## Abstract

Arid desert regions of Rajasthan and Gujarat are exposed to a high level of solar irradiance (> 5 kWh/m$^2$/day), which can be harnessed with the concentrated solar thermal technologies. For example, the central receiver based solar air tower is a point focusing system, which uses heliostat for concentrating the beam radiation onto an open volumetric air receiver. This comprises of porous absorbers that are exposed to a high heat flux beyond 800 kW/m$^2$ and are open to atmosphere. In this thesis, the addressed pertinent challenges for operating such a receiver in arid deserts are as follows:

(a) The concentrated solar irradiance onto an open volumetric air receiver follows quasi-Gaussian distribution along the radial direction, which can promote the thermally induced flow instability, more probably in the centrally located absorbers. The underpinning theoretical and numerical investigations with the circular straight pore based cylindrical absorber are presented. The findings are necessary for operating a system using such a receiver. Based on assumptions, it is found that the thermal induced flow instability is unforeseen up to the desired temperature of 750 K for solar convective furnace. However, a need of more detailed analysis is realized.

(b) The absorber pores are prone to dust deposition leading to a partial or the complete blockage. As a consequence, the formation of a local or a wide area hotspot and an eventual failure of the receiver are envisaged. To investigate the same, both the theoretical and the computational analyses are performed with volumetric and non-volumetric heating conditions including the radiation based heat losses. The investigations revealed that even a 100 μm thick layer of the deposited dust in an absorber pore of diameter 2 mm can lead to an elevation of temperature up to 150 K at a given operating condition. To mitigate the effect of dust deposition a cyclone separator based cleaning strategy is proposed.

(c) Finally, a seven equations based one-dimensional zonal model is developed and is validated with the reported in-house experimental data. In this model the absorbers are divided into categories viz. central and peripheral. The performed analysis aims at identifying the important parameters viz. porosity, geometric dimensions, air return ratio that are relevant to the performance assessment of such a receiver in terms of the thermal efficiency.

Therefore, the undertaken research may be considered as a step towards realizing the open volumetric air receiver based furnace system in desert regions.


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