Design and Manufacturing of Portable Metal Melting Furnace

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ABSTRACT

The expanding interest for aluminum scrap (as waste constituent) in our environment can't be ignored. Henceforth, an enhanced arrangement of continuous aluminium recycling as a secondary aluminium generation is composed and developed. A gas-fired crucible furnace is designed and manufactured for melting aluminium scrap. This furnace is a modified model appropriate for labs and workshops. This heater is composed and manufactured utilizing locally accessible materials and LPG gas as the thermal energy source in heating up the system to the melting point of aluminium (659 °C). The liquid aluminium is poured to a desired shape and size either as a aluminium block or final product.

***Keywords**—Furnace, Aluminium, Melt treatment, Materials*

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1. INTRODUCTION

Making aluminium from crude materials is a compound process. However once made the metal can be softened down and improved without losing any quality.The procedure can be performed again and again.Recycling of aluminium not only saves energy but also reduces around 95% of the greenhouse gases emission as compared to 'primary' production process. Recycling 1 tonne of aluminium saves 9 tonnes of CO2 emissions; So when you consider that 1 tonne of CO2 is equivalent to driving 2800 miles the benefits of recycling really begin to become compelling.The motive of this project is design and manufacturing of a portable metal melting furnace which will operates on LPG gas with the help of burner. Melting of metals, glass, and different materials has been an essential process for a few 1000 years, creating liquid fluids that can be emptied and cemented into valuable shapes. The melting process is not only responsible for the energy consumption and cost-effectiveness of producing the castings , but it is also critical to the control of quality, composition, and the physical and chemical properties of the final product. In this venture we will plan and make a convenient metal melting furnace which will work on natural gas with the assistance of burner.

2.LITERATURESURVEY

Secondary aluminium production (recycling) saves 95% energy needed to produce aluminium from its ore [1]. Hence, it is more of economic importance that aluminium recycling becomes a major source of aluminium production [2]. Aluminium is primarily used to produce pistons, engine and body parts for cars. Beverages cans, doors, sliding door and aluminium foil. It may also be used as sheet metal, aluminium plate and foil, Rods, bars and wire, aircraft components, windows and door frames. The leading users of aluminium include the container and packaging industry, the transportation industry, building and construction industry [3]. Aluminium can either be produced from bauxite ore (primary aluminium refining) or from aluminium scrap (secondary aluminium refining). Refinement of aluminium ore is sufficiently expensive that the secondary production industry commands much of the market. It is recorded that about 40% of aluminium in the US is recovered from secondary refining [4]. Hence, the interest of this project lies on the secondary aluminium production. Furnace is a space surrounded on all sides by walls and a roof for heating metal or glass to very high temperatures [5]. The earliest furnace was excavated at Balakot, a site of the Indus valley civilization. Then, furnace was most used for the manufacturing of ceramics objects [6]. Furnaces operate in aggressive environment, where several components-molten metal, furnace lining, atmospheric gases, and products from combustion of fuels- coexist at extreme high temperature. Aluminium melting furnace derives its heat from solid fuel (coke and breeze), natural gas, electricity, or other source of energy. Furnaces vary in design, geometry, production capacity (melting rate), materials of construction, and mode of operation [7]. Other factors related to the energy source also affect the furnace design which includes how the energy is transferred to the molten material, how combustion gases are removed, and what refining and treating equipment must enter the furnace, how long the holding periods are, and how the molten metal will be tapped. Several factors come into play besides the core ingredient of heat and metal.[8]

3. PROPOSED SYSTEM

3.1.Concept Diagram

We are going to develope a circular furnace built of steel sheet and for support the steel bars are utilizedY. Furnace is implemented with rotary wheels for simple moving. Furnace will be covered with steel sheet lid having a round opening. Inner wall of furnace is covered with insulation. There will be arrangement for putting graphite crucible. As we start burner the inner side will start heating and steadily melting.The operating temperature required in the furnace depends on the required+ melting and pouring temperature of the materials being melted. They can range from about (650 F)350 °C for zinc alloy to (3100F) 1700 °C for alloy steels. But for aluminium, the operating temperature is greater than 650 °C. There are various types of furnaces and all the furnaces are mainly classified according to their energy source, and applications. The different types of furnaces are: Crucible Furnaces, Induction Furnaces, Dosing Furnaces, Immersion Furnaces, Reverberatory Furnace, Stack Furnace, etc. The furnace of interest in this research work is the crucible furnace.

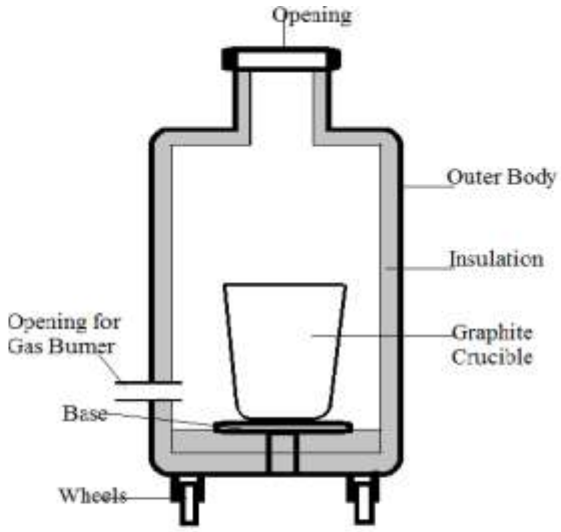

Fig 1. Concept diagram

4. MATERIALS AND METHODS

4.1.Materials Selection and Criterion

The materials used in the course of this research work are sourced locally and selected based on their thermal properties, insulation ability and availability. The selected materials and there specifications are shown in the table below. The components used for the manufacturing are Metallic plate, Insulating material (glass wool), Burner, Gas Cylinder, Gas pipe, LPG Gas, Graphite Crucible, Gas regulator.

Sr.no	Components/ Materials	Quantity	Specification
1	Metallic plate	1m x 2m sheet	3 mm thickness (mild steel)
2	Insulating material	1	Glass wool
3	Burner	1	Locally fabricated
4	Gas Cylinder	1	5 kg
5	Gas line/pipe	1	1500 mm
6	Gas	5 kg	LPG
7	Crucible pot	1	Graphite crucible
8	Gas regulator	1	1.0 kg/hr

Table 1. Component selection table

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4.2.Design Model

The design of this research work is based on thermodynamic analysis of furnaces, materials availability, energy source and transfer. The following parameters guided during the design and fabrication of this melting furnace

- Materials availability: Materials for the construction of the furnace are selected due to their availability and ability to withstand the desire temperature and purpose of the system.
- Energy source and transfer: Cooking gas (butane) is combusted in air (oxygen) and the heat produced is directly used as the thermal energy source. Energy transfer applicable in the design is multimode, which is a combination of radiation, convention and a little of conduction.

4.3.Structural Design

The structure of the furnace is cylindrically designed. This cylindrical structure is so desired, technically due to effectiveness in thermal distribution within the furnace chamber. The structure is explicitly detailed in the drawing below

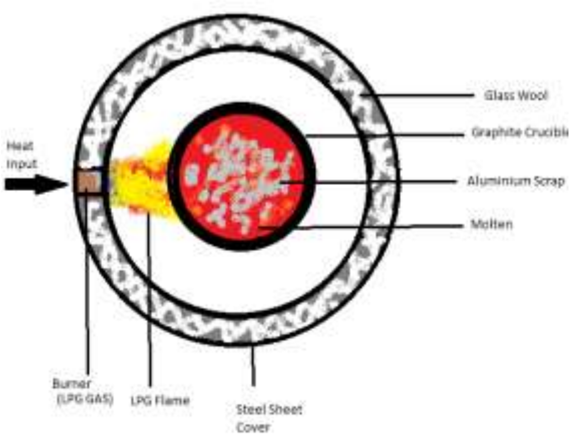

Fig 2. Melting operation

4.4.Major Feature of the Furnace

The design model is a modification having the following under listed features;

i. The body and chamber: the body is formed from a cylindrical shape of 2mm thick steel sheet. The body form a melting chamber enclosing the insulating materials (glass wool), and crucible.

ii. The burner: the burner is externally attached to the body and tangentially positioned to burn the supplied gas (using atmospheric oxygen as the heat source to the melting chamber.

iii. The crucible: the crucible is a locally made graphite pot placed in the melting chamber for the purpose of holding the molten aluminium to the time of casting.

iv. Roof/cover: the use of furnace cover is critical to energy efficiency. This is constructed with the same materials as the body, which reduces conduction and radiation heat loss.

v. Circular opening: a circular opening of 150 mm diameter pipe is attached to the cover, for reduction of internal furnace pressure gradient built across the ceiling, and waste gas exit and to introduce fresh oxygen into furnace for proper combustion.

4.5.Fabrication Procedure and Assembly

3 mm mild steel sheet metal was cut to dimension and shaped to form the cylindrical structure of the furnace. Glass wool was used as insulating materials, cut and placed internally on the sheet-metal floor and wall.The circular furnace is provided with opening and closing lid with small opening at top. The inside of furnace is provided with a circular platform for placing a graphite crucible. The whole inside surface is insulated with glass wool insulation. Liquefied Petroleum Gas (LPG) will be used as a fuel. The gas burner will be provided for burning process. Gas burner flame will be in direct contact with graphite crucible. The four wheels will be there for movement and portability of the furnace.

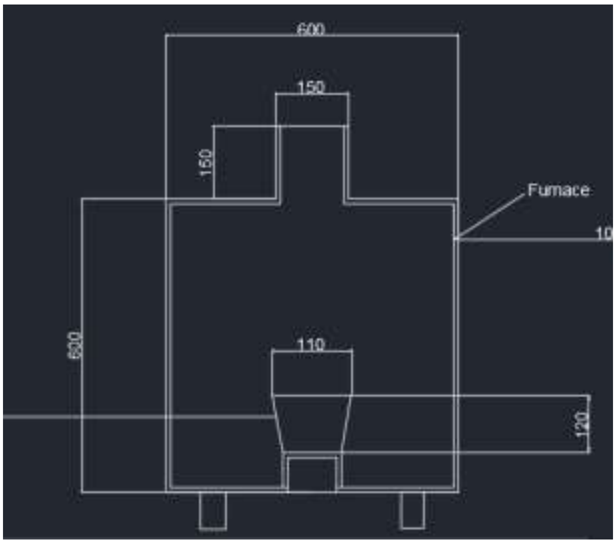

Fig 3. Furnace dimensions

5. SCOPE

In this furnace we have used a single burner but for more uniform heat distribution we can introduce more number of burners. The insulating material we used in this furnace is glass wool which can insulate temperature up to 250 ^{0} C which is favourable to the aluminium melting. If we want to use the furnace for different metals having higher melting point, then we have to replace the glass wool by other insulating material which can insulate higher temperatures. For pollution control, we can replace the LPG by CNG but, it affects the furnace cost and availability.

6. RESULTS

After a thorough analysis and calculations, the following parameters were used during the designing and fabrication of aluminium melting furnace using locally available materials. The obtained parameters as calculated are shown in Table 2 below.

6.1.Furnace Performance and Evaluation

The aluminum melting furnace was evaluated to ascertain its performance by melting aluminum scraps at a temperature of 660 °C. In first 15 minutes preheating treatment should be done so that furnace will be ready for further melting process. The results obtained were tabulated as indicated in Table 2.

6.2.Preheating

Time (minute)	Temperature (Degree celcius)
0	35
05	180
10	310
15	370

Table 2: Performance Analysis of the Furnace during preheating

6.3.Actual melting after preheating

Time (minute)	Temperature (Degree celcius)
0	370
10	520
15	680

Table 3. Performance Analysis of the Melted Aluminum Scrap on the Furnace

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