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Radiation absorption characteristics of a multistage free-falling particle receiver

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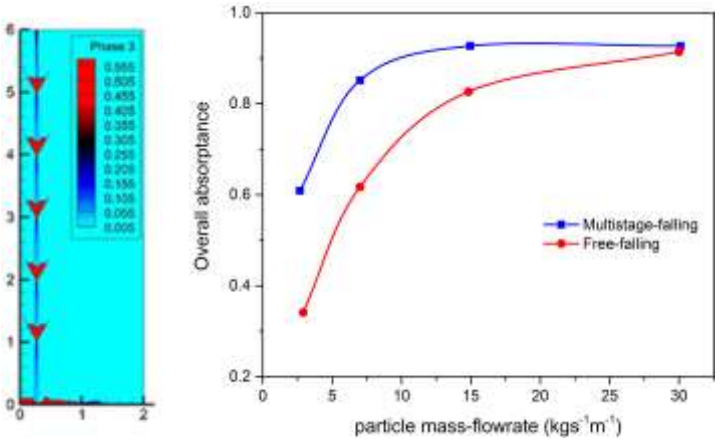
Introduction

A free-falling particle receiver is the simplest of the particle receiver which utilises freely falling solid particles as the heat transfer medium to absorb the irradiated solar energy [1]. Recent study has shown free-falling particle receivers suffers from inherent drawbacks resulting from hydrodynamic instabiliity and inefficient radiation absorption at part load operation, which limited their performance [2, 3]. A low radiation absorption efficiency at part loads arises from low volume fractions of the falling particles which increases the transmittance of the particle curtain resulting in significant reflection losses from the receiver. This problem becomes acute when the falling height is longer, flow rate is smaller, and the particle size is larger [2, 4]. Flow instability resulting from perturbation of the particle clusters in the curtain is an additional issue with free falling particle receiver. Uneven heating across the falling particle curtain could also be one of the main drawbacks of a free-falling particle receiver [2] .

The present work discusses the thermal efficiency evaluatuon by radiaition absorption and thermal modelling of the novel multistage concept [5]. In comparison, the multistage concept addresses the key drawbacks of a free-falling particle receiver and is expected to be significantly efficient in trapping solar energy. As shown in Fig. 1 (a) the free-falling particles are collected by multiple troughs distributed evenly along the height of the particle receiver and made to fall again. This re-establishes the initial stable free-falling curtain structure eliminating hydrodynamic instablity and inefficient radiation absorption due to increased particle volume fractions. Mixing of particles in the troughs also results in more homogenoes particle temperatures. An Eulerian-Eulerian multiphase flow CFD model with discrete ordinates radiaitve solver is used to solve the mass, momentum, energy and the radiative transport equations to evaluate the performance of the multistage concept.

Multiphase CFD and absorption characteristics

Figure 1 (a) shows some preliminary results of the CFD simulation carried out to investigate the interaction of particle flow and multiple troughs. A comparison of the overall absorptance of the multistage concept vs the free-falling receiver shows that at part-load operation (lower particle mass-flowrates) the multistage concept has a significant improvement in the absorption efficiency (Fig.1 (b)).



(a) **(b)**

Figure 1. Eulerian-Eulerian CFD modelling of multistage free-falling particle receiver: (a) particle volume fraction for V shape troughs and (b) overall absorptance

References

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