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STABILITY ANALYSIS OF THE FIRST ORDER STEADY-STATE SOLUTION IN THE CZOCHRALSKI CRYSTAL GROWTH PROCESS

Author(s): **Najib Georges, Nabil Fares, Arthur Dave Snider**

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Abstract:
The Czochralski crystal growth manufacturing process results in small periodic and undesirable fluctuations in the crystal diameter under certain conditions. These fluctuations have strongly nonlinear characteristics and seem to appear at combinations of critical values of certain parameters, such as the rotational velocity, the ratio of crystal radius to crucible radius, and the temperature gradient. This paper uses perturbation theory to try to identify the critical combinations of parameters that lead to these fluctuations. Firstly, the zero and first order equations were obtained. Secondly, numerically-based steady-state solutions of these equations were calculated, and finally, the stability of the steady-state solutions was examined. It was observed that the steady-state solutions do not exhibit any unusual patterns for any values of the configuration parameters. Furthermore, all the steady-state solutions were found to be stable for all initial conditions; therefore, the steady-state solutions and the analysis of their stability did not indicate the source of the observed fluctuations. This suggests that a better approximation of the equations such as second order perturbation analysis may be needed to identify the conditions that lead to the observed fluctuations.

For full paper, contact:
Prof Muhammad Masood Rafi
Editor, NED University Journal of Research
Ph: +92 (21) 99261261-8 Ext: 2413; Fax: +92 (21) 99261255
Email: NED-Journal@neduet.edu.pk
Website: http://www.neduet.edu.pk/NED-Journal