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Development of an Electric induction furnace for heat treatment of ferrous and non-ferrous alloys

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ABSTRACT : *A 3kg capacity Electric induction furnace with a power rating of 2500W for heat treatment of ferrous and non-ferrous alloys was developed. The furnace which is made from mild steel sheet was monolithically lined with fire clay refractories and designed to attain a temperature of 1200^{0}C on the automatic control panel. This project was primarily undertaken to build local capacity in foundry practice in Nigeria and to encourage the demonstration of fundamental foundry practice for undergraduates of a Nigerian University.*

KEYWORDS -*Furnace, Temperature, induction, Foundry, Ferrous, Non-ferrous*

I. INTRODUCTION

1.1 Background of the Study

Electric Induction heating is a non-contact heating process which is used to bond, harden or soften metals or other conductive materials [1, 2]. In advanced manufacturing processes, induction heating provides an appealing assemblage of speed, consistency and control. Induction heating has a good heating efficiency, high production rate and clean working environments. The fundamentals of induction heating have been apprehended and utilized in manufacturing since the 19th century [1, 3, 4]. Historically, the early development of Induction furnaces started from the discovery of the principle of electromagnetic induction by Michael Faraday. However, De Ferranti in the late 1870s started experimenting with induction furnaces in Europe. Edward Allen Colby patented an induction furnace for melting metals in the year 1890 and produced the first steel the United States in 1907 [5].

During World War II, the technology grew rapidly to satisfy pressing wartime demands for a quick and authentic method of hardening metal engine parts. Lately, the concentration on lean manufacturing techniques and emphasis on improved quality control have led to a rediscovery of induction technology, along with the development of precisely controlled solid state induction power supplies [1]. In a majority of the heating methods, a torch or open flame is instantly applied to the metal part, but with induction heating, heat is actually "induced" within the part itself by circulating electrical currents [1]. On account of heat being transferred to the product through electromagnetic waves of which the part never comes into direct contact with any flame, there is no product contamination and when duly set up, the process can be replicated and controlled. This dissertation deals on the construction of an electric heat treatment furnace with easier and better control system and timing unit.

Typical applications of induction heating are melting of metals, heating of metals, brazing and welding and all sorts of surface treatments. However, by using electric conductive recipients (e.g. graphite) also other materials like glass can be heated. Surface hardening techniques are suitable for steel with a carbon percentage of at least 0.3 %, where the work piece is heated up to approximately 900°C and after that it is chilled [4]. This technique is used for the hardening of gear wheels, crankshafts, valve stems, saw blades, spades, rails, and many other things. The inductive process has the advantage that the treatment can be localized very accurately.

II. MATERIALS AND METHODOLOGY

This chapter introduces the materials and methods employed in the design and development of the electric induction heat treatment furnace.

2.1 Materials

The materials utilized for the design and development of the Electric heat-treatment furnace are: 1.5 mm thick steel sheets, kaolin clay, hard wood saw dust, temperature controller, switch, light indicators, wire, heating element-copper coil. Tables 1-2 show the detailed materials used in the development of the electric heat treatment furnace and their cost implications. The total costs for a unit is $862 (Eight hundred and sixty two dollars).

2.2 Furnace casing

The steel sheet selected is a mild steel of composition: 0.15% C, 0.45% Mn, 0.18% Si, 0.031% S, 0.001% P, 0.0005% Al, 0.0008% Ni and 0.1867% Fe. It was selected for the fabrication of the furnace casing because of its light weight, good strength, excellent formability, weldability, availability, and low cost of purchase. The furnace casing houses all the components of the furnace including: the refractory bricks and lining, the electro-technical devices (temperature controller, light indicator etc.), the coils. The design was made taking into consideration that the control box should be attached to the casing, and the control box must have holes for easy wiring. The casing was made from a 1.5mm thick flat sheet of mild steel. The sheet was cut to size of 500mm and then folded into box shape. The folding joint was seam welded for strength and rigidity.

2.3 Design/Model Drawings

The design/model drawings of the furnace were achieved using AUTOCAD. Figures 1-11 show the various views and sections of the electric heat treatment furnace developed.

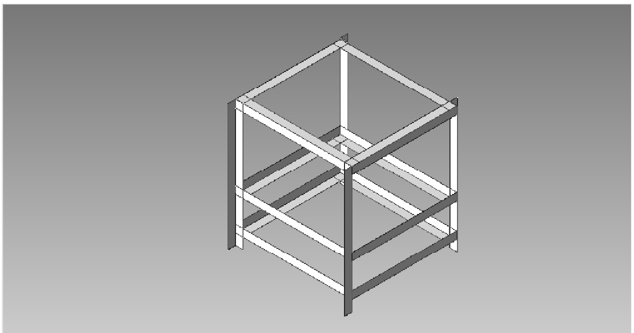

Figure 1 Skeletal Frame Work of the Furnace.

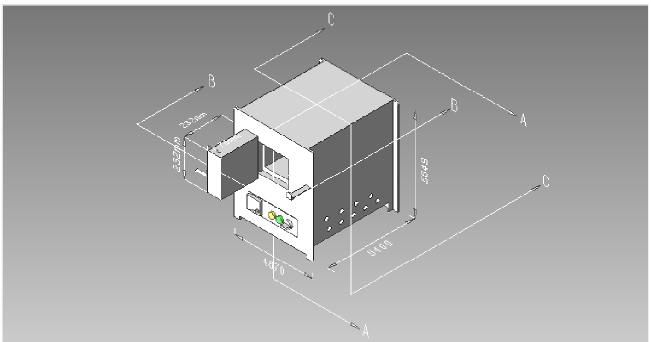

Figure 2 Furnace Pictorial view with Detailed Dimensions

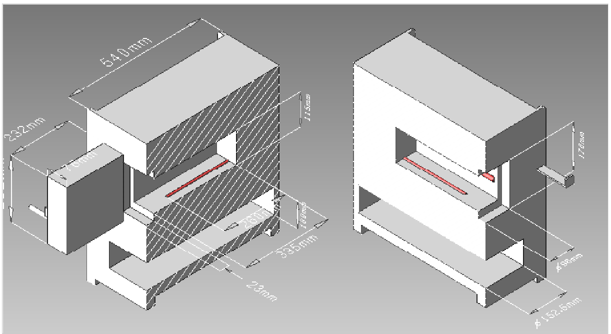

Figure 3 Section A-A of the Furnace

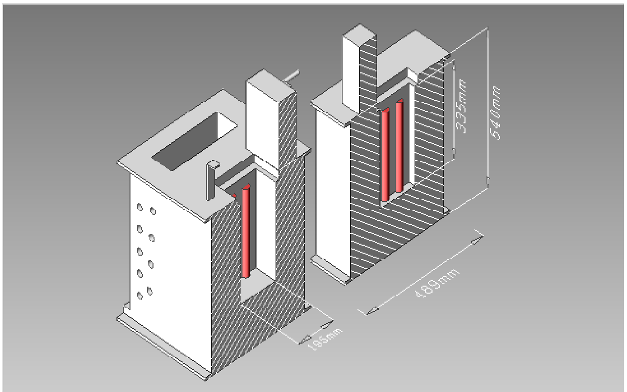

Figure 4 Section B-B of the Furnace

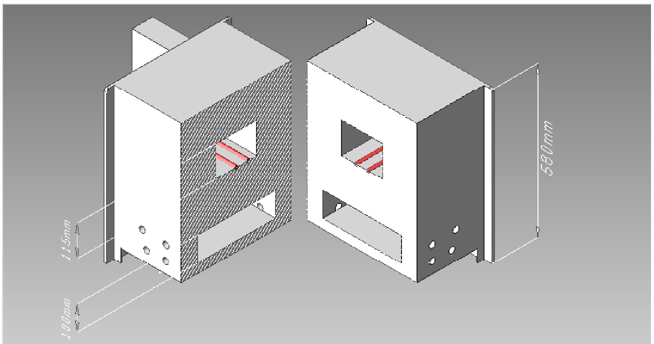

Figure 5 Section C-C of the Furnace

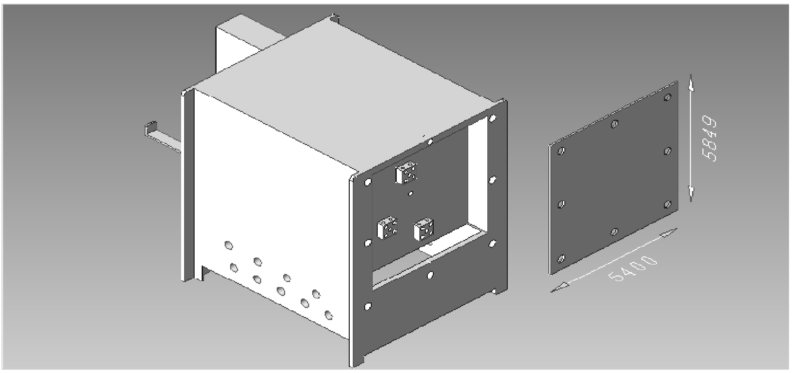

Figure 6 Back View of the Furnace.

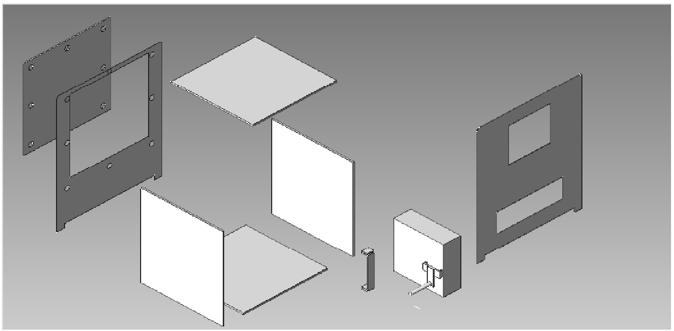

Figure 7 Parts of the Furnace

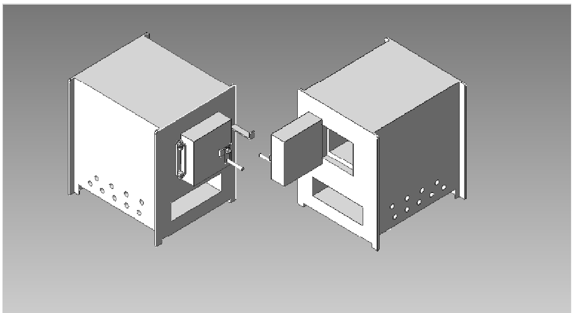

Figure 8 Furnace with the Door Opened and Closed

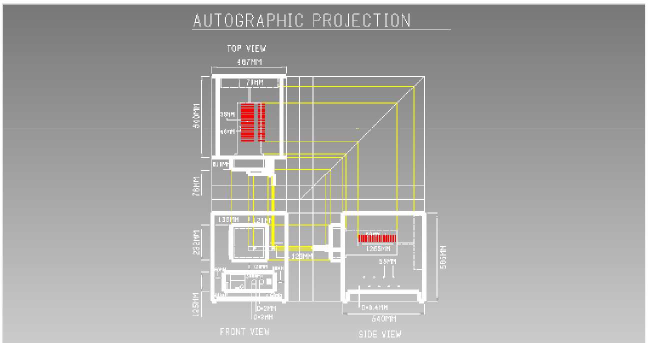

Figure 9 Autographic Projection of the Furnace

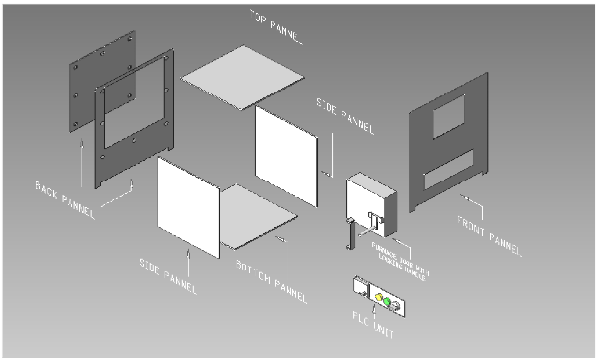

Figure 10 Labeled Furnace Parts

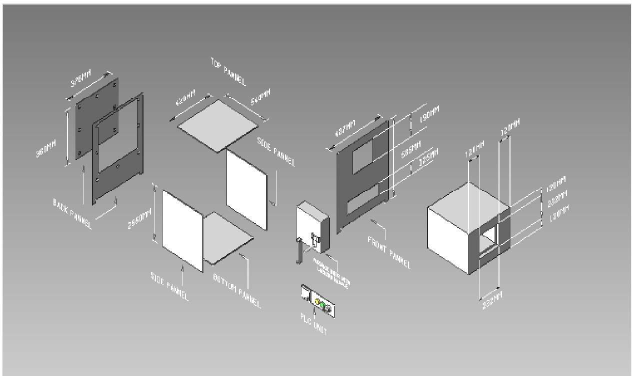

Figure 11 Dis-Assembling Drawing

Table 1 List of Materials, Their Source and Function

S/N	MATERIAL	SOURCE	FUNCTIONS
1	Metal sheet	Diamond Metraco International Ltd, 1387 Bridge Head Market, Onitsha	Metal sheet was used to build the casing or panel of the furnace. It is capable to withstand high temperature It hardly gets burnt It has the tendency to withstand sagg
2	Angle iron	Zonal Steel company, A377 Bridge Head Market, Onitsha	It acts as a reinforcement to the casing and through which the legs are provided
3	Asbestos sheet	Naze Timber shop, Owerri	This contributes to retain the heat in the furnace i.e. it prevents heat loss. It prevents damage to the metal casing by preventing excess heat that mat burn the metal body or cause corrosion
4	Fire clay	Nwanneji & Sons (Nig) Itape	This was used for casting. It has the tendency to withstand crack and breakage when heated. It has the ability to retain heat
5	Beads	Bridge Head Market Onitsha	They act as insolators to prevent current from escaping the induction coils. The prevent shock
6	Induction coils	Rusana Electrical store, No. 65 Old Aba Road PH	It produces heat for heat treatment
7	Temperature relay	Rusana Electrical store, No. 65 Old Aba Road PH	It displays the temperature of the furnace. It displays working principles
8	Circuit breaker	Rusana Electrical store, No. 65 Old Aba Road PH	It controls the working principles of the electrical parts
9	Switch	Rusana Electrical store, No. 65 Old Aba Road PH	It acts as the powering section of the furnace
10	Indicators	Rusana Electrical store, No. 65 Old Aba Road PH	One indicates power ON and OFF, the other indicates danger
11	Electrodes	Elinus and son Enterprises, Steel Market, Owerri	It was used for the joining and welding together of components
12	Water	School borehole	It was used to make the solution of fire clay and silica
13	Cable	Onitsha	For the connection and wiring of the electrical and power systems
14	Fuse	Rusana Electrical store, No. 65 Old Aba Road PH	For the transfer and grip of current
15	Filler	Shop 35 A, New market, Owerri	It was used for filling up of opened regions on the panel
16	Paint	Shop 35A New market, Owerri	It was used for the nice looking and finishing of the project
17	Template	University workshop	It was used for the excavation of the opening for heat treatment portion

Table 2 Bill for Engineering Measurement and Evaluation

S/N	MATERIAL	QUANTITY	UNIT COST ($)	TOTAL COST ($)
1	Metal sheet (1.5mm)	1	36	36
2	Angle iron 2X2	1	31	31
3	Template	-	16	16
4	Asbestos	¼ roll	13	13
5	Fire clay	3 bags	47	141
6	Purslin Beads	200	0.5	100
7	Heating Element	5	9	45
8	Temperature relay	1	128	128
9	Circuit breaker	1	31	31
10	Switch	1	5	5
11	Indicators	2	2.6	5.2
12	Electrodes	1	10.25	10.25
13	Cable/wire	15Meters	1.30	19.5
14	Fuse	1	5	5
15	Filler	-	-	8
16	Paint	1	13	13
17	Transportation/Logistics			105
18	Labour costs			150
	Total			$861.95

III. FURNACE PERFORMANCE AND EVALUATION

The Electric heat treatment furnace was evaluated to ascertain its performance by heat treating mild steel with the following dimension: length 150mm and diameter 50mm at the range of temperature 35˚-1200˚ over a period of 2000 seconds. The results obtained were tabulated as indicated in Table 3 and graphically in Figure 12. It was observed that the temperature of the furnace was maintained at 1200 degrees over a period exceeding 2000seconds and this shows that the furnace was designed to attain a maximum temperature of 1200˚.

Table 3 Performance Analysis of Heat treatment of mild steel conducted on the furnace

Time (Seconds)	Temperature (Degree)
0	35
30	200
120	400
260	600
580	800
1000	1000
1500	1200
2000	1200

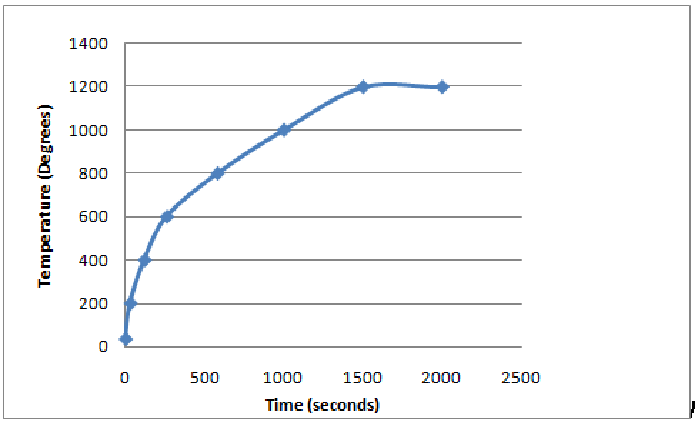

Figure 12 Graphical representation of the performance of the furnace during heat treatment of mild steel.

IV. CONCLUSION

This project was undertaken to design and develop an electric induction heat treatment furnace for undergraduate students' demonstrations on heat treatment processes such as annealing, normalizing, case hardening, tempering, spheroidizing etc. in the Mechanical Engineering Foundry Shop. The furnace was constructed putting into consideration; its temperature attainment, capacity of metals it can hold, the depth/surface area to be heat treated, operators safety, space to be occupied in the workshop floor, cost restrictions, availability of the materials used, its maintainability and portability **.**

Finally, the actualization and realization of this project is a boost to the development of local manpower capacity in Nigeria and also to advance the reliability of engineering materials in service.

REFERENCES

[1]. *http://www.gh-ia.com › Induction Heating retrieved on 29/1/2015.*
[2]. http://www.inductivelogic.co.uk/induction-heating-products.html retrieved on 29/1/2015.
[3]. Bala, K.C. (2005). Design Analysis of an Electric Induction Furnace for Melting Aluminum Scrap, AU J.T. 9(2): 83-88.
[4]. Anaidhuno, P. U. (2014). Construction of an Electric Heat Treatment Furnace, M. Eng Thesis; Mechanical Engineering Department; Anambra State University, Nigeria.
[5]. Gandhewar, V.R., Bansod, S.V., Borade, A.B.(2011).Induction Furnace-A Review,International Journal of Engineering and Technology Vol.3 (4), 277-284.