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Design and Fabrication of Charcoal fired Crucible Furnace

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Abstract— **The study carried out a design and fabrication of Charcoal fired Crucible furnace. Now-a-days an immensely colossal variety of heating techniques/furnaces are available. Taking into consideration the effect of cost, safety, simplicity and facilitate of construction we are going for conventional heating furnace. In this research work 3kg capacity of aluminum crucible furnace that is fired with charcoal. The capacity of furnace drum is 0.34 m3. The air blower discharge into furnace at the rate of 0.2m^3/s. Charcoal fuel as high calorific value 6900 KJ/Kg. This paper shows the design and fabrication of crucible furnace and aluminum melted and casted to compose.**

***Keywords*— Crucible furnace, Charcoal, design, Fabrication, Casting, Aluminum.**

I. Introduction

Furnace is the tool that is used to warmth and melting the metal. In traditional technique the furnace may be heated by fuel as in lots of furnaces coke is used. Now a days the various sort of furnaces is available like electric furnace, oil fired furnace, diesel furnace, induction furnace, cupolas, crucible and direct gas fired furnace. The furnace is on the whole used for casting the metal. Crucible furnaces are one of the oldest and simplest styles of melting furnace unit used in the foundry. The furnaces use a refractory crucible whichincludes themetal charge.The price isheated t hrough conduction of warmth through the walls of the crucible. The heating fuel is generally coke, oil, gas or electricity. Cruciblemelting is normally used wherein small batches of low melting factor alloy are required. The capital outlay of those furnaces makes them appealing to small non-ferrous foundries.

A crucible furnace is a simple and very old type of melting unit generally used in foundry. The crucible furnace typically uses a refectory crucible with contains a metal fee. The real crucible is a container that could face up to very excessive temperatures and is consequently used to melt materials inclusiveof metals.The rate isheated using co nduction through the partitions ofthecrucible;its typically fu eled byusing coke, oil, gasoline or electricity.

Types of Furnace

Interestingly, how we commonly classify a furnace is by the method used for removal of the metal from the crucible.

1. Tilting you would mechanically tilt the crucible to the mould
2. Lift Out lifting it out then pouring it into the mould.
3. Bale Out ladled the metal out into the mould.

Blacksmith is an historic and known trade to humans. With the increase within the use of metals because of their amazing mechanical properties, foundry operation keeps increasing. Aluminum is certainly one of the maximum recycled steel international over, and according to, aluminum recycling is considered one of the most lucrative business practices in Nigeria and the sector at large. This will be attributed to the truth that it takes lesser amounts of energy to supply aluminum via recycling than through its ore. Therefore, it's far vital to harness every to be had supply of strength to ensure that the enterprise of aluminum recycling in Nigeria, gains extra ground. In trying to reap this task, using furnaces can't be overemphasized. A furnace is a lagged enclosure designed in general for heating of metals so that it will obtain a metallurgical change. This exchange should either be to refine the microstructure of the metal as inside the case of a warmness remedy furnace, or it may be to reap the pouring temperature of the steel as inside the case of melting. It to this cease that this take a look at intends to design and assemble an oil-fired furnace with the primary objective of making sure high efficiency in melting of aluminum, by successfully minimizing warmness losses, and maximizing heat generation.

II. Material Selection

The choice of materials for the construction of the furnace was based on the following engineering requirements:

- Weldability: This is the ability of the material to be welded
- Toughness: This is the ability of the material to withstand shock and absorb energy due to impact.
- Fatigue: This is the ability of the material to withstand cyclic stresses.
- Ductility: This is the ability for the material to be drawn into wire.
- Durability
- Availability

The mild steel plate used for fabricating most components of the furnace is ductile, thus making it possible for it to be rolled, folded and bent without cracks or fractures. The under listed materials were specified for the design of charcoal fired crucible furnace.

I. Mild steel plate (2mm)
II. Flat bar (5mm mild steel)

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III. Refractory bricks
IV. Graphite Crucible
V. Air blower
VI. Crucible holders

III. METHOD OF CONSTRUCTION

The charcoal fired crucible furnace was designed majorly to melt aluminum material. However, the crucible furnace can also be used to melt other metals such as copper whose melting temperatures falls within its designed operation temperature range of 500^0C to 1200^0C. Some of the equipment used in fabricating the various parts of the furnace are as follows:(a)Folding/rolling machine (b) Drilling machine (c)Welding machine (d)Cutting tools (e)Marking/Measuring tools etc.

Fabrication of Furnace Drum

The furnace drum was made from a mild steel plate of 2mm thickness. The mild steel plate has been welded the construction of steel plate base subsequently welded to the bottom of the folded drum with the aid of an arc welding machine. See fig.1

Fig.1 Furnace base

The dimensions of the furnace drum were 700mm length and 650mm width and the height of the drum is 800mm. the volume of the furnace drum is 0.34m^3

Fig 2

Fig.2 & 3 welding process

A. *Refractory Brick*

The inner surface of the furnace drum was lined round with a single layer of bricks of about 115mm thickness using the refractory mixture comprising of sodium silicate, kaolin, sawdust and water as a binder to fill the spaces in between bricks in order for them to hold firmly together. The base of the furnace was lined with double layer of bricks of about 230mm thickness using the same mixture. See fig.4

Fig. 4 Refractory Brick

B. *Graphite Crucible*

Graphite crucible is widely used in metallurgy, foundry, machinery, chemical industry and other industry sectors for the smelting of non-ferrous metals and their alloys because of its excellent properties and it has a good technical and economic effect. The dimension of the graphite crucible were 72mm outer diameter, 66mm bottom diameter, 51mm internal diameter and height 110mm. see fig.5

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Fig.5 Graphite Crucible

C. Air Blowers

An air blower is the device which is used for generating the flow of air at substantial pressure. Generally air blowers are used for vacuum cleaners, air conditions, and car cleaning purpose. The air blower discharge into furnace at the rate of 0.2 m^3/s.

Fig 6 Air blower

D. Crucible Holders

The main crucible holders uses are related to pick up, remove and handle hot container crucible. They are used in foundry to move crucibles containing hot molten metal to mold cavity. This is made up of mild steel material. See fig.7

Fig.7 Crucible Holders

IV. WORKING PRINCIPLE

The furnace is first and predominant preheated before firing it by means of igniting flammable materials which includes charcoal in the flamable chamber. While the charcoal is still burning the valves that manage the deliver of charcoal on the supply pipe and air from the air blower thru the nozzle respectively are slightly opened to allow in drops of gas and air beneath pressure. The air is blown over the gasoline to atomize as well as oxidize it for combustion. As the combination of air and fuel blows over the pre-lit coal it helps to preserve the combustion. As this maintains over time, the temperature rises gradually within and around the crucible, thereby melting its content material. The furnace temperature can be study directly from a thermocouple inserted into the furnace via the cover. When the crucible content is absolutely melted and is prepared for pouring, the crucible is lifted out by a lifting tong, which is treated by way of two persons after which poured into the organized mould cavity. The holes on the edges of the furnace are made to preserve a balance among the pressure within and out of doors the system.

Fig 8 Furnace Setup

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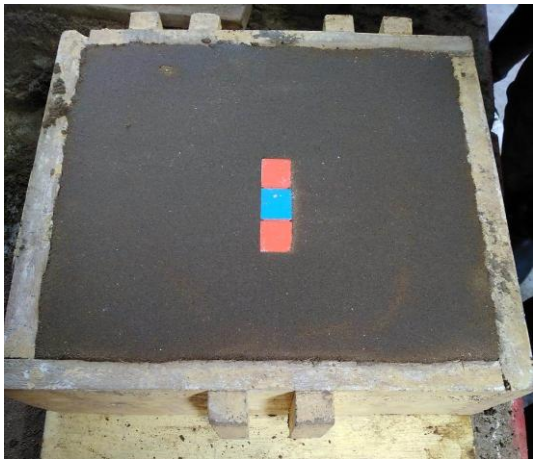

Fig 9 Pattern Molding

V. Design Analysis

A. *Design Analysis of Furnace Drum*

The furnace drum was made from a 3mm thick mild steel plate. The Detailed dimensions of the furnace drum are as follows:

1. Height of the furnace drum before laying bricks (h)= 800mm
2. Height of combustible space of the furnace drum after laying of bricks (h1) = 600mm
3. Internal height of the furnace drum before laying of bricks (d) = 780mm
4. Internal height of the furnace drum after laying of bricks (d1) = 550mm
5. Inlet diameter of the burner nozzle = 80mm
6. Outlet diameter of the burner nozzle = 30mm
7. Total height of the drum = height of drum + height of cover = 800 + 98 = 898mm.
8. Thickness of the metal plate = 2mm

B. Design of Crucible & Brick

The detailed dimension of the Furnace crucible and refractory brick are as follows:

- Height of crucible = 110 mm
- Width of crucible= 66 mm
- Thickness of crucible= 10 mm
- Taper bottom portion= 70 mm
- Density of bricks used= 4900 kg/m^3
- Mass of brick = 3.98 kg
- Weight of brick = mass*gravity

W = 3.98*9.81= 39.04 N

C. Design Analysis of Air Blower

The air blower is rated as follows;

- Outlet pressure = 1300 N/m^2
- Speed = 2650 rpm
- Power = 0.45 KW
- Voltage = 220 V
- Current = 2.5 Amperes
- Average rate of air flow from blower = 0.2m^3/sec
- Average rate of fuel flow = 0.055m^3/min

VI. Performance Of Furnace

The furnace was fired and the time taken to raise the Temperature to 660°C was 25 minutes. Thereafter, the 3 kg of aluminum scrap was placed in it. A holding time of 23 Minutes was required to completely melt the aluminium Batch. The furnace design temperatures are as follow:

- The ambient temperature, Ta = 28°C
- The melting temperature of the aluminium, Tm = 660°C
- Furnace Maximum Design Temperature = 850°CThe efficiency of the furnace is 35.67% as per the calculation.

Table 1 furnace temperature with respect time

Time (min)	Temperature attained (^{0}C)	Heat rate (^{0}C/min)
4	120	30
8	203	25.375
12	298	24.84
16	386	24.125
20	469	23.45
24	598	24.916
28	745	26.61
32	876	27.37

VII. Result And Discussion

From the results acquired above, the performance of the furnace was determined to be within the range of 25% to 38% showing that maximum of the heat generated in the furnace was absolutely used inside the melting of the metal. A crucible furnace of 3kg melting ability has been designed consistent with the set goal of the studies work. Withthe design efficiency of about 17%,when compared wih the performance of 21% obtainable from the conventional crucible furnace, it is able to be stated to be over76%efficient aswellas effective, andmay comfortably u pdate the traditional imported crucible furnace in keeping with the Federal Government import substitution policy so one can conserve foreign exchange. Moreover, with layout temperature range of 500^{0}C to 850^{0}C, aluminum may be with ease melted the use of the 3kg melting furnace.

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