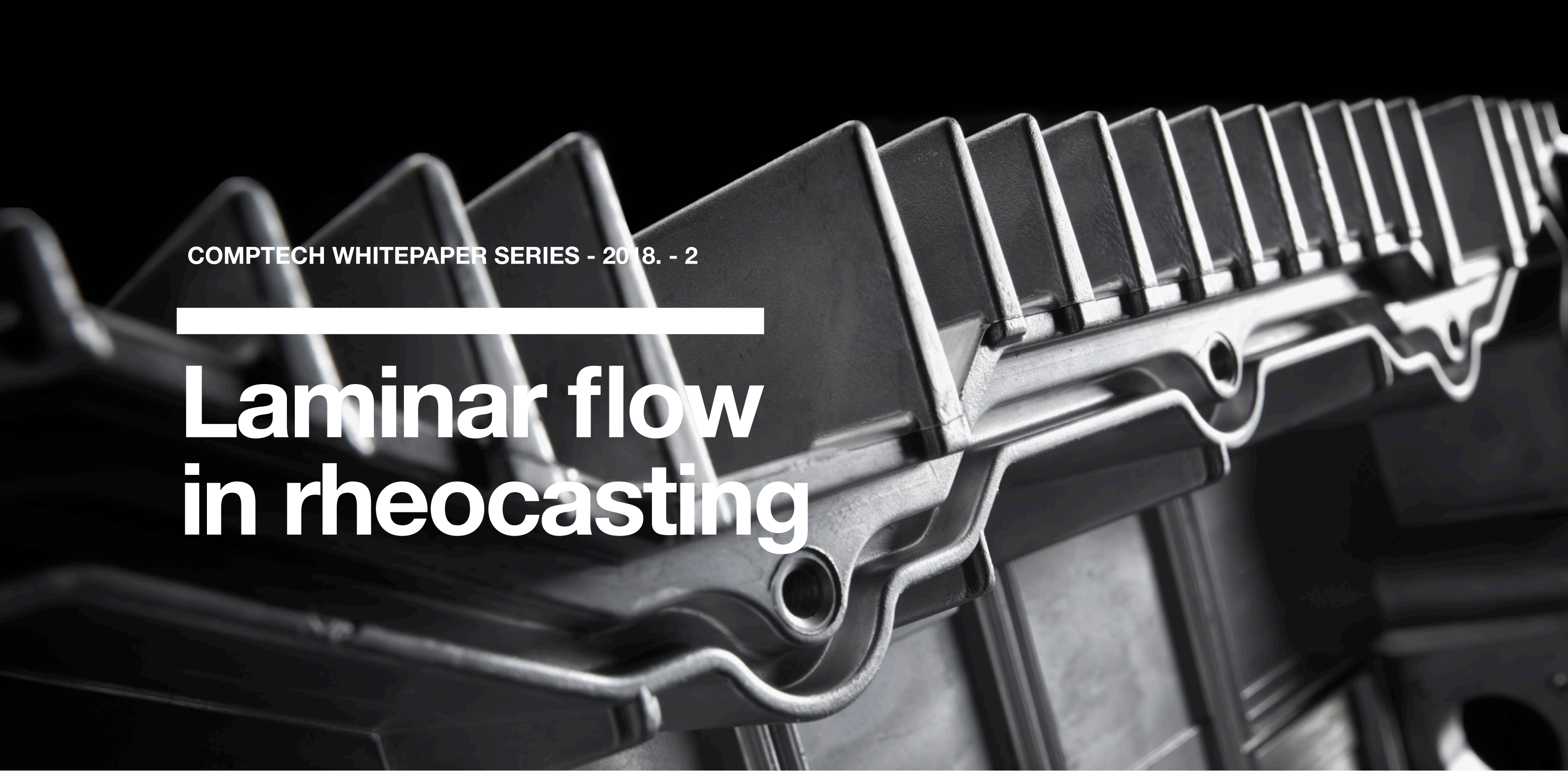

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Laminar flow in rheocasting

Advantages

One of the major advantages with rheocasting comes from the fact that the viscosity of a semi-solid slurry has a significantly higher viscosity than that of a liquid metal. Basically, we can expect a liquid metal to behave like water, which easily separates into droplets if not handled (poured) very carefully. The viscosity of a semi-solid slurry strongly depends on the solid fraction, but also on the shear rate. A high solid fraction and a low shear rate will both lead to an increased viscosity, which gives a favorable cavity filling, since the risk for metal splashing ("surface turbulence") is reduced.
In traditional High Pressure Die Casting (HPDC), a large part of the air in the cavity get mixed with the metal during filling due to the very short fill times and high velocities. Thereafter, the high pressure built up during the intensification phase will help to compress the trapped air. However, there will always be trapped air which causes porosity, leakage and bad mechanical properties in the finished part.

High Solid fraction

In rheocasting, the velocity during filling is often ~10 times lower than in HDPC ("low shear rate"). Using a slurry with a sufficiently high solid fraction (typically > ~30 %), this means that viscosity during filling will remain high and that filling will be laminar with no air entrapment. This is a key factor to get success with rheocasting!

The importance of solid fraction is illustrated in the figure below, showing the simulated flow (metal velocity) for the same gate speed (4.3 m/s) at varying solid fractions, at the end of filling. The areas where air is trapped at this moment are indicated with white circles. Obviously, there is a dramatic change when going from 15 % to 35 % solid fraction in the slurry. The RheoMetal process, typically runs around 35-40 % solid fraction, as compared to many other processes on the market where the solid fraction rarely reaches more than 15-20 %.

Another example is shown below. Here, it can be observed how the cooling fins are filled in a heat sink application, where the solid fraction is 35 % and 15 % respectively (gate speed is ~8 m/s). For a "good slurry", (35 % solid) the fins fill up laminarly and only some air risk to get trapped close to the gate; see white circle (left).

However, this problem can easily be solved with a properly positioned overflow. When using a “bad slurry” (15 % solid), there is a significant back-filling of the fins and the metal splashing backwards will solidify quickly and trap most of the air in the fins (right). The customer buying this heat sink will not be satisfied with the quality!

The simulations were done using the program SIGMASOFT® Thixo (www.sigmasoft.de).
Finally, some pictures from the reality are shown. The turbulent filling and related trapped air in HPDC (left) has resulted in a very porous casting. The pores extend almost over the whole cross section. The rheocasted part, which was filled in a fully laminar way, is virtually porosity free.T