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Thermal Analysis of Induction Furnace Wall

Prakhar Patel[1], Rishabh Agarwal[2], Tapan Patel[3], Roy Suraj[4], Nirajkumar Mehta[5]

[1234]*UG Students, Mechanical Engineering Department, ITM Universe, Vadodara, Gujarat, India*
[5]*Associate Professor, Mechanical Engineering Department, ITM Universe, Vadodara, Gujarat, India*

Abstract— Induction furnaces can also be labeled largely into three classes: (1) Core-type low-frequency induction furnaces, (2) core-less high-frequency induction furnaces, and (3) core-less low-frequency induction furnaces. All induction furnaces operate on the principle of inducing an electric present into the metallic to be heated. With the aid of supplying an alternating current to a fundamental induction coil, a reverse alternating current is prompted into any electrical conductor mendacity inside the magnetic subject of the coil. This action may be likened to that of a transformer where a main coil surrounds a secondary coil, besides that the predominant motive of induction heating is to generate heat in the metallic charge which corresponds to the secondary coil on this analogy. Right here, we are doing finite detail analysis of induction furnace wall. We are interested to find out heat transfer throughout melting of substances. If we will calculate heat losses then we can also find efficiency of induction furnace.

Keywords— Heat Enhancement, Fins, IC Engine, Finite Element Method, Advanced Heat Transfer

I. INTRODUCTION

The principle of induction melting is that an excessive voltage electrical supply from the most important coil induces a low voltage, high current in the metal, or secondary coil. Induction heating is comfortably a system of transferring heat energy. Furnace is a gadget that is used to heat material with a view to alternate their shape as like in shaping and forging or the properties of the material will also be converted. These furnaces are traditionally used for melting the metals which can be used for casting. Furnace will also be termed as a type of oven. It is an enclosed constitution within, which the material is heated to very excessive temperatures. It is a gadget that is designed to perform the water or air heating and is circulated during a constructing in a heating system. The amount of heat that is to accept is prior decided to the material. There exists a sufficiency in the liberation inside the furnace to heat the specified inventory. A suitable heat transfer from the gases to the surface of the heating inventory takes place. Temperature should be uniform within the stock. The heat loss from the furnace is minimized to the least viable. In the furnace, molten metal directly comes in contact with the supplied inventory.

II. LITERATURE REVIEW

Prior research work of Dr. Nirajkumar Mehta is used as a competent reference. Induction furnace study evaluation is finished to be analized by study traits. (Nirajkumar Mehta, could 2012). A review is finished on purposes of distinct numerical methods in heat transfer with its purposes. (N C Mehta, Vipul B Gondaliya et al, February 2013). Thermal fatigue evaluation of induction melting furnace wall is completed for silica ramming mass. (N C Mehta, Akash D Raiyani et al, February 2013). An assessment is finished for research on induction heating. (Vimal R Nakum et al, April 2013). An evaluate is completed for metal forming analysis making use of distinctive numerical ways. (N C Mehta et al, may 2013). Transient heat transfer analysis of induction furnace is finished by using finite element evaluation. (Vipul Gondaliya et al, August 2013). Thermal fatigue analysis of induction furnace wall is completed for alumina ramming mass. (N C Mehta et al, October 2013). Thermal evaluation of hot wall condenser is done for domestic refrigerator using numerical method for temperature distribution. (Akash D Raiyani et al, July 2014). Optimisation of wall thickness is done for minimum heat loss for induction furnace by using finite aspect evaluation. (Dipesh D Shukla et al, December 2014). A review is completed on numerical evaluation of furnace. (N C Mehta et al, April 2015). Thermal fatigue evaluation of induction furnace wall is done for zirconia. (Nirajkumar Mehta et al, April 2015). Evaluation of finite change method and finite detail process is performed for 2 D transient heat transfer problems. (Nirajkumar Mehta et al, April 2015). Thermal fatigue evaluation of induction furnace wall is done for magnesia ramming mass. (Nirajkumar Mehta et al, June 2015). Advanced mathematical modelling of heat transfer is completed for induction furnace wall of zirconia. (Nirajkumar Mehta et al, December 2016). Evolved heat transfer evaluation is finished for alumina situated refractory wall of induction furnace. (Nirajkumar Mehta et al, December 2016).

III. FINITE ELEMENT ANALYSIS

Honda Shine bike is selected for this investigation which is shown in Figure 1. Extended surfaces or fins are provided on its IC Engine which are clearly visible in Figure 2. We have measured dimensions of rectangular fins which are provided in the IC Engine to enhance the cooling effect. We had prepared a 3D Model of Fins Geometry on the IC Engine of Honda Shine using Solidworks which is shown in Figure 3. We have converted the file into iges format so that we can import it to the ANSYS Software. We had used ANSYS Software for Finite Element Analysis for these fins by used forced convection boundary conditions. ANSYS is one of the best software for advanced heat transfer analysis. Figue 4 indiactes applications of temperaute and convection as boudary conditions for the finite element solution using ANSYS.
Figure 5 shows the post processing results of ANSYS Analysis where maximum temperature is 110.17 °C and minimum tempeartue is 33.558 °C. Cooling curves are plotted by readings so that we can understand the process and time required for cooling when we stop the engine. Normally it takes 1 hour or 1 hour and 15 minutes to reach to atmospheric temperatures. The comparative graph is shown in Figure 6. We can get temperature distribution with respect to time as it is a transient thermal analysis.

Table I
Material Properties

Material Properties Of Silica Ramming Mass		UNIT
Elasticity Constant	180	Gpa
Poission's Ratio	0.22	-
Density	2800	KG/m3
Thermal Expansion Co- efficient	6.8	µM/°C
Thermal Conductivity	1.7	Watt/m k
Specific Heat	950	J/kg k

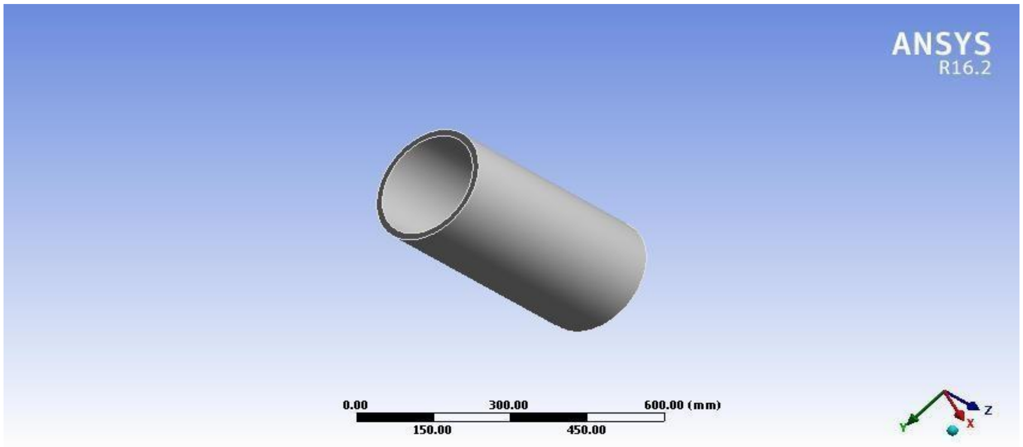

Fig. 1 *3 D Model of Induction Furnace Wall*

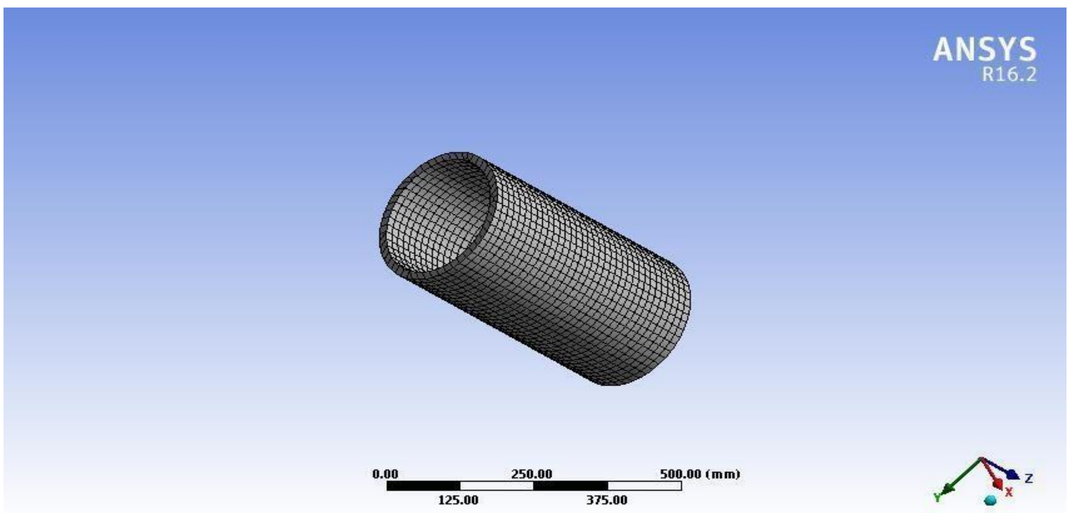

Fig. 2 *Meshing of Induction Furnace Wall*

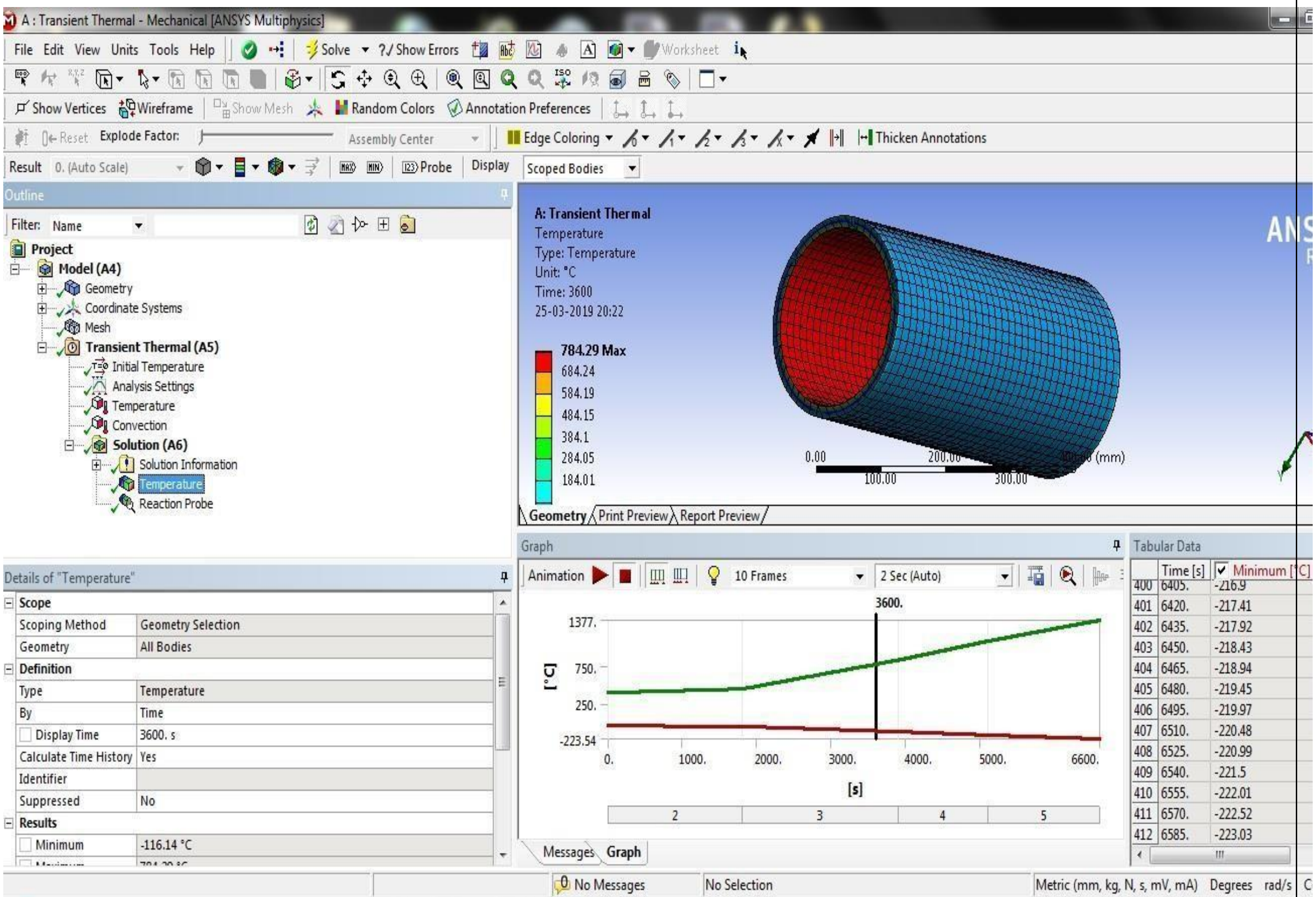

Fig. 3 Finite Element Analysis Results

IV. CALCULATIONS

We have six sides of the furnace we calculate heat losses for the entire wall. As per our geometry & dimensions we calculate efficiency & heat losses for both with & without Insulation.

Total Power consumed - 88 Kw
Time Taken - 109 minutes Power
Factor - 0.95
Voltage - 800v
Ampere - 130 A
Frequency -
3000Hz
Amount of metal - 150 kg

Material Used - Pig Iron with 3% carbon
Ramming Material - Silica Ramming
Mass Diameter - 230mm Ramming Mass
Thickness - 15mm Ramming Mass
Depth - 510 mm

1. HEAT TRANSFER THROUGH CONDUCTION Q(conduction)=
(T1 - T2) / 1/(2*3.14*1.7*0.51) * Lnr2/r1
=(1377 - 45) /(1/544) *.012
= 60384 W

2. HEAT TRANSFER THROUGH CONVECTION
Gr = 9.81 * (0.5)^3 * 1.39*10^-3 * 1360/(1.6)^10
= 2318/109.95
= 0.026… .... Eq -1

Pr = (7.86)^5 * 1005 / 0.026
= 860512.85……………………………………..Eq -2

Re = Gr * Pr
= 0.021 * 860512.85
= 18070.77…………………………………………Eq - 3

Nu = (Re)^0.33 * 0.14
= 3.55……………………………………………..Eq - 4 Nu = h lc/k
= Nu * k / l
= 3.55 * 1.3 / 0.5
= 9.244… ....Eq - 5

Q(convection) = h * A * ΣT
= 9.244 * 0.4082 * 1360
= 5131.808 W

3. TOTAL HEAT LOSS

Q = Q(conduction) + Q(convection)
= 60384 W + 5131.808 W
= 65515.808 W

4. Efficiency of furnace-:
Efficiency = total heat supplied - total heat reject / total heat supplied
= 88000 - 65515 / 88000
= 25%
Thus the efficiency of furnace wall is 25%.

V. CONCLUSION

Induction furnace is highly used to heating & melting nowadays for different materials. Also there is huge problem to replace those refractory materials because of low life cyle & also there are heat losses. Because of the heat losses the efficiency decreases. By FEA analysis of induction furnace wall, we conclude heat losses and also thermal fatigue failures due to thermal stresses. In this research, we have selected silica ramming mass wall of induction furnace in which we have done experimental analysis, mathematical analysis and by Ansys. We have found that the efficiency of furnace is 25%.

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