**MULTISCALE MODELING OF THE SOLIDIFICATION STRUCTURE OF HIGH-PRESSURE DIE CAST ALUMINUM A383 ALLOY**

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**Abstract**

A numerical model is being developed to predict the solidification structure and evolution during high-pressure die casting (HPDC) of a modified A383 alloy. The model predicts the grain size, equiaxed-columnar transition and the phase composition of the as-cast structure, including the formation of inclusions, such as iron-rich -al (sludge).

The modelling approach consists of integrating a macroscopic model for prediction of fluid flow and solidification conditions in HPDC A383 components with a microscopic solidification structure model developed at the University of Alabama.

The aim of the integrated model is to accurately predict the evolution of the solidification microstructure including the formation of inclusion defects in HPDC A383 components. The model predictions are being compared against experimental measurements (e.g. amount, type of inclusions and phases, porosity) in A383 samples extracted from various regions of an HPDC engine block. The validated model can then be applied to determine the effects of different solidification conditions on the as-cast microstructure.

**Introduction**

The objective of this work is apply a transient multiscale modeling approach to get insights into the effects of key processing parameters on the solidification structure of HPDC Al-383. This includes the piston intensification pressure, cooling water flow, cycle time, characteristic size of the feeding gates and the optimal concentration of additives such as Sr. The modeling approach consists of integrating a transient macroscopic model (Ansys Fluent, Nova Flow and Solid) with a mesoscopic solidification structure model. The integrated model can predict the solidification structure evolution of both columnar and equiaxed grains and the columnar-to-equiaxed transition (CET) as well as final phase composition. The integrated model can assist thus in achieving better control of the solidification structure and mechanical properties in the product.

The capabilities of the model include the modeling of the effects of process parameters such as the mold cooling conditions, piston velocity profile, cycle time, and the composition of the alloy. Thus, grain size, grain morphology, grain direction, CET, porosity and phase composition can be predicted.

A schematic of the HPDC process is illustrated in Figure 1. Figure 2. Presents a schematic diagram showing the coupling between the transient computational fluid dynamics model (Ansys Fluent) and the casting solidification structure code (SolMicro).

**Ansys Fluent description**

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**Nova Flow and Solid description**

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**SolMicro description**

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**Description of simulation setup data and process data in tables**

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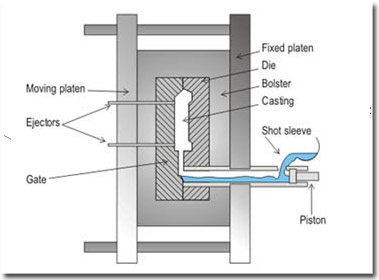


Fig. 1. HPDC diagram placeholder



Fig. 2. Simulation flowchart

As shown in Figure 2, **Ansys Fluent** is used to simulate the energy, momentum and solute transport computations to predict temperature, velocity and concentration distribution in the casting. These results are validated using the **Nova Flow and Solid** software running a parallel simulation and experimental work.

Then, the **SolMicro** uses the concentration distributions and cooling rates, mushy-zone thermal gradiants, and solidification time from **Ansys Fluent** to predict the microstructure.

Table 1. Process parameters

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Table 2. Simulation parameters

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