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INVESTIGATIONS OF FEEDING BEHAVIOUR FOR ALUMINIUM ALLOYS SAND CASTING- A Review

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Abstract -The quality of the sand casting depends vastly on factors such as riser size, casting geometry, material used in casting etc. Even after taking care of these factors, shrinkage porosity is a major problem in Al and Al Alloy castings. Therefore, to avoid such defects in Aluminium castings, study of feeding mechanism for them is crucial. In the following review, factors such as solidus velocity of the metal, metal composition are effect on the feeding behaviour is study.

Keywords-feeding behaviour, riser, solidification time shrinkage porosity.

I. INTRODUCTION

The formation of porosity in aluminum alloys is a well-known problem relating to its good thermal conductivity, freezing range, and a large decrease of hydrogen solubility from a liquid state to solid state. This inevitable casting defect greatly deteriorates the soundness of casting. As such, numerous efforts have been carried out in an attempt to understand the feeding process of aluminum alloy by temperature measurement and to investigate the feeding behaviour.

II. LITERATURE SURVEY

Sand casting widely used of Al and its alloys but the main problem faced in the casting of Aluminum and its alloys are shrinkage porosity defects. In Aluminum-silicon alloys having an excellent fluidity and castability. Many factors are influencing the selection of the casting process. The factors are fluidity of the metal, solidification behaviour of metal, shrinkage defects and its tendency. In which paper focusing on the feeding behaviour of the Al alloys. Based on the feeding behaviour of the metal possible to the prediction of the shrinkage porosity in the casted part. Here few kinds of literature on feeding behaviour on Al alloys. Poirier [8] *et al.*, in modeling the feeding behavior of A1-4.5 pct Cu, found that the porosity content decreased with increasing solidification rate and thermal gradient because of the smaller interdendritic spaces. Pathak and Prabhakar [9] et.al. postulated for aluminum alloys that the feeding efficiency is determined by both the pasty zone factor, feeding efficiency as influenced by pasty zone (FEP), and the interdendritic feeding time, feeding efficiency as influenced by the time allowed during the last stage of solidification (FET). However, a contradiction exists as these two so-defined parameters, *i.e.*, FEP and FET, cannot be satisfied simultaneously; if the solidification rate is increased to improve the FEP, the FET will be sacrificed and *vice versa*.

The author was pay attention and carried out further work on to the feeding behaviour of A1-7Si-0.3Mg (LM25) Y.W. LEE [1], et.al. Work on the feeding behaviour of solidifying Al alloys (LM25) plate casting. The systematic change of riser size, together with the variation of geometries of solidifying A1-7Si-0.3Mg plate castings, was tested by thermal analysis to model the interdendritic feeding behaviour based on Darcy's law. Darcy's law is applicable to certain thermal condition in solidify of casting. Using Darcy's law to analyze the interdendritic porosity in the casting part. The applicability of Darcy's law depends on the regime of solidification time. A new feeding efficiency parameter integrating all individual thermal variables, denoted as $(G.\ T^{2/3})/V_s$ (where G is the thermal gradient, t is local solidification time, and V, is solidus velocity), is found satisfactory to predict the formation of porosity. In this work CO_2 mold was prepared using silica sand is used in casting. For thermal analysis thermocouples were used at the center of the cavity. The thermocouple arrangement was center of the cavity to along the longitudinal direction from free end to riser end, two types of test were conducted i.e. X-ray radio grapy and for density measurement Archimedes principle. X-ray photographs of castings along the longitudinal center cross section reveal two kinds of micro cavities, *i.e., the* surface puncture pinhole and the internal porosity. Based on experiment work and its result author say that, Solidification time

alone cannot be considered as an independent thermal variable to characterize the feeding behaviour of a casting. Result also show that Combined geometries of a casting and its riser size exert a great influence on the thermal variables of the AI-7Si-0.3Mg alloy in a complicated way. Together, these thermal variables synergize to govern the feeding behavior of the casting.

There were other references further an analysis on same alloys but focus on to the solidus velocity because author have an idea about that the solidus velocity also influencing the feeding behaviour of the metal. E. CHANG [2], et.al. "The Role of Solidus Velocity in the Feeding Behaviour of AI-7Si-0.3Mg Alloy Plate Castings". In this study the solidus velocity is proposed as a useful parameter to characterize the feeding of Al-7Si-O.3Mg alloy. In casting riser size and length of the casting both influence on the solidus velocity from free end to riser end. With the help of solidus velocity predict the porosity in casting. In the experiment work plate was used as specimen. Based on the plate dimensions the riser dimensions were calculated. A centre slice 3 mm thick was subjected to X-ray radiography and centre rectangular blocks 8 mmx 10 mmx 25 mm in size were used for density measurement. The author has found that two types of casting defects related to solidification were found i.e. sinking of the surface and shrinkage in the cavities. Here not only the top surface but defects at the bottom surface also observed. The phenomenon of surface sinking can easily avoid by increasing the riser size to provide sufficient mass feeding. X-ray radiographs of the longitudinal cross section of castings reveal two kinds of cavities—macro-shrinkage clusters and dispersed porosity.

From the paper indicate following conclusions

1) Riser size and casting length both the influence on solidus velocity.
2) Abnormally high solidus velocities of castings occurrence of surface sinking.
3) The solidus velocity is particularly useful as a parameter to characterize the porosity formation in LM25 alloy.

Till now only focus on to the metal and its solidus velocity analysis how the effect on to the feeding behaviour. But this author was pay attention on to the feeding characteristics affected by the alloying element. Manas Dash [3] et.al. Finding the Effect of key alloying elements on the feeding characteristics of aluminum–silicon casting alloys. In this paper effect of the alloying elements like Si, Fe, Mg, Mn, Cu, Sr, and Ti and the cooling rate amount of the porosity retained in the casting. the density of samples taken from locations along the length of a plate cast in sand is measured using Archimedes' principle following ASTM procedures. The percentage porosity is calculated from the difference between theoretical and measured density. The relative contribution of each of the alloying elements to porosity formation is calculated using analysis of variance. Among all of the alloys Fe and Si base alloys don't have contribution in porosity. Fe and Si form Al5FeSi, which is needle like. The length of Al5FeSi needles in the absence of Mn, increase with increasing Fe content and decreasing cooling rate. But presence of the Mn opposite effect can be shown in the needles. In sand castings, which freeze slowly, the presence of strontium increases porosity. Presence of high amount of copper, around 3.5% forms Al2Cu, which along with Al5FeSi needles blocks the feeding path. Finally, it was found that the cooling rate plays the biggest role in feeding issue as it has the highest contributor to the variance in percent porosity.

The feeding behaviour also dependent on casting geometry like riser size, specimen shape and size etc. for this reasons the riser design should be appropriate and optimum. Riser play major role into the solidification and feeding behaviour. Therefore, further suggested to the optimum riser design. Here authors work on to the optimization of the riser size for Al alloys casting and validate experiment work with simulation software. T Nandi [4]. et.al. Work on the optimization of the riser size of Al-alloy casting using the computer simulation and conventional method. In this study the plate casting is used to investigating the solidification behaviour of Al-alloy with different size of the risers. Using the simulation in casting method to reduce the trial and error in casting. With the help of the simulation author was found that the part decision regarding the part, orientation in mould, parting line, cores, cavity layout, feeders, neck and gating system. In this work the riser size is calculated by the modulus method and casting are produced by green sand casting method. In this work the authors were taken plate size of 100*100*20 mm and thickness of the plate was varied in case of different experiments. The simulation was performed in AutoCAST-X software. The simulation data was taken by authors same as the practical data. From the experiment result authors were analyzing a different relation between the modulus of riser and modulus of casting can be achieved. Simulate result was compare with the experiment result and finally they get relation between M_r and M_c i.e. $M_r = 1.07\ M_c$, where M_r is the modulus of riser, M_c is the modulus of casting.

Here in this area further work carried out by V. Gopinath [5] et.al. works on "Effect of Solidification Parameters on the Feeding Efficiency of LM6 Aluminium Alloy Casting" and finding the optimum riser dimension. Plate casting of dimension 240x150x25 mm is employed with the combination of different riser dimensions. Cylindrical riser of hemispherical bottom with H/D=1 are taken for this analysis. Solidification simulation was made with ANSYS software, then the solidification time and optimal riser diameters are compared with experimental results. In this work, ANYSYS 10.0 is used for temperature analysis of the riser and also helpful in finding optimum riser dimension for rectangular Al-alloy plate casting with iron end chill. Solidification simulation helpful in analyze the temperature distribution in casting section. Cooling curve is obtained from the Simulation data and find out the solidification time of riser and casting. The simulation results are verified experimentally for the optimal riser size and for the soundness of the casting. The plate casting properties such as porosity and ultimate tensile strength are compared with test casting properties and it is

observed that the riser diameter computed by ANSYS software is optimum and produces sound casting. From the experimental results obtained it has confirmed by author that the diameter of riser 100 mm and also has promoted the directional solidification which adds up to the casting soundness. These works are useful to design of the optimum riser for specially Al alloys. There are no standard data about the riser design of the Al alloys. Only work done on to the steel casting.

Nadiah Ahmad [6] performed work in his doctorate research problem on Riser Feeding Evaluation Method for Metal Castings using numerical analysis method. The author focuses on the pressure distribution of liquid metal at early stage of the casting, solidification, heat transfer of molten metal during the solidification. In this study the mathematical model is prepared by the author using Finite Volume Method. In this studied was concluded that identify the relationship between feeding behaviour and solidification and how the effect of riser size on to feeding behaviour of the metal.

Feeding behaviour also relate with the feeding distance of the riser in sand casting, with the help of the feeding distance we can say that how the feeding behaviour of the metal during the solidification. Casting solidifications having two aspects. One is directional solidification and other is progressive solidifications. solidification and the other is progressive solidification. Directional solidification depends mainly on the nucleation potential and thermal gradient of the material whereas progressive solidification mainly depends on the thermal conductivity of the material. V.S. Saravanan [8] et.al. work on" A Study on Relationship between Casting Modulus and Feeding Distance of Ductile iron.". the author has mainly focused on the feeding distance of the ductile iron because Very few research works are available on feeding distance of ductile iron but the information is very limited. This paper deals with the experimental procedures carried out to find out. This paper deals with the experimental procedures carried out to find out the maximum feeding distance of the ductile iron under certain conditions which indirectly expresses the solidification tendency of this material. To obtain the results a test pattern was developed and experiments have been carried out with certain fixed conditions with minimum variations. Experimental plan main objective to study of the feeding behaviour of the ductile iron with various conditions. In this experiment specimen selected as a bar. Based on the bar size the riser size calculated with modulus method. Simulation carried out before perform the experiment work. With the help of the experiment authors were concluded that" feeding distance of the ductile iron is more than the steel due to the graphite perception during solidification." This work is useful to how the finding the feeding distance of the riser. Because there are no standard data of the feeding distance of the Al alloys.

III. OBSRVATION

Main observation that can be derived from the

i. Riser size influencing on the feeding behaviour of the metal.
ii. Casting geometry and size both effect on to the feeding behaviour of the metal.
iii. Solidus velocity of the metal effect on to the feeding behaviour.

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