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Swerea SWECAST AB succeeds in developing thin-walled steel castings using ProCAST

THE CHALLENGE

In most cases, thin-wall castings involve unnecessary waste and problems with meeting dimension tolerances. As know-how in thin-wall castings is limited, designers frequently incorporate safety coefficients on thicknesses that are needlessly large and drive away from the concept of developing lighter designs.

Can thin-wall castings be manufactured?

THE STORY

The "Production of thin-wall castings for lighter designs" was funded by the Swedish government. Its goal: create conditions to design and produce steel and aluminum thin-walled castings, and identify how simulations can be used to facilitate the production of thin-walled castings. The simulation software was first used to compare results of some trial runs, on prototype castings, and study how process parameters affect the filling process. This experience was later used on real casting parts.

THE BENEFITS

- The component wall thickness was reduced from 6mm to 3.5mm
- Casting weight was reduced significantly.
- 30% reduction in the total production cost

"During this project we used ProCAST software and that gave us the possibility to simulate & optimize thin-walled steel castings. ProCAST is a very competent software, when it comes to simulate thin-walled geometries"

Per Ytterell,
Managing Director (participant in the project, supplier of this steel component),
Smålands Stålgjuteri AB, Sweden

EXPERIMENTAL SCOPE

To study the flow of molten metal in a thin-walled steel casting using simulation. A prototype casting was considered: Cylindrical pipe 400 mm long, with a diameter of 100 mm and a wall thickness of 3 mm. (Fig. 1)

Fig. 1 - Thin walled Steel prototype casting

TRIAL RUNS

To manufacture this prototype casting, traditional sand and shell molds were used. The filling system developed for the study purpose was a pressurized system with a pouring basin. The primary interest was to study the metal behavior inside these thin walled molds during filling and understand how the melt solidifies thus leading to cold flows. Number of trials were carried out with varying process parameters like the pouring temperature & pouring rate, including filling of only partial mold cavity.

The results from these trials acted as a good library. Simulations were done using ProCAST to compare each of these trials.

PARAMETERS

There are many parameters that influence the mold-filling process. The extent to which these parameters are allowed to be altered depends on the simulation program that is used. The following five parameters which were believed to have the greatest effect of results were chosen for study during the comparison.

1. Wall friction;
2. Viscosity in mushy zone;
3. Heat transfer coefficient;
4. Mesh size;
5. Surface tension.

The objectives were to study the extent to which the various parameters affected the filling process, and to achieve the closest possible agreement between simulation and reality.

It turned out that all of the selected parameters affected the results to a greater or lesser degree. The strongest factors were wall friction, heat transfer coefficient, and viscosity in the mushy zone.

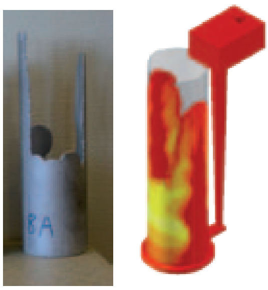

Fig. 2 - Trial run of partially filled prototype casting vs. Simulation results showing favorable correlation.

Wall friction is a parameter used in the software for effective treatment of liquid metal along the mold walls. This varies based on the alloy & the mold material. Heat transfer varies in function of temperature gradient, and it is essential to consider this, especially for thin-walled castings, to rightly replicate the thermal characteristics during flow. A temperature-dependent viscosity in the mushy zone completes a very good model setup.

Mesh size is of no great significance, provided that the model is properly represented and follows the original geometry. Surface tension is a complex phenomenon to simulate, and could possibly consume important computation time. Time being a constraint, it was finally not considered for this study. Also, surface tension is more important in aluminum than steel castings.

Special importance was also given to replicate the filling to achieve the right pressure head, flow rate & choke.

The outcome of this was a good correlation between simulation & practical test of the prototype casting. (Fig.2, Fig.3)

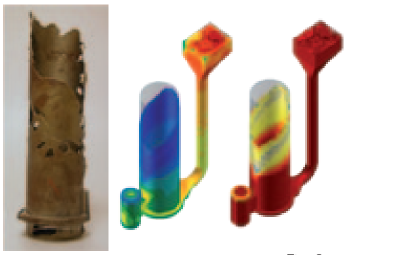

Fig. 3
Trial run of partially filled prototype casting vs. Simulation results showing favorable correlation. (Using a different set of parameters than Fig. 2)

PHYSICAL TRY-OUT ON INDUSTRIAL COMPONENT

Finally, the optimized process parameters obtained from these experiments were used to develop a thin-walled industrial steel part. Simulation was first carried out to develop an optimal filling and a feeding system on this new modified product design. The process parameters were optimized too for robustness. Figure 4 shows a thin shell-formed component. The results provided the confidence needed to go ahead with the redesign and cast industrial steel parts as low as 3.5 mm in wall thickness. (Fig.5)

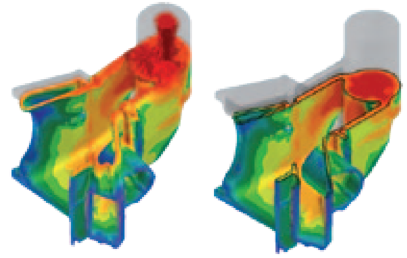

Fig. 5
Simulation results of thin walled industrial steel part

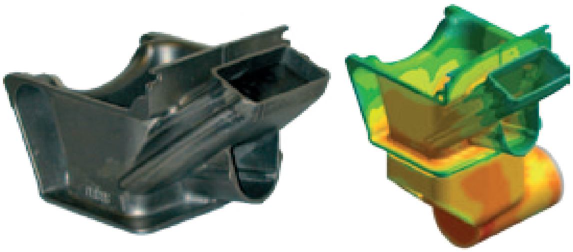

Fig. 4
Thin walled industrial steel part (left)
Simulated along with the filling system (right)

OUTCOME

The project has resulted in a viable method for developing and verifying materials data that can be used to simulate and produce thin-walled castings. Given correct information and suitable software, this has made it possible to predict as-cast molten metal behavior inside the mold cavities.

Another part of the project was to develop thin-walled Aluminum industrial parts (2mm). The same principle was successfully adopted.

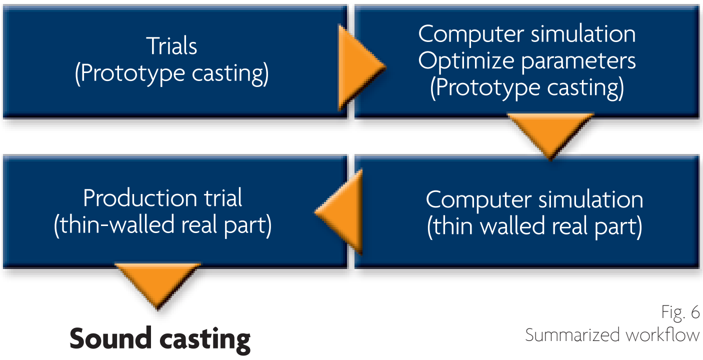

Fig. 6
Summarized workflow

To find out more on ESI's Casting Simulation Suite, visit: www.esi-group.com/casting

ABOUT SWEREA SWECAST AB

Swerea SWECAST, Swedish Institute of Casting Technolgy, is the R&D and training institute of the Swedish casting industry. Swerea SWECAST and Jönköping Technical University maintain a close cooperation within CIC, Casting Innovation Centre. CIC constitutes the largest single group of researchers in Europe working with foundry technology and related topics.

ABOUT ESI GROUP

ESI is a world-leading supplier and pioneer of digital simulation software for prototyping and manufacturing processes that take into account the physics of materials. ESI has developed an extensive suite of coherent, industry-oriented applications to realistically simulate a product's behavior during testing, to fine-tune manufacturing processes in accordance with desired product performance, and to evaluate the environment's impact on product performance. ESI's products represent a unique collaborative and open environment for Simulation-Based Design, enabling virtual prototypes to be improved in a continuous and collaborative manner while eliminating the need for physical prototypes during product development. The company employs over 750 high-level specialists worldwide covering more than 30 countries. ESI Group is listed in compartment C of NYSE Euronext Paris. For further information, visit www.esi-group.com.

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