IOP Conf. Series: Materials Science and Engineering **310** (2018) 012084 doi:10.1088/1757-899X/310/1/012084

DESIGN AND DEVELOPMENT OF TILTING ROTARY FURNACE

V. Sai Varun[1], P. Tejesh[1], B.N. Prashanth[1]
[1]Department of Mechanical Engineering, Amrita University, Bengaluru, India
E-mail: prashanth.pdm@gmail.com

Abstract. Casting is the best and effective technique used for manufacturing products. The important accessory for casting is furnace. Furnace is used to melt the metal. A perfect furnace is one that reduces the wastage of material, reduces the cost of manufacturing and there by reduces the cost of production. Of all the present day furnaces there may be wastage of material, and the chances of increasing the time of manufacturing as the is continuous need of tilting of the furnace for every mould and then changing the moulds. Considering these aspects, a simple and least expensive tilting rotary furnace is designed and developed. The Tilting and Rotary Furnace consists of mainly melting chamber and the base. The metal enters the melting chamber through the input door that is provided on the top of the melting chamber. Inside the melting chamber there is a graphite furnace. The metal is melted in the graphite crucible. An insulation of ceramic fibre cloth is provided inside the furnace. The metal is melted using Propane gas. The propane gas is easily available and economic. The gas is burned using a pilot burner. The pilot burner is more efficient that other burners. The pilot burner is lit with a push button igniter. The pilot burner is located at the bottom of the combustion chamber. This enables the uniform heating of the metal inside the crucible. The temperature inside the melting chamber is noted using a temperature sensor. The gas input is cut-off if the temperature is exceeding a specific temperature. After the melting of the metal is done the furnace is tilted and after the mould is filled it is rotated. The external gears are used to controlling the tilting. The results of studies carried out for the design & development of low cost, simple furnace that can be mounted anywhere on the shop floor and this can be very much useful for the education purposes and small scale manufacturing. The furnace can be rotated in 360 degrees and can help in reducing the time taken in manufacturing. The furnace is provided with a rotation motion to the base which helps in providing a uniform distribution of molten metal to various moulds and can be used to fill a number of moulds with minimal wastage of the molten material. Due to the tilting action provided to the combustion chamber, the flow of metal can be controlled easily during pouring of molten metal into the moulds.

1. Introduction

Casting is the best and effective technique used for manufacturing products. The important accessory for casting is furnace. Furnace is used to melt the metal. There are many types of furnaces available in the present day market. These include Tilting furnace, Rotary furnace which are used to melt the scrap metal or normal metal and then mould that molten metal in to the required product shape. A perfect furnace is one that reduces the wastage of material, reduces the cost of manufacturing and there by reduces the cost of production. Of all the present day furnaces there may be wastage of material, and the chances of increasing the time of manufacturing as the is continuous need of tilting of the furnace for

every mould and then changing the moulds. Considering these aspects, a simple and least expensive tilting rotary furnace is designed and developed.
In this design the furnace body has both the tilting and rotary motion incorporated. So that it can be used fill more mould at the same time and thereby reducing the time taken for manufacturing.
Figure 1, shows three dimensional wire-frame model of tilting rotary furnace.
Figure 2, shows three dimensional solid model of tilting rotary furnace.

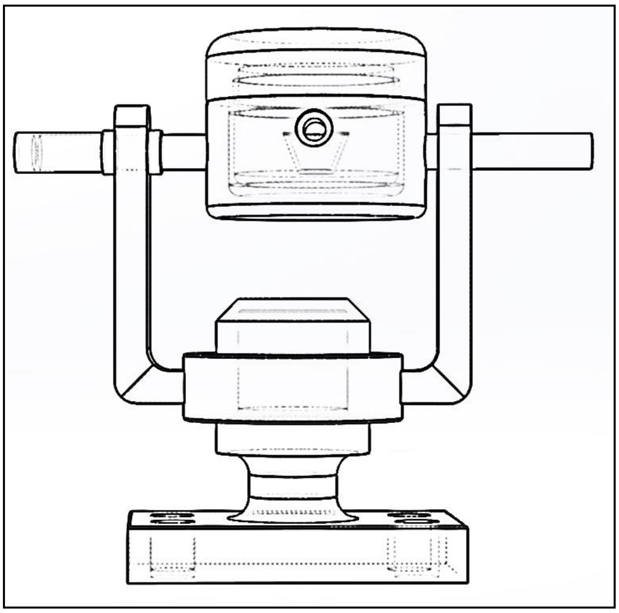
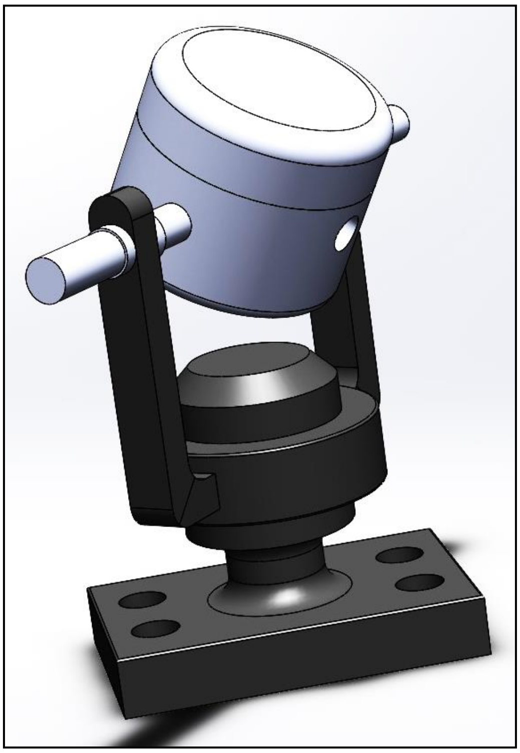


Figure 1. Three Dimensional Wire-frame Model of Tilting Rotary Furnace



`**Figure 2.** Three Dimensional Solid Model of Tilting Rotary Furnace

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2. Construction and Working

The Tilting and Rotary Furnace consists of mainly melting chamber and the base. The metal enters the melting chamber through the input door that is provided on the top of the melting chamber. Inside the melting chamber there is a graphite furnace. The metal is melted in the graphite crucible. Inside the melting chamber an insulation of ceramic fibre cloth is provided to reduce the loss of heat from the melting chamber. Propane gas is used as fuel for melting the metal. The propane gas is easily available and economic. The gas is burned using a pilot burner. The pilot burner is more efficient that other burners. The pilot burner is lit with a push button igniter. The pilot burner is located at the bottom of the combustion chamber. This enables the uniform heating of the metal inside the crucible. The temperature inside the melting chamber is noted using a temperature sensor. The gas input is cut-off if the temperature is exceeding a specific temperature. Once the metal is melted the furnace is tilted and the molten metal is allowed to flow out of the melting chamber. Once the mould is filled the melting chamber is rotated and all the moulds placed around the furnace are filled at a time. The tilting motion of the furnace is achieved by the external forces that are placed on the combustion chamber arms. And the design of base is done in such a way that it can be rotated easily.

Figure 3, shows the sectional drawing of tilting rotary furnace.

Figure 4, shows the layout drawing of tilting rotary furnace.

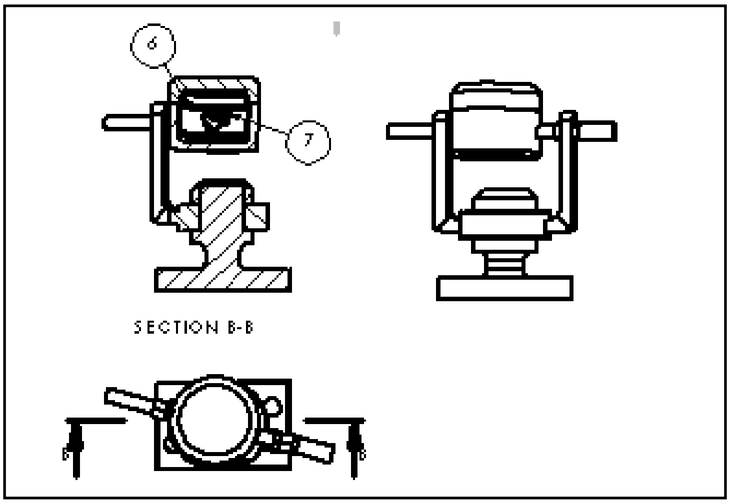

Figure 3. Sectional Drawing of Tilting Rotary Furnace

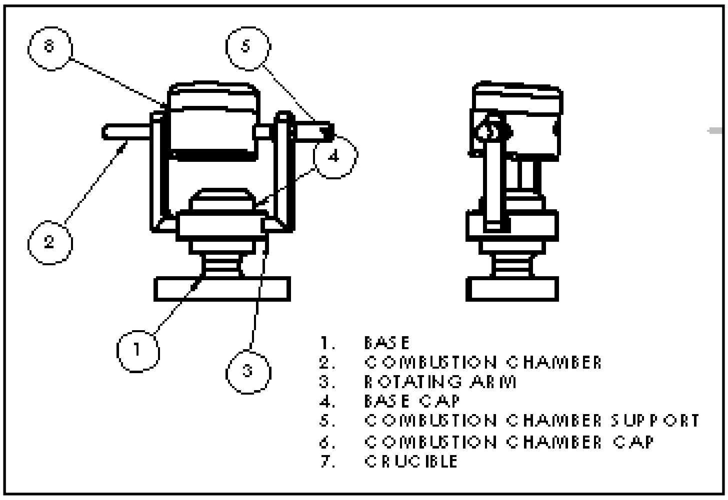

Figure 4. Layout Drawing of Tilting Rotary Furnace

All the materials that are chosen are dissipated in the Table 1.

Table 1. Material Selection and their usages.

Material	Usage
Ceramic Fibre Cloth	INSULATION: Working Temperature: 1800 F (Continuous), 2300 F (Maximum) Specific Heat (@2000 F): 0.27 Btu/lb F
Propane Gas	FUEL: Ignition Temperature in Air: 920- 1020 F Maximum Temperature: 3595 F
Pilot Burner	More Powerful Burner
AISI 1018	Melting Chamber
Grey Cast Iron	Base of Furnace
Graphite Cruicible	For Melting the Metal
Aluminium Alloy	For External Gears

Figure 5 (a) and 5(b) shows the different views of overall setup of the fabricated tilting rotary furnace.

Figure 5 (a) and (b). Different Views of Overall Setup of Fabricated Tilting Rotary Furnace

3. Calculations and Studies

3.1. Melting Chamber Design

The tilting rotary furnace design is a model that is built for the experiment purpose required melting capacity is 5 Litres.

3.2. Crucible Design

The details specifications of the tilting rotary furnace are dissipated in the Table 2.

Table 2. Design Details of Crucible.

Design Considerations	Specifications
Diameter of Crucible	0.3 m
Length of Crucible	0.2 m
Length of Body of Furnace	0.6 m
Diameter of Body of Furnace	0.5 m
Insulation Material	Ceramic fabric Cloth
Thickness of the Insulation	0.005 m
Area of Fabric Cloth Required	1.87 m^2
Heat Resistance of Fabric	1315.5^0 C
Heat Required to melt Aluminium	660.32^0 C

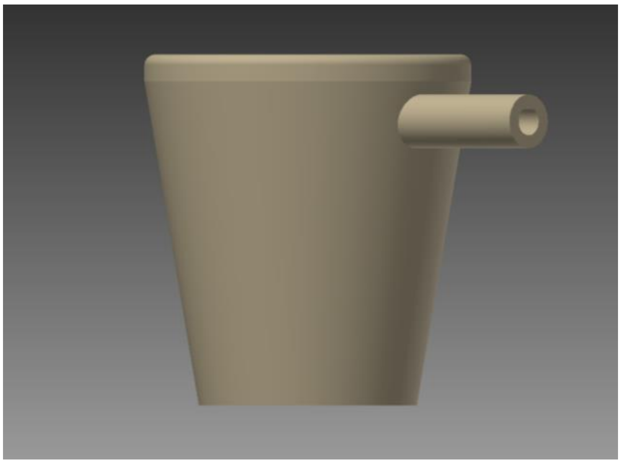

Figure 6. Three Dimensional CAD Design of Crucible

The extrusion in the crucible is clubbed with the chamber exit so that the molten metal will come out easily and without any major loss of material.

3.3. Calculation of amount of Aluminium melted per litre of propane:

3.3.1 Aluminium:

Melting point of Aluminium = 660.32˚C
Ambient Temperature = 20˚C
= 393 k
Mass of 1 Litre of Aluminium = 2.70 g/cm3 x 1000 ml
= 2700 g

3.3.2 Required energy to heat the metal to 660.32˚C

$$Q_H = m\ x\ C_P\ (T_2 - T_1):$$
$$= 2700 \times 0.91 \times (660.32 - 20)$$
$$= 1{,}573{,}266.24\ J$$

3.3.3 Energy required to change the state:

$Q_S = m\ x\ L$
= 2700 x 398
= 1,074,600 J

3.3.4 Total energy to melt Aluminium:

$Q_T = Q_S + Q_H$
= 1573266023 + 1074600
= 2647866023 J
Q_T = 735.518 W

3.3.5 Propane:

Molar mass = 44.1 g/mole
Liquid density = 0.493 g/cm3
Mass per litre = 493 g/L
Energy Density = 2220 KJ/mole

3.3.6 Moles per litre:

= (mass per litre) / (Molar Mass)
= 493 / 44.1
= 11.179 Moles

3.3.7 Energy Density per litre:

= (No. of moles) / (Energy density)
= (11.179 / 2220000)
= 24817687 J

3.3.8 Amount of Aluminium melted per litre of propane:

= (Energy per litre) / Energy to melt Al)
= 24817687 / 2647866
= 9.37 L

Based on the calculations done, 9.3 litres of Aluminium can be melted by burning 1 litre of Propane.

4. Experimental Outcome

Considering normal tilting furnace and tilting and rotating furnace are used to fill 10 moulds so the time taken for both the situations is noted down.
The total time taken to fill 10 moulds is dissipated in the Table 3.

Table 3. Time taken to fill the Moulds.

Furnace	Time taken to fill the mould	Time taken to change the mould	Total time taken to fill 10 moulds
Tilting Furnace	3 minutes	1 minutes	40 minutes
Tilting Rotary Furnace	3 minutes	30 seconds	30 minutes

5. Results and Conclusions

The results of studies carried out for the design concludes that the furnace can be mounted anywhere on the shop floor and this can be very much useful for the education purposes and small scale manufacturing. The furnace can also be rotated in 360 degrees and can help in reducing the time taken in manufacturing. The furnace is provided with a rotation motion to the base which helps in providing a uniform distribution of molten metal to various moulds and can be used to fill a number of moulds with minimal wastage of the molten material. Due to the tilting action provided to the combustion chamber, the flow of metal can be controlled easily during pouring of molten metal into the moulds. Since pilot burner is used there is uniform distribution of the heat inside the combustion chamber. The propane gas which is used to melt the metal is economic and easily available. The experimental result shows that the time taken to fill a specific number of moulds is decreasing compared to normal moulds.

Acknowledgements

The authors express their gratitude towards Management of Amrita School of Engineering, Bangalore, for their support and encouragement during this research study.

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