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Editorial

Casting Alloy Design and Characterization

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Abstract: Metal casting processes routinely used in the foundry industry (e.g., gravity or pressure casting) are subject to a wide range of operational parameters. Since there is a close correlation between solidification conditions, microstructure, and properties, the effects of the solidification thermal parameters and alloying elements on microstructure designs and the resulting properties in cast alloys have stimulated new research interest. Thus, this Special Issue aims to collect research articles focused on the design and characterization of cast alloys, especially on the interrelationship between solidification, microstructure, and properties; both experimental and theoretical research are welcome for contribution.

Keywords: casting; solidification; microstructure; properties; characterization; casting design

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1. Introduction

Casting processes induce a wide-ranging of solidification conditions, affecting the microstructure formations. Grain size and morphology, interdendritic spacing, solute segregation and precipitation, the presence of porosity, and other defects are strongly influenced by the thermal behavior of the metal–mold system during solidification, imposing a close correlation between solidification, the resulting microstructure, and the final properties [1]. Consequently, the temperature–time evolution during solidification is closely related to the structural integrity of shaped castings. Gravity or pressure die casting, continuous casting, and squeeze casting are some of the casting processes where product quality is affected by metal–mold heat-transfer conditions [2–4].

One simple, low-cost, and well-established method of investigating and understanding solidification evolution is thermal analysis based on the cooling curve, which can be acquired during the cooling of a molten metal or alloy in specific thermal analysis cups or dedicated solidification apparatus [5–8]. The technique consists of monitoring the metal during solidification using thermocouples, allowing researchers to obtain temperature–time cooling curves. Thermal solidification parameters, such as the phase-transformation temperature, the solidification range, and the kinetic range, the latent heat release, and the solid or liquid fractions, can be calculated.

However, industrial solidification processes parameters, such as thermal gradient, cooling rate, and interfacial heat transfer coefficient, are more complex than those involved in the thermal analyses. In order to improve casting quality, it is fundamental to understand and control the solidification process. An alternative approach to predicting the solidification behavior of metals or alloys is the use of analytical or numerical simulations by applying thermodynamic models, which incorporate phenomena such as heat and mass transfer, fluid flow, alloy solidification, and solid-state phase transformations [9,10]. There are a number of commercial software packages, such as Thermo-Calc, FactSage, Pandat, and Mat-Calc, known as CALPHAD tools (calculation of phase diagram methodology) [11], which have been used extensively in industry in recent decades. Modelling offers the ability to simulate operating parameters in order to guarantee that optimal conditions for casting processes are determined. In parallel, computer science, automation, and artificial intelligence techniques are being introduced for optimizing the manufacture process, reducing costs, and maximizing the quality of the final product [12–15]. However, it is important to note that the accuracy of numerical simulations depends on the precision of input information, such as the solidification thermal parameters and the thermophysical properties of the metal–mold system [16–20].

Since the control of microstructures during casting processes involves heat and mass transfer, solidification, and phase transformation, numerous studies have focused on the development of correlations to optimize the operating parameters as a function of a number of process variables. These include metal–mold chemical compositions, material thermophysical properties, mold design, cooling conditions, and others [21–27]. In addition, the influence of microstructure features (e.g., grain size, dendrite arm spacing, secondary phase, and defects), their influence on subsequent manufacturing processes (e.g., heat treatment and machining) [28–32], and their influence on corrosion and wear responses were performed in [33–35].

The flowchart shown in Figure 1 presents the main operational and metallurgical variables involved during solidification, and their intercorrelation with the final quality of the casting.

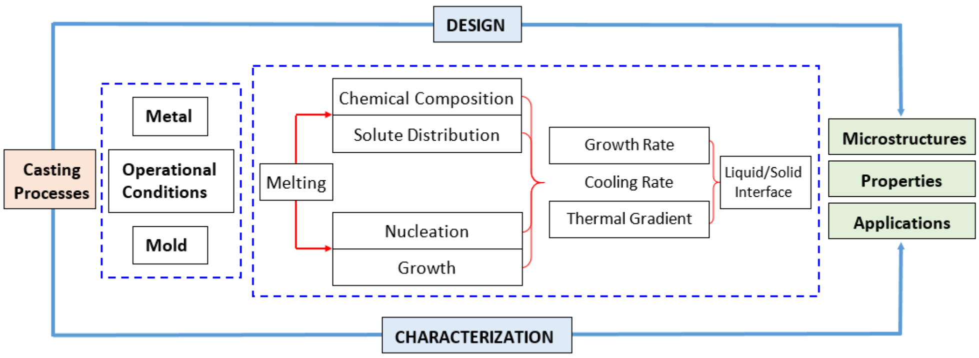

Figure 1. Operational and metallurgical variables during casting processes.

2. Contributions

This Special Issue is dedicated to works related to casted alloy designs and characterization. Contributions to research on the correlation between processing, properties, and microstructures are welcome. The scope includes, but is not limited to, the following technical topics: casting processes and novel techniques; solidification: experimental and theoretical studies; microstructure and property characterization; numerical and analytical simulations; heat and mass transfer; processing–structure–property relations; industrial applications.

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