Fabrication and Performance Evaluation Of Mixed Fuel Fired Furnace for Aluminum Melting

Dr. P.Prabhakara Rao[1], Sampath .V[2]

Department Of Mechanical Engineering, Kakatiya Institute of Technology & Science, Warangal, India

Abstract— Many foundries use coal as a major source for heating the furnaces which causes serious pollution to the environment. Around 6.6 billion tons of hard coal was used worldwide last year and 1 billion tons of brown coal. Since 2000, global coal consumption has grown faster than any other fuel. The manufacturing philosophy is to eliminate the use of heating elements requiring coal power and electrical power which is highly used in the region (AP).

Deliberate attempts were made to reduce the consumption of coke by replacing it with charcoal and oil. As a part of the project mixed fuel fired furnace have been designed and fabricated. For this purpose some initial melting and performance tests were performed using Aluminum alloy melting after initial test design modifications hade made to reduce the heat losses. Finally Mixed fuel furnace that runs on coke and diesel oil for melting non-ferrous alloys have been installed successfully eventually. This furnace can be effectively utilized as a melting furnace in our foundry laboratory.

Keywords—Coke fired furnace; Performance analysis; Crucible furnace; oil fired furnace;Mixed fuel fired furnace.

I. Introduction

This paper is about construction of crucible fired furnace. The furnace is used to heat and melt the solid metal and transform it to the liquid state. The furnace use of combustion of coal and diesel as a fuel and melt the solid metal inside that for a certain time. The fire brick coated with refractory inside the furnace will keep the heat around the crucible to make sure heat is not lost and save the time while melting the metal. After the metal totally melts, the liquid will flow out and used for casting. The main objective of this paper is to fabricate a furnace for melting aluminum in mini crucible using coal and diesel oil as heat sources. To carry out comparative study of coal and diesel fired sources.

II. Literature Review

K. C. Bala, [5], the paper deals principally with the mechanical and electrical requirements for induction furnace production. The mechanical aspect gives consideration to the geometrical components, cooling system, and the tilting mechanism. The electrical aspect deals with the furnace power requirement to make it functional.

K.K. Alaneme and S.O. Olanrewaju, [11], the research is centered on the design of a diesel fired heat-treatment furnace using locally sourced materials. The design philosophy is to eliminate the use of heating elements requiring electric power which is poorly supplied in the country. Design drawings were produced and mild steel was used for the fabrication of the furnace casing, while the other components needed for the design were selected based on functionality, durability, cost and local availability.

Martocci and Mihalow [15] the incentive for conducting research and development on reheat furnaces is substantial; the domestic steel industry spent approximately one billion dollars on fuel in reheat furnaces in 1981. Bethlehem Steel Corp. spent $145 million of that total, and neither figure includes fuel consumed in soaking pits or annealing furnaces. If we set a goal to save 10% of these annual fuel costs, that translates into $100 million for the domestic steel industry and $14.5 million for Bethlehem Steel. These large sums of money are significant incentives. The purpose of this paper is to review the historical heating practices and equipment at steel reheat furnaces along with current practices and instrumentation.

2.2 Melting of Aluminum

Various types of furnaces employed in melting of aluminum alloys in the foundry may be broadly grouped into three types:

1. Direct fuel fired furnaces.
2. Indirect fuel fired furnaces.
3. Electrically heated furnaces.

2.2.1 Direct Fuel Fired Furnaces

The direct fuel type is further classified into wet hearth and dry hearth. In wet hearth furnace products of combustion are in direct contact with the top of the molten charge and heat transfer is by combination and convection and radiation. In a dry hearth furnace the charge of the solid aluminum is placed on sloping hearth above the level of the molten metal so that charge is completely enveloped in hot gases. Heat is absorbed rapidly by solid charge, which causes melting and molten aluminum drains from the sloping hearth into the wet holding chamber.

3.1 Crucible

A crucible is a container use to hold metal for melting in a furnace. Crucible furnaces are of small capacity typically used for small melting applications. A crucible is needed to withstand the temperatures encountered in melting metals as shown in table 3.1.

The crucible material must have a much higher melting point than that of the metal being melted and it must have good strength even when white hot. The metal is placed in a crucible which is made of clay and graphite. The energy is applied indirectly to the metal by heating the crucible to melt metals such as zinc and aluminum because these metals melt at a temperature well below of steel as shown in fig.3.1. Thermal conductivity of the crucible is 25-50 W/Mk

Table: 3.1 Crucible properties

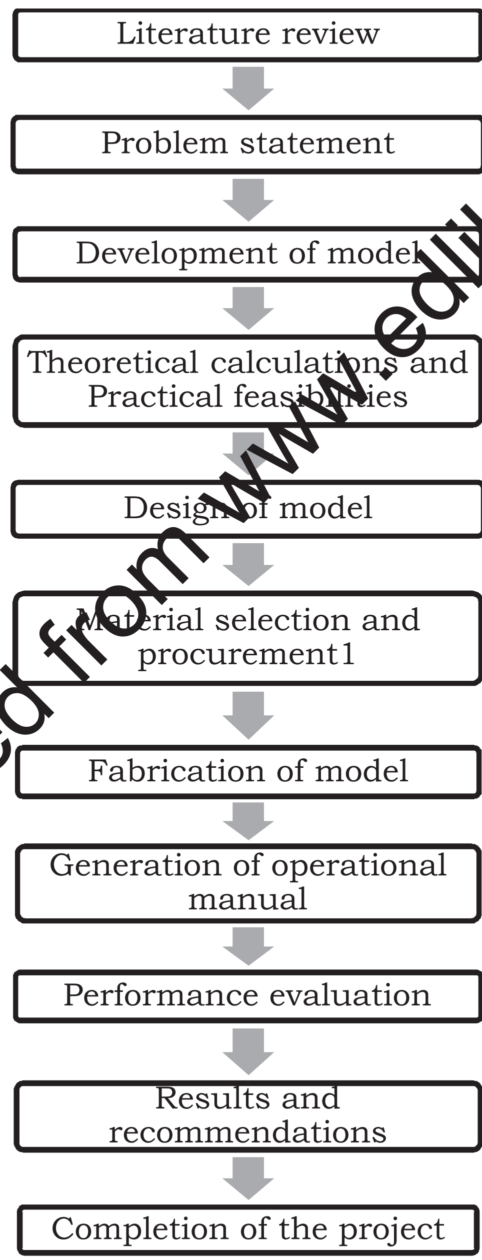
Material	*Percentage*
Graphite +C (%)	**30-55**
Sic (%)	20-55

Fig.3.1. Clay graphite crucible

3.2 Refractory Bricks

Refractory is a material which can withstand high temperature and does not fuse. Refractory materials are produced to meet the diversified as shown in Fig.3.2. Requirements of high temperature processes carried out in metal extraction, cement, glassmaking, manufacturing, ceramic industries.

4. Methodology



4.1 Construction of Furnace

Crucible furnace consists of crucible which is surrounded by refractory bricks, refractory cement. Arrange the refractory bricks one over the other filling the vacant space with refractory cement, which acts as a binder and also has good insulating property, the bricks must be closely packed as that no heat transfer may occur through the voids as shown in fig.4.1.

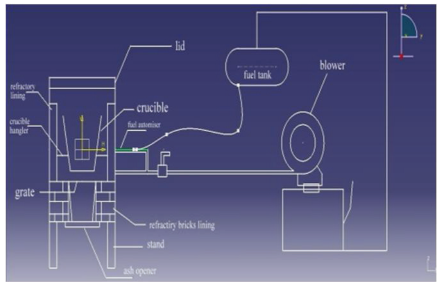


Fig.4.1 Furnace outline

4.2 Furnace Fabrications

Based on the available area in the workshop Mixed fuel fired furnace setup is installed by prior designing in CATIA as shown in fig.4.2 and fig.4.3.based on design calculation furnace is fabricated which is shown in Figures 5.1 and 5.2.

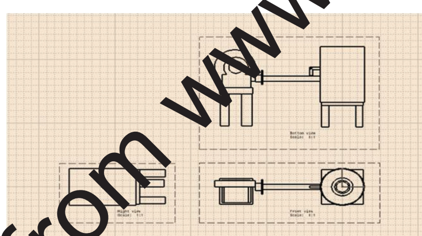


Fig.4.2 Furnace drafting

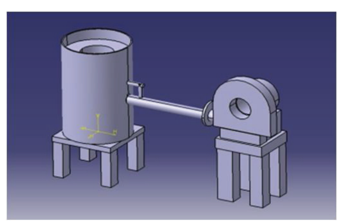


Fig4.3Assembled furnace

Fig.5.1 Fabricated Coke Fired Furnace

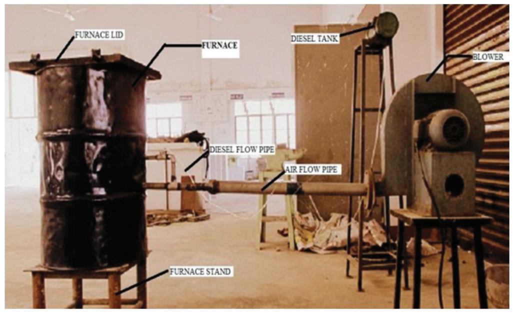


Fig: 5.2 Fabricated mixed fuel Fired Furnace

5.1 Performance Evaluation of Furnace

Performance evaluation is carried out under supervision of technicians by proper operational instructions. Heat transfer is shown in fig 5.1. First moulds of different patterns by calculating the amount of aluminum required. The moulds are dried two days and made ready for the casting. The crucible is preheated to 300°C in oven in order to remove moisture.

Based on theoretical calculations with 10-20%furnace is charged with B grade coke and crucible is placed on the crucible stand inside the furnace. The crucible filled with aluminum is surrounded by coke, wood pieces for initial ignition. Air is sent through the blower for combustion and dynamometer is connected to measure the temperature. Aluminum casting is made and following observations were recorded as shown in table 5.1.

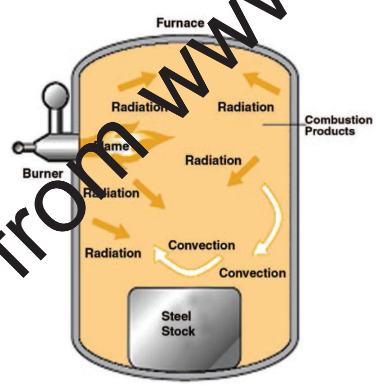


Fig.5.1 Heat transfer in furnaces

Table: 5.1 Observations for evaluation with coke

SI.NO	OBSERVATION	READING(MIN)
1.	Charging time	5.9
2.	Time for flame to start	3.2
3.	Time for continuous flame	4.2
4.	Melting start time	8.3
5.	Flux added time	12.5
6.	Time for complete melting of aluminum	29.6

5.2 Experiment Using Mixed Fuel:

During second experiment diesel is injected into the furnace through atomizing equipment from the diesel tank overhead. Diesel is atomized in the atomizer pipe placed over the blower and injected during firing by regulating valve. Furnace is covered with lid to decrease the heat loses as shown in table 5.2.

Table: 5.2 Observations for evaluation with Mixed Fuel

SI.NO	Observation	Reading(min)
1.	Charging time	4.1
2.	Time for flame to start	2.5
3.	Time for continuous flame	3.5
4.	Melting start time	6.8
5.	Flux added time	10
6.	Time for complete melting of aluminum	15.6

6. Results

Performance evaluation of the furnace was carried in two trails in first trail coke as chosen as a fuel melting of aluminum scrap was melted and castings were produced Second trail fuel is mixed fuel (diesel and Coke) furnace is operated melting was carried and castings were produced as shown in fig.6.1and 6.2 performance tests were conducted. There is no change in casting quality but Increase in efficiency of furnace when compared to coke fired is about 4.08% (refer to table 6.1).

It shows that the efficiency of the furnace is in the required range 20-30%.Castings produced were sound when fired with coke and diesel when compared to coke alone

Fig.6.1 Castings produced when fired with coke

Fig.6.2 Castings produced when fired with coke and diesel

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Table 6.1. Comparison between coke and mixed fuel fired furnaces

Factor	Coke fired	Coke and diesel fired
Time required for complete melting of aluminum	15min	25min
Cost of fuel	240/melt	280/melt
Cost of fuel for melting 100kg of aluminum	10000/melt	9800/melt
Advantage	Economical for lower melts(0-40kg of Al)	Economical for higher melts(40-200kg of Al)
Initial cost of the furnace for melting 10kg of Al	15000	18000
Efficiency of furnace	**28.16%**	**33.27%**

Conclusion

An energy efficiency of 28.2% was obtained when burnt with coke alone and it increased to 4% when fired with Mixed fuel (coke and diesel) the efficiency obtained in case of mixed fuel fired furnace is 32.3%.This is quite appreciable increase in efficiency. It is concluded that the furnace fabricated has reasonably for good efficiency with reference to standard efficiency (20-30%).The melting temperature was attained in short time starting from pouring time to tapping time. Finally Mixed fuel furnace that runs on coke and diesel oil for melting non-ferrous alloys have been installed successfully eventually This furnace can be effectively utilized as a melting furnace in our foundry laboratory. After the complete experimentation it is concluded that furnace may be effectively used for melting non-ferrous metals.

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