Some problems in metallurgical fluid mechanics

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Application of computational fluid mechanics in two areas of metallurgy is considered: solidification of liquid alloys and MHD turbulence. In the first class of problems, where the technical issue is to obtain a reasonably homogeneous composition of the cast, one has to consider not only the completely molten and solidified regions but also the "mushy zone" that is made up of small-scale dendrites, which appear between the first two regions. In the completely molten region, the composition is practically constant and the fluid is set into motion due to the inhomogeneous temperature field. In the mushy zone, on the other hand, solutal convection often dominates strongly over thermal convection. It is shown that laminar convection is of prime importance for the composition of the solidified alloy. In the second class of problems, two cases of turbulent MHD flows in cylindrical containers are considered: an electromagnetic furnace and an electromagnetic stirrer. In the electromagnetic furnace, the mean flow consists of two toroidal vortices. The mean motion in the electromagnetic stirrer is a swirling motion that is accompanied by a weak meridional circulation, which is reminiscent of that occurring in spin down phenomena. The MHD flows are computed by using large eddy simulation methodology with a new subgrid model of the Smagorinsky type that accounts for a variable mesh. Predictions from the all model computations are compared with experimental observations. In general, the agreement between theory and experiments is satisfactory.

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