Solidifying Aluminium Alloys

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Introduction

During solidification of Al–alloys in Direct Chill castings solid nuclei will form and grow out to dendritic crystals. These irregular crystal grains form together with the surrounding melt the **mushy zone**. It is this region where all of the microstructural characteristics of the cast are determined. When solidification proceeds, the grains will impinge on another and form a rigid **porous medium** at low liquid fractions.

Objective

The aim of our simulation is to get a better understanding of the interaction of liquid flow and solidification in the mushy zone at low liquid fractions. This might help to predict occurrence of casting defects, e.g. macrosegregation and freckles.

Numerical Model

A first model system which allows for numerical investigation was constructed. It consists of a rectangular 2–D tube network. The cylindrical tubes represent the liquid conducts of the mushy zone.

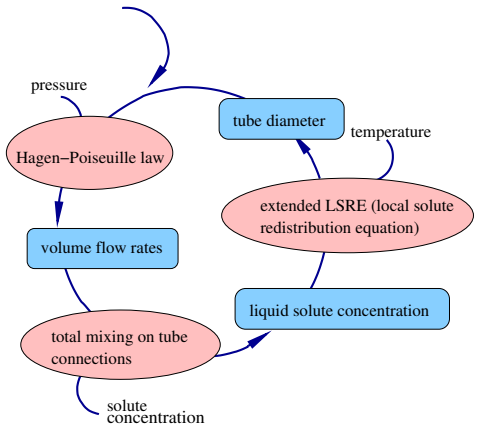

Figure 1: Evolution of the network. One turn corresponds to one time step.

The evolution of the network is based on three separate calculations which form one time step (see figure 1). An arbitrary temperature distribution within the tubes can be imposed. This distribution can even be varied in time.

Results

As expected, upon solidification the liquid fluid flow becomes hampered and permeability decreases. Using Darcy law we get permeabilities which quantitatively agree with measurements.

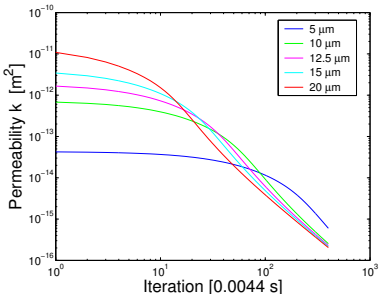

Figure 2: Evolution of permeability for different mean initial radii.

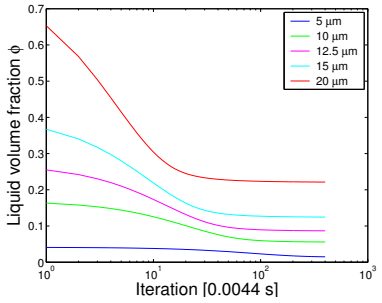

Figure 3: Evolution of liquid volume fraction for different mean initial radii.

The emergence of certain spatial correlations such as formation of freckles however was not observable. It seems that imposing the distribution of temperature within the tubes restricts the possibilities of self–amplifying and self–limiting processes.

Conclusion

We reduce the number of restrictions applied to the model. The convection–induced growth phenomena will be investigated.

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