Impact Factor (SJIF): 4.542

International Journal of Advance Research in Engineering, Science & Technology

e-ISSN: 2393-9877, p-ISSN: 2394-2444

Volume 4, Issue 4, April -2017

Design of Portable Metal Melting Furnace

M.V.Mugale[1], Gayatri Walhekar[2], Rucha Zagade[3], Siddhi Bajare[4], Shrutika Ghone[5]

[1]Assistant Professor, Department of Mechanical Engineering, NBN Sinhgad School of Engineering
[2-5] UG Student, Department of Mechanical Engineering, NBN Sinhgad School of Engineering

Abstract

Aluminium and its alloys are ever demanded metals in production of large number of vital component s of engine pistons car and aircrafts bodies, domestic appliances, electric tools and equipments etc .This demand is ever increasing because of physical and chemical properties of aluminium such as it is light in weight, chemical inertness, rustproofness,ductility,malleability,conductivity etc. Recycling of aluminium from its scrap and burr is also ever increasing and has reached almost 50% of total supply of aluminium in the market of developed and developing countries. This is because of high rate for the metal and its scrap ,simple process of recycling ,100% of regaining of strength and properties by recycled material beacause of no rusting and decomposition of metal, even over a period of 100 of years. Melting of recycled scrap and burr of aluminium in a furace is a critical step in tapping secondary big source of it ,hence, it must be controlled for cost effectiveness, fuel efficiency and ecological sustainability. And attempt is made in this direction in the project work under consideration. The furnace manufactured under the present project work is provided with portability by reducing the size and weight and mounting it on wheels. It is cost-affordable to any entrepreneur of small scale industry, not only for its initial capital cost but also beacause of its running and maintenance cost. As a furnace can be rolled on its wheels to any place, the cost of transportation of scrap and burr, its storage cost is saved. Also it uses LPG and not electricity as the source of heat,it is economical. Also reduces pollution as compared with traditional furnaces using natural coal as very less fumes,exhausts gases and no ash as waste product.

Keywords: melting, portable furnace, LPG, natural gas, graphite crucible

I. INTRODUCTION

The history of mankind has ever witnessed seven major technological breakthroughs, viz. invention of how to light up a fire, invention of wheel, electricity, steam engine, internal combustion engine, electron and microchip processor. The first and the foremost invention by human being is, thus, knowing how to light up a fire, which led to sophistication in food processing (i.e. roasting, boiling or frying of meat) to metallurgical processing(i.e. metal extraction from ores, casting of weaponry for hunting and battles ,manufacturing of domestic tools and appliances, articles and utensils to sophisticated machineries though heat treatment processes of annealing, hardening, quenching, tempering etc.) Melting of metals, glass or other materials and casting the molten matrix into articles or machine components of any designed shape, size and material properties has been a vital step in manufacturing process for several thousand years. The melting process is not only responsible for the energy consumption and cost-effectiveness of producing the castings.

Aluminium is most useful metal in industries. Most of the components are made up of aluminium due to its properties such as light weight, high corrosion resistance, good formability and non-toxicity. Around 27.4 million tons of aluminium has been used, since from past 100 years. Due to its huge and various types of applications, it can be used and reused, without losing any of its properties. In order to fulfil the application of reusing and recycling of aluminium, a new small portable aluminum melting furnace is designed, manufactured and tested having capacity of 3 kg aluminum burr.

Small scale industries generally produces 100 kg of aluminium burr per month, which is normally sold at very low prize. Furnaces which are available in the market having capacity range from 200 kg and above. There is no such furnace available in the market which will be suitable for small capacity. Also existing furnaces occupy large space of industries. The objective was to design such portable melting furnace which will be used by small scale industries for recycling and reusing the aluminium again.

It is observed that the major drawbacks with oil-fired or coal fired furnace are non-uniform flame distribution, oxidation of metal, scale formation, carbon loss of metals and emission of pollutants, also oil fired furnaces have low productivity and long start-up time[1]. With the help of new technology these problems can be overcome. Instead of oil fired or coal fired furnace the LPG fired furnace can be used to increase productivity and may reduce cost of production. Just by putting the idea of portable aluminium melting furnace which will be used by small scale industries. As we have made it portable in order to consume less space. Since LPG is used as fuel, it is cost reliable and ecofriendly.

II. Need of Aluminium Recycling

Aluminium recycling is the process in which aluminium scrap can be reused in products after its initial production. Recycling scrap aluminium requires only 5% of the energy used to make new aluminium. An elemental material, the basic properties of aluminum do not change with mechanical or physical processing. This means that aluminum is

intrinsically sustainable, once produced, aluminium scrap can be recycled many times without any loss in quality and it can be reused to fulfill consumer's requirements and industrial products. In addition to its elemental nature, aluminum also has unique physical properties when compared with other metallic materials. Few aluminum alloys have very high strength to weight ratio, few have excellent thermal and electric conductivity, few are great in corrosion resistance, and most of them have perfect malleability surface reflectivity and elasticity. The intrinsic physical uniqueness of aluminum has enabled the aluminum industry to make a wide range of high-quality and sustainable products.
The growth of the market for recycled aluminum is due in large measure to economics. Now a days , "Aluminium Recycling" is cheaper, faster, and more energy efficient & higher recovery rate of aluminum can be achieved. To achieve given output of ingot, recycled aluminum requires only about 10% of the capital equipment as compared to primary aluminum.

2.1 Why Aluminium should be Recycled:
Aluminium is 100% recyclable and experiences no loss of properties or quality during the recycling process. To recycle new aluminium only 5% of the energy used and emits greenhouse gases. It is for these reasons that approximately 75% of the aluminium ever produced is still in use today by recycling method.

2.2 Various methods of Melting of Aluminium:
There are different ways of classification of industrial furnaces. Most frequently they are divided by the following characteristics:
1. According to the technological purpose:
• melting – intended for melting materials e.g. blast furnaces, cupola furnaces, glass melting bath,
• heating – used for heating the material before rolling, forging, pressing, etc. e.g. forge furnaces, rolling mill furnaces,
• heat treatment – used for heat treatment viz hardening, annealing, tempering,
• burning – used for firing products e.g. kilns for firing refractory ceramic materials, lime kilns,
2. According to the heat source:
• flame - heat energy is obtained by combustion of solid, liquid or gaseous fuels,
• electrical - thermal energy is generated from electricity (arc furnaces, resistance
• furnaces, plasma furnaces, induction furnaces, electron furnaces)
• no external source – they use internal chemical energy of the processed metal and its additives.
3. According to the shape of working space (chamber):
• Continuous – either horizontal (pusher-type kilns, walking beam furnaces) or vertical (tower furnaces), the charge moves from the charging window to the withdrawal window,
• rotary-hearth furnace – charge moves together with the hearth, which has a circular ring shape,
• chamber – charge lies on the hearth during the whole technological process, the design can be either fixed hearth or bogie type, temperature of the working space is at all points practically the same.[1]

In the above classification of aluminium melting furnace, there is no as such aluminium melting furnace which is portable and used for small scale industry. All the furnaces uses fuel such as oil, coal, natural gas, etc. and used for high capacity of melting. Therefore our aim was to design such furnace which will be used by small scale industry with affordable cost, having melting capacity according to their requirement. The new design is based on easy availability of fuel, occupying less space and use of light weight refractory material [3], provided that burning of fuel will not emit any kind of hazardous gases.

III. Design Details

3.1 Construction:
The furnace is having a mild steel hollow cylindrical body 600 mm outer diameter and 600 mm height with vertical axis manufactured out of 3 mm M.S. plate having perforated bottom plate circular in shape. There are four apertures, each of 40 mm diameter, cut in the bottom plate. These apertures facilities facilitate aeration and ventilation required for the LPG flame heating the crucible inside the furnace. The top cover plate is also circular in shape provided with a central circular slot cut in it with diameter of 194 mm. Cylindrical chimney with outer casing of 270 mm outer diameter with 3 mm wall thickness and 200 mm height is mounted symmetrically over and around the central slot in the top cover plate. Also the chimney slot is kept open throughout to facilitate exhaust of the furnace. A glass wool lining of 10 cm thickness is provided to the inside vertical surface of the furnace as well as to that of the chimney but with 3.5 cm thickness. The top cover is openable about the fulcrum hinge on its periphery. Entire furnace is mounted on a frame having four wheels, elevating the bottom plate 187.5 mm above the ground surface to facilitate aeration of furnace. A graphite crucible is placed inside the furnace on the crucible holder suspended by three equispaced arms conveying from inner vertical wall surface towards the vertical axis of the cylinder.

Working:

The new portable aluminium melting furnace is made of mild steel, with internal layer of glass wool, is first fired by using LPG as a fuel, which is ecofriendly and produces very pollution. Initially graphite crucible is heated up to temperature 343°C provided with no forced convection but only natural convection. LPG produces heat cleanly. The process of heating graphite crucible up to desired temperature, so that aluminum can be placed in the crucible is known as preheating. Once the crucible is heated up to desired temperature aluminium burr is put in the crucible and slowly it heats up to its melting point 650 °c.

3.2 Components Used:

1. Steel Sheet: By using industrial process sheet metal is metal formed into thin, flat pieces. Steel sheet is most widely used fundamental forms in metalworking , can be cut and bent into a different types of shapes. Thicknesses can vary depending upon the applications; steel sheets which have extremely thin thicknesses are considered as foil or leaf, and pieces thicker than 6 mm are considered as a plate.

2. M. S. Square Pipes: This hollow structural section (HSS) is a type of metal profile with various shapes such as circular, square or rectangular having hollow tubular cross section. The cases in which loading in multiple directions is required HSS having rectangular sections are commonly used.

3. Wheels: A wheel is a circular component that can be used to rotate on an axle bearing. It is one of the main components of the wheel and axle which is from the six simple machines. Wheels and axles, combinely allow heavy objects to be moved easily with the facility of movement of transportation.

4. Glass wool: Glass wool is one of the best insulating material which is made of fibers of glass arranged using a binder into a texture similar to wool. The glass wool is having small air pockets which traps heat which results into high thermal insulation properties. Glass wool is available in rolls or in slabs, having different thermal and mechanical properties.[4]

5. Graphite Crucible: A crucible is a container which withstand to very high temperatures and is used for metal, glass, and pigment production and number of modern laboratory processes. Crucibles are usually made from clay and also can be made from any material that withstands temperatures high enough to melt or otherwise alter its contents.[2]

6. Gas Burner: A gas burner is used to generate a flame and to heat up products with the help of gaseous fuel such as acetylene, natural gas or propane. Some of the burners in order to have complete combustion contains an air inlet to mix the fuel gas with air.[5]

7. Gas Pipe: A gas pipe is a flexible hollow tube designed in order to carry gaseous fluids from one location to another. Hoses are also sometimes called pipes, or more generally tubing. The shape of a hose is usually cylindrical. Its design is based on a combination of application and performance. Common factors are size, pressure rating, weight, length, straight hose or coil hose, and chemical compatibility.

8. Regulator: A pressure regulator is a valve that automatically cuts off the flow of a liquid or gas at a certain pressure.To regulate gas pressure, gas pressure regulators are used and can not be used for measuring flow rates.

9. Gas Cylinder: A gas cylinder or tank is a pressure vessel used to store gases at above atmospheric pressure. Bottles are known as High-pressure gas cylinders. A gas cylinder is a container used to hold gases or liquids at a pressure different from the ambient pressure.

3.3 2D Design:

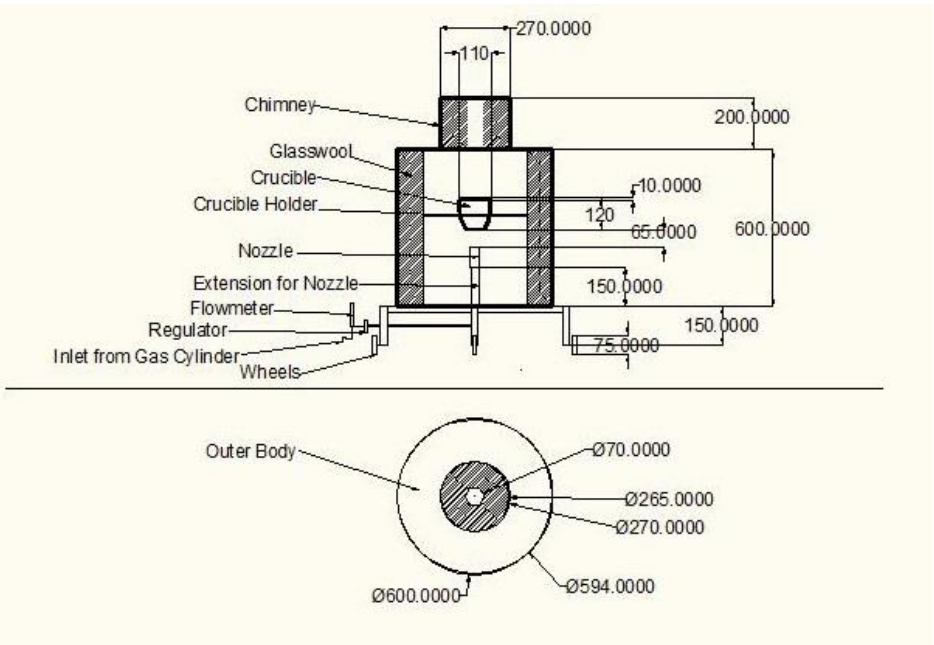

Fig.3.3 2D Model of Portable Furnace

IV. Selection of basic parameters

The current industrial furnace has been using firebricks as a refractory having thermal conductivity of 0.9 W/m-K. In order to minimize heat losses to the surrounding we have replaced firebricks by glass wool which possess thermal conductivity of 0.04 W/m-K, which comparatively less than firebricks. Many types of furnace uses fuel as coal, oil, natural gas which are having certain drawbacks, coal and oil produces NOx gases. Therefore to eliminate emission of these hazardous gases to the environment we have used LPG as fuel, which is locally available and ecofriendly.

Sr. No.	Parameter	Current material	Replaced by
1	Refractory	Fire Bricks	Glass wool
2	Fuel used	Coal, Oil, Natural gas	LPG

4.1. Properties of LPG over other fuels:

There are many properties of LPG which proves it as good source of fuel for melting aluminum. LPG is selected as a fuel because of its availability, good burning rate (8.2 mm/min.), no reaction with metal, stability during transport, sustainable [5], good calorific value[5] and it does not create any kind of pollution. It is non- hazardous and it is user friendly.

4.2. Properties of Glass Wool over Fire Bricks:

There are best properties of Glass Wool which differentiate Glass Wool as best refractory compared to refractory. Fiber glass wool is light in weight, flexible and acoustical insulation material used to provide the ultimate noise reduction, which is formed from resin bounded Borosilicate Glass fibers. One of the properties of Glass wool is water and fire resistant and has low density of combustion gas as well as low toxicity. It reduces transport of heat and sound. Its density in non-pressed state is 5-20 kg-m^3. Thermal conductivity is 0.03- 0.04 W/m^2-k in 10°C. [3]

V. CONCLUSIONS

The study undertaken in the present project is to design and fabricate the model of a portable furnace with less loading capacity but affordable to an ordinary entrepreneur running an aluminium processing workshop manufacturing aluminium metal products. Traditionally the burr getting daily generated in few kilograms is required to be stored continuously for months together to the capacity of at least a truck or container. It may be disposed off by transporting it to a big traditional furnace with high capacity hundreds of kilometers at extremely less rates. The proposed model will prove to be more efficient on the following lines-

1)It will be more cost effective: because it reduces the cost encurred on storing space engaged under scrap bin in which daily scrap burr is damped, the cost encurred on security engaged on scrap bins ,loading and unloading of the scrap and transportation of it to the big size conventional furnaces and the capital immobilized in the held up scrap of aluminium for months and years together etc.

2)It will be fuel efficient as it requires less enthalpy content, latent heat required to be invested because of very small size of furnace in heating the crucible, the air in the chamber of furnace , the body of the furnace in addition to the heat actually required to melt the metal in the crucible.

3)It will be ecologically sustainable; because the proposed furnace will be using LPG gas instead of conventional natural coal or diesel as the fuel for big capacity furnace. Thus it will be reducing the flue gas content along with the emission of soot getting generated and getting released in atmosphere causing heavy air pollution in the premises. Thus, this deterioration of air quality will be extremely required.

Hence, the objectives underlying the present project work may get fulfilled to the desired extent.

REFERENCES

[1] K.K. Alaneme and S.O. Olanrewaju, “Design of a Diesel Fired Heat-Treatment Furnace’’.
[2] Yusuke Sano*and Masahiro Kuritani ,“Continuous Aluminum Melting and Holding Crucible Furnace’’
[3] Puneet Sharma, Vijay Kumar Bhanot et.al , “Research Work On Fiber Glass Wool Reinforced and Epoxy Matrix Composite Material’’
[4] Oldřich Zmeškal[1], Martin Nežádal et.al ,“Thermal Conductivity Of Glass Wool Fiber”

Jagruti R Surange, Navneet K Patilm, et.al, “Performance Analysis of Burners used in LPG Cooking Stove-A Review”