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Dynamic Simulation of the Entire Crystal Growth Process: Multi-Scale Analysis of Melt Flow Transients

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This paper investigates the transient melt flow evolution during a complete Czochralski crystal growth process. Two basic time scales are considered. The short scale concerns the basic transients associated with flow oscillations at different process stages. Accurate understanding of the flow mechanisms at this scale is required to develop an average axisymmetric flow model for complete dynamic simulations. The long time scale is associated with the transients caused by the slower system evolution occurring during the complete growth process. In order to focus on the fundamental effects governing the flow, a model problem is considered where the liquid is placed into a possibly rotating container while a disk of smaller diameter rotates on its top surface. Both the container and the disk are isothermal. Several transient effects are investigated including the effect of disk radius increase or decrease, and abrupt changes of disk or container temperature or rotation rate.

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