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An Experimental Study on Low Cost Concrete Based Molten Salt Tanks

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ABSTRACTS

In a concentrated solar power (CSP) plant a field of heliostat mirrors is used to concentrate solar energy onto a receiver. Inside the receiver, a heat transfer fluid, such as water, thermal oil or molten salt, absorbers this incoming energy and transfers it to a steam turbine via heat exchangers to produce electricity. Molten salts have the advantage of possessing a high heat storage capacity, wide operating temperature range, and a very low cost (Nitrate salts: $0.5 USD/kg). The heat transfer fluid (typically molten nitrate salt $NaNO_3$:KNO_3 60:30) is stored in a two-tank configuration: hot salt storage tank (salt temperature ~ 838 K) and cold salt storage tank (salt temperature ~ 493 K). Recently there has been a push to reduce the levelized cost of electricity (LCOE) for CSP plants to make them cost-competitive with alternative renewable options such as photovoltaics. Cost reduction can be achieved in various ways including the use of a high temperature heat transfer fluid to improve heat to electricity conversion efficiencies. One viable option is to use molten chloride salts (NaCl:KCl 50:50) instead of nitrate salts which can achieve temperatures as high as 1273 K without any chemical decomposition. However, at these elevated temperatures salts become highly corrosive towards common construction materials such as stainless steel. A low-carbon stainless steel (e.g., Inconel 600) can help mitigate the salt attack but makes the overall system very costly. Thus, at higher operational temperatures, tank material and construction cost become the main cost driver instead of the heat transfer fluid cost itself. A low cost, commonly available tank material for storing these salts at high temperatures (> 493 K) can help in increasing the marketability of CSP technologies. Here we propose using engineered concrete as the primary tank material for storing molten salts in solar thermal applications. We have formulated composite structures, made entirely of concrete, and commonly used concrete additives, which help in sustaining thermal shocks expected due to daily temperature fluctuations (493 K – 838 K) and suppressing salt diffusion through porous concrete tank walls. More details regarding the performance of engineered concrete tanks in molten salts at elevated temperatures and the expected challenges posed by concrete-based tanks will be discussed in the CSME 2022 technical presentation.