21st SolarPACES International Conference (SolarPACES 2015), 13-16 October 2015

Preliminary Performance Analysis of a Transverse Flow Spectrally Selective Two-slab Packed Bed Volumetric Receiver

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Abstract

A new volumetric receiver concept has been investigated, based on an adaptation of the spectrally selective, two-slab packed bed volumetric receiver concept of Flamant et al. Both slabs comprise spheres of identical size – borosilicate for the transparent slab 1 and SiC for the opaque slab 2 – which are ordered in a hexagonally close-packed bed. The flow direction has been changed from parallel to the incident radiation and perpendicular to the window, to parallel to the window and perpendicular to the incident radiation (transverse flow). The gap between the window and slab 1 has been removed, so the bed is held in place by the sidewalls, the floor and the window, allowing arbitrary orientation and dispensing with the need for beam-down operation. The receiver has been subjected to constant solar radiative load of approximately 70 suns, and the effect of variations in flowrate, the degree of air preheating as well as the thickness of slab 2 on the outlet air temperature distributions have been measured. The effect of reducing the flowrate for both slab 2 thicknesses is to increase temperature everywhere relative to the maximum temperature, having the effect of "flattening" the pattern factor and tending towards more uniform temperature distribution. The effect of preheating for both slab 2 thicknesses is to move the location of maximum temperature deeper into the bed (away from the window). No significant effect is observed on pattern factor in the transparent region of the bed (slab 1), but temperatures in the opaque region increase relative to the maximum temperature. The results are consistent with the increasing contribution of radiative heat transfer relative to convective and conductive heat transfer as the bed temperature rises. In all cases, the air temperature closest to the window is lower than the maximum temperature, demonstrating the volumetric heating effect. Increasing the outlet air temperature (either due to preheating or due to decreasing flowrate), decreases the heating power absorbed by the air. This reflects the increasing degree of reradiation as the window temperature rises.