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DESIGN AND FABRICATION OF STIR CASTING FURNACE WITH BOTTOM POURING ARRANGEMENT FOR THE DEVELOPMENT OF PARTICULATE METAL MATRIX COMPOSITE

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Abstract

Melting is primary requirements for the development of Particulate metal matrix composites by casting route. In this work the design concept, Fabrication and performance evaluation of a 3kg capacity portable crucible furnace which uses electrical coil was carried out with locally the available material. The 3kg crucible furnace was designed, constructed using locally available engineering materials. Mild steel circular drum, mild steel (angle plate), asbestos, clay sand, stainless steel pipe, insulating material, thermocouple, refractory bricks and control panel. Stirrer with Speed control regulator arrangement and Bottom tapping facility during stirring of the melt was added feature. The stirrer with 0 to 800 rpm speed was designed and the manually operated bottom opening arrangement was fitted directly to the Cast Iron crucible. The electrical heating element provides maximum furnace temperature of 1000℃. The performance study and cost analysis of the developed Furnace was performed and the maximum temperature of 1000℃ was achieved in 45 minutes. The cost of the Furnace was estimated about Rupees 25000 (twenty Five Thousand Only) which can be fabricated in house for any institution for carrying out project works, For R&D to carry out the research with the development of the Particulate metal matric composite, Nano composite. This results in Low cost high efficient Equipment for the Composite Research laboratory.

Key Words: *Stirrer, Bottom pouring, Particulate MMC, Furnace.*

Introduction

Furnace is an enclosed structure in which material can be heated to very high temperature. The term furnace can also refer to a direct fired heater used in boiler application in chemical industries and for some metallurgical application.Crucible furnaces are one of the oldest and simplest types of melting unit used in the foundry. The furnaces use a refractory crucible which contains the metal charge. The charge is heated via conduction of heat through the walls of the crucible. The heating fuel is typically coke, oil, gas or electricity. J.Hashmi, *et, al* [1].Discussed the importance and difficulty of achieving a uniform distribution of particle reinforcement in the molten matrix and also during solidification of MMC. The uniform distribution of the MMC will have improved mechanical properties when compared to the non-reinforced material. A comprehensive study was carried out to establish the effects of controlled stirring during solidification on the microstructure and mechanical properties of aluminium alloys, in comparison to conventionally gravity chill cast material. A novel device comprising a grooved reaction bonded silicon nitride rod rotating in a tube-like crucible was used to process aluminium alloys in the mushy state. The major problem of this process is to obtain sufficient wetting of particle by liquid metal and to get a homogenous dispersion of the ceramic particles. P.K.Ghosh, *et,al* [2]. Proposes that effective stirring action is necessary to control distribution from immediately after the addition of the particles into the melt, until pouring into a mould and the results of stirring can only be deduced from the solidified MMC using optical examination. D.J.Lloyd, *et,al*[3]. Elaborated the study on stirring action and proposed that in composites produced by a foundry technique inhomogeneous distribution of ceramic particles in the casting has been identified as one of the primarily problems. Mechanical stirring is usually used during melt preparation or holding and, in this context, the stirring condition, melt temperature, and the type, amount and nature of the particles are some of the main factors to consider when investigating this phenomenon.

Design of Stir Casting Furnace

The cylindrical drum diameter is 50cm and length 40cm and it is made of mild steel. It consists of four legs and supported to cylindrical drum and length of leg is 50cm. Crucible is the container in which the metal is melted and then poured into a mold Crucible inner diameter is 12cm and outer diameter is 16cm the length of crucible is 18cm and thickness 2cm.

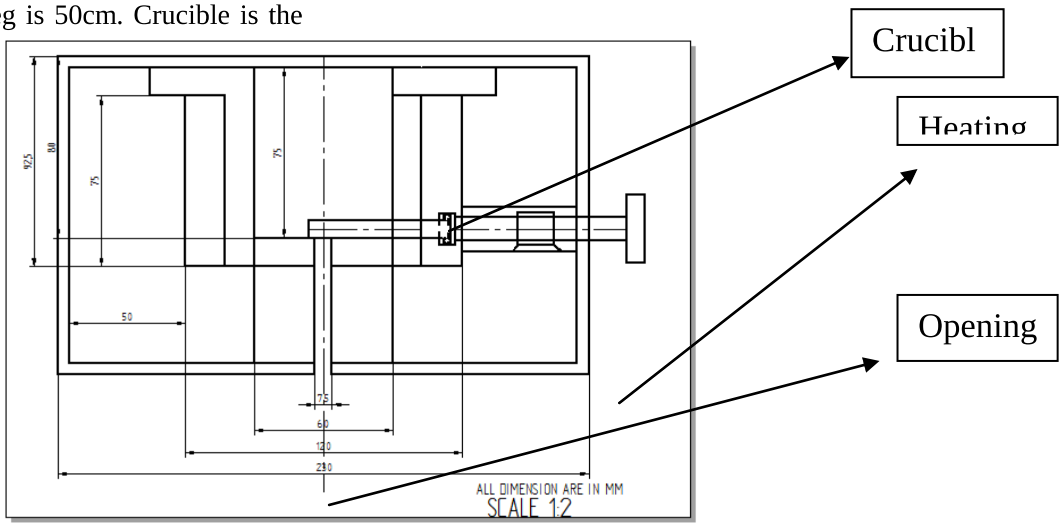

Fig 1 -2D drawing for furnace heating chamber

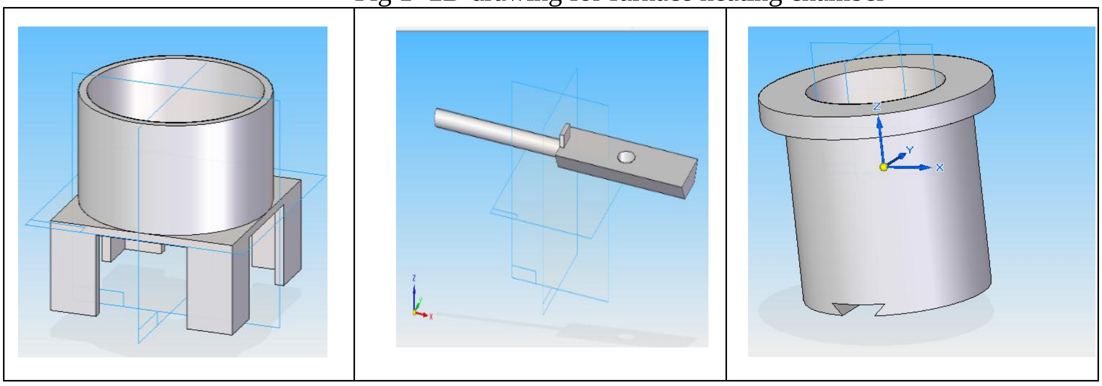

Fig 2 - 3D model body, frame, Crucible and slider

Design Calculations

Furnace wall: (Refractory lining)

Maximum element temperature Ti=1200° c temperature at outer surface To =30° c

Electrical supply V=220 volts, I=10 ampere.

Resistance of the conductor R=V/I=220/10=22 Ω

Heat developed $q=I^2R = V \times I = 220 \times 10 = 2200$ W

Thermal conductivity of refractory material k=1.5 to 3 w/mk

Thickness of the wall can be found out by using formula $q = \frac{KA(To-Ti)}{L}$

L is the thickness of the wall h=16 cm b=24 cm

$2200 = \frac{3 \times 0.0324 \times (1200-30)}{L}$ L=5.69 cm

For safety take L=10 cm, because assuming for avoiding heat loss in chamber.

Design for Crucible: (cast iron)

Dimensions of the crucible: crucible is designed for 3 kg capacity

Depth and diameter of the crucible are found by making use of density of the Aluminum. Which is equal to 2700 Kg/m^3

D=12 cm l=16 cm

Q=2200 KJ

Maximum furnace temperature (To):

Thermal conductivity of the crucible material (C.I) K=36.05 w/mk

Inner radius r1=0.06 m, Assume Outer radius as r2=0.085 m.

$$Q = \frac{Ti-To}{\frac{ln(\frac{r2}{r1})}{2\pi Kl}} = \frac{1200-To}{\frac{\ln(\frac{0.085}{0.06})}{2\pi\times36.05\times0.16}} ....4.3$$

To=1178 ̊ C Temperature inside the crucible.

Heating element: (Fe-Cr-Al) Kanthal-A1

Resistance of the wire R= 22 Ω

Resistivity of the wire r=1.60$\times 10^{-6}\ \Omega m$

Diameter of the wire d=2 mm

Cross sectional area A=$\frac{\pi d^2}{4}$=$\frac{\pi\times 0.002^2}{4}$=3.141$\times 10^{-6} m^2$.........4.4

Length of the heating element required:

R=$\frac{rL}{A}$.........4.5

$$22 = \frac{1.60\times10^{-6}\times L}{3.141\times10^{-6}}$$

L=45 m

Fabrication of Furnace

Body frame: The furnace body frame carrying the furnace chamber and stirrer mechanism. The frame is made with the same angle section mild steel bars as legs are weld joined. **Refractory Wall** :The walls are made with refractory bricks that are cut into the same shape as that of the furnace and are joined with the paste made up of ceramic powder and glue after the gaps in between are covered by pieces of ceramic blanket. **Ceramic Blankets**: The insulating material used in the furnace is ceramic blanket. Ceramic blanket are very high resistive material used in high temperature applications to avoid heat leakage and fire hazards. **Heating Coil**: Heating modules are produced from the high resistance wire by coiling them and then these coils are placed on the walls of the furnace to produce heat. A single phase 220v AC supply is connected to the heating module. **Stirrer:** a stirrer is required which can withstand the high temperature and doesn't affect the purity of the composite. The stirrer is made of a stainless steel rod whose front end is attached with a graphite fan. It is driven by a 0.5 HP AC motor and rotates at about 400 rpm. **Thermocouples** are temperature sensing devices used to measure temperature. The thermocouples used here is the iron constantans and chromel- alumel **(k type)** whose maximum range of operation is 1200°C. **Crucible:** The cast steel or cast iron which serves to our purpose as its melting temperature is about 2200° c which is far above our operating temperature.**Control panel:**. The control panel consists of ammeter, voltmeter, temperature controller, limit switch, electromagnetic relays. **Temperature controller:** Temperature of the furnace is maintained by auto cut off. It has a working range of 1200^{0}C and connected with a 220V AC supply. It is an on & off type controller.

The testing has been done with no load condition, means without feeding metal into the furnace, for determining the variation of temperature with time. The test also determines the heat obtained for the amount of heat supplied. Following graph shows the temperature variation with time. All the above readings are plotted to observe the variation of temperature with time. Temperature is plotted in X-axis and Time is plotted in Y-axis.

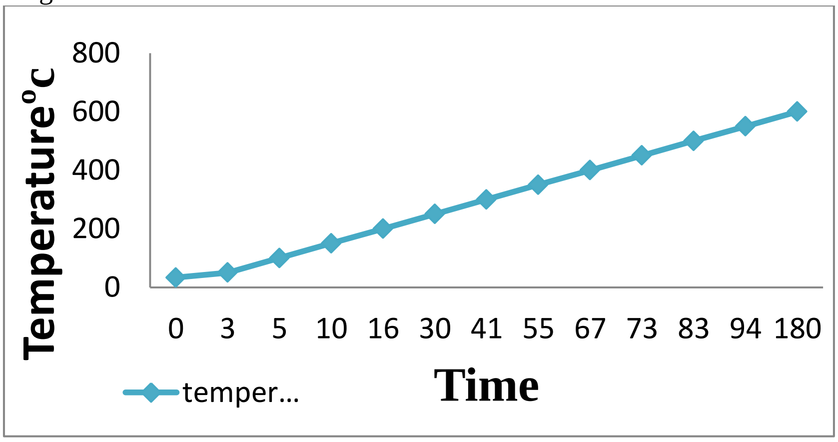

Fig 3 : Temperature vs Time plot of testing and Furnace fabricated.

As the temperature increases the time taken for the increasing in temperature is more. It is because of some of the heat losses in furnace at high temperatures.

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