

Simulation Analysis of the flow characteristics during Solidification process of PCM

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Phase change materials (PCMs) are widely applied in thermal energy storage systems due to their high latent heat capacity, and understanding their solidification behavior is crucial for optimizing heat release performance. In this study, the solidification process of a selected PCM was numerically investigated using STAR-CCM+ to analyze the associated flow characteristics and phase transition dynamics. To validate the simulation results, experimental measurements of the solidification process in a vertical annular container were compared with numerical predictions. The close agreement between the temperature evolution at different measurement points confirmed the accuracy of the model. Based on the validated simulation, detailed analyses of temperature distribution, solid fraction evolution, and flow field development during solidification were conducted. The results indicate that solidification initiates near the cooled surface, progressing inward with a non-uniform front due to the combined effects of conduction and natural convection in the remaining liquid phase. As the solidification front advances, natural convection weakens, leading to a transition toward conduction-dominated heat transfer in the later stages. The findings provide deeper insight into the interplay between flow behavior and heat transfer during PCM solidification, which can guide the design of more efficient thermal energy storage systems.

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