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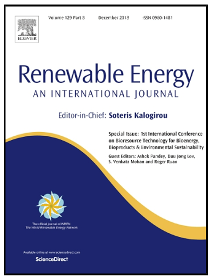

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An Improved, Generalized Effective Thermal Conductivity Method for Rapid Design of High Temperature Shell-and-Tube Latent Heat Thermal Energy Storage Systems

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Abstract

To avoid full — expensive — computational fluid dynamic (CFD) simulations, latent heat thermal energy storage (LHTES) systems are often modelled by incorporating natural convection Nusselt correlations. This enables fast, coarse optimizations for phase change materials (PCMs) selection and geometrical design. While this approach is very convenient and often works well, it is frequently invoked in an ad-hoc manner — outside of known limits. To broaden the limits of applicability for this approach, this study develops natural convection Nusselt correlations for high temperature shell-and-tube LHTES systems, which are under development for concentrated solar power (CSP) plants. In these systems there is a large gap between PCM melting point and heat transfer fluid, up to 280 °C, which drives melting process. To date, many correlations that have been developed (for low temperature PCMs) in the literature are only suitable for a specific geometry and/or PCM. Therefore, this study also expands on the literature by providing correlations that are appropriate for a wide range of realistic geometric parameters and high temperature PCMs. These new natural convection Nusselt correlations were obtained by comparing the heat transfer rates in conduction only and combined conduction/convection CFD models for several PCMs and geometries in the