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Analysis of Transient Effects in CZ and FZ Bulk Crystal Growth using Quasi-Dynamic Numerical Simulations. Application to Process Control and Optimization

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Quasi-dynamic numerical simulations provide a simple means to study the transient effects experienced by the crystal, the melt and the solidification interface during bulk crystal growth, without however necessitating a fully dynamic simulation (which would require complex geometrical and numerical methods in order to deal with the important geometrical deformations undergone by the system during the growth process). This simulation technique can also be used to study the transient effects resulting from a change of the operating conditions (heater power, pulling rate, crystal and crucible rotation rates, etc.) by decoupling them from the transient effects resulting from the geometrical changes and focusing on the short system time scales.

In this presentation, we study the results of a number of CZ and FZ bulk growth simulations and analyze the effects of applying different changes in the operating conditions, such as experienced by the system when the accelerated rotation rate technique is used. One of our objectives is to improve the quality of the grown crystal, typically by improving the Oxygen concentration uniformity. Another objective is the design of automatic controllers which can then be used to control the fully-dynamic growth process in off-line and on-line settings.