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Numerical Simulations of Porous Medium with Different Permeablities and Positions in a Laterally-Heated Cylindrical Enclosure for Crystal Growth

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Abstract

This paper presents an investigation of flow and heat transfer in a large diameter (6.25 in) cylindrical enclosure heated laterally and containing a porous block that simulates the basket of nutrients used in a crystal growth reactor. The numerical model entails the use of a commercially available computational engine provided by ANSYS FLUENT, and based on a two-dimensional (2D) axisymmetric Reynolds-averaged Navier Stokes (RANS) equations. The porous medium is simulated using the Brinkman-extended model accounting for the Darcy and Forchheimer induced pressure drops. The porous ‘plug’ effects are analyzed as both its permeability/inertial resistance and locations in the reactor are changed on a parametric basis, while the Rayleigh number ($Ra = \frac{g\beta\Delta T L^3}{\nu\alpha}$) is kept constant at 1.98×10^9. Additionally, the effect of different ratios of the hot to the cold zone lengths are investigated as a part of the current effort. For all cases, the velocity and temperature distributions in the reactor are analyzed together with the flow patterns in, and around the porous block. A comprehensive discussion is provided with regard to the effects of the position of the porous block and its permeability on both the immediately adjacent, and far flows. The consequences on the temperature distribution in the enclosure, when the ratio of the length of the hot-to-cold zones is changed, are also analyzed.

KEYWORDS: A1. Fluid flows; A1. Computer simulation; A1. Heat transfer; A1. Convection; A1. Seed crystals

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