Are all solidification simulation packages the same?

The area of solidification simulation technology may at first sight appear to be a very daunting prospect. How does the foundryman identify which software package will best suit his needs and be the most cost effective purchase for his company? One approach to answering this question is to compare simulation results from various packages for a component which has caused problems during production.

In November 1993 Pickersgill - Kaye of Leeds undertook an evaluation of solidification simulation software using a component with which it had experienced problems obtaining a sound casting. The selected component was a shell moulded lock case produced in HTB1 casting alloy weighing 1kg. Trial and error in the foundry had produced a sound casting at the third attempt. Could solidification simulation technology have achieved a 'right-first-time' result and reduced the development time and costs of the component?

Modelling the component

The casting geometry was modelled manually with the 3D solid modeller incorporated into the Mavis software. The solid modeller has been designed to be extremely user friendly and fast, enabling most geometries to be created within a few hours. Casting shapes are generated within a variable (non-cubic) domain and can contain up to eight million elements. The lock case geometry was generated within an hour from standard two dimensional drawings (fig 1).

The first method consisted of a single feeder and two gates at one end of the casting, this was modelled within a further 10 minutes. The next stage was to model method two which consisted of two additional feeders located at the end of the casting. Finally method three was modelled consisting of a feeder system with two gates located at the side of the casting. Prior to running the solidification analysis the casting geometry was checked by displaying the model from six different angles.

Solidification analysis

The solidification analysis requires parameters to be entered for the shrinkage percentage, mould conductivity, gate effects and the conductivities of any chills or insulators if present using sliding scales. The shrinkage percentage value used for HTB1 was 6%, and the conductivity of a shell mould was selected.

The x-ray analysis of the solidification simulation for the initial method predicted defects within the heavy sections furthest from the feeder, lug areas and the central boss (fig 2).

The simulated x-ray results for method two show that the defects at the end of the casting were effectively drawn into the feeders and eliminated, however porosity is still predicted in several areas (fig 3).

Finally method three was simulated and the results now predict the removal of the major defects adjacent to the feeder (fig 4). The minor porosity within the lugs and the central boss resulted in very small surface sinks which were not considered to be a problem after machining.

The simulation result for each method compared very well with the actual production problems experienced during the development of the pattern equipment.

| Modelling of component shape | 60 mins |
| Modelling of methods 1, 2 and 3 | 30 mins |
| Simulation time for each method | 30 mins |
| Total time for analysis | 180 mins |
| Actual development time for pattern equipment | 1 month |

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IMPROVING YIELD

Alternative software facilities

The Mavis software can also predict the macroscopic order of freezing, this can provide very useful information for determining the feed paths, within the component and also to locate any potential isolation of liquid metal (fig 5). Ideally the casting would be simulated without a method and assuming no volumetric contraction from liquid to solid. The macroscopic freezing pattern would then be used to determine the likely location of the feeders. With this approach it would have been possible to avoid methods one and two completely therefore reducing the time to achieve the desired result even further. A full finite difference numerical analysis could also be carried out on the final method in order to establish the solidification times, temperatures within the casting and mould, cooling rates and temperature gradients.

Other considerations when evaluating software

The simulation results had clearly shown that Mavis would have produced a ‘right-first-time’ method for the casting within three hours, significantly reducing the time and costs of development. The software had been proven in terms of results but there were other considerations of near equal importance to be taken into account when deciding which package would suit the company best. The Mavis software was selected because it was extremely easy to use both in terms of solid modelling and simulating the solidification of components, it had the benefit of combining both rapid and full numerical simulators within a single package and was relatively inexpensive to purchase.

Pickering-Kaye now operates the Mavis software in conjunction with Pro-Engineer CAD system which enables 3D solid models to be imported directly into the Mavis software. Component parts can be simulated at the design stage and potential problems highlighted before the final design has been approved. Also, the software has enabled the in-house component designers to gain an appreciation of the problems associated with the production of castings. It is anticipated that significant improvements will be made in terms of casting yield and reduced scrap.

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Stelpur for steel

Conventional running and gating systems had, until recently, to form an integral part of the steel casting production route, writes Nick Child product manager Stelex and Stelpur at Fosoco (FS) Ltd. Running systems have a heavy impact on the metal yield of the casting and yield has become a very sensitive issue in steel foundries.

The necessity for a conventional running and gating system has been removed by the development of Stelpur which comprises a Stelex ZR ceramic foam filter at the base of a Kabunin 70 insulating sleeve. Four sizes are available for castings up to approximately 200kg in weight - larger sizes are under development.

The Stelpur unit is used to replace a suitably positioned feeder of similar size. Metal is introduced into the casting cavity by pouring directly into the Stelpur. The sleeve acts as a pouring cup and the filter absorbs the impact energy from the metal preventing sand erosion as the mould fills. During mould fill the filter will prevent non-metallic inclusions entering the mould and also ensure non turbulent fill. When pouring is complete the Stelpur acts as an efficient feeder, the presence of the filter does not impede feed. The metal in the filter is the last metal poured and therefore the hottest in the cast system, this is ideal for directional solidification from the casting into the Stelpur feeder.

As well as improving the yield of the casting, the filter will also improve cast quality and promote the production of clean castings reducing the need for costly upgrading. Stelpur is ideally suited for application to many impellers which are usually cast with extensive running systems up into the centre of the casting. It can be applied as the central feeder and the metal poured directly into the casting. Foundries have reported a doubling in the number of castings they can obtain from a ladle of metal. Improved definition is obtained on thin vanes in the casting due to the controlled non turbulent metal fill. The excellent directional solidification promoted by the Stelpur allows removal, or reduce sized feeders on the outer diameter of the casting.

Tremendous yield benefits were recently achieved with a carbon steel valve casting, produced two per box. The old system had a 40% yield - by using Stelpur and exothermic sleeve technology the yield was increased to 71%.

As well as improving yield the application of Stelpur dramatically reduced rectification cost.

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