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Editorial

Microstructure, Mechanical Properties and Solidification Behavior of Metals and Alloys

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1. Introduction and Scope

The microstructure constitutes one of the pillars of the materials tetrahedron [1], bringing together the phases (matrix, second phases, intermetallic compounds, inclusions, etc.) and their morphologies. Its configuration is directly linked to the material composition and subsequent synthesis or processing. The solidification microstructure of alloys is fundamental in the production process of metallic components, as the occurrence of defects will result in significant losses in subsequent manufacturing operations [2,3]. Therefore, the study of the solidification of metals and alloys in metal/mold systems will always be important. For example, in fast solidification, there is a rapid release of latent heat under transient conditions. In most cases, this allows the achievement of a better set of final properties due to the growth of metastable phases. When higher cooling rates are used, refined microstructures, reduced microsegregation, and growth of secondary phases not predicted by the diagrams are obtained [4–6]. Fabrication processes such as welding, surface treatment, high-pressure die casting (HPDC), squeeze casting (SC), and selective laser melting (SLM) take place under fast solidifying conditions, and the final properties will depend on solute segregation and the type of microstructures produced.

This Special Edition sought to bring together works that expressed the timelessness of these studies about the effects of processing parameters on the microstructure of solidified products, and their effect on mechanical properties. Altogether, five articles were published that contributed to the dissemination of this knowledge about aluminum alloys, zinc alloys, and low carbon steels.

2. Contributions

The five articles published in this Special Issue covered topics such as non-ferrous alloys, mechanical properties, solidification modeling, and microstructural growth. Each of them allowed for a better understanding of the effects of solidification processing parameters (cooling rate, growth rate, composition, etc.) on the microstructure.

The article published by Wang et al. [7] aimed to study the effect of Cu addition on the strength and toughness of steel samples prepared by the metal cored wire via tungsten inert gas (TIG) welding. The authors highlighted that the addition of copper favored the formation of bainite over martensite, and considering copper contents up to 1.79 wt.%Cu, the retained austenite fraction had a positive effect on toughness. They noted that copper-rich precipitates represent an important relationship with the observed tenacity levels. Finally, they concluded that Cu precipitation reduced the crack initiation energy of deposited metals and had little effect on the propagation energy.

Regarding zinc alloys, two articles were published that contributed to the advancement of the state of the art of the metallurgy of Zn alloys and their applications. The first one also evaluated the economic aspects of recycling $AnAl_4Cu_3$ alloys. The authors verified that the addition of 3 wt.% of Cd contributed to the increase in the alloys' fluidity at the expense of mechanical strength. The addition of Cd improved the casting aspects of the alloy, however, this addition must be carried out for applications that do not require high values of mechanical strength [8]. The work of Septimio et al. [9] proposed a diagram showing the coupled zone of Zn–Al alloys as a function of the cooling rate, which showed a wide range of microstructural morphology sensibly influenced by the composition and cooling rate.

Silva et al. [10] carried out experimental analyses aiming at correlating the primary, secondary, and tertiary interdendritic spacings to the solidification cooling rate and growth rate developed during an unsteady state solidification of an Al-7wt.%Si-*x*wt.%Mg alloy. They observed that a consequent increase in the Mg_2Si fraction tends to increase the values of the primary dendritic spacing. However, this same behavior is not verified for the growth evolution of dendritic side branches. A multiple linear regression (MLR) analysis was developed permitting quantitative correlations for the prediction of tensile properties and hardness from microstructural parameters to be established.

Liu et al. [11] proposed a numerical model to reduce pretreatment as a novel strategy to alleviate the center porosities in large billets. The simulation results showed that the position with the maximum strain moved toward the center of the billet as the reduction amount increased. The authors verified that the reduction of the pretreatment employing a thermal gradient can increase the deformations in the center of the billet. The topic addressed by Liu et al. has a great potential for application by the steel and non-ferrous metallurgy industry.

3. Conclusions and Outlook

Manuscripts published in the *Microstructure, Mechanical Properties and Solidification Behavior of Metals and Alloys* Special Edition contributed to the update of the state of the art concerning studies on the correlation between microstructure and properties of solidified metals and alloys. These papers are addressed to academic and industry researchers who are looking for new information that can contribute to the optimization and innovation of new processes or others already established.

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