A Design Approach: Heat Treatment Furnace

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Abstract— In this global world which is growing very fast, it is rather very important to make the continuous changes in the manufacturing sectors in order to remain in the competitive world of pinnacles. Also it is mandatory to meet the designs of various heat treatment furnaces in order to meet the changes in demand of the furnaces; economically feasible .This research presents the effects of heat treatments on the mechanical properties of mild steel. The design closely revealed the parameters and the features such as: casing design, the insulating system, the heating system, the safety control systems and also the external environment temperature. The final result gave a maximum temperature of 9200C in the furnace heating zone and 320C in the external casing zone for about 30 minutes. The result obtained makes it possible to heat treat ferrous and non-ferrous metals and their properties.

Key words: Heat, furnace, ferrous, design calculation feasible, non-ferrous

I. Introduction

Heat treating is the controlled heating and cooling of a material to achieve a certain mechanical properties, such as: hardness, strength, flexibility and the reduction of residual stresses. Much heat treating process requires the precise control of temperature over the heating cycle. Heat treating is used extensively in metal production and in the tempering and annealing of glass and ceramic products.

Basic standard parameters for the construction and design of heat treatment furnace comprises of: the casing design, the insulating system, the electrotechnicals and the safety/control systems.

A. Aim:

The aim of the work is to develop a feasible heat furnace capable of withstanding controlled elevated temperatures.

B. Motivation:

The main motivation for the work is to make available low price heat furnace that can be affordable for all the aspiring and budding manufacturing or technical institution.

II. Methodology

A. Design Considerations and Material Selection:

Owing to the fact that the normal temperature of the human body ranges from 35^0C to 45^0C. Above this temperature would be harmful to the operator. Hence to curb the possible effect to burnt as a result of temperature value above the side range of temperature: a design calculation is carried taking some assumptions and constant into considerations to achieve a temperature of less than 35^0C at the outer casing. .

This will equally enable to safety of charging and unloading of the specimen with ease. It is assumed that the maximum temperature attainable in an ideal case 1200^0C, but due to the heat incurred, assumption is made such that: 9500C is reached in 60 minutes.

1) Amount Of Heat From Input Source:

The heat source is generated from the industrial heating element which is assumed to take a period of 1hour to attain its maximum loading capacity. This is supported by the Joule- Lenz's law.

$$E = I^2Rt$$

Where:-

E = Electrical energy;
I = Current flowing in the circuit;
R = Resistance to flow in the circuit;
t = Time taken for maximum heating;
By ohm's law; V = IR
V = Voltage across the circuit
Hence,
$E = V^2t/R$
V = 230 Volt
R = 1.85 Ω
t = 3600 sec.
Then: $E= ((230)^2*3600)/1.85 = 102940540.5$ Joules
But, Rate of heat flow;

$$Q = E/t =102940540.5/3600 = 28594.59 \text{ J/s}$$

B. Design Assumption and Constant:

Convective coefficient of air (hair) =800W/km^2 (Rajput, 1999)
Door efficiency (£) =1
Heating time (t) =1 hr
Resistance in the circuit(R) =1.85Ω
Thermal conductivity of the brick (kb) =3 W/mk (Mark Handbook)
Voltage across the circuit (v) =230v

1) Temperature of Brick Wall (Tb):

Heat transfer from the furnace air to the brick wall is by convection. Hence, by newtons law of cooling;

$$Q =h_{air}A (T_{air}-Tb)$$

Where;
A =Total surface of bricks
=2[(L*B) + (B*H) + (H*L)]
=2[(0.225*0.1125) + (0.1125*0.075) + (0.075*0.225)]
A = 0.10125 m^2.

$$28594.5=800*0.10125*(950- T_b)$$

$T_b = 596.98\ ^0$C.

2) Temperature of Internal Wall Casing (T_i):

The heat transfer from the brick wall to the internal wall casing by conduction and its utilizes the Fourier law i.e.

$$Q = K_bA(dt/dx) = K_bA((T_b-T_i)/ dx)$$

Where

A = Total surface area of the casing
= 2[(L*B) + (B*H) + (H*L)]
= 2[(0.235*0.125) + (0.125*0.125) + (0.125*0.235)]
= 0.14875 m^2.

dx = Thickness of the bricks = 75 mm.
$28594.59=3*0.14875*((596.98- T_i)/0.075)$

T_i = 116.39 ^{0}C.

3) Temperature of Air Space (T_s):

Between The Internal and External Casing:

The heat transfer in the air space environment from the internal wall casing is due to convection by newton's law is still invoked.

$$Q=h_{air}A(T_i\text{-}T_s)$$

Where;

A=Difference in the area between the external and the internal wall casing.

The external wall casing,

$$A_{ext}=2[(L*H) + (B*H) + (L*B)]$$
$$=2[(0.460*0.360) + (0.360*0.360) + (0.460*0.360)]$$
$$=0.9216 \ m^2$$

The internal wall casing,

$$A_{int}=0.14875 \ m^2$$

Hence,

$$A = A_{ext}- A_{int}$$
$$=0.9216\text{-}0.14875$$
$$=0.77285 \ m^2$$
$$28594.59=800*0.77285*(116.39\text{- } T_s)$$
$$T_s=70.141 \ ^0c$$

4) Temperature of the External Casing (T_E):

The heat transfer from the air space to the external wall casing of the furnace is by convection and can be expressed by the newton's law of cooling.

$Q = h_{air}A(T_s – T_E)$

A = Total surface area of the external casing which takes a rectangular configuration.

= 0.9216 m^2.

$$28594.59=800*0.9216*(70.141\text{- } T_E)$$
$$T_E = 31.36 \ ^0C.$$

5) The Volume of External Casing (V):

The external volume houses the entire furnace system and conforms to a rectangular box. It is calculated following the expected temperature at its surface (T_E = 31.36 ^{0}C)

$$V =L*B*H$$
$$=0.460*0.360*0.360$$
$$V=0.05961 \ m^3$$

C. Design Considerations and Materials:

The consideration in our work is based on the logical necessity of heat treatment furnace data. It is aimed at meeting the desired standard as expected for an electrical heat treated furnace.

1) Design in PRO-E:

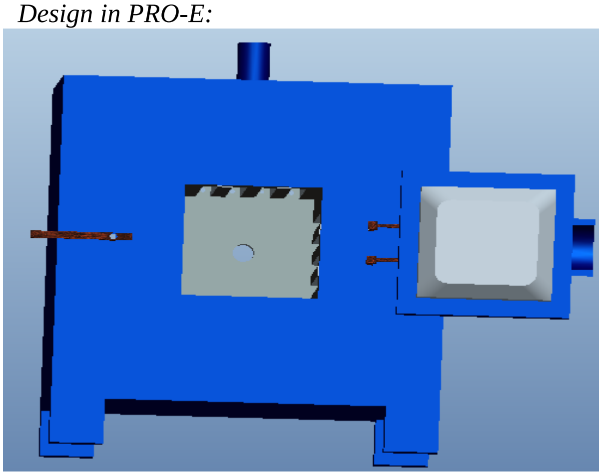

Fig. 1: Design in PRO-E

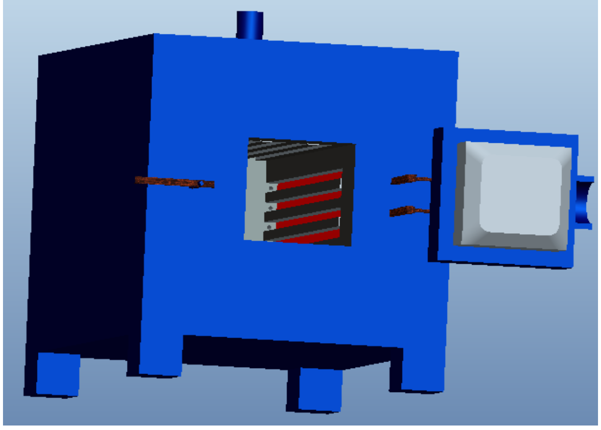

Fig. 2: Design in PRO-E

D. Evaluation:

1) Maximum Temperature Achieved:

By means of temperature gauge thermocouple, initial maximum temperature archived by furnace 1000^{0}Cbut for subsequent operation average maximum temperature attainable temperature is given 950^{0}C.

2) Time Taken to Achieve Maximum Temperature:

Although, theoretical prediction for gaining temperature at 950^{0}in 60 minutes.

3) Applications of Heat Treatment Furnace:

We achieved maximum temperature upto 950^0. By comparing with this, some heat treatment operation and there relative process temperature it would be carried out the following heat treatment process. Annealing, normalizing, hardening, quenching process

E. Operation Procedure:

Put the material to be heated in the furnace after which the furnace should be closed. The switch of the furnace on from the main. Then set the desired temperature in controller. After achieving desire temperature controller automatically stop working till the temperature drop. Ten keep the material in the furnace till the socking process should not complete. Then switch off the furnace before removing material from the furnace.

III. Conclusion

The furnace was specifically designed for controlled heating of material sample range of 1000^{0}C. But it can equally be adopted for use in other heating operations of same temperature. The result obtain makes it possible to heat treat both ferrous, non-ferrous and their alloys to enhance their properties for needed use in services with safety.

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