Design and development of a permanent mould for separately poured specimens with controlled microstructure by numerical process simulation

Stefano Spigarolo[1], Giulio Timelli[2]

[1]Department of Industrial Engineering,University of Padova

[2]Associate professor at Department of Management and Engineering, University of Padova

Introduction and Objectives

Since mechanical properties of a product are key requirements in the automotive sector researching the best alloy composition ,or the most effective heat treatment, is a common task in the improvement process of a product. Those theoretical studies have to be eventually validated through experimental tests performed on the final product.

This work aims to provide a flexible way to obtain tensile test specimens by gravity die casting, avoiding all the machining operations necessary to extract a specimen from the final product and creating an easier route to test heat treatment recipes.

Methodology

In order to obtain a suitable specimen the main aim of this work is to mimic the microstructure of the product: since thermal gradients and cooling rates are correlated with microstructure, it is therefore important to be in control of the temperature during the process. In this project the target secondary dendrite arm spacing of the specimen was inside the range of 40-50 microns.

The software employed in the numerical simulation was MAGMA 5 and it was used to test several different process conditions.

The mesh element number, selected after a convergence test, was 685984; afterwards, process boundary conditions were tuned to control the microstructure.

If undesired results appear, iteration of the process with changes in process definition or mould desing

Starting mould

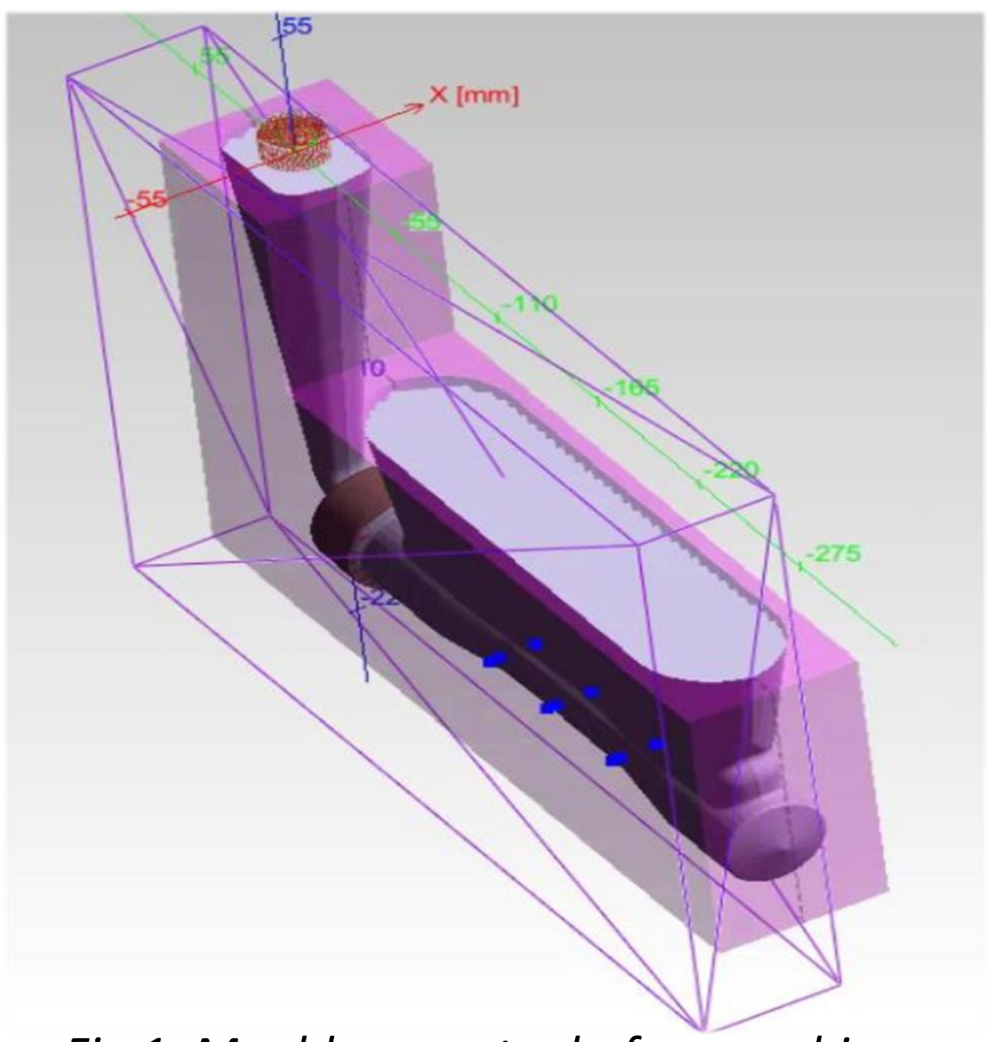


Fig 1: Mould geometry before meshing

Process simulation

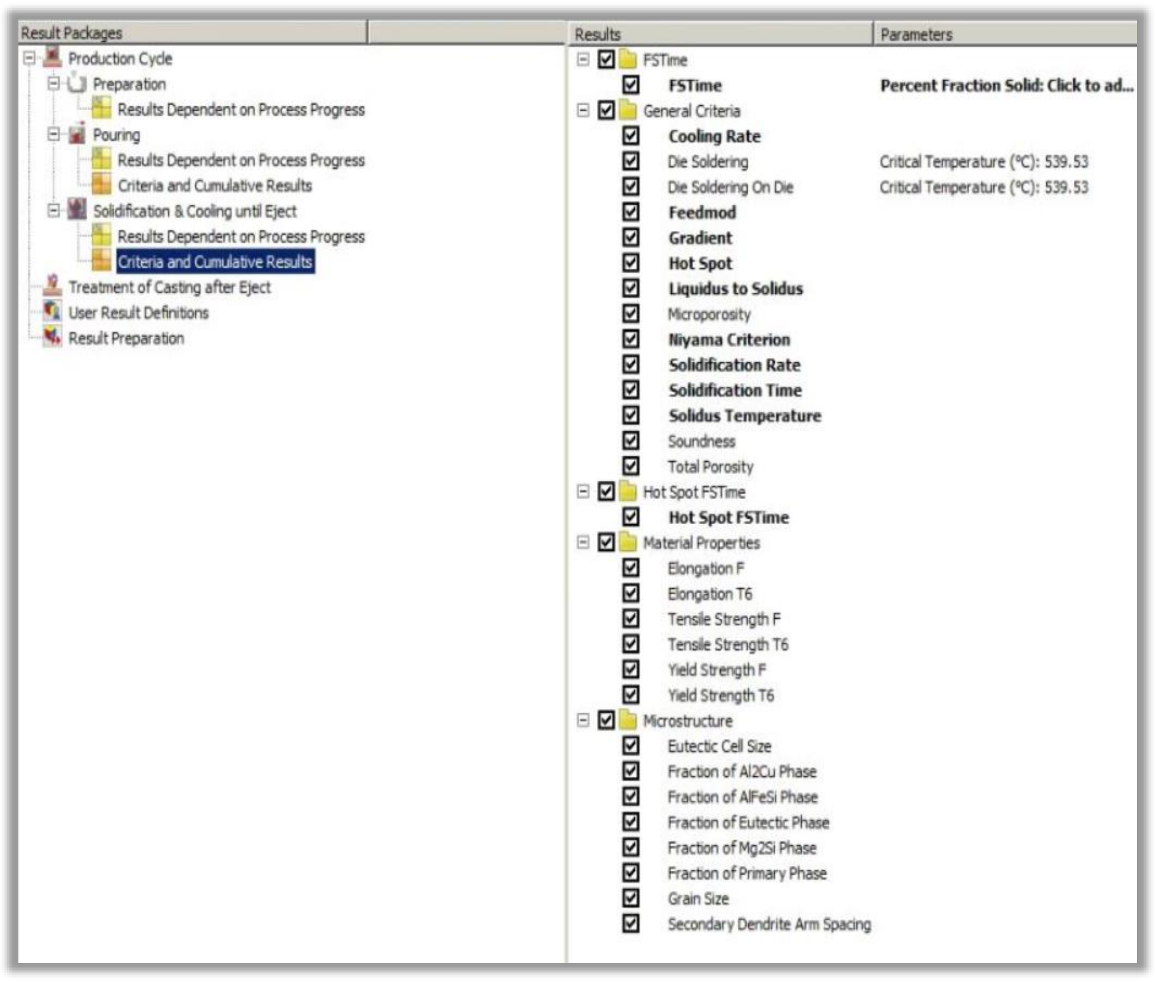


Fig 2: Solidification results definition

Post process analysis

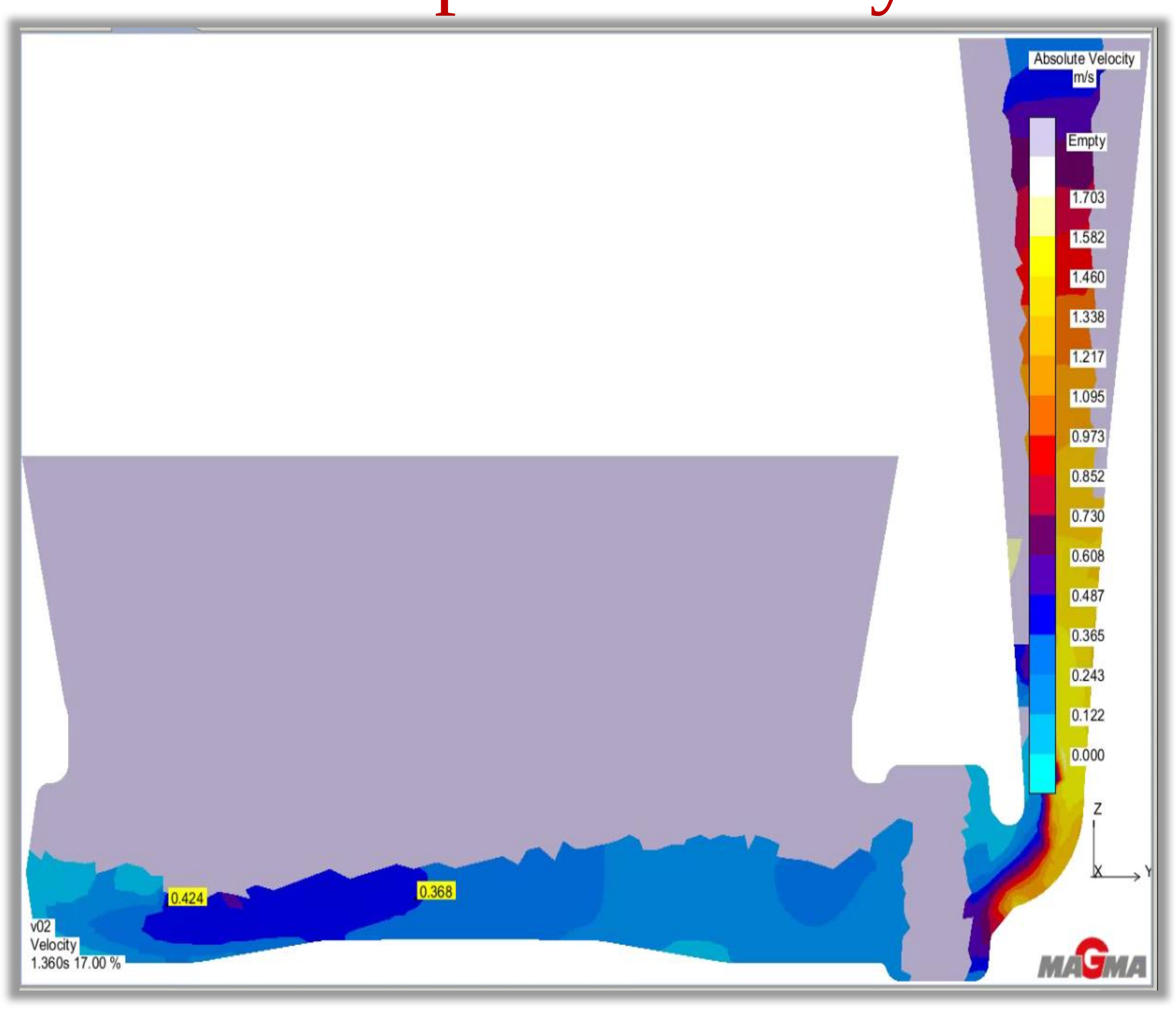


Fig 3: Fluid velocity at 17% of the filling phase

Results and Conclusions

Fig.4: Specimen Total porosity

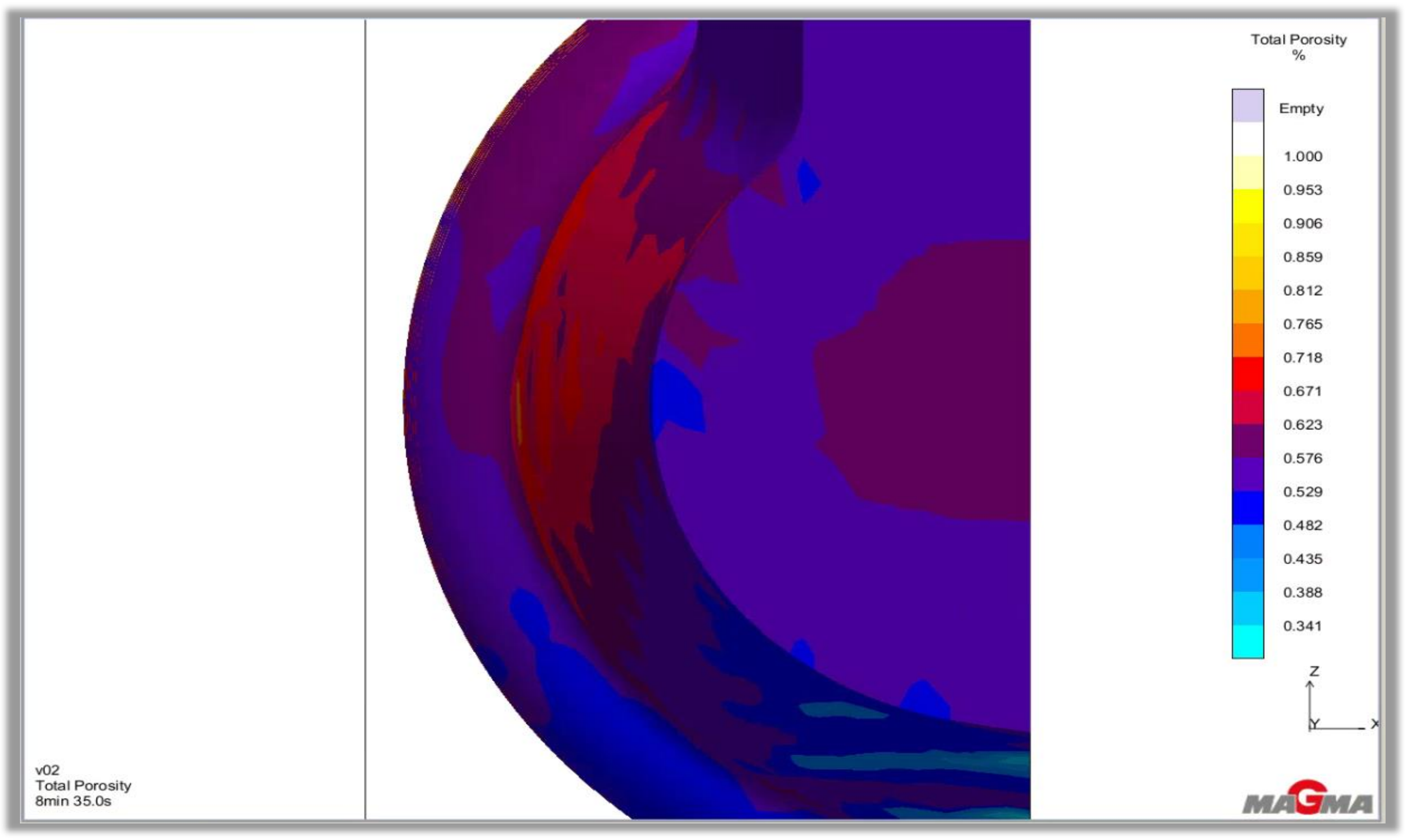
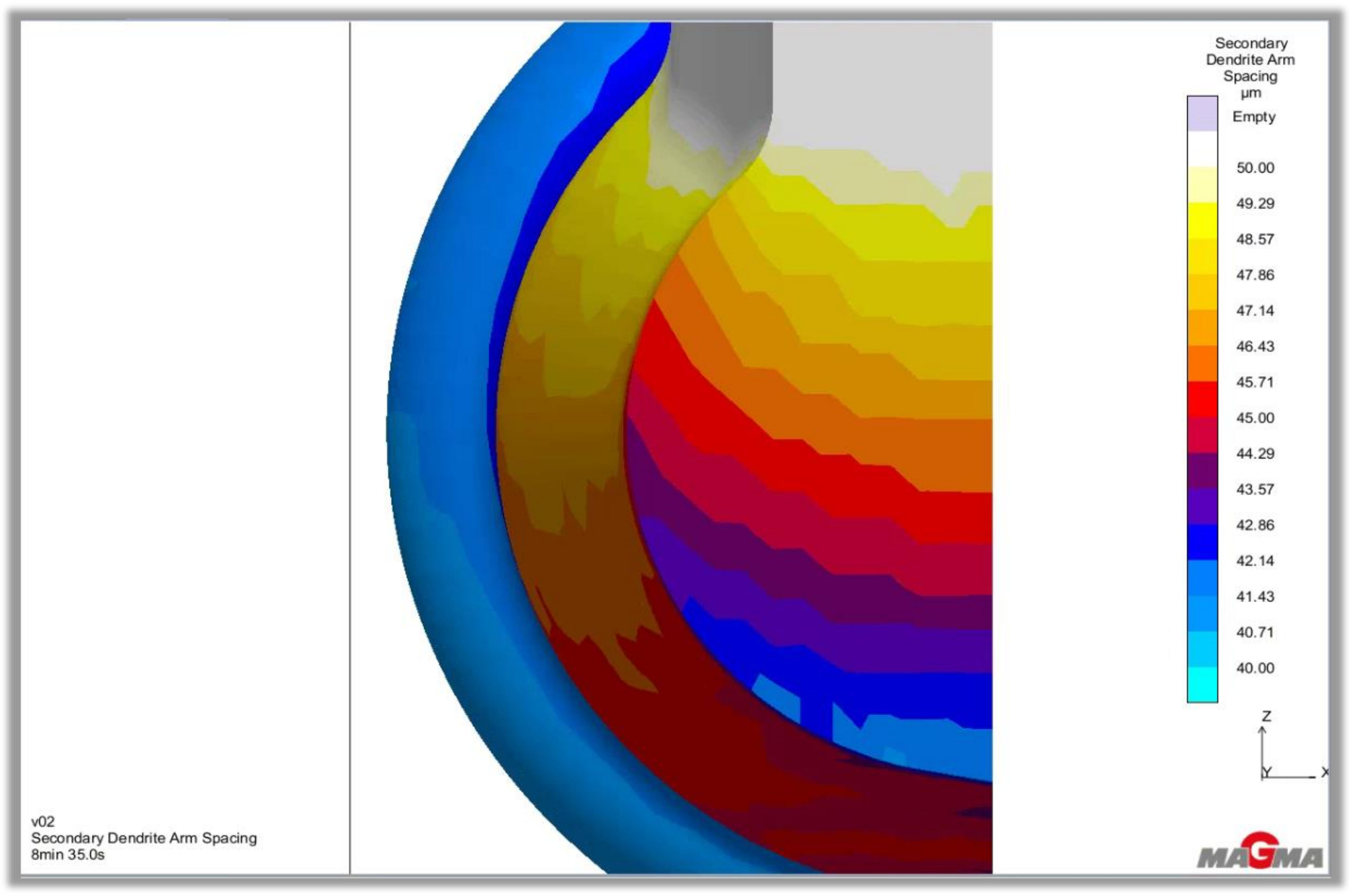


Fig.5: Specimen SDAS



By progressively tuning mould design and process conditions (i.e. alloy and mould temperature) the desired microstructure was finally reached, as presented in Fig. 5. The other important requirement that was kept under strict control was the percentage of porosity, which was lowered to a maximum of 0.623 %.

Porosities are dangerous crack initiation sites and are maintained at a low level by carefully controlling fluid velocity, solidification path , hot spot formations, gas developements and cold shots.

The method to avoid time consuming machining operations and product wastes was eventually developed using MAGMA 5.