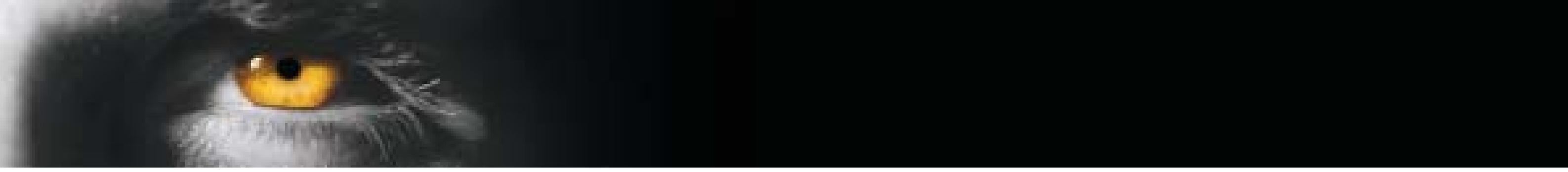

e-Tips

Nr. 3

Optimisation of flow behaviour in high pressure die casting

High pressure die casting used in the automotive and aerospace industries are usually light weight and complex thin walled components. These pieces are cast within tight dimensional tolerances and with high mechanical strength.

A common defect found in high pressure die cast components is porosity resulting from excessive turbulence and gas entrapment. The porosity defects are associated with the entrapment of surface oxides. The design of the gating system, the positioning of the vents and the optimum velocity of the metal at the in-gate are crucial to the quality of the castings. Porosity defects are usually only detected during trial production, after the dies have already been manufactured which is a cost intensive operation.

The Process

High pressure die casting involves injecting liquid metal, usually aluminium, zinc or magnesium, into a die cavity using a hydraulically powered piston. More sophisticated machines will allow one to set the piston velocity and injection pressure in order to control the velocity of the liquid metal at the in-gate. This process is used for the production of high volume complex thin walled components.

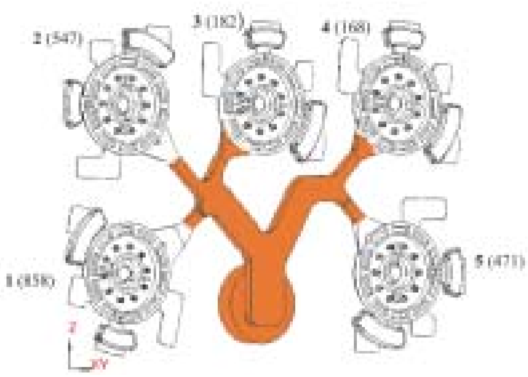

Figure 1: Metal arrives at the gate in the following order: 3-4-5-2-1, with 3 & 4 being nearly identical. The figure within brackets indicate the number of porosity rejects. (Procast™)

The Case

The production of a high pressure die cast component using a multi-cavity die resulted in castings with unacceptable levels of rejects due to gas porosity defects. The aim was to study the root cause of the problem and propose some modifications to the casting design in order to improve the casting yield.

The Analysis

It was found that the number of rejected castings varied depending on its position in the die. After simulating the process, a strong correlation was found between the number of rejects and the order in which the castings were filled. The castings which filled last showed a much higher reject rate than the castings which filled first, as shown in Figure 1. The simulation demonstrated the importance of designing multi-cavity dies in such a way that all the components are experiencing the same filling and cooling conditions. This will introduce more consistency in the process and allow a greater level of control over the casting conditions.

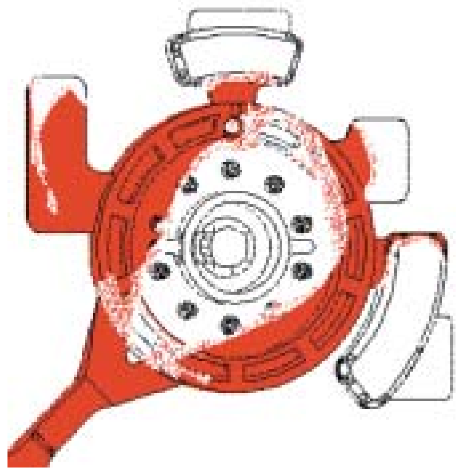

Figure 2: Original gating design with delta area at the in-gate. (Procast™)

During filling, as shown in Figure 2, simulation showed that the metal moves along the outer walls and displaces the gas to the centre of the casting. The overflow positioned at the centre did not help enough to bleed off the gas. Modifying the in-gate by removing the delta area helped to displace the gas to the opposite end of the casting. However, as shown in Figure 3, the gas was still not able to escape to the outer overflows and vents.

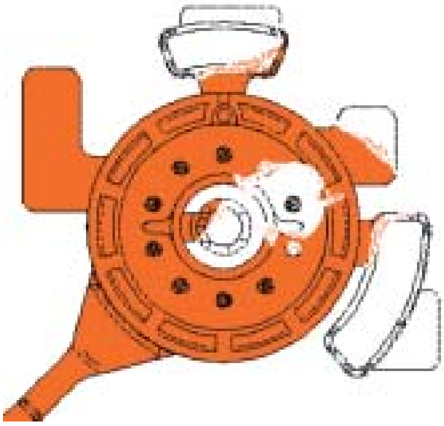

Figure 3: Modified in-gate without delta area. (Procast™)

Extending the overflow through the centre helped to reduce the gas entrapment in this area but not sufficiently to solve the problem, see Figure 4. Simulation was used to redesign a complete new gating system which would help to displace the gas to the outer regions of the casting so that more efficient venting could be achieved. In Figure 5, the first simulation of the redesigned tangential in-gate shows the desired filling behaviour.

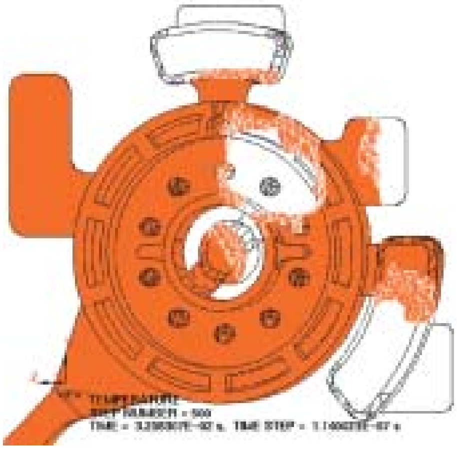

Figure 4: Modified overflow in order to help gas entrapment in the centre region. (Procast™)

After studying the flow behaviour of the first simulation with the redesigned in-gate, an optimal positioning of the overflows and vents was identified, this is shown in Figure 6. The final casting design, with improvements to the in-gate and vent positioning helped to reduce the reject rate by more than 20%.

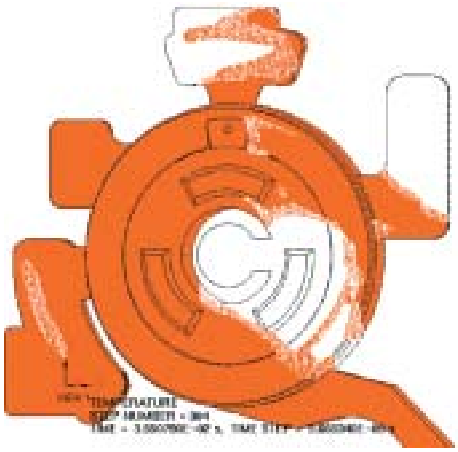

Figure 5: Redesigned in-gate without optimal overflow positioning. (Procast™)

The Opportunity

Making changes to the dies after it is already in production can be quite expensive and time consuming. Process simulation is a powerful engineering tool which allows one to, not only solve casting problems during production, but also study casting design decisions during the development stage. This approach can save a lot of time and expensive trial and error production costs.

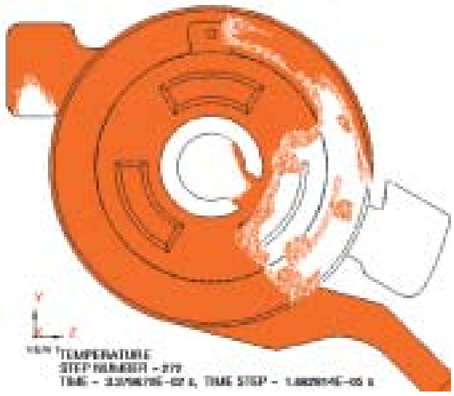

Figure 6: Final gating design with improved flow behaviour and efficient venting. (Procast™)

Procast™ - Simulation software for shape casting, a trademark of UES Software Inc., Annapolis, MD (USA)

calcom

Calcom SA
Parc Scientifique EPFL, CH-1015 Lausanne, Switzerland
phone: +41 21 693 2918 / fax: +41 21 693 4740
mail@calcom.ch / www.calcom.ch