ABSTRACT

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Doctoral dissertation entitled:

Low-pressure casting technology for sanitary fitting components made from next-generation brass alloys.

This doctoral dissertation addresses the development and optimization of low-pressure die casting (LPDC) technology for sanitary fitting components manufactured from next-generation low-lead brasses. These alloys represent a direct response to stringent environmental regulations imposed by the European Union, the World Health Organization (WHO), and the Four Member States Initiative (4MS), which restrict the maximum lead (Pb) content in materials contacting water intended for human consumption to below 0.2 wt.%. Although advantageous from a public health perspective, the reduction of lead significantly impairs the technological properties of Cu-Zn alloys and increases their susceptibility to surface and shrinkage defect formation, thereby justifying comprehensive experimental and applied research.

The scope of material and methodological investigations involved a thorough characterization of CB771 and CB770 casting brasses, encompassing thermodynamic calculations, chemical composition analysis, and energy-dispersive X-ray spectroscopy (EDS) phase microanalysis. Casting properties were evaluated by assessing susceptibility to shrinkage defects, fluidity, and mold filling capability. Solidification kinetics were investigated concurrently via thermal-derivative analysis (TDA) and dilatometry. The experimental program was further extended to include mechanical property evaluations, dezincification resistance testing in accordance with the PN-EN ISO 6509 standard, and machinability assessments.

The experimentally determined thermophysical properties—comprising temperature-dependent density, heat of crystallization, and liquidus and solidus temperatures derived from dilatometric and TDA curves—were utilized to calibrate and validate numerical simulations of

the casting process within the MagmaSoft environment. Integrating these tailored material datasets into the simulation software yielded high agreement between predicted and experimental cooling and crystallization curves. This enabled accurate forecasting of the location and geometry of shrinkage cavities in complex-geometry castings, including washbasin faucet bodies and internal valve cartridges.

The experimental and numerical simulation results were subsequently validated under industrial manufacturing conditions, leading to the successful commercial implementation of LPDC technology for sanitary components using CB771S brass with a lead content restricted to below 0.15 wt.%. The optimization of key processing parameters, combined with structural modifications to the permanent molds, achieved the complete elimination of shrinkage defects on critical functional surfaces and reduced manufacturing costs, while meeting all required standards for pressure tightness and final product surface quality.