esi get it right®

Leveraging ProCAST to put an end to conventional trial-and-error testing

A study made for a Swiss foundry

THE CHALLENGE

A Swiss foundry deemed that the production cycle of the die casting heat sink component was too long compared (Fig. 1) to other cast parts of similar weight and size. More disturbing was the fact that cast parts sporadically remained stuck to the fixed die half, instead of being withdrawn with the movable die. This led to time-consuming interruptions of production and eventually, lowered productivity. ProCAST was successfully used to diagnose this situation and to quantify the potential improvements.

THE BENEFITS

Improve productivity by:

· Reducing the production cycle

· Removing air entrapment

· Removing part distortions

Simulation carried out on the heat sink with ProCAST showed a very good agreement with measurements and provided reliable indications of corrective actions regarding the die design and the optimization of the spraying sequence.

Cycling analysis

The Swiss foundry selected High Pressure Die Casting (HPDC) over Gravity Die Casting (GDC) for the heat sink, as it delivers parts with thinner walls, closer dimensional limits and smoother surfaces. Production is faster and labour costs per casting are lower, as are finishing costs.

The pressure die casting process involves the repeated injection of molten metal into a die cavity. The temperatures within the die undergo a cyclic variation with a period equal to the casting cycle time. The cycling analysis consists of simulating these repeated injections until a steady state is reached by strictly taking into account the timing of the different phases. Heat transfers due to the thermal control by oil stream in the die forms (Fig. 2) and to the quenching effect of the spraying phase (Fig. 3) are also simulated with time-dependent conditions.

Cycling analysis first enabled the Swiss foundry to examine the number of cycles needed to reach the steady state. Figure 4 illustrates the simulated temperature curves of different points located at specified

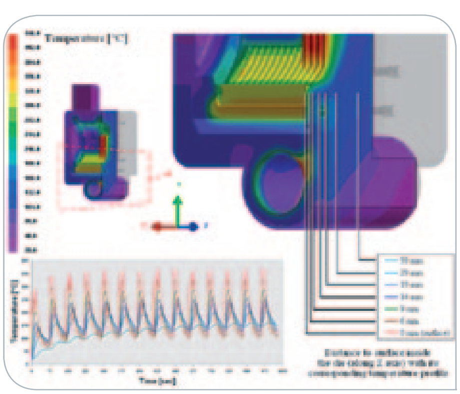

Fig 4: Cycling analysis with simulated temperature curves of different points located at specified distances to surface

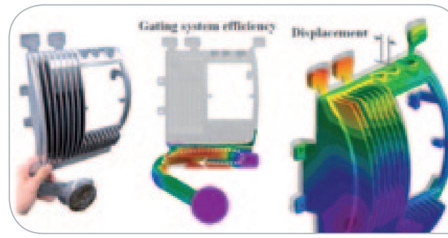

Fig 1: Heat sink component

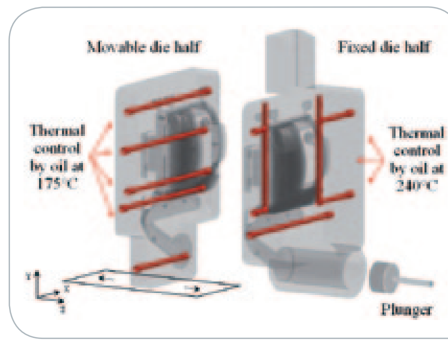

Fig 2: Timing sequence of the HPDC process

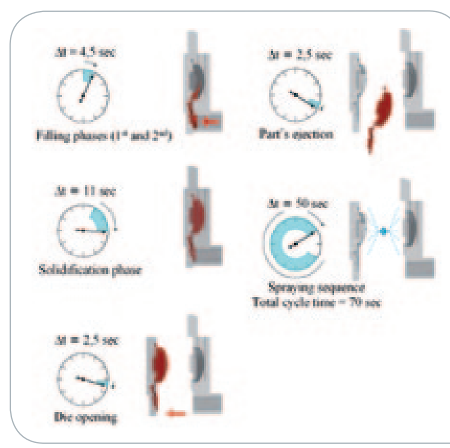

Fig 3: Layout of the heating & cooling channels

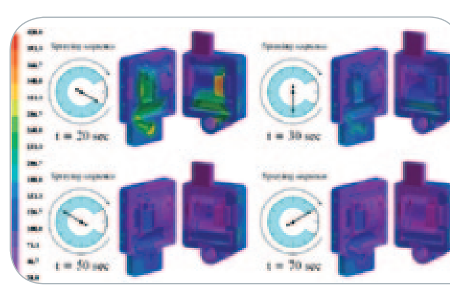

Fig 5: Temperature distribution of the die halves at different time steps in the course of the spraying phase of the 15th cycle

distances to the surface of the die. A cold or insufficiently pre-heated mold will lead to the formation of possible cold shuts. Thermal gradients between the surface of the die, hit by molten metal during the injection, and the core of the die, influenced by the local cooling and heating channels, account for stresses, resulting in possible premature failure of the dies. Hence simulation helps assess these gradients and adjust the thermal control so that the adequate operating temperature is reached prior to starting production.

Special attention was also paid to the spraying sequence. As shown in figure 3, the cavity was fully filled after only 4.5 seconds, while 50 seconds were programmed for the spraying phase mainly to give time to the lubricating substance to penetrate between the lamellas of the fixed die half.

This spraying time, which was disproportionate to the other time intervals, was causing an excessive cooling down of the surface temperature of the die halves. Simulation results confirmed this observation (Fig. 5 on previous page). Indeed, patterns of temperature distribution during the spraying phase in the dies at two different time steps of a given cycle (t = 50 sec and t = 70 sec) were very similar. This demonstrated that the spraying phase was efficient at the thermal point of view only for the first 30 seconds. 20 seconds could potentially be saved on a total cycle time of 70 seconds.

Filling and distortion analysis

A critical point when designing the gating system was the radius of curvature of the elbow joining the main runner to the cavity's gate. Simulation results clearly showed the undesirable spinning of metal flow in the gate prior to entering the part's cavity if a non-optimised radius of curvature was combined with an inadequate timing of the first phase. Risky areas due to air entrapment inside the lamellas could be highlighted by simulations, fitting outstandingly the sample parts that exhibited visible defects in the tips of the lamellas (Fig. 6).

Substantial improvement of the gating system was achieved to get a smoother and more uniform filling of the cavity and, hence, a lowered rejection rate.

Distortion analyses predicted sizeable displacements of one of the corners of the cast part, after ejection from the movable die half, combined with a twisting effect. Cast parts currently must be reworked with a machine press, leading to additional costs of manufacture. Casting simulation with ProCAST provided reliable indications for design optimization and quality control (Fig. 7).

The Conclusion

One of the main challenges for a die designer is to achieve the gating system right the first run. Casting simulation helps estimate the effect of the different relevant technical parameters, thereby avoiding potential problems in production.

Simulation carried out on the heat sink with ProCAST showed a very good agreement with measurements and provided reliable indications of corrective actions regarding the die design and the optimization of the spraying sequence.

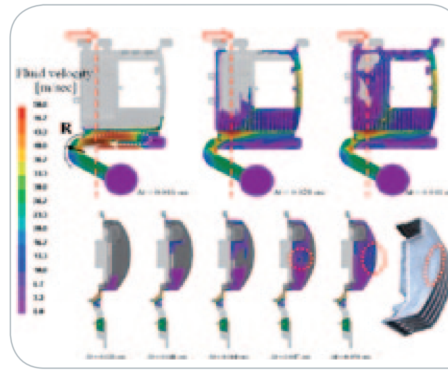

Fig 6: Filling patterns in front view and in cut view at different time steps. The black arrow represents the radius of curvature (R) of the gating system. The dotted white line highlights the undesirable spinning of metal flow in the gate.

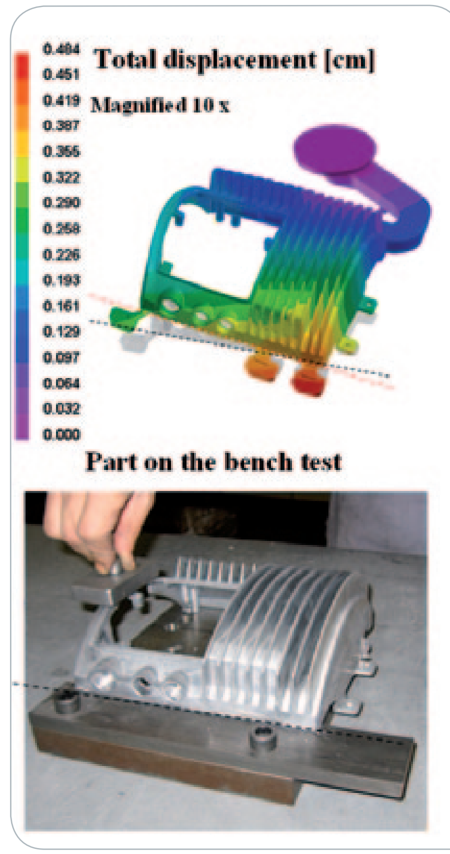

Fig 7: Simulated distortions compared to a real cast part placed on its bench test. The shaded contour depicts the non-deformed part. The hand is indicating where the machine press has to apply the pressure on the part to eliminate distortions.

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

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