SUTCAST

Improved Casting Productivity by Simulation

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Inside this story:

- **The casting quality and productivity can be greatly improved by proper processes design analysis using a today available advanced simulation technology**
- **Casting process modeling is no longer luxury**
- **The ultimate results of case study presented here were:**

✓ **Reduction of lead time and avoiding casting process design by try and error**

✓ **Increasing cast part production speed by a factor of over 2**

Process modeling is no longer luxury, but a necessity for survival in the casting industry. The casting industry has seen rapid advancement in commercial simulation technology. Many metal casting process analysis software are now available not only for thermal and flow modeling, but also for calculation of grain structure, porosity and mechanical property simulation.

Modeling provides engineers with a way to understand the process dynamics and evaluate the quantitative effects of various process variables on the quality of the resulting products. Furthermore, casting modeling allows process engineers to make virtual castings and to optimize their casting process in terms of quality, yield and productivity without actually making castings. These capabilities make modeling more powerful than any other tools previously available to process engineers.

Casting and solidification processing involve many physical phenomena such as fluid flow, heat transfer, solidification and defect formation. Thus, the success of casting process modeling should be judged by its ability to solve practical problems. In general casting process modeling can be used by process engineers to develop new processes, as well as optimizing existing ones in practice.

Figure 1 shows the flow chart in which the 3D CAD and simulation tools are utilized to improve the casting process design.

Computer simulation based on the design procedures described above have been implemented with one case study.

Let's consider an automotive wheel made of aluminum alloy A-356. During simulation of the casting process, mold filling and solidification are examined and die design and casting process are optimized.

The wheel is cast using low pressure die casting process. In this process the most important elements of machine are the movable upper die half (top core), the fixed bottom die half (bottom core) and the slides. The dies and the slides are usually made of hot working steel H13.

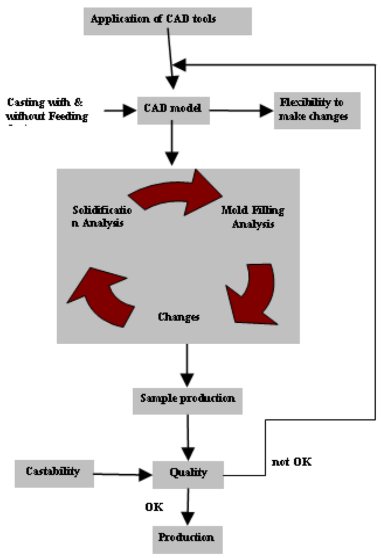

Fig.1 Flow chart for improvement of the casting system design

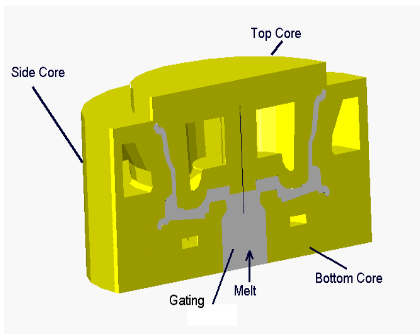

Fig.2. Geometry of the first casting system

This cast part initially was made from die shown in Fig. 2 designed by engineers based on their experiences and cast by a low pressure die casting machine.

The virtual inspection of the cast part revealed central shrinkage at the transition between the spokes and the well of the wheel casting as shown in Fig 3.

Fig.3 Shrinkage distribution in real cast part

The part maker decided to redesign the cast die using computer modeling. Solidification simulation of initial design showed macro shrinkage defect in location and size precisely in agreement with real cast wheel, Fig. 4.

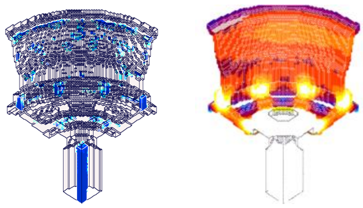

Fig.4 Shrinkage and thermal distribution

In order to remove macro shrinkage and to decrease the solidification time, mold design was modified on the basis of:

1. Application of padding for improvement of directional solidification guaranteed by modeling.
2. Inserting water cooled copper chill.
3. Adjusting the temperature distribution of different die parts.
4. Die heat transfer control with applying different coating thicknesses

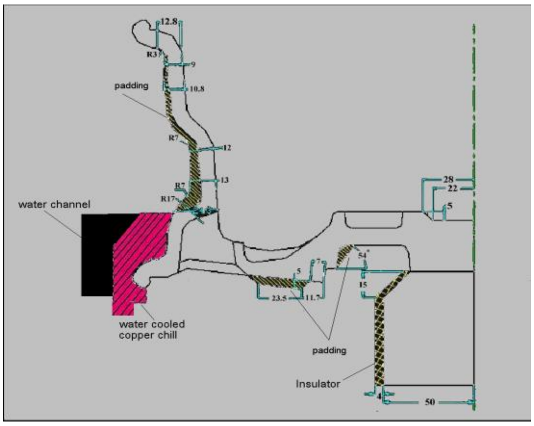

Fig.5 Final die design for wheel

The proposed geometry is presented in Figs. 5 and 6.

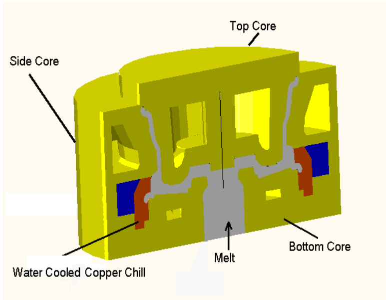

Fig.6 Geometry of final casting system

Fig. 7 presents the thermal distribution and macro shrinkage in modified design.
There is no sign of macro shrinkage or porosity inside the wheel.

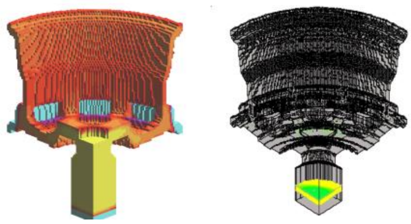

Fig.7 Shrinkage and thermal distribution in improved design

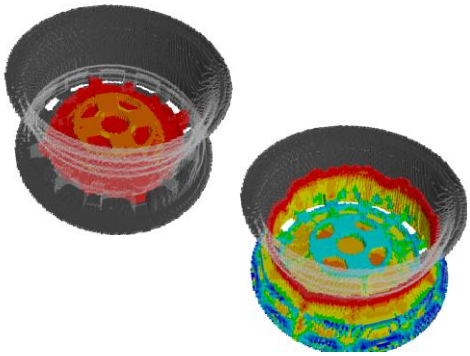

Fig. 8 represents the fluid distribution in improved design 0.42 seconds after Pouring.

At this time in the well of the wheel, temperature falls below the solidus temperature, thus filling is stopped.

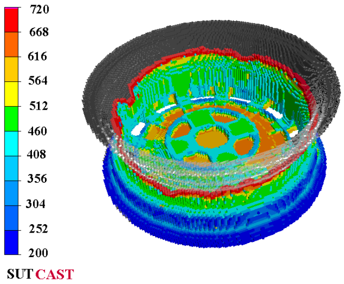

Fig.8 Incomplete filling (time= 0.42 Sec)

In the second step initial conditions of simulation were changed. Pouring temperature was set to 750°C and the mold initial temperature was increased Up to 300°C and the contact surface with melt of the upper die half, the fixed bottom die half and the slides were coated with various thicknesses. Fig. 9 shows the filling stages of ring after modifying initial conditions and applying coating.
Clearly, temperature in well of wheel is increased and the mold is filled completely.
The ultimate results of simulation were:

1. Reduction of lead time and avoiding casting process design by try and error.
2. Increasing the cast part production rate by a factor of about 2.5.

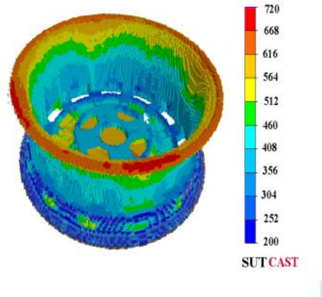

Fig.9 Filling sequences and thermal Distribution in improved design after modifications on initial condition