Modelling of the High Pressure Die Casting Process

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Introduction

Numerical simulation is a powerful and cost-effective tool to optimize manufacturing processes whilst providing access to quantities that are difficult to obtain experimentally. Simulation of the high pressure die casting (HPDC) process has been initiated at BCAST to assist in the design of experiments and investigate flow, heat transfer, microstructures and defect formation in HPDC components during manufacturing. The project aims to understand the variability of mechanical properties in HPDC parts, which is a major concern to achieve weight reduction through lighter designs. To address this challenge in a cost effective manner, a combined experimental and simulation based approach has been developed.

Modelling and Calibration for Thermal Die Cycling

During HPDC process, several die cycles are necessary before obtaining steady die condition and sound casting quality. Accurate description of thermal die cycling (TDC) process is prerequisite for robust HPDC modelling. In this work, TDC process is modelled in *ProCAST* software and further validated against infrared camera measurements. (Fig.1). On this basis, shot number before reaching steady state could be determined and used for actual HPDC process.

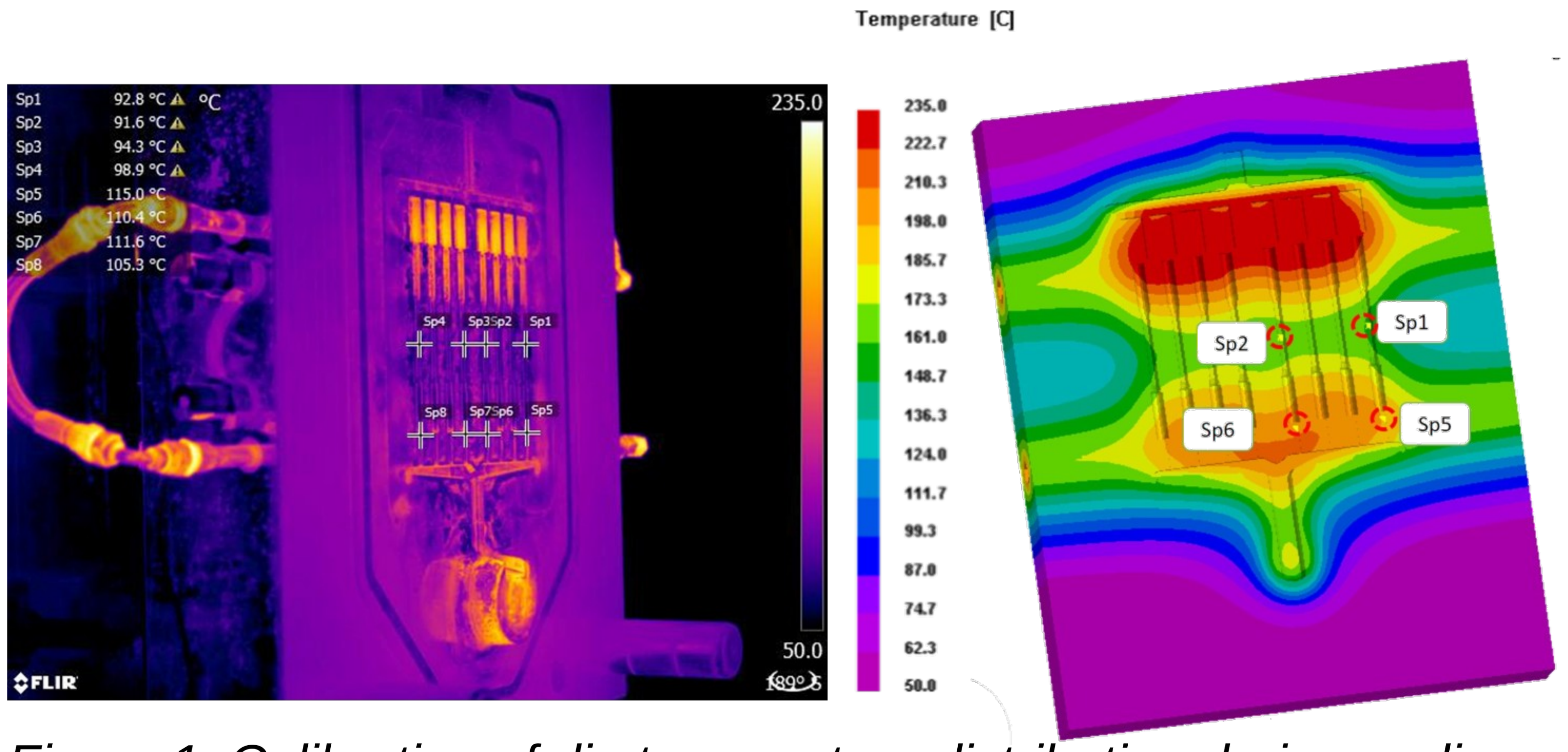

Figure 1. Calibration of die temperature distribution during cycling process against infrared camera measurements

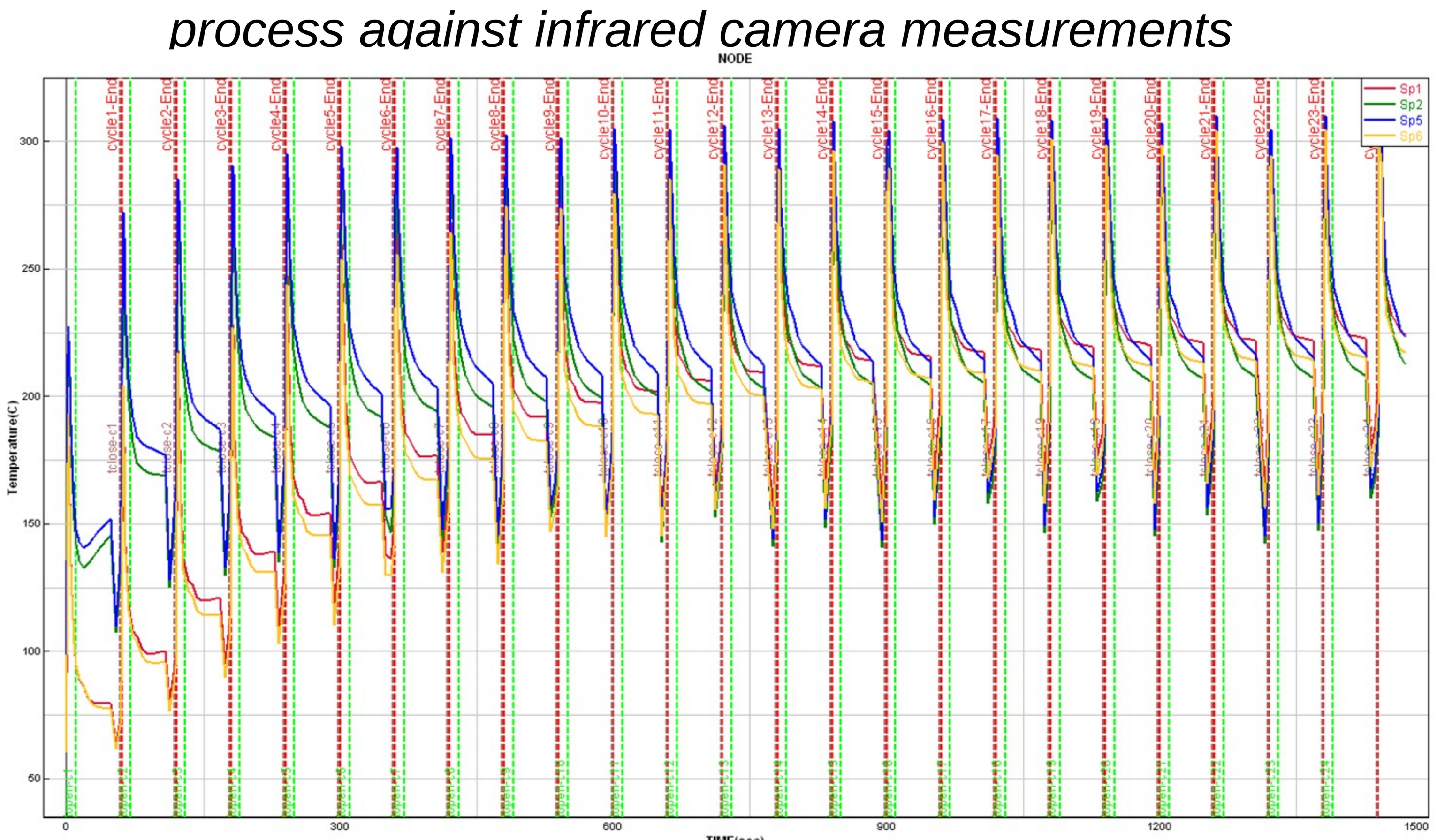

Figure 2. Evolution of temperature profiles at sampling points in the die with multiple thermal cycles

Cast Defects Prediction under Varied Piston Profile

The influence of piston profile on melt flow and defects formation in shot sleeve and die cavity are studied systematically. The melt free surface evolution is described using volume of fluid method (VOF), air entrainment amount during filling is quantified using GAS 4 model in *ProCAST* software considering vent condition and gas pressure. The oxides indicator is used to characterize the distribution of oxides regarding melt flow behaviour and melt contact time with air. Three sets of piston profiles are selected with slow shot velocity changing from 0.2-0.3m/s, 0.4-0.6m/s and 0.6-1.0m/s. Evolution of melt free surface in shot sleeve, air entrainment in shot sleeve and defects formation in final cast tensile bars are modelled and compared respectively. As is shown in Fig.3, proper slow shot piston velocity could be determined and suggested for real HPDC process, which help in further understanding in variability for cast tensile bar mechanical properties.

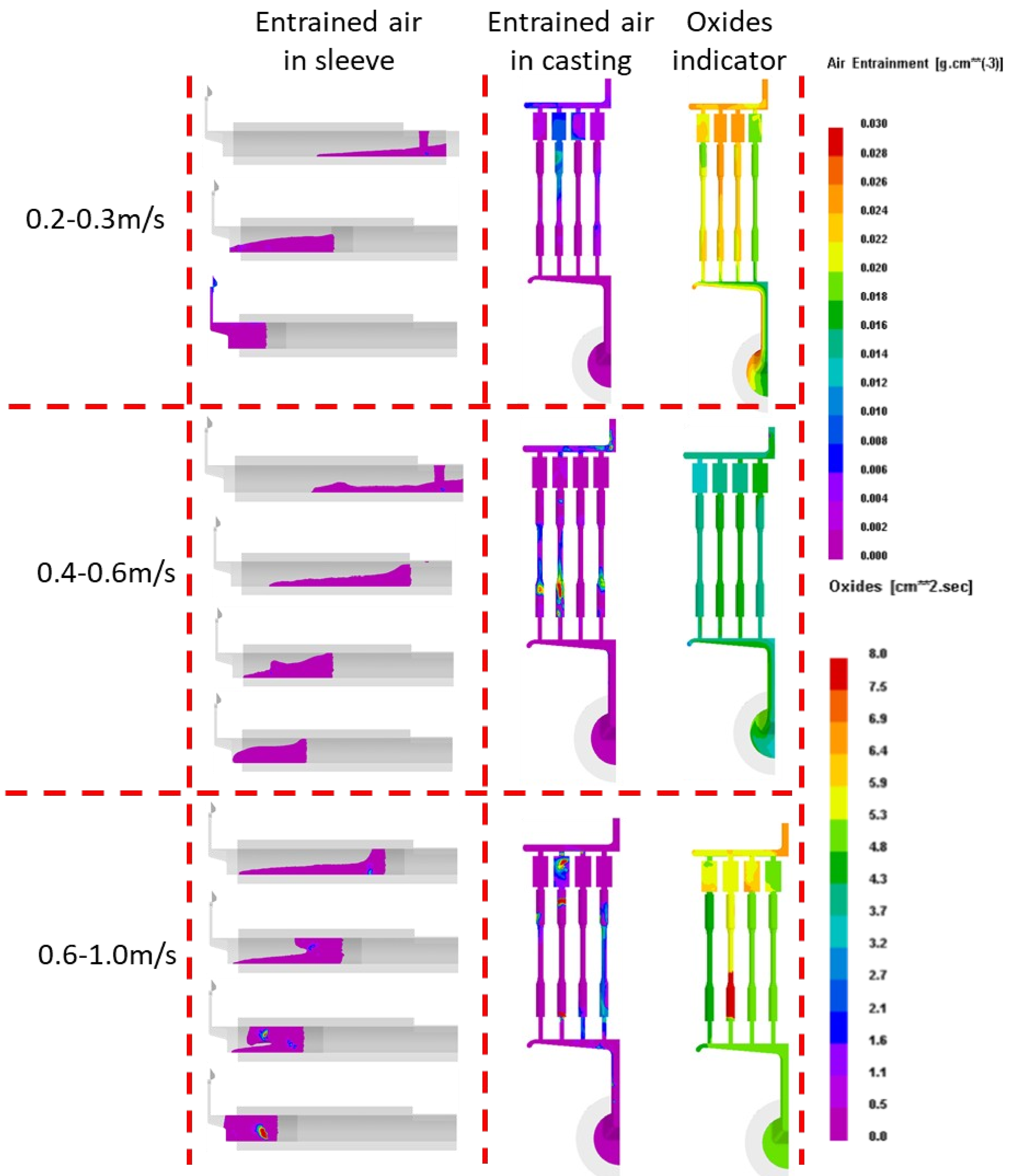

Figure 3. Influence of piston profile on melt flow and defects formation

Shrinkage Porosity Modelling and Validation

The formation and distribution of shrinkage porosity during HPDC process is modelled using POROS 1 model and NAPM model in *ProCAST* software. The POROS 1 model considers the critical solid fraction for inter-dendritic melt flow and mainly focuses on macro-shrinkage (hot spot). While the second model is based on heat transfer calculation and considers segregation of gaseous elements (mainly hydrogen in aluminium alloy) and its pressure drop in mushy zone, it is suitable for prediction of micro shrinkage porosity. A comparison between modelling results and Micro-CT scanning can be found in Fig. 4.

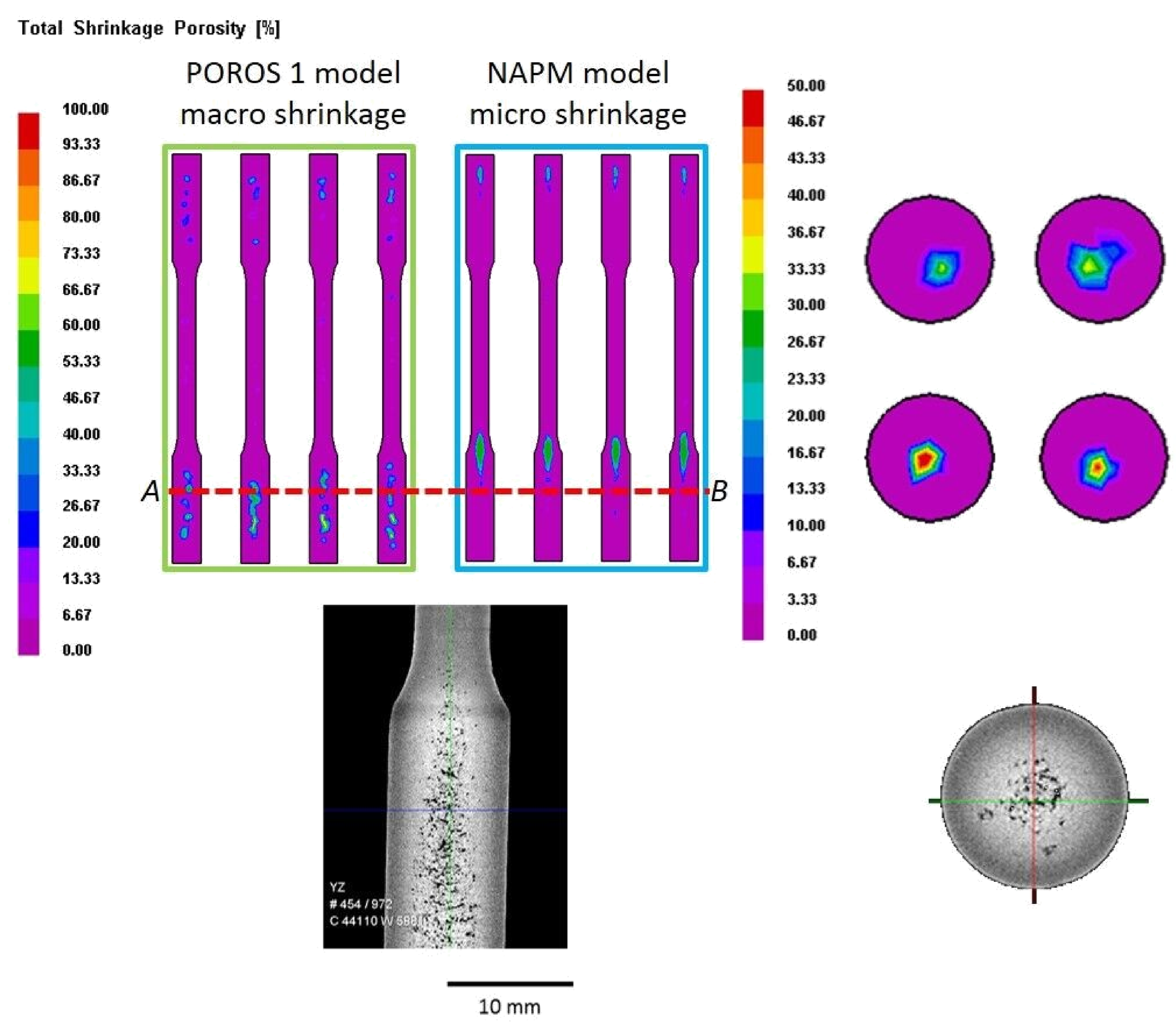

Figure 4. Comparison of shrinkage porosity predictions (four tensile bars of different locations) against Micro-CT results.

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