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Transient Heat transfer Analysis of Induction Furnace by Using Finite Element Analysis

KEYWORDS

Vipul Gondaliya	Mehul Pujara	Niraj Mehta
PG Student, Mechanical Engineering Dept., B.H.Gardi College of Engineering & Technology, Rajkot, GTU	Asst. Prof., Mechanical Engineering Dept., B.H.Gardi College of Engineering & Technology, Rajkot, GTU	Head of Department, Mechanical Engineering Dept., Noble Engineering College, Junagadh, GTU

ABSTRACT *An induction furnace is an electrically run furnace used for melting & heating (heat treatment) metals. Induction heating is widely used in today's industry, in operations such as metal hardening, preheating for forging operations.*

The aim of present work study is to prepare a finite element model of induction furnace. The result of finite element model will be validating with experimental investigation carried out in industry (Austin bearing-junagadh). After comparing results of FEA model we can change the refractory material or by taking 3-10 mm thick insulation and results compare with FEA results. Finally, for improvement in efficiency of the induction furnace.

I. INTRODUCTION

The induction was first invented in 1877 in Italy. The first use of the furnace was in 1927 in Britain. It was until World War II, when the need for aluminum casting grew significantly, that the induction furnace went into wider usage.

Furnace is a term used to identify a closed space here heat is applied to a body in order to raise its temperature. The source of heat may be fuel or electricity. Commonly, metals and alloys and sometimes non-metals are heated in furnaces. The purpose of heating defines the temperature of heating and heating rate[1-3]

In today's scenario the induction furnace is used mostly in industry for heating & melting, the main problem occurs in small scale industry the heat losses & efficiency of furnace. As in Austin bearing junagadh the efficiency we found is around 60 percentages with high heat losses.

II. DESCRIPTION OF PROBLEM

The induction furnace used in AUSTIN BEARING COMPANY junagadh where the problem is very high heat losses & there for the efficiency of furnace is low by using insulating material we can minimize the heat losses & there for increase the efficiency of furnace. There is furnace which is used in heat treatment of bearing which is having three zones.

Figure 1 induction furnace (Austin bearing junagadh)

Table 1General data of induction furnace

Type	Electric heated continuous furnace
Duty	Hardening of small components
Maximum temperature	900 °c
Electricity	65Kw
Control zone	3
Lining detail	HFI & CFI bricks
No. of coil	18

III. PREPROCESSING OF FEA BY ANSYS

The accurate simulation of Induction heating furnace refractory wall is done for finding out temperature distribution heat losses by using proper solving conditions. These solving conditions include initial and boundary conditions, material properties and assumptions etc. Finite Element Analysis using ANSYS was performed to calculate temperature field and heat flux generation inside the induction heating furnace

3.1 Analysis Model

Based on drawing and dimensions available from Austin bearing limited junagadh, a model is developed using Pro E software. We had converted this model in iges format which is universal format for all modeling software then it is imported into ANSYS.

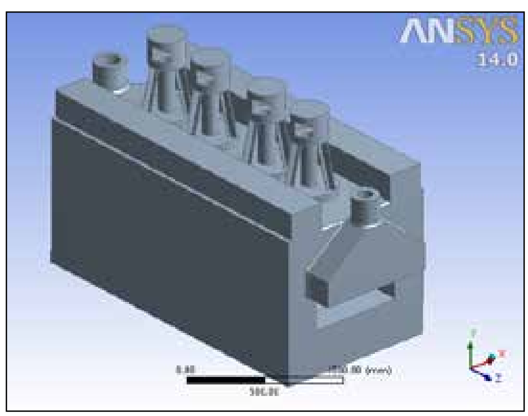

Figure 2 Analysis model

3.2 Initial and Boundary conditions, material properties and basic assumptions

To solve this heat transfer problem of induction melting furnace wall, the following initial and boundary conditions, ma-

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terial properties and basic assumptions are made:

- Refractory Materials for induction furnace wall meets the basic assumptions in the science of mechanics.
- Environmental Temperature is homogeneous at 22° C.
- Ignore the effect of gravity field.
- The surface of induction furnace wall is clean.
- The initial temperature of the induction furnace is set 22° C and it is agreement with the ambient temperature during solving the problem.
- Heat flux is considered constant for this analysis.

Calculation of Heat Flux:

- Heat Flux = Heat Generated / Area
- Heat Flux = Qg /(W*L)
- Heat Flux = 65 kw/(0.930*1.675) m2
- Heat Flux = 65 kw / 1.5577 kw/ m2
- Heat Flux = 41703 watt/ m2

IV. RESULTS AND DISCUSSION

We did analysis of induction furnace by taking experiment of furnace for validation of the FEA analysis. We compare the graph of temperature vs time for both FEA & experimental data also done FDM analysis by taking 2D geometry & considering corner as nodes. There temperature is than again compare with both experimental & FEA results. Finally we take 5 mm thick insulation of zirconia & again done FEA analysis again compare it with experimental data.

MATERIALS PROPERTIES OF HFI BRICKS			UNIT
1	Thermal conductivity	0.5	K/cal/m/hr/°c
2	Specific heat	900	J kg^-1 c^-1
3	Bulk density	4900	kg/m^3
4	Initial temperature	22	°c

Table no.2 Material properties

4.1 Results of temperature distribution & heat flux (without insulation)

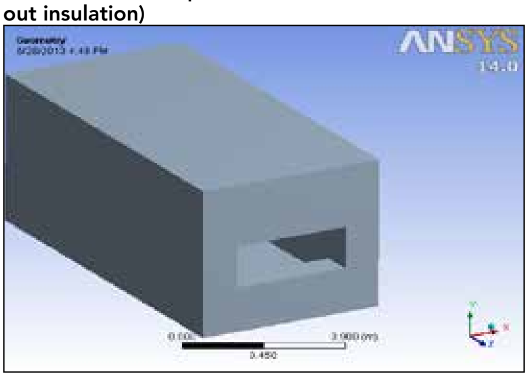

Figure 3 model(without insulation)

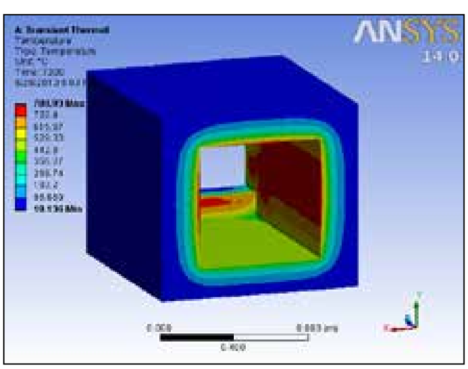

Figure 4Temperature distribution (cross section)

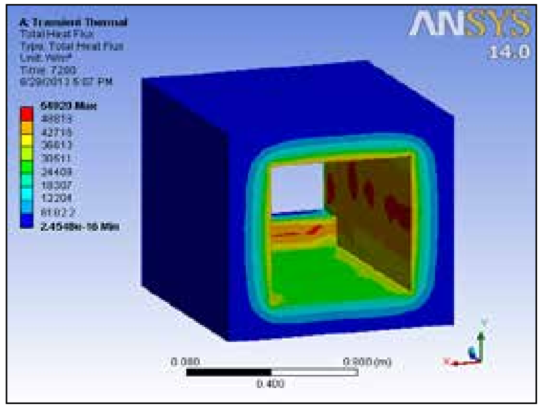

Figure 5Heat flux distribution (cross section)

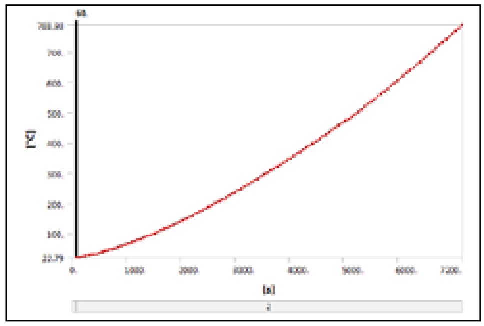

Figure 6 Result Graph Temperature vs time (Without insulation)

4.2 Results of temperature distribution & heat flux (With insulation of zirconia 5 mm thickness)

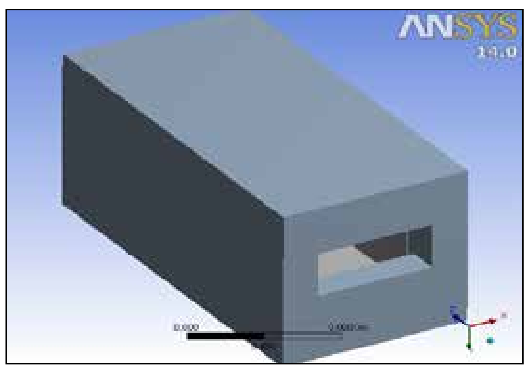

Figure 7model (with insulation)

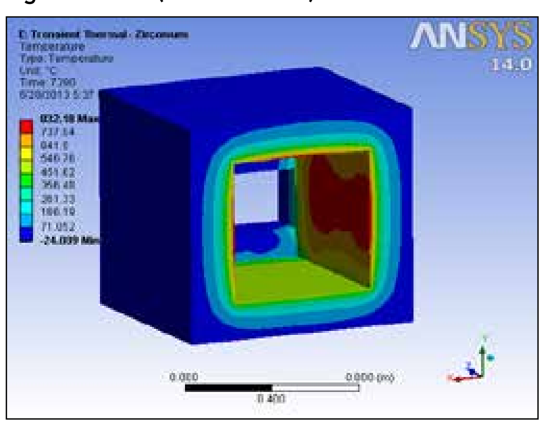

Figure 8 Temperature distribution (cross section) With insulation

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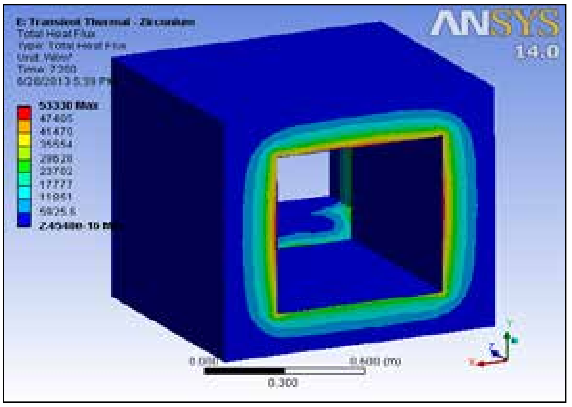

Figure 10 Distribution (cross section) With insulation

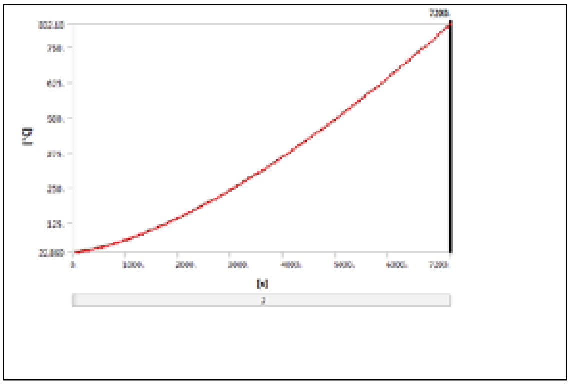

Figure 10 Result graph Temperature vs time
(With insulation)

4.3 calculations of efficiency & heat losses
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

We have
Width
W1=W3=0.215 m, W2=W4=0.185 m, W5=W6=0.215m
So, Area
A1=A3=2.0233 m^2, A2=A4=2.189 m^2, A5=A6=1.11m^2

Case 1 without insulation
R (Insulation value) value for bricks area 1 & 3

So, heat losses
Similarly for area 2 & 4, 5 & 6 we calculate

Q (2 & 4) = 4.793 kw/m^2
Q(5 & 6) = 1.992 kw/m^2

So, Total heat loss is
Q(1) + Q(2)+Q(3)+Q(4)+Q(5)+Q(6) = 20.874 kw/m^2

Efficiency of furnace
Case II with insulation (Zirconia)
R (Insulation value) value for bricks area 1 & 3

So, heat losses
Similarly for area 2 & 4, 5 & 6 we calculate

Q (2 & 4) = 3.447 kw/m^2
Q(5 & 6) = 2.280 kw/m^2

So, Total heat loss is
Q(1) + Q(2)+Q(3)+Q(4)+Q(5)+Q(6) = 16.946 kw/m^2

Efficiency of furnace
From both the case based on FEA analysis we can say that the efficiency is increased by using insulating materials.

4.4 Finite difference method analysis (FDM)
Finite difference method is used to predict the temperature at each node by applying the heat transfer equations based on the position of the node whether there is convection or any other mode of heat transfer now

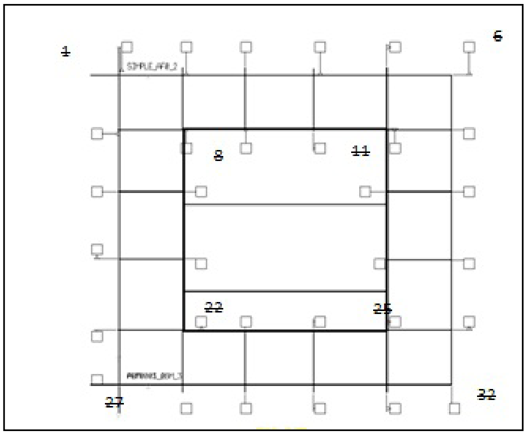

Figure 11 2D Cross sectional view

As shown in figure we consider cross section of furnace & apply heat transfer equations at node no. 1,6,8,11,22,25,27 & 32 we find that the temperature at all nodes is almost same as we got after 7200 second (2 hours) we got 822 °c at inside nodes is near to out FEA result.

4.5 Experimental Results
For experiment set up is already available at industry. The thermocouple is attached at different zones & taking results at every minute we got 120 readings at each thermocouple also by taking average of 3 thermo couple at each minute we got graph as figure no. 14 graph of temperature vs time which is plotted based on experimental reading from industry. We can easily compare the Figure no 6 & Figure no 10 with Figure no 14 than it is shown that the temperature difference in both cases is nearly same with experimental graph.

Figure 12 Thermocouple

Figure 13 Panel for reading

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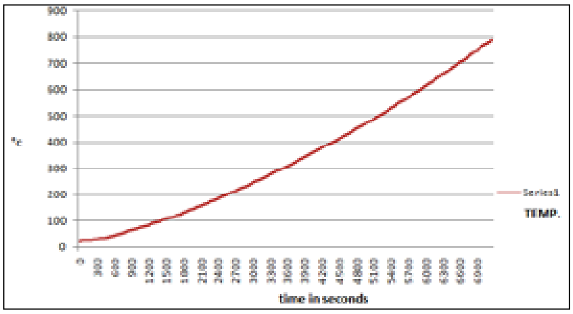

Figure 14 Result graph temp vs time (Experimental reading)

V. FUTURE SCOP OF WORK

Here is the thermal analysis of induction furnace is for increase the efficiency & minimize the heat losses by taking insulation material further it can be possible to design whole furnace & also by taking different kind of refractory material itself.

VI. CONCLUSION

Induction furnace is highly used to heating & melting now days for different materials. Also there is huge problem to replace those refractory materials because of life & also there are heat losses. Because of heat losses the efficiency is decreases. By FEA analysis of induction furnace we conclude that for both cases.

- Without insulation the efficiency of furnace is 67 % & with insulation 73 % so we achieved higher efficiency & less heat losses.
- The comparison of experimental temperature is nearly same with FE analysis & FDM

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