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DESIGN AND DEVELOPMENT OF SOLID-FIRED FURNACE FOR ALUMINIUM MELTING

RENUKA S. PANCHBHAI[1], PROF. DR. R. N. BAXI[2]

1. M. Tech Student, CAD-CAM, G. H. Raisoni College of Engineering, Nagpur, India
2. Professor, Mechanical Engineering Department, G. H. Raisoni College of Engineering, Nagpur, India

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Abstract: Aluminum castings have played an integral role in the growth of the aluminum industry since its inception in the late 19th century. Aluminum can be recycled to help save natural resources, however, when they are discarded to landfill, they can take up to 500 years to decompose. This is because only 5% of the energy is needed to recycle aluminum to remake aluminum products from aluminum cans. There is no waste material. This aluminum can be melted down into ingots. These compact ingots, also called pigs, can be recycled or re melted later for more advanced metalworking projects. These empty cans that made of aluminum are to be used as a raw material for melting the aluminum in the *solid-fired or biofuel furnace*. A solid-fired melting furnace can be used to melt down metals like brass, copper and aluminum. A CAD model of such furnace is explained in this paper. The software used for the CAD model is Pro-Engineer Software.

Keywords: Pro-Engineer Software, Solid fired furnace, Crucible, Material selection

Corresponding Author: MS. RENUKA S. PANCHBHAI

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INTRODUCTION

The proposed work in which, we are supposed to design and fabricate a solid-fired furnace to overcome the problem of melting the aluminum. The project idea is popped-up from the PIT furnace which was available in our college workshop, but remove from there because it occupy more space and hazardous for the environment of the college premises. So that the alternative for that furnace is the solid-fired furnace due to which it can be included in workshop practical of our regular academics.

Moreover, this furnace will be in use for few months or when the practical performed according to the college schedule, so that this furnace can be useful for outer aluminum melting section department that they can use it as rental basis.

The proposed process occurs in our furnace in which bio-fuel such as sawdust, wood chips, grass, urban waste wood, agricultural residues etc., are used to melt the Aluminum. The raw material will be the aluminum beverage cans that are used for keeping cold drinks, which can be easily available.

The internal body of furnace is made of Mild steel in which aluminum will melt at 660.32°C, so that the temperature of cast iron container should be near about 800°C, as a factor of safety. And the refractory will be made of fire brick because the materials are widely available and relatively inexpensive.

2.0 OBJECTIVE & SCOPE OF WORK:-

The objective of this paper is to explain the design of the solid-fired or bio-fuel furnace for melting 2 kilogram aluminum process. This will be an alternative for PIT furnace which was available in college workshop. Also to lower the cost of raw material i.e., aluminum beverage cans which are easily available in our surrounding. It is well known fact that aluminum can be recycled infinitely and can be used no. of times.

3.0 LITERATURE SURVEY

3.1 About Melt

Aluminium (or aluminum) is a chemical element in the boron group with symbol Al and atomic number 13. It is a silvery white, soft, ductile metal. Aluminum is remarkable for the metal's low density and for its ability to resist corrosion due to the phenomenon of passivation.

Table 1 Physical properties of Aluminum

Physical properties	
Phase	Solid
Density (near r.t.)	2.70 g·cm^{-3}
Liquid density at m.p.	2.375 g·cm^{-3}
Melting point	933.47 K, 1220.58 660.32 °F , °C,

Aluminum is a sustainable metal and can be recycled over and over again. Aluminum is theoretically 100% recyclable without any loss of its natural qualities. A can is generally turned into a new can and back on store shelves within 60 days. Cans are usually available through curbside pickup or community drop-off locations nationwide.

In our project, we are using aluminum cans i.e., the cans which we use for cold drinks or oil, as a raw material which can be easily available in our country. And Aluminum Food Cans, it is commonly used for pet food cans and has a different recycling market than aluminum beverage cans.

3.2 Solid biofuel:-

A biofuel is a fuel that contains energy from geologically recent carbon fixation. These fuels are made by a biomass conversion (biomass refers to recently living organisms, most often referring to plants or plant-derived materials). This biomass can be converted to convenient energy containing substances in three different ways: thermal conversion, chemical conversion, and biochemical conversion. This biomass conversion can result in fuel in solid, liquid, or gas form. This new biomass can be used for biofuels. Biofuel have increased in popularity because of rising oil prices and the need for energy security. When raw biomass is already in a suitable form (such as firewood), it can burn directly in a stove or furnace to provide heat or raise steam.

When raw biomass is in an inconvenient form (such as sawdust, wood chips, grass, urban waste wood, agricultural residues), the typical process is to density the biomass. A solid fuel can also be made to micron particle and the combustion can be made as rapid as furnace oil. In fact this is done in the pulverized fuel fired boilers. The coal is made as powder to a size of 76 micron and burnt like burner. It is cost prohibitive to prepare a solid fuel to such micron particle for use in small boiler. Next in order of response we have fluidized bed combustors. The response is fairly good and it has been found possible with coal the response is as good as oil. With a fluidized bed pollution is major issue. Cost effective solutions are yet to come for small boilers.

Hand fired wood fired / coal fired boilers are known for less pollution. But when we use a wood log in a furnace the burning rate is slow for the reason that the oxygen has to diffuse through the wood / coal particles and react with the fuel to complete the process of heat liberation. This inherently results in poor response [7]. In our project, solid-fired or biofuel i.e., coal, charcoal, soya bean husk, groundnut waste, wood chips, grass, urban waste wood, agricultural residue which is easily available in our city that can be used as fuel for melting the aluminum. It will be quite cost efficient. But a problem with the combustion of raw biomass is that it emits considerable amounts of pollutants, such as particulates and polycyclic aromatic hydrocarbons.

3.3 Furnace:-

A furnace is an equipment used to melt metals for casting or to heat materials to change their shape (e.g. rolling, forging) or properties (heat treatment). Furnace ideally should heat as much of material as possible to a uniform temperature with the least possible fuel and labor. The key to efficient furnace operation lies in complete combustion of fuel with minimum excess air. Furnaces operate with relatively low efficiencies (as low as 7 percent) compared to other combustion equipment such as the boiler (with efficiencies higher than 90 percent. This is caused by the high operating temperatures in the furnace. For example, a furnace heating materials to 1200 oC will emit exhaust gases at 1200oC or more, which results in significant heat losses through the chimney.[1]

3.3.1 Types of Furnace

In Box-type furnace, the radiant section has generally a square cross section. And in Vertical Cylindrical type furnace, the radiation section is in the shape of a cylinder with a vertical axis, and the burners are located on the floor at the base of the cylinder. The heat exchange area covers the vertical walls and therefore exhibits circular symmetry with respect to the heating assembly.

3.3.2 Appropriate furnace

Cylindrical furnace are often preferred to box-type furnace. More uniform heating rate in cylindrical furnace and higher thermal efficiency. In box-type, square corners require extra insulation and wastage of refractory. Furthermore, cylindrical furnaces require smaller foundations and construction areas and their construction cost is less. High chimneys are not essential in cylindrical furnaces because they normally produce sufficient draught.

4.0 DESIGN CONSIDERATIONS

Cylindrical furnaces are often preferred to box-type furnace. More uniform heating rate in cylindrical furnace and higher thermal efficiency. In box-type, square corners require extra insulation and wastage of refractory. Furthermore, cylindrical furnace requires smaller foundations and construction areas and their construction cost is less. High chimneys are not essential in cylindrical furnaces because they normally produce sufficient draught.

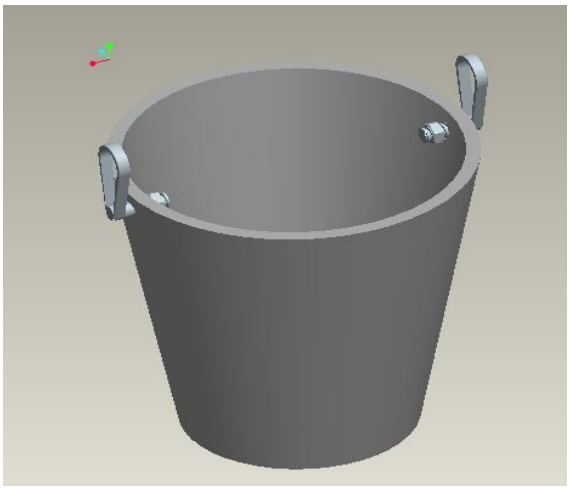

Figure 4.1 Isometric Drawing of Cylindrical-type furnace

Furnace is used to heat and melt the solid metal and transform it to the liquid state. The fire brick coated with refractory inside the furnace will keep the heat around the crucible.

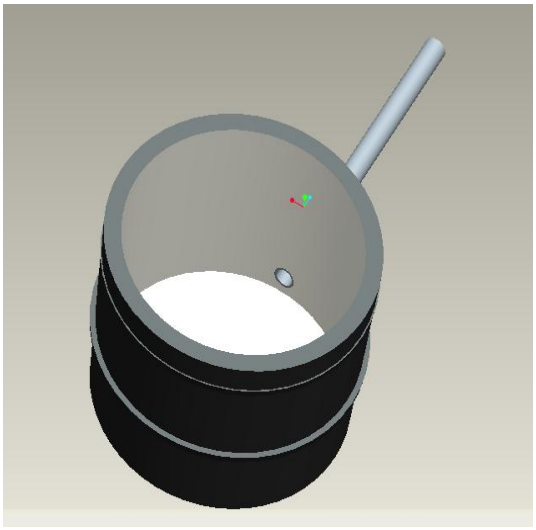

Figure 4.2 Furnace outer shape and automated drafting

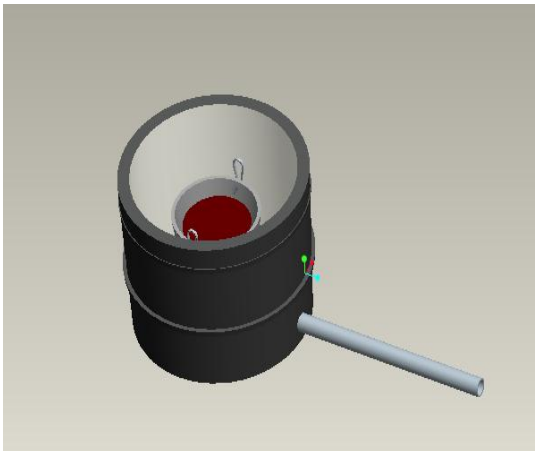

Figure 4.3 Total parts showing crucible, melt and furnace

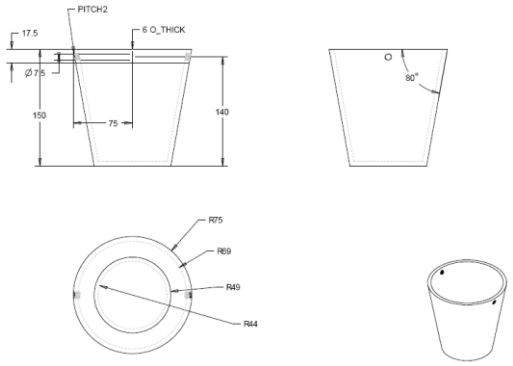

Figure 4.4 Drafting of Crucible

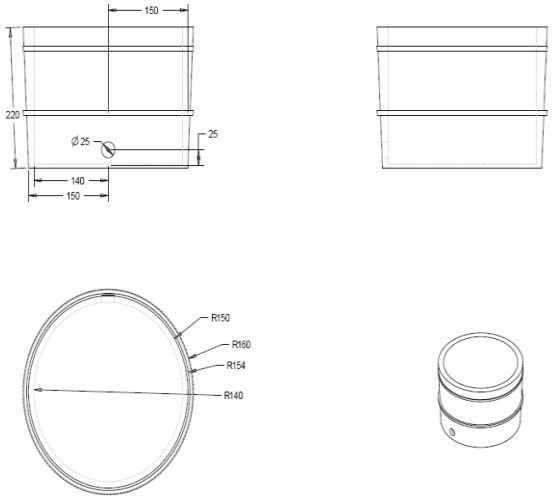

Figure 4.5 Drafting of furnace

5.0 MATERIAL SELECTION

The furnace life and energy efficiency depends on the proper selection of furnace materials and its behavior in the furnace environment. The properties and quality determine the extent of heat loss during steady state condition and storage heat loss during transient condition. For melting aluminum in the furnace, it is necessary that the material of furnace should have high melting point as compared to aluminum. Melting point of aluminum is 660.32oC and that is for low carbon is 1350-1530oC (nearly twice of aluminum M.P.) and hence it can be used.

For melting aluminum in the furnace, it is necessary that the material of furnace should have high melting point as compared to aluminum. Melting point of aluminum is 660.32oC. Low carbon steel can be selected for furnace body as well as for crucible[2]. Melting point of low carbon steel:- 1350-1530oC (nearly twice of aluminum M.P.) Low Carbon steel or Mild steel is the most common form of steel. It is often used when large amount of steel is needed. It is a carbon steel typically with maximum of 0.25% carbon. It is a general term for range of low carbon (a maximum of about 0.3%) steels that have good strength and can be bent, worked or can be welded into an endless variety of shapes for building materials. The reason for selecting Low carbon steel/ Mild Steel for furnace. Mild steel having high melting point (1350-1530oC) than Aluminum (660.32oC). It's density of M.S. is 7.87 g/cm3 higher than Al having density 2.7 g/cm3. Its price is relatively low. Thermal conductivity is 55 W/mK [6]. It contains approximately 0.05%-0.32% carbon, makes it malleable and ductile. It has relatively low tensile strength. It has high strength and hardness. High temperature resistant

6.0 CONCLUSION

The solid fired furnace is the furnace that uses solid fuel i. e., coal, charcoal, wood soya bean husk, groundnut waste etc. which are easily available in our city, which are used for melting 2 kilogram aluminum at 660.32oC. furthermore, the briquettes or other solid biofuel can also be used by converting it into particles of 76 microns that the heating process can be faster more times than the traditional process in which biofuel simply put into the furnace. Moreover, this project can be overcome the problem of melting aluminum cans that are usually find in college cafeteria.

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