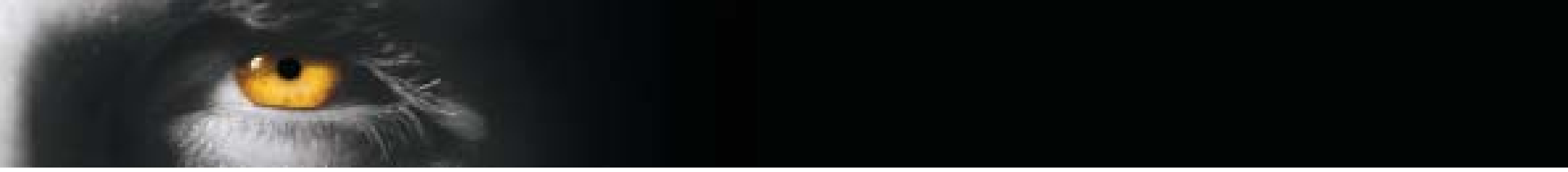

Understanding the Lost Foam Casting Process

e-Tips
Nr. 7

The lost foam casting process (LFC), also known as the evaporative pattern process, is mostly used to produce high volumes of complex automotive components. Although there has been a rapid increase in the use of this process world wide, not too much has been clearly understood about the factors which influence the thermal and flow behaviour of the metal and foam during casting. Thus, in order to get a good understanding of the process, there has been a strong drive from industry to produce physical models which are used to simulate the lost foam casting process.

In order to simulate the process, besides the free surface fluid flow, solidification, and mechanical analysis that it has in common with other casting processes, one must now also consider the heat transfer between the liquid metal and the Foam, the liquefaction and pyrolysis of the foam pattern, the transport of liquid foam and gas products, the influence of the ceramic coating, and the effect of the trapped gas on the movement of the liquid metal.

The Process

The lost foam process involves moulding expanded polystyrene into cast pre-forms using standard aluminium dies. These pre-forms are then glued together to form complex shapes which are then assembled around a gating and runner system. The foam pre-form is then coated with a permeable ceramic coating which helps to prevent inclusions forming as a result of sand erosion during filling. Dry sand is then compacted by vibration around the assembly in simple moulding boxes. The liquid metal is then poured into the mould, causing the foam to progressively burn up as the metal moves to completely replace the pre-form pattern. For each casting produced a new pattern must be made, thus known as the lost foam casting process.

The main benefits of the lost foam process includes increased dimensional accuracy, increased production rates, increased geometric complexities, less machining and better process control. Some disadvantages include longer development times for new castings, expensive pre-form tooling and the need for tighter process control. Some of the problems associated with the lost foam process include:

- Merging of liquid metal streams or trapping of foam products can lead to internal casting defects and cold shut;
- The back-pressure created by gas entrapment or the inability of the gas to escape from the pyrolytic zone fast enough can result in incomplete pattern fill;
- Excessive temperature drop in the metal due to the retardation of the filling velocity can result in the creation of surface folds and misruns, particularly in thin sections.

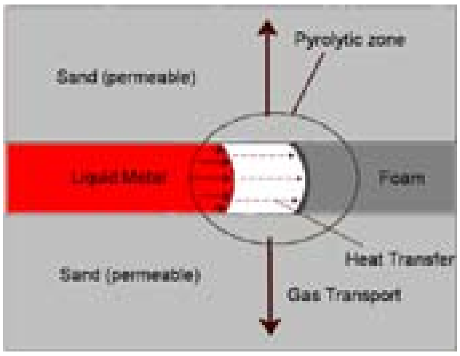

Figure 1: The figure shows the pyrolytic zone were the metal is advancing and the foam is progressively disappearing through pyrolysis.

A schematic representation of the pyrolytic zone is shown in Figure 1. Pyrolysis occurs in the foam as a result of the energy created during foam ignition, where the gas, given off by the heated foam, causes the break-up of the solid foam.

The Analysis

The simulation of a 2D bottom fed aluminium casting, comprising of a pre-form foam region (pouring cup, down sprue, and part) surrounded by a silica sand mould region, is shown in Figure 2. The sand material is considered to be porous with a given permeability. The model takes into account the gas transport through the mould and also considers the effect of the pre-form ceramic coating.

The flow of gas is driven by the pressure gradient in the sand. In Figure 2, contours of pressure show the evolution of gas during casting. The pressure contours follow the movement of the pyrolytic zone. It is evident that the gas will flow from the pyrolytic zone towards the outside boundaries of the sand. The build up of pressure in the mould will result in the flow of gas from the mould to the outside surroundings.

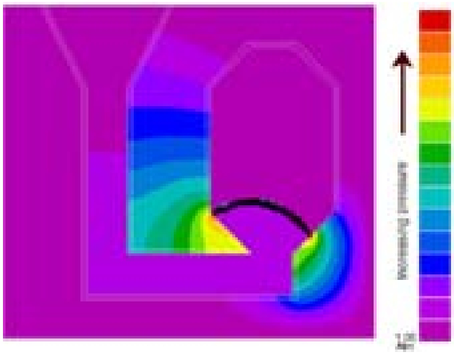

Figure 2: The pressure contours, caused by the formation of gas, follow the movement of the pyrolytic zone (Procast™).

In an industrial case, during the simulation of a sand cast aluminium component a comparison was made between a casting without the lost foam pre-form (Figure 3), and a casting with the lost foam pre-form (Figures 4 & 5). In both cases the gas transport in the mould was taken into account.

The flow behaviour of the metal differs significantly in the two cases. In the first simulation, as shown in Figure 3, we can see that the metal flows directly to the bottom of the mould cavity and then progressively moves to the top. In the second simulation, as shown in Figure 4, we can see that the metal is significantly retarded by the foam burnout causing the metal to flow in a vertical fashion before completely filling the foam pre-foam. The effect of gravity in the second simulation is hampered by the foam burn out. The filling time for the first simulation was 10 seconds while for the second simulation was 13.6 seconds.

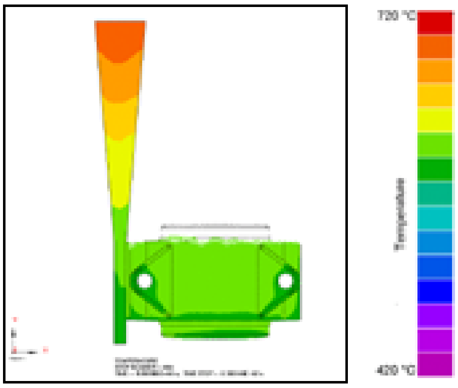

Figure 3: Contours of temperature during the filling of a mould when simulating a sand casting without the use of a pre-form foam pattern (Procast™).

In Figures 5, velocity vectors show the transport of gasses in the mould. The highest gas velocities are closest to the edges of the pyrolytic zone, where the zone comes into contact with the mould. The gasses are then transported through the mould until it escapes into the surroundings. This is clearly shown in Figure 5, where the vectors are evident on the outside surfaces of the mould.

The Opportunity

The lost foam casting process has been successfully simulated using process modelling software, taking into account the burn-out of the pre-form foam pattern, the thermal heat transfer across the pyrolytic zone, the influences of the ceramic coating as well as the transport of gasses from the pyrolytic zone through the mould.

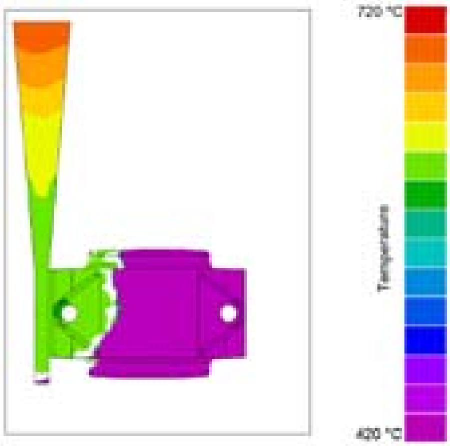

Figure 4: Temperature contours showing the position of the pyrolytic zone after 10 seconds (Procast™).

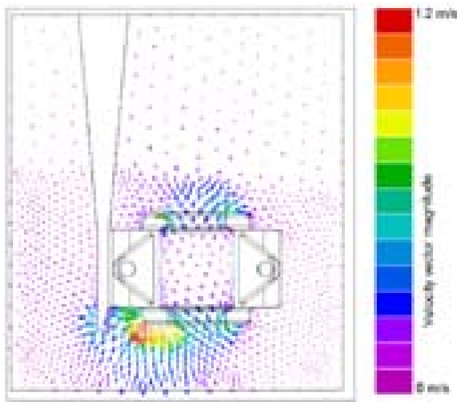

Figure 5: Velocity vectors showing the gas transport in the mould after 10 seconds (Procast™).

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