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OPTIMIZATION OF METAL FIN DISTRIBUTIONS IN LATENT HEAT STORAGES

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Abstract: Over the past years, latent heat storages have gained increased interest due to their superior storage capacity. High storage capacities are achieved as a result of the high latent heat of melting of Phase Change Materials (PCMs) [1]. However, the low thermal conductivity of PCMs limits the charging and discharging performance significantly, causing long charging and discharging times. Heat transfer enhancement techniques for PCM storages are extensively studied both experimentally and numerically [1]. Highly conductive fin structures are often employed as they extract the heat from the heat transfer fluid and easily conduct it into the PCM domain. However, it has been observed that the charging power steeply drops in time [2]. As the PCM melts gradually its ability of absorbing heat from the heat transfer fluid decreases as a result of increased thermal diffusion lengths. Moreover, due to the limited input power and limited convection of the heat transfer fluid, the PCM does not melt uniformly. Therefore, uniform fin distributions can be outperformed by new designs with irregular fin distributions, as some spots could benefit from a higher fin density. In this research, the performance of PCM storages is optimized by optimally spacing the highly conductive metal fins in the PCM storage. The fin shapes are rectangular and their size is kept constant, whereas the fin positions are altered. An adjoint-based optimization strategy is used for efficient gradient calculations combined with consecutive BFGS updates. The optimization procedure is performed for different fin widths, fin amounts, and input powers. It is shown that the optimal fin distribution strongly depends on the fin widths and higher performances are reached with smaller fin structures. The optimal fin positioning shows a trend towards reduced fin spacing, i.e. higher fin density, towards the exit of the heat transfer fluid channel. Decreasing the input heat generates optimal designs with more densely spaced fins.

References

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