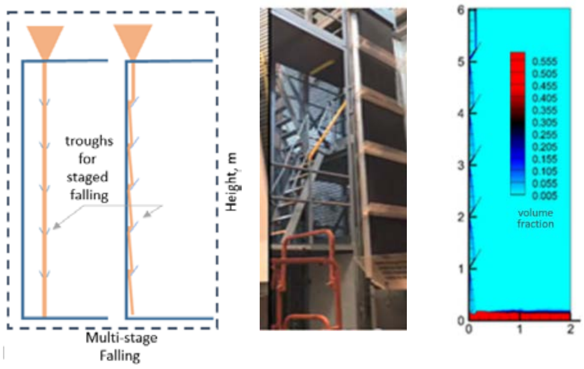
RADIATIVE HEAT TRANSFER IN A SOLAR FREE-FALLING PARTICLE RECEIVER

Apurv Kumar[1,*], Jingjing Chen[1], Jin-Soo Kim[2], Joe Coventry[1], and Wojciech Lipiński[1,**]
[1]School of Electrical, Energy and Materials Engineering, The Australian National University, Canberra, Australia.
[2]CSIRO Energy, Newcastle, Australia.

Solar particle receivers are being pursued to enable higher temperatures (>700 °C) with direct storage for next-generation dispatchable concentrating solar power (CSP) plants, process heating, thermochemistry, and solar fuels production [1]. Advancements in the free-falling solar particle receiver technologies mainly aim to increase radiation absorption by the particle curtain [1]. A particle receiver analysis is a complex problem of two-phase flow dynamics and heat transfer, involving extensive multi-scale multi-physics modelling. Here, we present numerical modelling of particle–gas mass–momentum equation coupled to the radiative transfer equation using Eulerian–Eulerian and the discrete ordinates method in a novel multi-stage free-falling particle receiver as shown in Figure 1.



(a) (b) (c)

Fig.1: Solar free-falling particle receiver: (a) schematic diagram, (b) experimental setup, and (c) numerically calculated particle volume fraction.

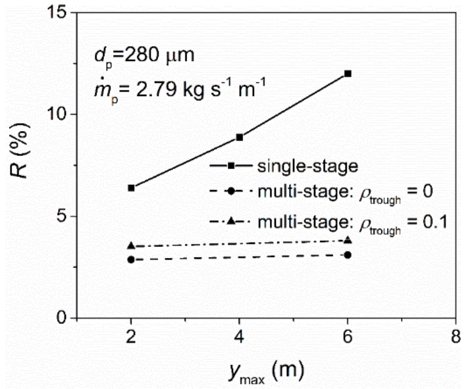


Fig.2: Numerically calculated reflection loss for single- and multi-stage free-falling particle receivers as a function of receiver height and trough reflectivity.

The multi-stage receiver is designed to hold and release the falling particles by uniformly placed troughs (Fig. 1a). The repeated falling pattern creates a denser particle curtain as shown in Figs. 1b and 1c. Figure 2 shows that reflection losses can be reduced by more than 50% by employing a multi-stage instead of a single-stage free-falling particle receiver.

Future work includes modelling of a full-scale receiver system by coupling multi-phase mass, momentum, energy and radiative transport for two-phase flows featuring polydisperse particles.

References

1. C.K. Ho, A review of high-temperature particle receivers for concentrating solar power, *Applied Thermal Engineering*, 109 (2016) 958–969.
2. A. Kumar, J.-S. Kim, W. Lipiński, Radiation absorption in a particle curtain exposed to direct high-flux solar irradiation, *Journal of Solar Energy Engineering*, 140(6) (2018) 061007.