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Assessment of the Thermal Performance of Solar Expanding Vortex Receiver

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A steady state heat transfer model is developed for analysing the thermal performance of the Solar Expanding Vortex Receiver/Reactor (SEVR) for the sensible heating of inert particles. The SEVR features a vortex flow of transport gas to convey a suspension of particles through the receiver, where the particles are directly irradiated by concentrated solar thermal radiation entering the receiver through an aperture. Fluid mechanic studies of the SEVR have identified a number of advantages of the SEVR over existing vortex-based particle receivers, but its thermal performance has not previously been assessed.

The model couples radiation, convection and conduction heat transfer with mass transport through the reactor, using mean particle residence time and flow field data from a validated model of the SEVR fluid mechanics. The receiver geometry is discretised in one dimension to solve the steady state energy equations of the particle and gas phases and the receiver wall by the Gauss-Seidel iteration technique. Model validation will be achieved by comparison to experimental measurements of particles undergoing sensible heating (as well as a calcination chemical reaction) in an existing solar vortex receiver at a scale of 5 kW thermal input.

Assessments of the receiver thermal performance will be made as a function of key operational parameters including solar thermal input, particle loading, particle/air flow mass flow rates and receiver geometry. Further assessments will be made of the scaled up operation of the receiver to provide information of the applicability of a SEVR to large-scale CST systems.