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Thermal load and bending analysis of heat collection element of direct-steam-generation parabolic-trough solar power plant

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Abstract

The reliability of heat collection element (HCE) in parabolic trough collector (PTC) system is of importance to the solar thermal energy harvesting. The present work proposes the 2D-finite volume method (FVM) and 3D-finite element volume (FEM) coupled model to conduct the thermal load and bending analysis of the HCE of direct-steam-generation (DSG) PTC solar power plant. The emphasis is focused on the evaporation and superheating stages of a DSG loop in re-circulation mode due to the presence of the phase-change process and the relatively lower heat transfer performance, respectively. It is found that the thermal deflection is far less than 1 cm for a 4-m HCE in the evaporation stage. However, in the superheating stage with $DNI=1000 \text{ Wm}^{-2}$ (DNI being the direct normal irradiance), the circumferential temperature difference and the deflection of a 4-m HCE can reach up to 48 °C and 2.16 cm, respectively. It should be pointed out, based on the present work, that the non-uniform heating and local overheating issues exist in the evaporation and superheating stages, respectively, the latter of which seems more serious and potentially causes damage.

Keywords: Concentrating solar power (CSP); Direct steam generation (DSG); Heat collection element (HCE); Thermal bending

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