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Investigation of Heat Transfer Mechanism Inside Shell and Tube Latent Heat Thermal Energy Storage Systems

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Abstract : The main objective of this research is to study the heat transfer processes and phase change behaviour of a phase change material (PCM) in shell and tube latent heat thermal energy storage (LHTES) systems. The thermal behaviour in a vertical and horizontal shell-and-tube heat energy storage system using a pure thermal conduction model and a combined conduction-convection heat transfer model is compared in this paper. The model is first validated using published experimental data available in literature and then used to study the temperature variation, solid-liquid interface, phase distribution, total melting and solidification time during melting and solidification processes of PCMs. The simulated results show that the combined convection and conduction model can better describe the energy transfer in PCMs during melting process. In contrast, heat transfer by conduction is more significant during the solidification process since the two models show little difference. Also, it was concluded that during the charging process for the horizontal orientation, convective heat transfer has a strong effect on melting of the upper part of the solid PCM and is less significant during melting of the lower half of the solid PCM. However, in the vertical orientation, convective heat transfer is the same active during the entire charging process. In the solidification process, the thermal behavior does not show any difference between horizontal and vertical systems.

Keywords : latent heat thermal energy storage, phase change material, natural convection, melting, shell and tube heat exchanger, melting, solidification
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