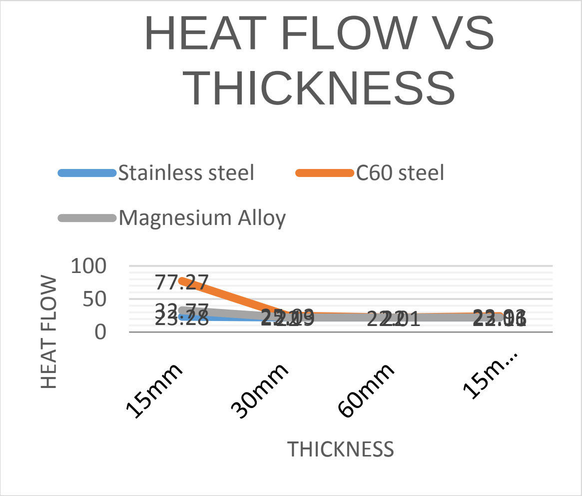


Fig no: 29 Graphical representation of heat flow vs thickness

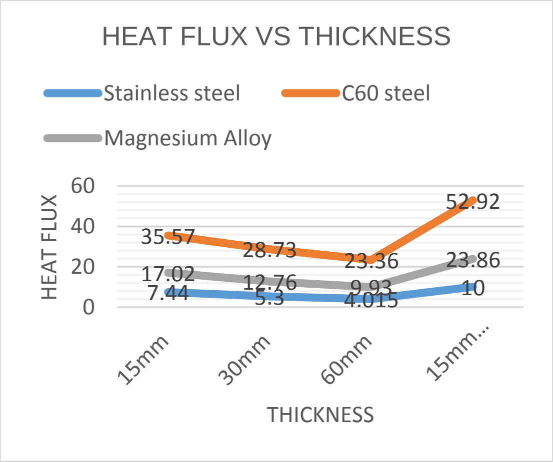


Fig no: 30 Graphical representation of heat flux vs thickness

**TABLE NO: 2** HEAT FLUX VS THICKNESS

| HEAT FLUX FOR 15,30&60 MM CYLINDRICAL CROSS SECTION THICKNESS PROFILE | | | | |
|---|---|---|---|---|
| s.no. | MATERIAL | HEATFLUX((W/MM 2) 15MM | HEATFLUX((W/MM 2) 30MM | HEATFLUX((W/MM 2) 60MM |
| 1 | Stainless steel | 7.44 | 22 | 22 |
| 2 | C60 steel | 35.57 | 25.03 | 22.01 |
| 3 | Magnesium Alloy | 17.02 | 22.19 | 22 |

**TABLE NO: 3** 15MM HEXAGONAL CROSS SECTION

| FOR 15 MM HEXAGONAL CROSSSECTION THICKNESS PROFILE | | | |
|---|---|---|---|
| s.no. | MATERIAL | HEAT FLOW (DEG) | HEAT FLUX (W/MM2) |
| 1 | Stainless steel | 22.01 | 10.00 |
| 2 | C60 steel | 23.93 | 52.92 |
| 3 | Magnesium Alloy | 22.16 | 23.86 |

- From table:1 heat flow vs thickness it is found that c60 steel has fast drop of temperature when compared to stainless steel and magnesium alloy for different thickness cylindrical cross sections.
- From table:2 heat flux vs thickness it is found that c60 steel has fast rate of heat flux when compared to stainless steel and magnesium alloy for different thickness of cylindrical cross sections.

- From table :3 heat flow and heat flux for 15 mm hexagonal cross section heat flow and heat flux are fast drop in c60 steel when compared to stainless steel and magnesium alloy.
- From the Fig no:29 it is found that heat flow rate is high for c60 steel when compared to the stainless steel and magnesium alloy.
- From the Fig no:30 it is also found that heat flux in c60 steel is more compared to other two materials.

## CONCLUSION

The main aim of the work was to unravel the thermal drawback in quench victimization business FEA tools and to match the results with custom computer code so as to search out out the foremost economical technique of quench simulation. Modeling of the thermal phenomena during a quench comprehend 2 main challenges

i) the warmth generation load and also the material properties have the non-linear dependency on temperature and magnetic flux

ii) the warmth transfer between the conductor and water goes through totally different transfer and boiling regimes relying upon temperatures, heat flux, and integrated heat.

By Doing Thermal Transient Analysis for different cross sections 15mm, 30mm & 60 mm thickness profiles are analysis and Material Variation Stainless steel C60 steel &Magnesium Alloy.Quenching process in material C60 steel is fast than stainless steel and magnesium Alloy. Time step of 100 sec quenching process is checked. From result table it suggested thickness variation from 15 to 30 and 30 to 60 mm various material best way to result from thickness 30 to 60 mm temperature drop is less with respect to time.

Profile changing Hexagonal shape 15mm thickness and from result table it is shown C60 steel is fast drop in temperature than other two materials

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