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Design and Fabrication of a Stir Casting Furnace Set-Up

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ABSTRACT
Now-a-days a large variety of heating techniques/furnaces are available. There may be many method for supplying heat to the work but heat is produced either by combustion of fuel or electric resistance heating. Taking into consideration the effect of cost, safety, simplicity and ease of construction we are going for an electrical resistance heating furnace with indirect heating provisions. The stir casting furnace has two main parts that enable to perform all its operations, they are: Furnace Elements and Control Panel. This paper shows the design and fabrication of stir-casting furnace and aluminium melted and casted to form.
***Keywords* –** Stir casting furnace, design, fabrication, casting, aluminium

I. INTRODUCTION

Stir-casting is also otherwise known as "Semi-Solid Metal Casting" or "Rheocasting" or "Compocasting" and is mainly use with the non-ferrous metals. The process combines the advantages of casting and forging. SSM is done at a temperature that puts the metal between its liquidus and solidus temperature. Ideally, the metal should be 30 to 65% solid. The metal must have a low viscosity to be usable, and to reach this low viscosity the material needs a globular primary surrounded by the liquid phase. The temperature range possible depends on the material and for aluminium alloys is 5–10 °C, but for narrow melting range copper alloys can be only several tenths of a degree.

When an electric current flows through a material (preferably a good conductor) some energy is dissipated in the form of heat due to the resistance offered by the material. This phenomenon offers a good, clean, and easily controllable source of heat, and is used on a very large scale in industrial and domestic heating. The object or work can be heated "indirectly" by exposing it to an electrically heated radiator or heater, or element. Alternatively, the object itself can be used as a resistance or heater in which heat is generated internally.

1.1 Principle

If the resistance of the conductor is R (ohms) and a current I (amps) is flowing through it, for a time t (sec), the heat produced (H) is:

$$H=I^2Rt \text{ (Joule)} \quad (1)$$

The power dissipated P (watts) is:

$$P=I^2R \text{ (Watt)} \quad (2)$$

The conductor is called "heater" or "heating element".Resistance materials are available up to a maximum useful temperature of 2000 C. However, there is no one material for the whole range and all types of atmospheres. Each material has its own maximum useful temperature in a given atmosphere.

For example, a metallic material which can be used up to 1500^0C in air (oxidizing) can be used only up to 1150^0C maximum in a reducing atmosphere. Available materials can be classified as follows:

1.1.1 Metallic alloys

These are Fe-Cr-Al alloys or Ni-Cr-Fe alloys and can be used in the range 1000–1400^0C depending on the grade. Metallic alloys are the cheapest heating materials and are used in the majority of industrial and domestic heating applications.

1.1.2 Refractory metals

Tungsten, molybdenum, and tantalum can be used from 1500 to 2000^0C.

1.1.3 Noble (precious) metals and alloys

These are platinum or platinum-rhodium alloys useful in the range 1200–1800^0C.

1.1.4 Non-metallic elements

These are readymade elements made from silicon carbide or molybdenum disilicide and are useful in the 1200–1750^0C range.

The heating element or electric resistance alloy generally used is Kanthal A1 (22% Cr, 5.8% Al, Fe-remaining). Its maximum and continuous service temperature is 1400oC and electrical resistivity is 145×106 Ωcm.

1.2 Casting methods

1.2.1 Mould temperature

The use of metal die produces marked refinement when compared with sand cast but mould temperature is only of secondary importance in relation to the structure formation. Its principal signification lies in the degree of expansion of the die with preheating .Expansion diminishes the risk of tearing in casting. In nonferrous castings, the mould temperature should neither be too low or too high.

The mould should be at least 25 mm thick with the thickness increasing with size and weight of casting.

1.2.2 Mould coatings

Various types of coating materials are used. The coating material is sprayed on the inside of the metal mould. The purpose of the coating is to reduce the heat transfer to the mould. Defects like shrinkage and cracking that are likely to occur in metal moulds can be eliminated, thus increasing the die life. The role of coating and solidification can be adjusted to the optimum value for a particular alloy by varying the thickness of coating layer. For aluminium alloys, the coating is a mixture of Silicate and graphite in water.

1.2.3 Mould life

Metal mould in casting is subjected to thermal stresses due to continuous operation. This may lead to failure of the mould. The magnitude of the stresses depends on the mould thickness and thickness of the coating layer, both of which influence the production rate. Deterioration takes place faster in cast iron mould than in steel mould.

Stir Casting is characterized by the following features:

- Content of dispersed phase is limited (usually not more than 30 vol. %).
- Distribution of dispersed phase throughout the matrix is not perfectly homogeneous:
  - There are local clouds (clusters) of the dispersed particles (fibers).
  - There may be gravity segregation of the dispersed phase due to a difference in the densities of the dispersed and matrix phase.
- The technology is relatively simple and low cost.

II. DESIGN

2.1 Design of furnace elements

While considering the design of stir casting furnace several important elements of the furnace come to mind. They are:

- Body frame
- Walls
- Insulating materials
- Pot/Container
- Heating wire
- Thermocouples / Temperature sensors
- Crucible
- Stirrer
- Cover Plate
- Control Panel

2.1.1 Body frame

The furnace body is of the dimension 46×46×46 cm^3 and rises to a height of 16 cm on four legs made of angle section mild steel bars. The frame is made with the same angle section mild steel bars as the legs and is weld joined. The sides are made of galvanized plates of steel and the top side is made with mild steel plate which is bolted to the frame and has a circular opening on top.

2.1.2 Walls

The walls are made with refractory bricks (Fig 1) that are cut into the same shape as that of the furnace and are joined with a paste made up of ceramic powder and glue after the gaps in between are covered by pieces of ceramic blanket.

Fig 1 Refractory Bricks

2.1.3. CERAMIC BLANKETS

The insulating material used in the furnace is Ceramic blankets (Fig 2). Ceramic blankets are very high heat resistive material used in high temperature applications to avoid heat leakage and fire hazards. These have very low value of thermal conductivity and highly flexible and can be easily cut and used as insulating material. An important parameter associated with the use of ceramic blankets is critical thickness of insulation. The critical thickness of insulation is the minimum thickness that must be provided so that the heat loss could be minimized and for cylindrical surfaces its value is twice that of its thermal conductivity. Ceramic blankets are produced from exceptionally pure oxides of alumina and silica using the spinning process.

Advantages:

- Low thermal conductivity.
- Excellent handling strength.
- High thermal shock resistance.
- Low heat storage.
- High corrosion resistance.
- Sound absorption and fire protection.

Fig 2 Ceramic Blankets

2.1.4 Pot/container

The pot/container is made of the ceramic clay shaped into a cylinder of diameter 10cm and height 15cm. The working temperature of the pot is approximately 1400^{o}C.

2.1.5 Heating wire

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. The high values of current passing through the resistive wires convert the electrical energy into heat energy thereby serving the purpose.

Generally two types of heating wires for furnace are available as KANTHAL and NIKROTHAL. We are taking Kanthal wires due to its higher value of operating temperature range and wear resistance. Kanthal are electric resistance alloys of iron-chromium-aluminium. While considering the use Kanthal wires in furnace certain property of resistive wires i.e. "Surface loading effect" is to be taken into consideration. Surface loading effect: "The surface loading capability of a resistive wire describes the safe limit up to which heat per unit surface area of the wire that can be produced without melting or damaging of the wire."Therefore, while choosing the wire for the furnace the ratio of specific resistance to the surface area of the wire need to be optimized so as to lie within the permissible safe limit. This is done on the basis power required by the furnace and the maximum surface loading possible.

After obtaining the required diameter of the wire necessary length needs to be calculated to meet the power requirements.

Advantages:

- Improved hot strength giving:
  - Better stability of the heating element.
  - Lesser need for element support.
  - Low resistance change (ageing).
  - Longer element life.
- Excellent oxide giving:
  - Good protection in corrosive atmospheres.
  - No scaling and impurities.
  - Longer element life.

2.1.5.1 Wire design

Standardised data:

Melting point of aluminium = 660.3^{o}C

Weight of aluminium to be melted = 0.5 kg (max)

Maximum temperature to be reached = 1000^{0}C =1273 K

Specific heat for aluminium = 0.91 kJ/kgK

Latent heat of fusion for aluminium = 398 kJ/kg

Density of aluminium = 2.70 gm/cm^3

Specific heat of graphite = 0.17 kJ/kgK

Density of graphite = 2.09 gm/cm^3

Calculations:

Heat required to be produced to keep aluminium in molten state at a temperature of 1000^{0}C (1273 K)

= (1273-300) × ((0.91×0.5)+(0.17×0.5)) + (398×0.5)

=724.42 kJ

Taking an approximate of 12 minutes to do the work, the power needed to be produced will be

=724.42/720=1.02KW (say time taken is 12mins)

Taking efficiency of the furnace to be 0.6 the actual power required will be= 1.02/0.6=1.764 KW

(efficiency is taken to be 60%)

Then the coil resistance to produce this much power is= V^2 / P_{act} = 2102 / 1764 = 25 Ω

Again taking surface loading effect to be 1.5 W/ cm^2 we get the surface area to be = (1.764×103) / 1.5= 1176 cm^2 (Surface loading factor is 1.5 W/ cm^2)

Now the ratio of the surface area of the heating coil to the resistance is calculated to be =1176 / 25 = 47.04 cm^2 /Ω

The specific wire according to our requirements can be looked up in the KANTHAL handbook corresponding to the ratio.

There is no specimen in the handbook whose surface area to resistance ratio (cm^2/Ω) is equal to 47.04, so the next ratio inline is considered whose cm^2/Ω ratio is 57.04 , the wire with diameter 1.5 mm and resistance per unit length of wire to be 0.821 Ω/m

Now the length of the wire is = 25/0.821 =30.56 M ~ 31m

So the net resistance of coil is

= 31×0.821 = 25.451 Ω

The power production capacity of the coil is now = 2102 / 25.451 = 1.732 KW

Weight of the coil is = 12.5×31 = 387.5 gm

2.1.6 Crucible

Crucible (Fig 3) is the container in which the metal is melted and then poured into a mould to perform casting. The material of the mould should have very high melting point, high strength and should be a very good conductor of heat so that heat loss should be less.There are several materials available for this purpose like silicon-carbide, cast steel and graphite. For our requirements the silicon-carbide crucible is best suited, however the cost is very high so can't be afforded. We have taken here a graphite crucible which serves to our purposes as its melting temperature is about 2700°C which is far above our operating temperature.The crucible is made in a shape of a cylinder with decreasing diameter so that the upper portion remains a cylinder however the bottom part takes the shape of a hemisphere. A handle is attached to the side of the crucible to hold it while placing it inside the furnace and while pouring hot metal into the mould cavity.It can withstand very high temperatures and is used for metal, glass, and pigment production as well as a number of modern laboratory processes.

Our design specifies the use of graphite crucible in the furnace because:

- It is readily available.
- The cost is affordable.
- Graphite is good conductor of electricity

Fig 3 Graphite crucible

2.1.7 Stirrer

The method used in fabrication of MMC requires the dispersed phase that is the ceramic particles (SiC) to be mixed in solid state in the liquid metal. So for uniform mixing of the ceramic particles in the liquid metal it is needed that the mixture be stirred well. So, 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 ½ HP AC motor and rotates at about 400 rpm. The stirrer is inserted vertically into the crucible about one third of its height after adding the ceramic particles. Here we have provided ways for stirring through external mediums that can be attached to the furnace at any point through the top.

2.1.8 Thermocouple

Thermocouples are temperature sensing devices used to measure temperature. These are highly effective, accurate, highly sensitive and cheaper. Here we are using a copper-constantan thermocouple. It is required to know the temperature of the liquid metal at all points i.e. why thermocouples are used. The thermocouple used here is the Iron-Constantan and Chromel-Alumel (K type) whose maximum range of operation is 1200ºC.

2.1.9 Cover plate

The cover plate of the furnace is made up of Mild Steel of dimension 46cm×46cm. A portion of circular cross-section of about 6 inch diameter was cut at the centre of the cover plate. Another hollow cubical cover made up of galvanized plate was clamped to the mild steel cover plate which is fixed to the furnace top permanently with the help of bolts. The hollow cover was filled with ceramic blanket. In order to lift the cover, two handles made up of Bakelite were attached.

2.1.10 Control panel

The control panel has following parts

- Body
- Fan
- Ammeter
- Voltmeter
- Temperature controller
- Energy regulator
- Energy meter
- Selector switch
- Limit switch
- Contactor
- Guerter circuit (AC to DC converter)
- Transformer
- Connectors (both Porcelain and Plastic)

The body of the control panel is made of Bakelite.

2.2 Design of control panel

The sole purpose of the control panel is to control and maintain the conditions inside the furnace with maximum efficiency.

2.2.1 Control panel body

The body of the control panel is made of Bakelite due to good electrical and thermal insulation reasons as well as less price and easy construction options. To join the Bakelite sheets aluminium flanges are used. These flanges are riveted to the sheets where as the front side is bolted to facilitate opening the control panel in future.

2.2.2 Ammeter

Ammeter (Fig 4) indicates the current flowing through the circuit at a particular instant of time through the circuit. The ammeter used here is a moving iron (MI type) Ammeter having dial area 72mm^2 and has a range of 10A. The manufacturer of this ammeter is M –Tech industries.

Fig 4 Ammeter

2.2.3. Voltmeter

The voltmeter (Fig 5) is connected in the circuit to measure the voltage across the coil. This one is also moving iron (MI) type voltmeter with dial area of 72mm2. The range of the voltmeter is of 300V. This is also manufactured by M-Tech Industries.

Fig 5 Voltmeter

2.2.4 Temperature controller

The temperature is the most important instrument in the whole panel. This instrument measures and displays instantaneous temperature through the thermocouple placed inside the furnace. Besides this the temperature controller regulates the current flow inside the furnace to maintain the set temperature and hence avoids over-heating. When the temperature inside the furnace rises above the set temperature the controller activates the electro magnet inside the contactor to cut the circuit and when temperature falls below the set temperature the electro magnet is demagnetized to again complete the circuit to start heating. Hence, temperature of the furnace is maintained. The temperature controller (Fig 6) is manufactured by Multispan Instruments Corporation. It has a working range of 1200^{0}C and connected with a 230V AC supply. It is an on & off type controller.

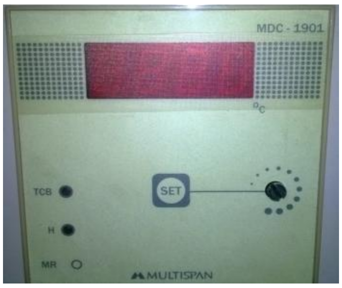

Fig 6 Temperature controller

2.2.5 Limit switch

The limit switch (Fig 7) is placed on the backside wall of the furnace to break the circuit when furnace door is opened. So while the operator opens the door, the door pushes the limit switch and stops heating to avoid any harm to the operator.

Fig 7 Limit Switch

2.2.6 ENERGY METER

The energy meter (Fig 8) is placed in the control panel for experimental purpose. It calculates the net energy consumed by the furnace to perform a job. This data is used to calculate the efficiency of the furnace. The energy meter we have used is manufactured by JUVAS Company and operates at 240V and 50Hz and has a temperature tolerance in between 25^{0}C to 29^{0}C.

Fig 8 Energy meter

2.2.7 Electromagnetic relays

The other name for this device is contactor. The power supply is provided to the heating wires through these because they have high temperature and current sustainability. This much amount of high current cannot be passed through the controller directly because it may get damaged. So in turn the controller operates the contactor there by controlling the supply. It has an electromagnetic core in it which gets magnetized upon getting signal from the controller and cuts the supply and when it demagnetizes the connection is re-established. The relay we have used here has 25Amps current carrying capacity and is operated with 12 V DC supply.

2.2.8. Transformer

The transformer is used to convert the 220V AC supply into 12V AC supply because 12V is the operating range of the relay.

2.2.9 AC TO DC CONVERTER

This is a rectifier which converts the 12V AC output from the transformer in to 12V DC supply which is fed to the relay. It uses a Guerter circuit (Fig 9) to perform this.

Fig 9

2.2.10 Selector switch

A 15Amps 250V rotary selector switch is used to on or off the power supply.

III. FABRICATION OF STIR CASTING FURNACE

3.1 Step 1

The first part in the construction of the furnace is the body of the furnace. To work with highest efficiency the furnace has to produce heat as well as retain it within the walls of the furnace, so that the heat loss in the furnace is very less. To achieve this, the furnace needs to be as insulated as possible while being able to withstand the thermal stresses developing within the furnace. The construction of the body starts with building the furnace frame. The furnace frame is made of mild steel angle sections weld joined, upon which galvanized steel plates are also welded to form the body. Galvanization of the steel sheets adds to the insulating property of the furnace wall which is much needed, as a result we are able to keep the temperature of the walls at near about atmospheric temperature and avoid over-heating. But with an exception to the sides the top side of the frame is made of mild steel plate and instead of weld shutting it we have bolted it to the frames with screws and the plate has an opening cut in the center which will serve to the purpose of placing the crucible inside and removing it while operating the furnace. This top plate is not screwed to the frame until all the things inside the furnace are completely built.

Fig 10 Construction of the frame of furnace

3.2 Step 2

In order to reduce the thermal conductivity of the furnace after making the frame the inner sides of the frame plates are coated with an insulating paint as well as lined with thin sheets of soft asbestos. The use of asbestos sheets and insulating paint greatly improves heat trapping capabilities of the furnace. After that the inner sides of the frame is lined with insulating bricks made of refractory materials ,which also acts as insulators and traps the heat lost from the coils. Due to use of the refractory bricks which are remarkably light overall weight of the furnace also decreases which is an advantage to the furnace and eases the furnace handling and moving. To avail complete heat trapping and avoid heat loss through any gaps all the gaps within the adjoining walls are covered with pieces of ceramic blankets. Then a paste is made from ceramic powder, glue and water which acts as cement for the furnace and hence used for closing the gaps where previously we had packed ceramic blanket pieces. The main reason for using the paste is that ceramic powder can withstand very high temperature and at the temperature the paste can still maintain its cohesive properties. After that the furnace is left as it is to become dry.

Fig 11 Stacking of refractory bricks inside the furnace frame

Fig 12 Packing ceramic blanket pieces and applying the ceramic paste

3.3 Step 3

The next part in the building is the pot and coil set-up. The pot is made up of ceramic particles and is heated up to a temperature of 2100^{0}C in phases. It is done so that it can get heated up to 2100^{0}C and still remains intact. The pot is an important part of the furnace as the coil is wrapped around it as well as the crucible is placed inside it. The pot can be made in various shapes and sizes and generally is made with square cross section, but here the furnace is subjected to top loading so we have taken a pot of circular cross section.

3.4 Step 4

After making the pot according to requirement (i.e., fixing the pot height depending upon the furnace size as well as the crucible size), the coil is wrapped around the pot. The dimensions (such as the wire diameter and length) of the heating wire are determined specific to our furnace requirement and size. Here we have chosen to go with the APM grade KANTHAL which has the highest temperature range of heating i.e., about 1600^0C in the whole KANTHAL family. The calculation through which we arrived at the conclusion of wire diameter and length is explained in the design section. After getting the wire we have to make it into a helical coil by wrapping and turning it around a thin rod in a lathe, and the ends are made into hooks so that they can be easily connected to the power supply. After that the coil that is obtained from above said process is wrapped around the pot in a helical manner leaving some of the wire at the ends along with the hooks. To fix the coil around the pot the top and bottom end of the coil is tied to the top and bottom of the pot respectively with GI wires and knotted with nose plies. For maintaining uniform heating around the pot equal distance is maintained between two consecutive lines of the helix around which the coil is wrapped and the gaps are filled with thin pieces of ceramic blankets. This avoids any type of contact between any two consecutive coil lines and hence avoids any chances of short circuit. The parts of the coil that we had left at the top and bottom of the coil is covered with small ceramic beads for insulation purpose.

Fig 13 Winding the coil around the pot

Fig 14 Covering the coil with ceramic beads

3.5 Step 5

After we have wrapped the coil around the pot, pieces of ceramic blankets are wrapped around the complete setup in layers until the whole thing fits perfectly inside the furnace walls. And after placing the pot assembly inside the furnace the rest of the place that is remained blank in the furnace is completely packed with ceramic blankets till the top of the pot. After that the furnace is again covered with square cut pieces of the ceramic blanket till it touches the top of the furnace and then the top plate is screwed to the frame. To make an opening the upper layers of the ceramic blankets are cut with a knife with the same hole as that on the upper mild steel plate. There are three holes drilled at the bottom of the furnace through which the two terminals of the coil and one bimetallic temperature sensor is passed. They are connected to the control panel through porcelain connectors attached to the bottom of the furnace.

Fig 15 Wrapping of ceramic blanket around the coil and pot

Fig 16 Drilling holes through the base and inserting the pot in the furnace

3.6 Step 6

The top lid of the furnace that covers the opening at the upper side is made with the same galvanized steel plates as that of the furnace frame. The lower face of the cover has the same opening as that of the furnace top. Between the two plates of the lid two layers of ceramic blanket are placed and the part of the blanket coming out of the opening in the lid in the form of a balloon act as the projection of the lid and covers the furnace opening and therefore complete heat entrapment occurs. The two face of the lid are screwed shut. On the top of the lid is the locking mechanism for the door / lid. The door is hinged at the other end with lock screws. There is a limit switch at the back side of the furnace to stop the heating process when the door was opened so as to ensure operator safety. Two handles are provided at the two sides to assist the operator in opening the door.

Fig 17 After fixing the cover and the Bakelite handles

3.7 Step 7

Now the second order of construction is making the control panel to regulate end control the temperature and heating inside the furnace. The control panel is made out of Bakelite boards and joined through aluminium angles and channel sections with screws and rivets . The part and instruments are fixed within the control panel. The power is also supplied to the furnace through the control panel. The heating coil is joined to the control panel with glass wires. These have high temperature sustainability. The glass wire contains high quality copper wires and they are coated with glass fibres as insulating material to save the copper from thermal damages.

The main supply is controlled by a selector switch. The supply is given directly through the selector switch to the Ammeter (which gives the net amount of current flowing through the coil at a particular instant), then the supply is provided through the energy meter which calculates the net energy consumed in the whole circuit. The voltmeter is connected in parallel across the heating coil (which denotes the net voltage across the coil). The supply from the Ammeter goes to the porcelain connector at the bottom of the furnace.

The bimetallic thermocouple is connected to the PID temperature controller through a wire from a similar porcelain connector below the furnace and joined across the NC circuit of the controller. The temperature controller analyses the emf generated in the thermocouple to indicate the temperature inside the furnace. A supply of 220V is also supplied to the controller. The output of the controller goes to a miniature transformer which converts the 220V AC supply into a 12V AC output. This output is then connected to a "GUERTER CIRCUIT" which converts this 12V AC supply into a 12V DC output. This 12V DC supply is given to a contactor consisting of a latch and a coil acting as an electromagnet. The supply that is given from the Ammeter to the furnace is passed through this connector. When the temperature of the furnace goes above the set temperature the controller gives a 220V AC output which gets converted into 12V DC through the transformer and the Guerter circuit. When the contactor receives this 12V DC supply the electromagnet gets magnetized and pulled the latch there by breaking the circuit, hence avoiding overheating of the furnace.

The limit switch attached to the back of the furnace is connected to the heating coil in series to the contactor. So if either one of the contactor or the limit switch breaks the circuit the heating effect stops immediately.

The input power supply is controlled with an energy regulator connected in series to the heating coil circuit. The energy regulator controls the energy flow rate by tripping the circuit purposefully in continuous time intervals instead of letting the power flow to the furnace continuously. It contains two metallic strips that get bent when heated up to a particular limit. And when the strips get bent the circuit breaks and hence energy flow is regulated. The gap between the two metallic strips can be changed by twisting the knob on the regulator and hence the time upto which the current can flow though the circuit can be found out. As a result it gives the best controlled output. This is how the temperature is controlled in the furnace through the control panel.

There is an exhaust fan fixed at the back of the control panel to maintain the temperature inside the box at atmospheric temperature.

The readings from the energy meter, voltmeter, ammeter to calculate the efficiency of the furnace. Earthing is provided to the furnace to avoid any kind of leakage current in the furnace to ground.

Fig 18 Control Panel

IV. MELTING AND CASTING OF ALUMINIUM

4.1 Melting of Aluminium

4.1.1 Step 1

The furnace is heated upto a temperature of 950^{o}C, in 3 phases in 3 days, so as to remove any moisture present inside the furnace or on the heating wire. Even a single drop of moisture can damage the heating coil permanently. So, it is necessary to remove any moisture present inside the furnace. In the 1st phase (i.e., on the 1st day), the furnace was heated up to a temperature of 500^{o}C. The top cover is kept open until a temperature of 300^{o}C is reached, so that the moisture can escape when heated. After attaining 300^{o}C, the cover is closed. In the 2nd phase (i.e., on the 2nd day), the furnace was heated up to a temperature of 750^{o}C and the rest of the procedures were followed. In the 3rd phase (i.e., on the 3rd day), the furnace was heated up to a set temperature of 950^{o}C. After reaching this temperature the heater automatically shut down.

4.1.2 Step 2

The aluminium scraps were cut into small pieces and hammered to get small tablets of aluminium scrap. About 100 gm of aluminium scrap was taken in the graphite crucible. The graphite crucible was placed inside the container of the furnace. A base made up of refractory material was placed below the crucible, to prevent it from tilting or tumbling down. The furnace along with the crucible containing the aluminium scraps was heated up to a temperature of about 800^{o}C to melt the aluminium completely. The crucible was taken out of the furnace with the help of tongs and by taking other safety measures like wearing insulating hand gloves. The energy meter reading was noted to find out the efficiency of the furnace.

4.2 Casting of molten aluminium

A mould was prepared for casting the molten aluminium, by pressing a mixture of sand and clay into a stainless steel container such that a hollow impression of the required shape of the cast is formed. After preparing the mould, the molten aluminium was poured into the mould from the crucible and was left to solidify. When the casting is done, it was separated from the mould.

V. CONCLUSION

Hence, we successfully fabricated a Stir-Casting Furnace set-up. Aluminium scrap was melted successfully using the furnace and casting of the molten aluminium was done. The energy meter reading was noted. Hence, the furnace is efficient and can be used for fabrication of Metal Matrix Composites (MMCs) in future.

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