International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Impact Factor (2012): 3.358

Development of Full Mould Casting using Polystyrene Cutting Machine

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Abstract: ***Full mould casting process uses polystyrene foam as the pattern. The pattern is kept in sand mold. As the metal is poured, the foam vaporizes, and the metal takes its shapes. The gas from the foam flees through the sand. The advantage of this process is that complex shaped casting can be made without draft or flash. Moverover the process has less energy consumption and less waste residues than other casting processes. The present study is to fabricate a polystyrene cutting machine to cut poly styrene to shape pattern and evaluate full mould casting process. The present work Al-Si eutectic alloy is used to produce casting. Aluminum silicon eutectic alloy generally called L-M 6 contains 10 to 13 percent by weight silicon. Due to its good casting properties, high strength to weight ratio and excellent corrosion resistance, this alloy finds applications in automobile aircraft and marine industries. This alloy is best suited for automobile components like piston, cylinder, intake manifolds etc. Test result is encouraging. In modification shown the casting product has good mechanical properties and surface finish. Test result shown that LM 6 alloy casting using modifier given good casting shape with complicated profile casting in full mould process.***

Keywords: Mould, polymer, poly styrene, casting, complex shaped casting

1. Introduction

Full mould process had been developed to produce casting with low production cost, less energy consumption and less environmental damage. In this method pattern is coated with water based refractory slurry, dried and placed in a mould flask. Without removing the polystyrene pattern, the molten metal is poured into the mould.

This action immediately vaporizes the pattern and the molten metal fills the mold cavity, completely replacing the space previously occupied by the polystyrene pattern. The heat degrades the polystyrene and the degradation products are vented into the surrounding through vent holes.

The flow velocity in the mold depends on the rate of degradation of the polymer, studies have shown that the flow of the molten metal is basically laminar, with Reynolds number in the range of 400 to 2000. In this project work Al-Si eutectic alloy is used for casting production . Al-Si alloys generally have excellent casting and very good resistance to corrosion. LM6 is the eutectic alloy of Al-Si (LM 6) which containing 10-13% by weight of silicon. Aluminium has a density of only 2.7 gram/cc, approximately one third as much as steel. As the density of silicon is 2.3 gram/cc, it is one of the few elements that may be added to aluminium without loss of weight advantages.

Mechanical properties of Al –Si eutectic alloys can be improved by modification. The process of adding sodium fluorides or other alkali fluorides to the molten metal to improve the mechanical properties is termed as modification.

2. Process Details

A. Fabrication of poly styrene cutting machine

In polystyrene cutting machine cutting action is carried out by heating the cutting wire. This machine is working under the principle of Joules heating law expressing the relationship between the heat generated and current flowing through a conductor. The temperature requirement is calculated by equating heat energy to electrical energy as given below.

$$H = I^2RT$$

H= Heat energy
I= Current passing through the wire
R= resistance of the wire
T= time taken

$$H= mst$$

m =Mass of the wire
s= specific heat
t= temperature

$$I^2RT = mst$$

$$t =I^2 RT/(ms)$$

Hence t can be found out. In the present work t is obtained from 70℃ to 120℃ by using regulator.

When a quantity of current is passing through the wire the nichrome wire is heated due to this heating polystyrene material is evaporated. The electrical system contains a step down transformer which transforms the 230v main supply to 12v supply, a volt meter is connected to the transformer. With the help of regulator again controlling the voltage.

Polystyrene cutter is consists of a thin metallic wire made up of nichrome and to produce desired pattern shape. As the metallic wire is passed through the pattern material to be cut , the heat from the wire it vaporizes the material just in contact and pattern profile is made. The basic parts of a poly styrene cutting machine is shown in fig1.

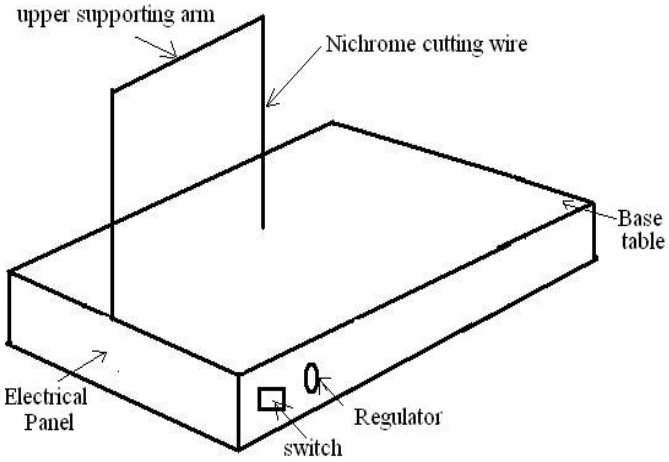

Figure 1: polystyrene cutting machine

B. Pattern Making

Pattern is made by polystyrene material. The standard dimensions are marked on the thermo cool and the pattern is cut by using developed hot wire foam cutter. Then the pattern sections are assembled with glue, forming a cluster. The gating system is also attached in a similar manner. The foam cluster is covered with a ceramic coating. The coating forms a barrier so that the molten metal does not penetrate or cause sand erosion during pouring. After the coating dries, the cluster is placed into a flask and backed up with bonded sand. After compaction the mold is ready for pouring.

C Modification

Mechanical properties of Al –Si eutectic alloys can be improved by modification. Unmodified Al –Si eutectic alloys contain silicon phases in the form of large plates with sharp sides and ends. Modification does break up the needle like silicon flakes within the grain and changes it to the fine dispersed form, even though it does not actually refine the grain size of the metal. The globules of modified structure are seen, to be the ends of silicon fibers which form an inter network. It is this transformation which is responsible for the enhanced properties associated with modified Al- Si casting. Several elements causes modification, includes Alkali metals, Alkaline earth metals and rare earth elements. Of all theses, sodium is the most effective in producing a fine uniform fibrous structure.

D. Moulding Techniques

Since LM –6 alloy has good castability and suitable for any type of mould, Green sand l moulding sand is used. Natural sand mould are having high permeability and fairly low green strength which is best suited for theses alloy. The properties of the moulding sand used are as follows

Table 1: Properties of moulding sand used

Grain fines	AFS NO 70
Clay content	5%
Moisture content	6%
Green compression strength	1Kg/cm^2

E. Casting Temperature

Casting temperature is maintained at the minimum possible 700℃. The increase in casting temperature increases the grain size which reduces the tensile strength of the cast piece. Hence all castings are done at the minimum melting temperature

F. Melting

A measured quantity of Al- Si eutectic alloy is placed into a high speed electrical furnace. To achieve sound casting the following chemicals are added.

- Coverall flux (containing various salts likes alkalis chlorides and alkali fluorides) is used to prevent oxidation of molten metal.
- Grain refiner are used to produced a fine grain structure. Grain refinement improves resistance to hot tearing, decreases the porosity and increases mass feeding. In this work, 'Nucleant-2' grain refiner is used.
- Degassing agents are added to remove the dissolved gases.

When the required temperature level in the furnace is reached, measured quantity of charge, in the form as scrap and ingot metal, is kept into it. When the charge becomes pasty condition coverall flux is sprinkled over its surface at a rate of 5gr/kg. The crucible should have sufficient temperature to keep the temperature of the melt from falling. Again coverall flux is added to the melt surface at a rate of 5gr/kg. After attaining the maximum temperature, melt is degassed and grain refined on a falling temperature, each adding at a rate of 2.5 gr/kg. Both of them are plunged into the molten metal using a perforated plunger and kept under the melt till the bubbling action ceases. On completion of the bubbling action, the surface flux cover of the melt is rabbled and skimmed cleanly. A layer of modification compound is added to the clean melt surface from 0-2% weight at a temperature about 710℃ and the mechanical properties of casting are found.

G. Mechanical Test

In this project work, mechanical properties of test bar casting such as uniaxial tensile strength and hardness have been evaluated.

1) Ultimate Tensile strength is found out using universal testing machine(U T M). Tensile test helps in determining tensile properties such as tensile strength, yield point % elongation, %reduction in area and modulus of elasticity.
2) Brinell hardness number is found out using Brinell hardness tester. Brinell hardness number is given by
   $BHN=2P/\Pi D\ (D-\sqrt{D^2-d^2})$
   Where P= Load applied (100kg)
   D= Ball diameter (10mm)

This gives the resistance of test bar to plastic deformation.

3. Results & Discussions

i. Polystyrene cutting machine

Design and fabrication of hot wire foam cutter are carried satisfactory. The hot wire foam cutter is very simple to use and is cheap in cost, Also it is very simple in construction. By using the hot wire foam we can obtain good cutting surface as compared to any conventional cutting method.. The cost of pattern is very cheap as compared with any other patterns.

ii. Strength

The values obtained from different experiments are given in fig2. From experiments conducted without modification, it is observed that the ultimate tensile strength for unmodified alloy is 61.31Mpa. From the investigation the relation between tensile strength and modification addition is shown in fig2.. In unmodified alloy the silicon is in the form of large plates like structure with sharp edges. So whenever a formation of crack, that will propagate at a faster rate. But by applying modification the silicon structure becomes finer fibrous, which contribute to higher values of ultimate tensile strength. By addition of modifier from 0.5 to 2 percentage the tensile strength is found increasing to the maximum at 1.5 percentage and further addition is found decreasing as the excess material gives as filler material without contributing enhanced strength.

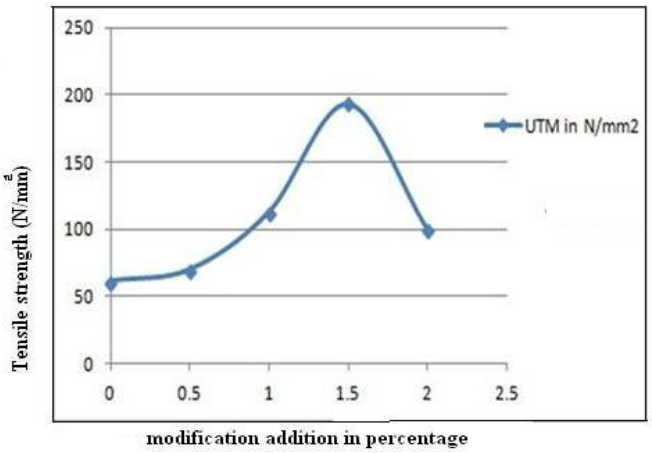

Figure 2: Effect of modification on tensile strength

iii. Hardness

From the experiment it is observed that Brinell hardness number increases as shown in the fig 3, from 48 to 71. The finer, fibrous grain may lock dislocation movement, which contributes increases in the hardness.

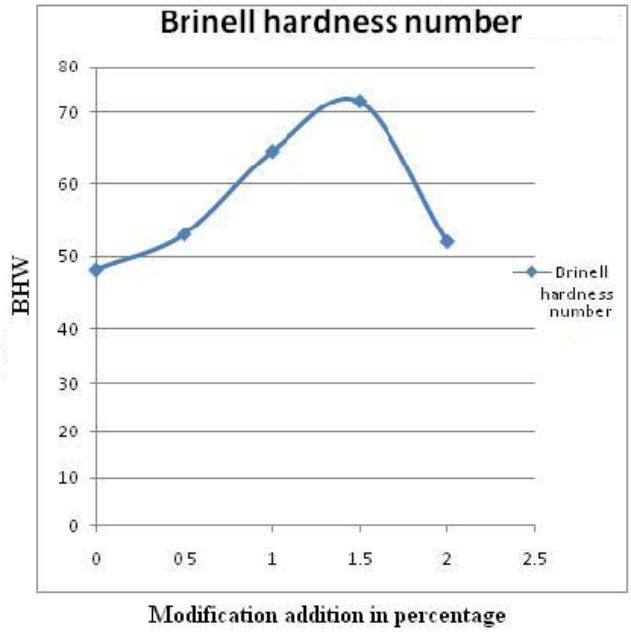

Figure 3: Relation between modifier addition and BHN

4. Conclusions and Scope for Future Work

From the experiments conducted to study the full mold casting process using LM6 alloy, the following conclusions are made

Aluminium silicon alloy is best suited for full mold casting process

- Poly styrene cutter developed is very effective to produce intricate pattern.
- Modification treatment using sodium salts increases mechanical properties such as ultimate tensile strength, and hardness..
- The surface finish is found to be good and required tolerance is obtained.
- This casting process takes less time as compared to other casting process.

5. Scope for Future Work

The pattern being a destructive one can also be used in self setting sand with the help of CO_2 gas.

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