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Simulation of Riser Size from Mushy Zone of Unrisered Alsi7mg Alloy

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Abstract: Solidification simulation packages incorporate risers in their Finite Element meshing programs. The placement of the risers is normally juggled in different positions until the best positions are obtained. Also riser sizes are also determined based on riser size calculations. This work has narrowed down position options by first simulating unrisered castings of an AlSi7Mg alloy. Using the location of the mushy zone and the size of the zone, appropriate size and locations were determined for the riser thus limiting the number of trial and error simulation runs. Using the size and locations of mushy zone it has been discovered that risers of equivalent lineal size should be placed in the locations of these mushy-zones. Simulations were done using a rectangular block and a gas burner.

Key words: Simulation, Riser, Mushy-Zone, AlSi7Mg

INTRODUCTION

Many commercial simulation softwares are available for solidification simulation[2,9,1] and Ekkinc,[4]. These rely heavily on the user's knowledge of riser locations and calculation of riser sizes to effect proper feeding of their casting to get sound castings. Many research software follow the same pattern[3,5,6,7,8] Therefore risers are drawn at p ossible l ocations with the calculated sizes before meshing and simulation. This method involves a lot of trial and errors combined with possible use of chills and paddings. However, with busy schedules of foundry engineers sitting long times at design tables juggling riser locations are not very pleasant jobs as simulations could take long times depending on the complexity of the part. As the solidification simulation phenomenon is well known, it is now easier to simulate possible scenarious in the casting engineer's mind. However to avoid unnecessary delays in product design, this work uses mushy zone layer of alloys (using the common ternary alloy AlSi7Mg alloy) to locate riser size and location).

MATERIALS AND METHODS

2-D Simulation of unrisered rectangular AlSi7mg alloy solidifying in chilled steel mould was done. Having determined the mushy zone, the lineal size and position was obtained and the riser placed in position. The simulation program was run again. This method route was then compared with hitherto used methods of simulation. The Finite element method of analysis of the solidification process was done using the Fourrier equation

$$\rho C_P \frac{\partial T}{\partial t} - \frac{\partial}{\partial x}\left(k_X \frac{\partial T}{\partial x}\right) + \frac{\partial}{\partial y}\left(k_Y \frac{\partial T}{\partial y}\right) = Q$$

with boundary conditions: Neuman condition applied at the riser tops

$$k_X \frac{\partial T}{\partial x} n_X + k_y \frac{\partial^2 T}{\partial y^2} n_Y + h(T - T_\infty) = 0$$

and Diriclet conditions hT=r applying at the mould interfaces since the mould is chilled.

Where

h = weight of casting
r = Temperature
K = thermal conductivity
T = nodal Temperature
T_ϕ = ambient temperature
Q = Heat generated in casting from latent heat of solidification

The Matlab pdetool was used in running the simulation program.

RESULTS AND DISCUSSIONS

Fig. 1 shows the simulated solidification of unrisered AlSi7Mg alloy in a chilled steel mould. The temperature profiles could be seen showing locations of hot spots in the casting as a result of non-feeding of the casting. Potential shrinkage cavity zones are the center of the casting and areas located near the two short sides where hot spots are located. The mushy layer i.e the area where

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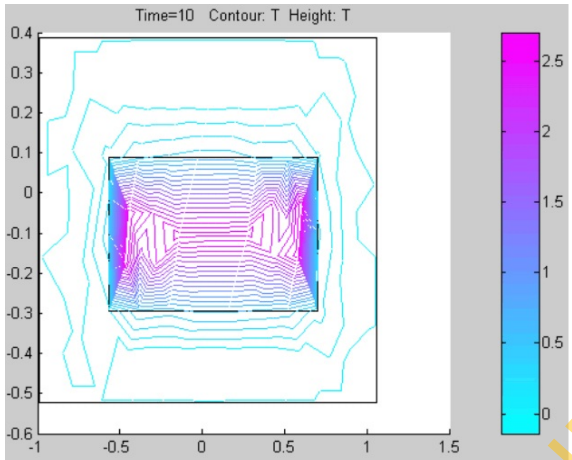

Fig. 1: Unriserd AlSi7Mg solidifying in a steel mould showing the temperature profiles. The mushy zone could be seen.

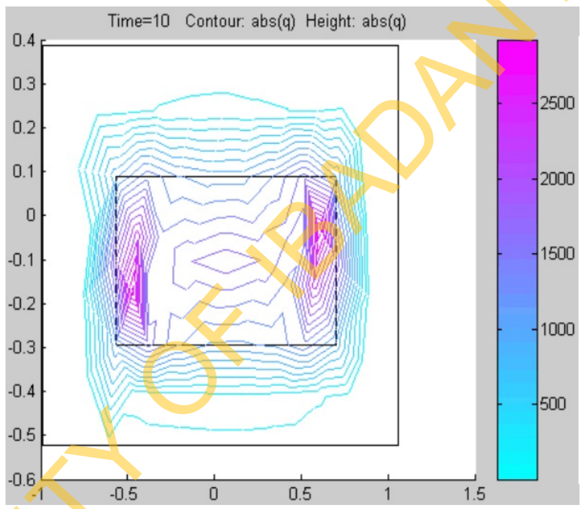

Fig. 2: The heat flux of the same AlSi7Mg alloy in the mould.

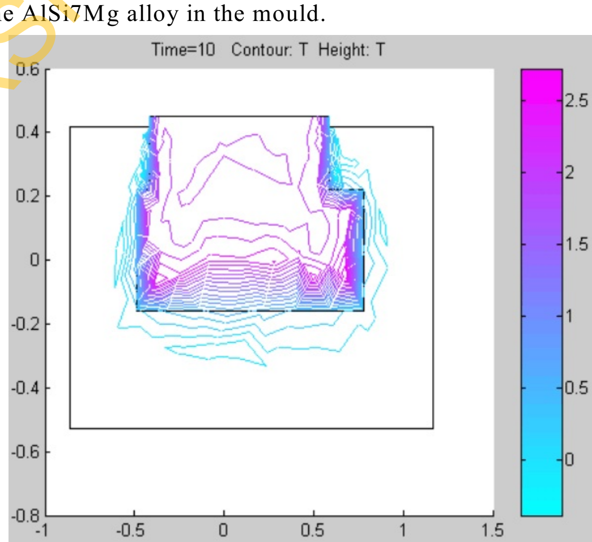

Fig. 3: Riser properly located to feed mushy zone area.

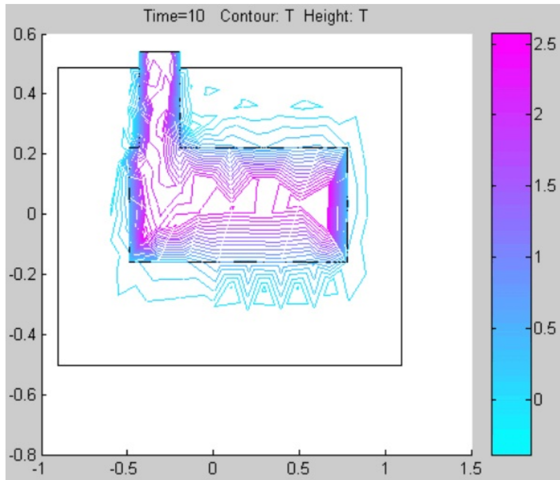

Fig. 4: Improperly located riser showing hot spots.

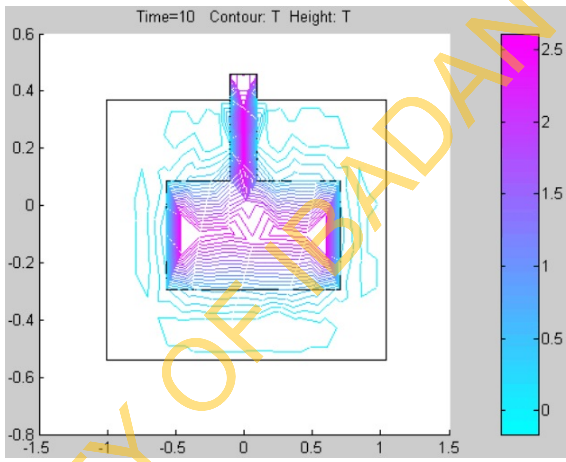

Fig. 5: Wrong sized riser showing piping in riser due to solidification taking place rapidly at riser sides. Hot spots are seen in the casting.

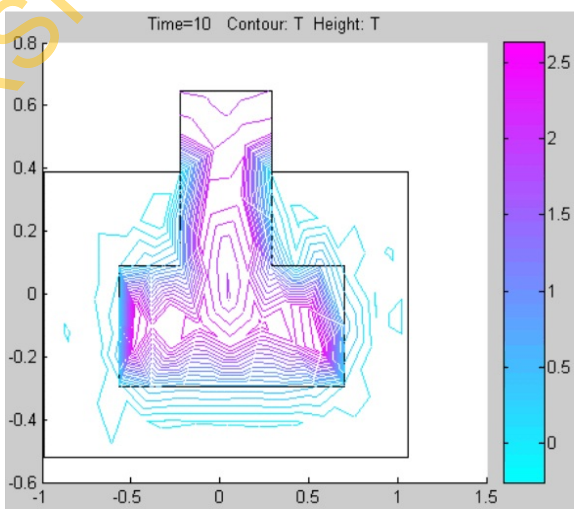

Fig. 6: Risered casting but not covering the mushy –zone. The hot zone could be seen rising into the riser but some hot zone could be seen on the lower sides of the casting.

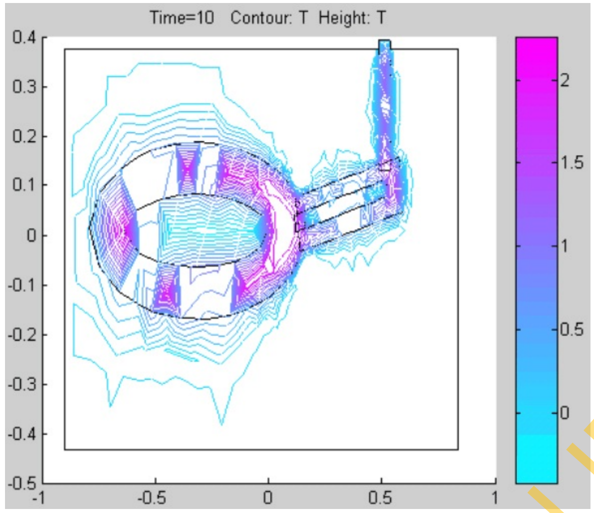

Fig. 7: solidifying gas burner in a steel mould showing the hot spots

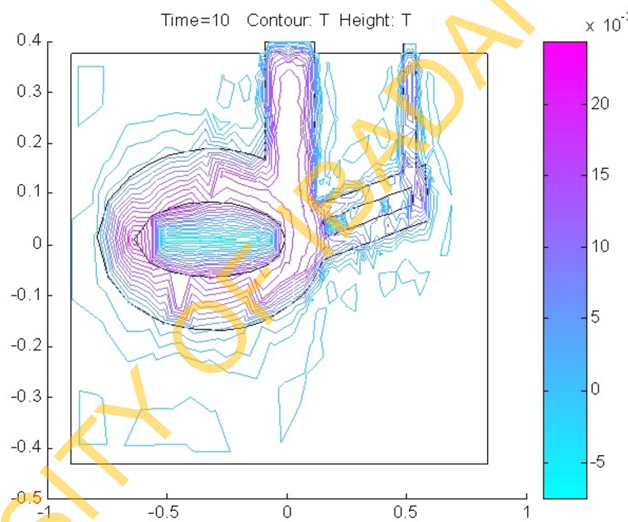

Fig. 8: Riser properly located on mushy –zone. Heat zone could be seen going into the riser.

temperature is between liquidus and solidus temperatures of the alloy of the alloy is the time when essentially there can be no more feeding of liquid metal into the casting. At this time there will be shrinkage cavities occurring at different hot spots in the casting. Even when some hotspots are taken off by chills, like the two side spots, the central cavity will show a shrinkage cavity.

Fig.2 shows the heat flux in the same casting. The heat flux could be seen to be the same in the center if the casting. At the shorter sides of the casting the heat flux is greater.

Because of the high temperature gradient and localised hot spots. In the mould, the heat flux is seen to be the same.

Fig.3 shows the same casting with a riser, the size of the mushy zone placed right on the mushy- zone. Heat center could be seen entering into the riser. This casting is properly fed.

Fig.4 shows an improperly placed and small sized riser. Hot spots could be seen in the casting. This casting will not be sound.

Fig 5 shows a small riser appropriately placed. Hot spots could be seen as well in the casting. The riser itself has started solidifying at the sides and piping has started forming in the riser.

Fig.6 shows a bigger but inappropriate sized riser placed on the casting. Hotpots could still be seen in the casting resulting in unsound casting.

Fig 7 shows a gas burner with gating and the heat centers could be seen in different portions of the casting. Wehile the heat center at the front sides couild be solved by chills, the back heat center intersecting with the gas inlet arm can not be solved by chills. Fig 8 is seen with a riser placed on the mushy zone solving the problem of inadequate feeding. Also the heat center is seen rising into the riser.

Conclusion: It is possible to simulate riser sizes and locations more accurately by observing mushy-zones sizes and positions in castings in alloy castings.. This work has narrowed down position options by first simulating unrisered castings of an AlSi7Mg alloy. Using the location of the mushy zone and the size of the zone, appropriate size and locations were determined for the riser thus limiting the number of trial and error simulation runs. Using the size and locations of mushy zone it has been discovered that risers of equivalent lineal size should be placed in the locations of these mushy-zones.

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