Design and Manufacturing of Portable Metal Melting Furnace

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Abstract

Aluminium scrap is increasing day by day in environment; hence it is necessary to recycle that scrap. Aluminium recycling is an excellent example in the efficient utilization of secondary aluminium recovery. Hence an enhanced system is designed for continuous recycling of aluminium. Efficient melting of scrap is a critical issue in order to accomplished higher metal recovery. A crucible furnace is designed and fabricated for melting the aluminium. This furnace is a modified model suitable for labs and small scale industries.

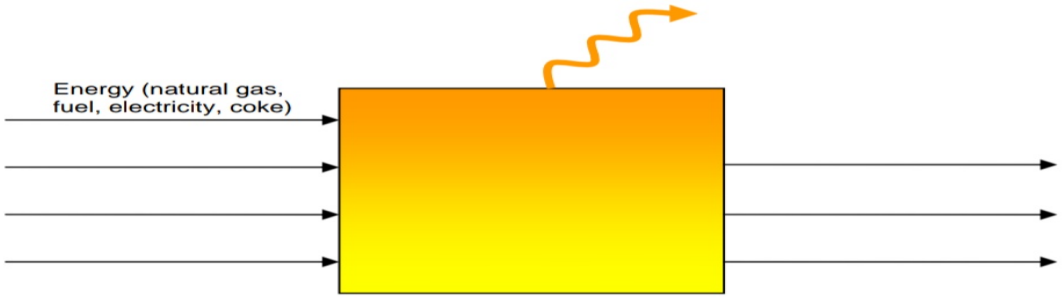
The increase in use of fossil fuels as thermal energy source, pollutant emission control has become a global concern. The furnace is manufactured using locally available materials and LPG (Liquefied Petroleum Gas) as thermal energy source to heat up the crucible upto melting point of aluminium. Use of LPG will reduce the emission of greenhouse gases (GHGs). The molten aluminium is then poured into mold of required shape and size.

Keywords: Aluminium, furnace, LPG, portable, heat transfer, crucible.

INTRODUCTION

Aluminium can be produced by either refining from bauxite ore (primary production) or from aluminium scrap (secondary production or recycling). Once made, the aluminium can be softened down and improved without losing any quality. Recycling aluminium saves energy as well as reduces 95% greenhouse gas emissions compared to producing aluminium from its ore. Melting process is mainly responsible for energy consumption as well as it is critical to control the facet, composition and properties. Hence, recycling aluminium becomes more of economic importance and major source of aluminium production as well.

Furnace operates in aggressive environments, where several components molten metals, furnace lining, atmospheric gases and products from combustion of fuels coexist at extremely high temperature. Several factors come into play besides the core ingredients of heat and metal.



Fig,1:Schematic of melting process

A melting furnace derives its heat from solid fuels, LPG, electricity or other source of energy. Furnaces vary in design ,geometry, capacity productivity, material of construction and mode of operations. Other factors related to the energy source also affect the furnace design, which include how the energy is transferred to the molten metal. The operating temperature required in the furnace depend on the melting and pouring temperature of the materials being melted.

The effectiveness of furnace can be expressed in different ways, the primary aim is to determine quantity of fuel essential for the melting operations The aim of the project is to design and manufacturing a furnace for secondary production of aluminium which will use LPG as fuel. The furnace is implemented with rotary wheels for easy movement. In this venture we will plan and make convenient furnace which work on LPG provision of burner.

R. Goldstick et al. [1] experimented and concluded recycling saves energy and also reduces greenhouse gas emissions compared to producing aluminium from its ore. As most of aluminium is formed by recycling hence it is more economical. Hence, it is more of economic importance that aluminium recycling becomes a major source of aluminium production.

Amit Joshi et al.[2] studied that aluminium is basically used to produce pistons, engine and body parts for cars, doors, sliding door and aluminium foil. It may be also used as sheet metal, aluminium plate and foil, Rods, bars and wire, aircraft components, windows and door frames .Melting of metals has been an essential process for a few 1000 years, molten metal can be emptied into valuable shapes.

T.Niehoff et al.[3] emphasis on furnace is a space surrounded on all sides by walls and a roof for heating metal or glass to very high temperatures .It derives its heat mainly from coal or solid fuel hence there is necessity of using alternative source of energy for environment sustainability and to make the operation more flexible.

Vivek R. Gandhewar et al.[4]has discussed present practices followed in induction furnaces and focus on enhanced the efficiency of steel melting processes also concluded that induction furnace limits the type of scrap to be melted.

Bo Yunjang et al[5] work considers the other factors related to energy source also affect the furnace design which includes how the energy is transferred to metal. The energy is transferred with the help of graphite crucible which offers high thermal conductivity and reduces carbon contamination. [6]Mineral wool is used for insulation which can withstand temperature up to 1200C.

Oldrich Zmeskal et al[8] studied the thermal properties of mineral wool (glass wool), the fiber material are mostly used as thermal insulation in industrial furnace, hence it is primary aim to develop a method to determine its properties like specific heat thermal diffusivity and its conductivity.

Nieckele Angela et al[7]Due to worldwide use of fossil fuels the global warming has become an issue of global concern. With the use of LPG, gas reduction in Green House Gases (GHGs) emissions such as CO, SOx, and NOx can be done.

PROPOSED SYSTEM:

There are various types of furnaces classified according to their energy sources and applications such as cupola furnace, electric arc furnace, induction furnace, stack furnace and reverberatory or crucible furnace. The furnace of interest in this research work is crucible furnace. The outer body of circular furnace is built of steel sheet and square pipes are used for support. Inner wall of furnace is lined with the help of insulation. There will be arrangement for putting graphite crucible. After starting the burner, inner side will start heating and melting. The operating temperature required in furnace will depend on materials being melted. For melting aluminium the temperature must be greater than 659^0C.

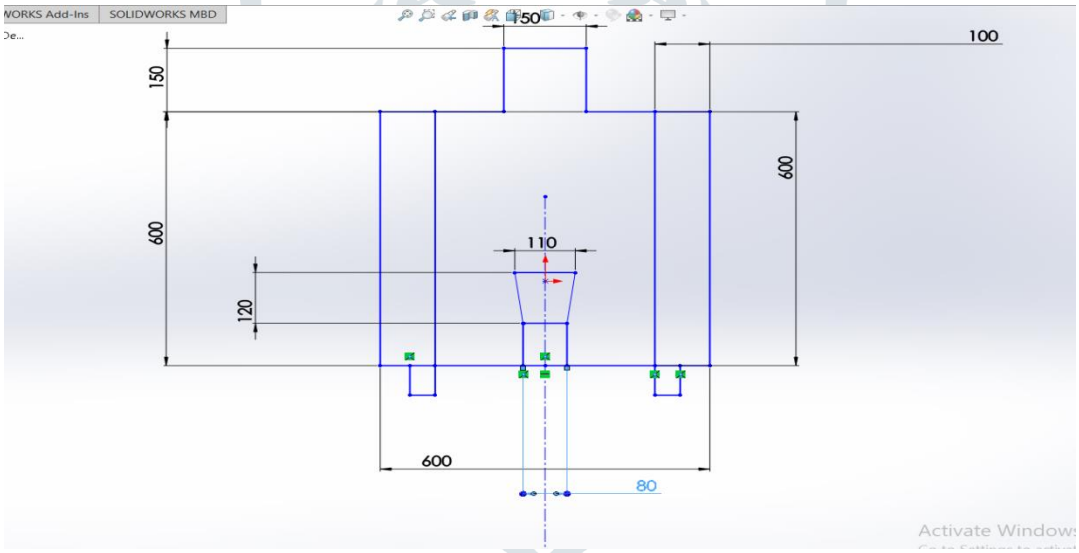


Fig.2 Proposed system

Material Selection:

The materials are selected based on thermal properties, local availability and insulation ability. The materials selected and specifications are shown in the table below.

Sr no.	Components	Specifications
1	Steel sheet	2mm thickness
2	Square pipes	
3	Insulating material(Mineral wool)	Thermal conductivity=0.04W/mk
4	Graphite crucible	Conductivity=6W/mk
5	Burner	
6	Regulator	1kg/hr
7	Gas line	1500mm

1. Steel sheet: 2 mm thick steel sheet is used to form outer cylindrical body of a furnace.
2. Square pipes: these are used for support.
3. Insulating Material: Mineral wool is used to reduce the heat transfer from the furnace.
4. Graphite Crucible: The graphite pot is placed in furnace with the help of arrangement so as to melt the aluminium and hold the molten aluminium up to time of castings.
5. Cover: This is provided to reduce the conduction and radiation heat loss.
6. Circular opening: This is provided to introduce fresh oxygen for proper combustion and waste gas exit. Also, for reduction of pressure gradient.

DESIGN MODEL:

The design is based on thermal analysis of the furnace, materials availability, energy source and transfer. Temperature distribution across the furnace is analyzed so as to ensure the thickness of insulation and safety of operator.

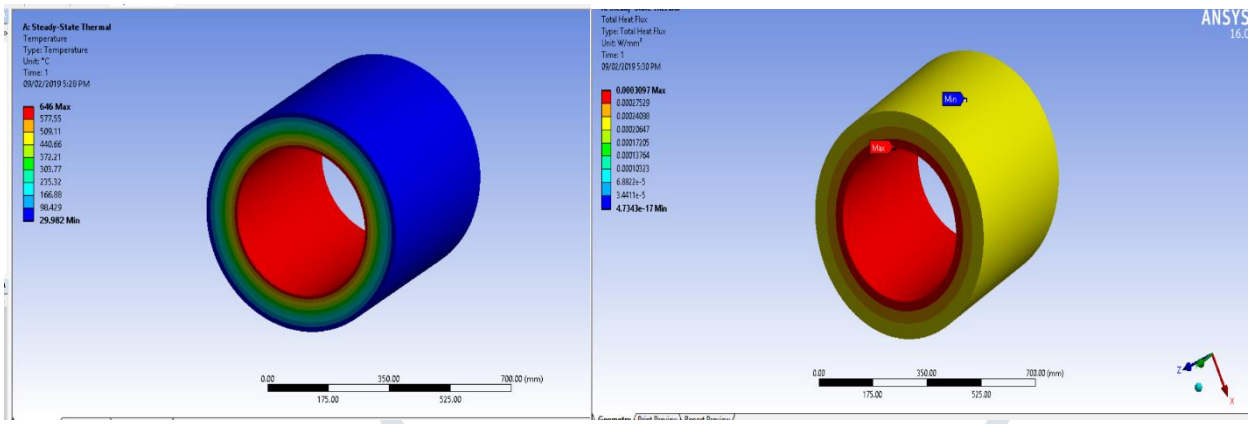


Fig.3 Thermal analysis

SCOPE:

The insulation used is mineral wool which can withstand temperature up to 1200°c, which is favorable for aluminium melting. If we want to melt the metal with higher melting point we can use other insulating material which can sustain higher temperature. Also, for uniform heat distribution multiple burners can be used.

Conclusion:

This research work was undertaken to design and manufacture an aluminum melting furnace for laboratory and workshop use. The furnace was manufactured considering its temperature attainment, capacity of metals it can melt, safety of operator, space occupied in the workshop floor, cost and availability of the materials used, its maintainability and portability. This research has revealed that the locally fabricated aluminum melting furnace for laboratory and workshop operations have reduced the amount of Green House Gases(GHGs) emissions such as CO,NOx and SOx due to use of LPG. Hence, a more effective and performing furnace were developed. The developed Aluminum melting furnace will not only melt Aluminium but also a metal that have a melting temperature below 700 ^{0}C.

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