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Liquid metal processing and casting

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Liquid Metal Processing and Casting, represents a key stage in the development of many metallic materials, providing the final product with many of its intrinsic properties. During the last thirty years, an increasingly large number of scientific papers have been devoted to the characterization of the various processes involved, detailing both sophisticated experimental measurements and the mathematical modeling and numerical simulation of processes. LMPC2003 Conference, held in Nancy, France, in September 2003 under the auspices of Société Française de Métallurgie et des Matériaux (SF2M), was the fifth in the series of "International Symposium on Liquid Metal Processing and Casting," previously held in Santa Fe, New Mexico. The presentations and ensuing discussions covered a range of topics from theoretical mathematical models of microstructural evolution to industrial-scale experimental investigations. Although many metallic systems were studied, the focus was on specialty steels, nickel-base superalloys, and titanium alloys.

From the 48 papers presented at the conference, 21 were selected and reviewed for publication in this special issue of the Journal of Materials Science to highlight the key scientific and engineering advances in the field. This selection shows the intense interest in the advanced modeling of the processes with most studies including results from industrial trials for validation. The significant advances in computational fluid dynamics (CFD) methods to include the additional physics of solidification, segregation and electromagnetic forces are illustrated by their application to simulation of processes ranging from consumable electrode remelting (VAR-ESR) to induction skull melting, nucleated casting and spray deposition. As with all modeling exercises, the quality of the output is dependent on the accuracy of the input parameters. Since our knowledge of both the physical and chemical properties of high-temperature systems is still very sparse, a few papers address this problem with approaches ranging from high temperature experimental measurements to "first principle" computations.

More than one third of the contributions are related to vacuum arc remelting (VAR) as applied to superalloys, titanium or steel. The experimental observation of the final product, industrial-scale experiments and integrated modeling are the subject of these papers, which combine to form an excellent review of the process detail and provide an exceptionally good correlation of model predictions to reality as illustrated by the examples taken from industrial processes. Furthermore, the papers demonstrate many novel experimental and computational developments, including:

- The development of a method to measure the transient current flows and magnetic fields during VAR using a combination of instrumentation and analysis using simulations.
- Three dimensional simulations of the influence of external electromagnetic stirring on the fluid flow, heat transfer and free surface during induction skull melting. These simulations, together with studies of other processes, illustrate the importance of matching the power and frequency to the properties of the alloy being cast, with studies ranging from steels to Ti-Al.
- Microscopic and mesoscopic modeling of solidification structures is progressing rapidly. These models are now coupled into macroscopic codes, predicting the grain structure of 2 tonne ingots to illustrate how varying the macroscopic process parameters affects the final ingot microstructure.
- Model-based process control is a promising tool for the optimization of the remelting operation. The behavior of the electric arc, as well as electrode defects, can be handled and their influence on the ingot quality will soon be predicted with confidence.

In summary, this special issue highlights the dynamic combination of experimental and computation research which is being applied to both fundamental and industrial topics of core interest to the field of liquid metal processing and casting.

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