Experimental and Numerical Analysis of Paraffin Waxes during Solidification inside Spherical Capsules

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Abstract

The present study experimentally and numerically explores the solidification process of three organic phase change materials inside spherical capsules. The offset and the onset temperatures as well as the latent heat, are measured experimentally, while properties, such as density, specific heat, thermal conductivity, viscosity and thermal expansion were obtained from the literature. Initially, the molten phase change material is assumed to fill the insides of the spherical capsules. A transient simulation of the PCM's solidification process was performed using ANSYS/ Fluent 18.2. A numerical model was validated against the experimental results obtained for the RT-47 solidification process using a spherical capsule with an internal diameter of 100 mm. The three commercial paraffin waxes selected in this study, RT-47, RT-50 and RT-60, are primarily used in latent heat thermal energy storage systems. The investigation is performed for spherical capsules that have internal diameter of 80 mm, 90 mm and 100 mm. A temperature of 10 °C higher than the PCMs' onset temperature was used as an initial temperature during the investigation. Conversely, temperatures of Δ5 °C, Δ10 °C and Δ15 °C below the PCMs' offset temperatures were set for the outer surface of the encapsulated sphere. A dimensional analysis of the results was then performed and presented as the liquid fraction and Nusselt number versus the product of the Fourier and Stefan numbers. Dimensionless correlations are developed based on the results of the analysis, which can be employed to design efficient thermal energy storage systems for a packed bed, which encompass the cases considered herein.