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EMS Route Designed for SSM Processing

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Abstract: ***The various segments of the EMS arrangement are established. Also, the experimental EMS system comprises the cooling as well as shearing for getting the final microstructure of the semisolid cast billets. The comprehensive experiments are performed with the stated electromagnetic stirrer (EMS) using molten A356 aluminum alloy at pouring temperature of 625 °C. Through the reasonably moderate cooling the stirring intensity corresponding to the shear rate of 200 s^{-1} is used. The semisolid cast billets thus manufactured are sliced to make samples for further processing which is successively intended for metallographic analysis with optical microscope. It also illustrates the microstructure thus obtained at the stated shear rate. It is observed that the grains are almost uniformly distributed because of the moderate cooling alongside the shearing. Additionally, it also demonstrates the corresponding grain size frequency distribution as developed from the stated metallographic analysis. As a whole, the present study unveils the experimental preparations accompanied by the instrumentations besides the trials (such as melt preparation, treatment and transfer, temperature measurement with K-type thermocouple and flow measurement with rotameter) for semisolid casting experiments (with the EMS) and microstructure studies considering A356 aluminum alloy.***

Index Terms: ***Mould, Processing, EMS, Semisolid.***

I. INTRODUCTION

Amongst all the solidification techniques, as compared to the techniques already reported in the literature [1-7], the use of electromagnetic stirrer (EMS) is unparalleled one owing to the uniform properties and morphology of near net product alongside the productivity. It carries out an adaptable viscosity standard of the A356 aluminum alloy semisolid slurry (as used in the present case) for the steering course to symbolize the melt as semisolid material (SSM) slurry.

For the solidification forming procedure utilized in the current investigation effort, a cylindrical mould is introduced for manufacture of the semisolid cast billet having 100 mm diameter as well as 500 mm length. The mould be made up of two components. The topmost component of the mould is enclosed by an electromagnetic stirrer (EMS) of 350 mm length, called as the region of vigorous stirring. The bottommost component of the mould (150 mm length) is meant for cooling the A356 aluminum alloy melt. In the topmost portion of the mould, a clay graphite container and vacuum space surrounding the mould are erected, so as to lessen the radial heat transfer. The upper surface of the mould is exposed to atmosphere while the bottom surface is sealed with an adiabatic ceramic plate.

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In the current investigation, molten A356 aluminum alloy with 7.32 % Si is chosen for solidification practices by means of electromagnetic stirrer (EMS) that is usually intended for semisolid casting usages. The melt pouring temperature of the A256 aluminum alloy is 625 °C. A water cooled stainless steel mould is placed at the underneath of the graphite made refractory tube for removing heat from the molten A356 aluminum alloy.

II. DEPICTION OF EMS SYSTEM AND RELATED PRACTICES

Figure 1 describes the schematic sketch of an electromagnetic stirrer (EMS) system. It consists of a graphite made refractory tube, EMS coils, EMS water jacket, mould cooling arrangement, stirrer cooling arrangement, cooling mould along with end cap at the bottom and the space at the underneath for the solidified A356 aluminum alloy melt. It also shows the space at the core for the molten A356 aluminum alloy, broken dendrites at the phase change interface and mould heat flow lines. The A356 aluminum alloy melt at a very suitable temperature is poured into graphite made refractory tube placed within the EMS. The A356 aluminum alloy melt is cooled from underneath. The A356 aluminum alloy melt in the graphite made refractory tube is within the purview of the electromagnetic field. When the electromagnetic forces apply on the solidifying A356 aluminum alloy melt, it break the dendrites due to shearing at the solid-liquid boundary as depicted schematically in figure 1. It is anticipated that maximum of the heat removal throughout solidification befalls at the foot of the mould. As, the uppermost surface is open to atmosphere, there is cooling because of convection as well as radiation. Furthermore, since the graphite made refractory tube is having determinate thermal conductivity, certain volume of heat dissipation in the radially outward direction will at all times be exist. The specified EMS system will cause skyward progress of the solidification facade. The degree of movement of the solidification boundary will be sure of additional factors such as cooling rate from underneath as well as the stirring intensity.

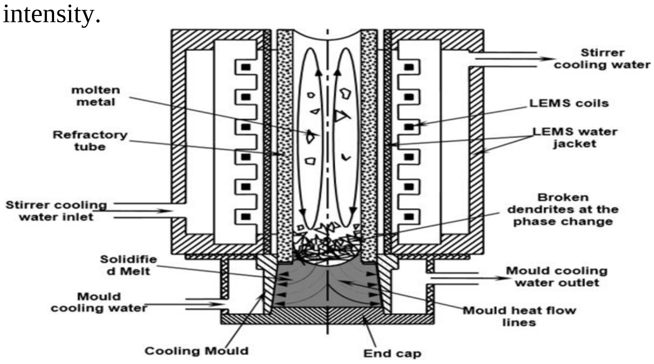

Figure 1. Schematic of EMS system

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III. EXPERIMENTAL FACILITY AND PROCEDURES

Figure 2 depicts a clear and vibrant photograph of the EMS experimental facility which is used for the present operations.

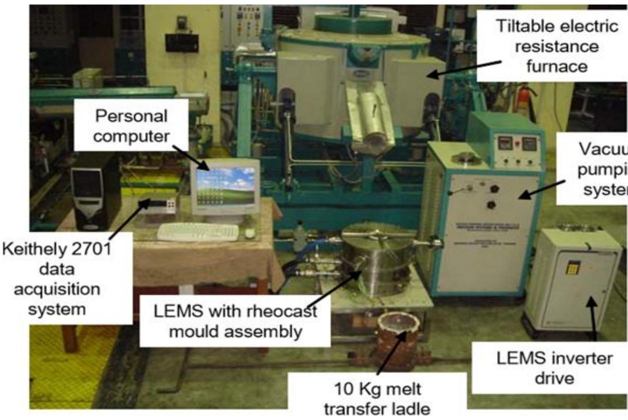

Figure 2. Photograph of experimental facility

Figure 3. Melt transfer to ladle and pouring into EMS

As demonstrated in figure 3, the operations involve the A356 aluminum alloy melt preparation and treatment within the electric furnace, the melt transfer to the ladle and pouring into the EMS using a tilting mechanism attached to the experimental arrangement at the underneath. As illustrated in figure 4, it also accompanies the melt temperature measurement through the "T" bar arrangement using K-type thermocouple. It also encompasses the flow measurement using a rotameter.

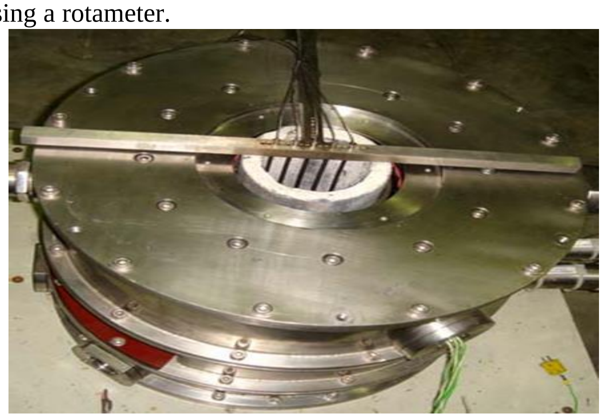

Figure 4. "T" bar arrangement for melt temperature measurement using K-type thermocouple

IV. RESULTS AND DISCUSSIONS

The comprehensive experiments are performed with the stated electromagnetic stirrer (EMS) using A356 aluminum alloy at melt pouring temperature of 625 °C. With very moderate cooling the stirring intensity corresponding to the shear rate of 200 s^{-1} is taken into the considerations. The semisolid cast billets thus obtained are sliced to prepare specimens for further processing.

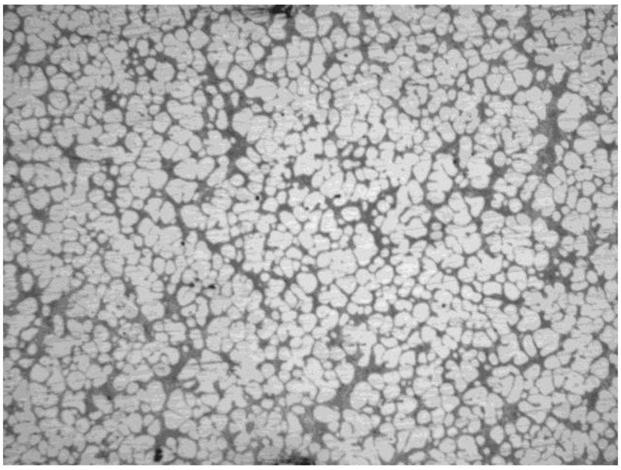

Figure 5. Microstructure obtained at shear rate of 200 s^{-1}

The specimens in turn are used for metallographic analysis by means of optical microscope. Figure 5 shows the microstructure thus obtained at the stirring intensity corresponding to the shear rate of 200 s^{-1}. It is observed that the grains are almost uniformly distributed due to the moderate cooling along with the shearing. In addition, figure 6 depicts the corresponding grain size frequency distribution as obtained from the stated metallographic analysis.

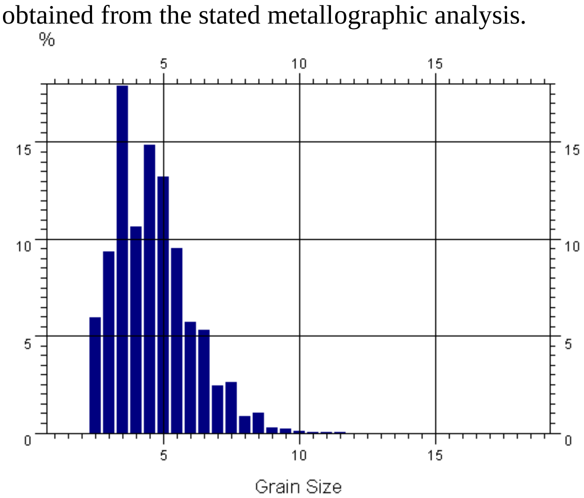

Figure 6. Grain size frequency distribution

V. CONCLUSION

The different components of the EMS system are demonstrated. The experimental EMS arrangement also includes the cooling and shearing for obtaining the ultimate microstructure of the semisolid cast billets.

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The rigorous experiments are accomplished with the specified electromagnetic stirrer (EMS) using A356 aluminum alloy at melt pouring temperature of 625 °C. With relatively moderate cooling the stirring intensity corresponding to the shear rate of 200 s^{-1} is applied. The semisolid cast billets thus produced are cut to prepare specimens for further processing which is sequentially used for metallographic analysis using optical microscope. It also demonstrates the microstructure thus observed at the stated shear rate. It is witnessed that the grains are almost uniformly distributed due to the moderate cooling in conjunction with the shearing. Furthermore, it also illustrates the corresponding grain size frequency distribution as acquired from the stated metallographic analysis. All together, the current investigation exhibits the experimental preparations along with the instrumentations besides the trials (such as melt preparation, treatment and transfer, temperature measurement with K-type thermocouple and flow measurement with rotameter) for metal casting experiments (with the EMS) and microstructure studies using A356 aluminum alloy.

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