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Multidimensional Modeling of Solidification Process of Multi-Crystalline Silicon under Magnetic Field for Solar Cell Technology

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Abstract : Molten metallic flow in metallurgical plant is highly turbulent and presents a complex coupling with heat transfer, phase transfer, chemical reaction, momentum transport, etc. Molten silicon flow has significant effect in directional solidification of multicrystalline silicon by affecting the temperature field and the emerging crystallization interface as well as the transport of species and impurities during casting process. Owing to the complexity and limits of reliable measuring techniques, computational models of fluid flow are useful tools to study and quantify these problems. The overall objective of this study is to investigate the potential of a traveling magnetic field for an efficient operating control of the molten metal flow. A multidimensional numerical model will be developed for the calculations of Lorentz force, molten metal flow, and the related phenomenon. The numerical model is implemented in a laboratory-scale silicon crystallization furnace. This study presents the potential of traveling magnetic field approach for an efficient operating control of the molten flow. A numerical model will be used to study the effects of magnetic force applied on the molten flow, and their interdependencies. In this paper, coupled and decoupled, steady and unsteady models of molten flow and crystallization interface will be compared. This study will allow us to retrieve the optimal traveling magnetic field parameter range for crystallization furnaces and the optimal numerical simulations strategy for industrial application.

Keywords : multidimensional, numerical simulation, solidification, multicrystalline, traveling magnetic field