Particle Egress through an Open Vortex-based Solar Particle Receiver

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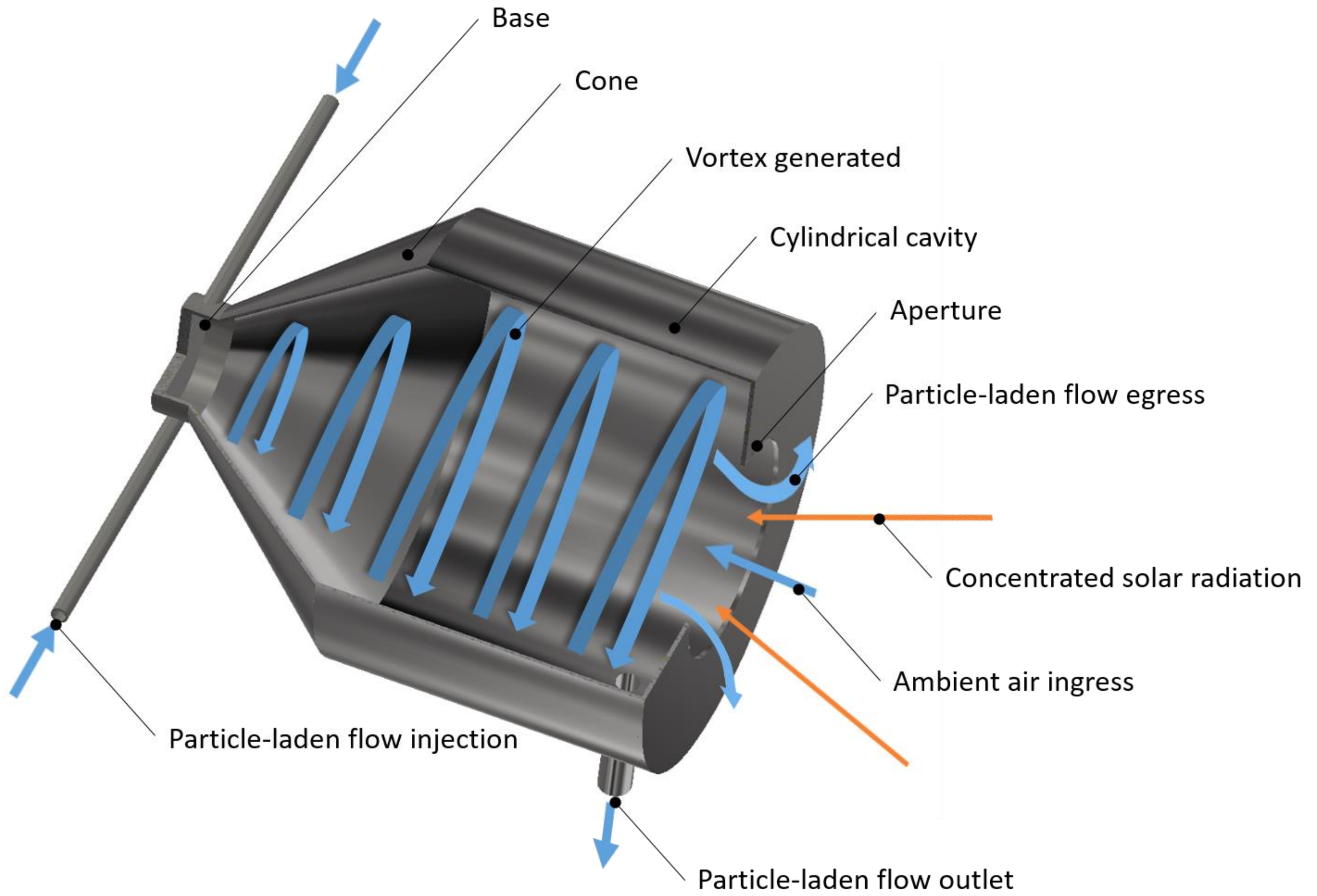
Zoom link: Please click this URL to start or join: https://adelaide.zoom.us/j/8204521952?pwd=ZjRyeVRjTXBGT1lqMzZqVktlZUk0UT09 Passcode: 405420

Introduction

- CST is able to act as an alternative energy resource for Bayer alumina refining process in Australia mainly due to:
  - ability to reach a temperature higher than 1000 ℃;
  - being more cost-effective than natural gas;
  - little greenhouse gas emission.
- The Open Solar Expanding-Vortex Particle Receiver-Reactor (SEVR), designed by the CET, is the core technology for the project, "integrating concentrating solar thermal energy into the Bayer alumina process", funded by Australian Renewable Energy Agency (ARENA).

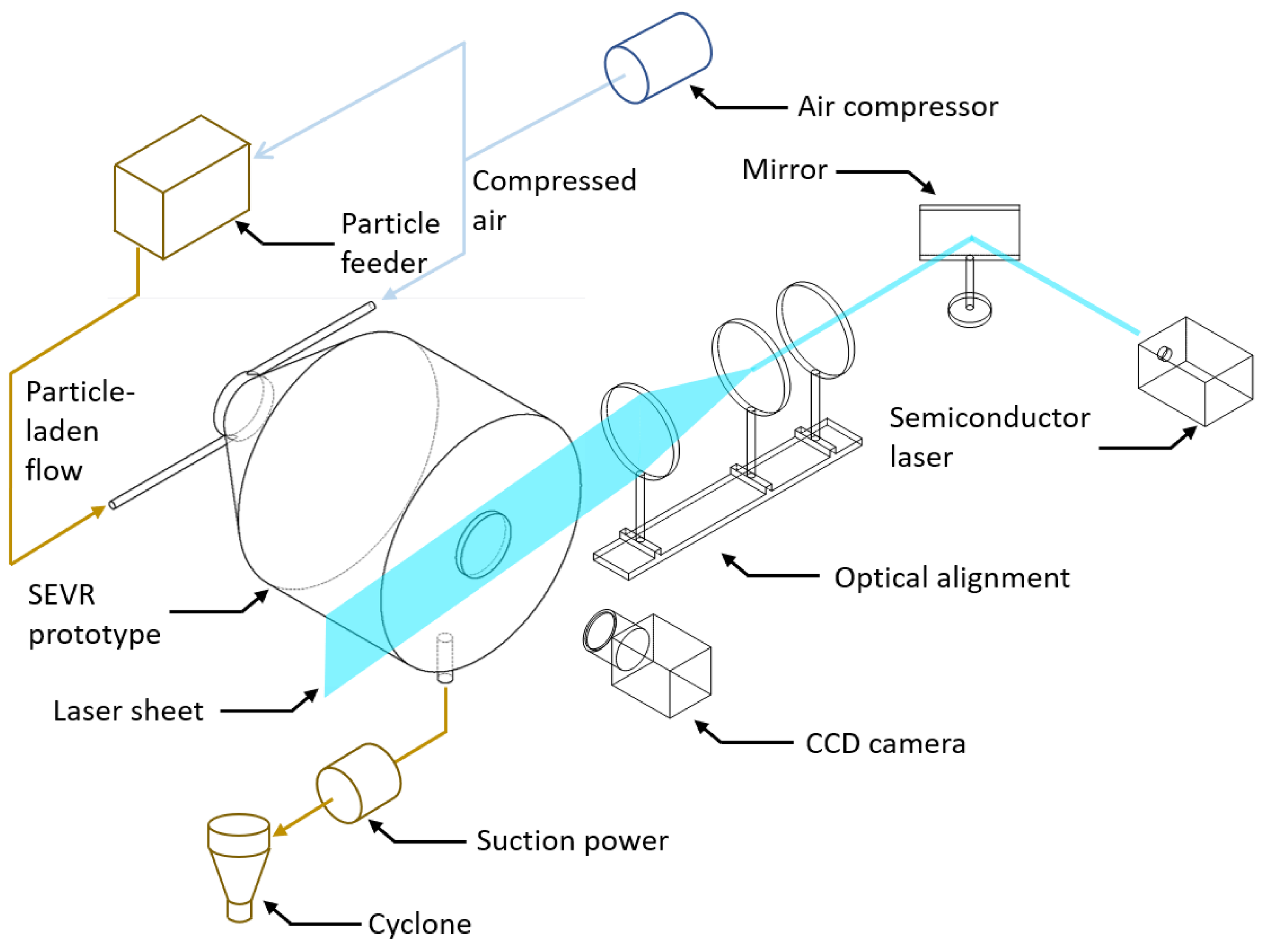


Aims and Objectives

Understand the characterization of the iso-thermal two-phase flow within an open-to-atmosphere vortex-based solar particle receiver:

- Investigate the particle egress through the aperture of the current concept;
- Identify the key parameters that actively and passively control the particle egress of the SEVR;
- Investigate the feasibility of the receiver acting for different applications (beam-down & tower-mounted).

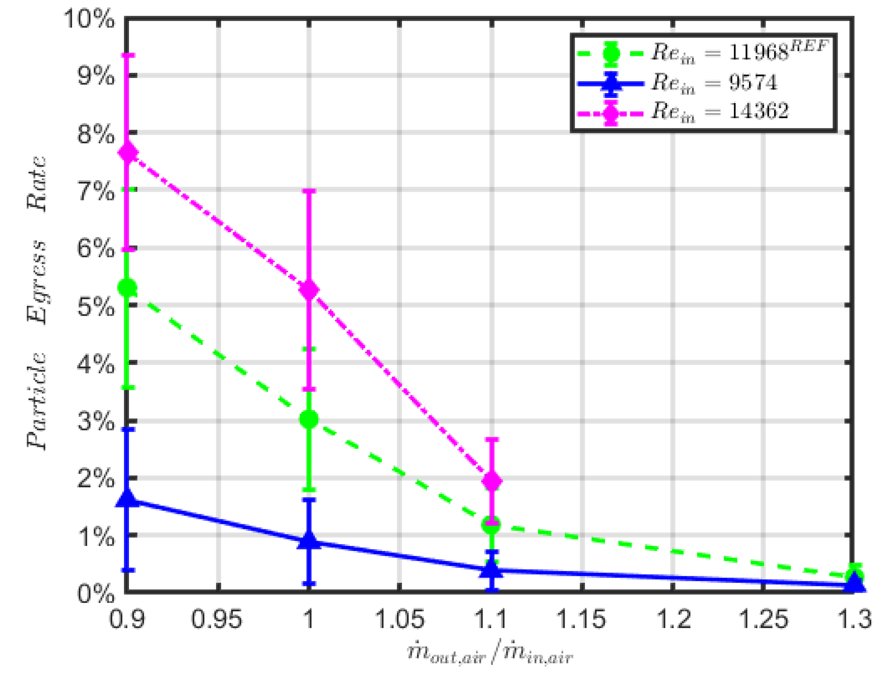
Experiment Setup

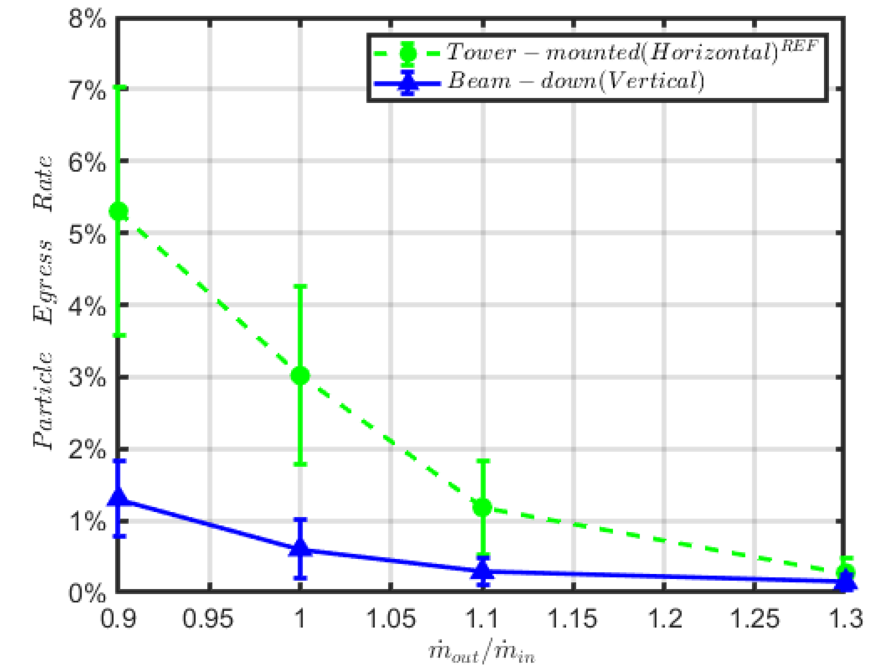


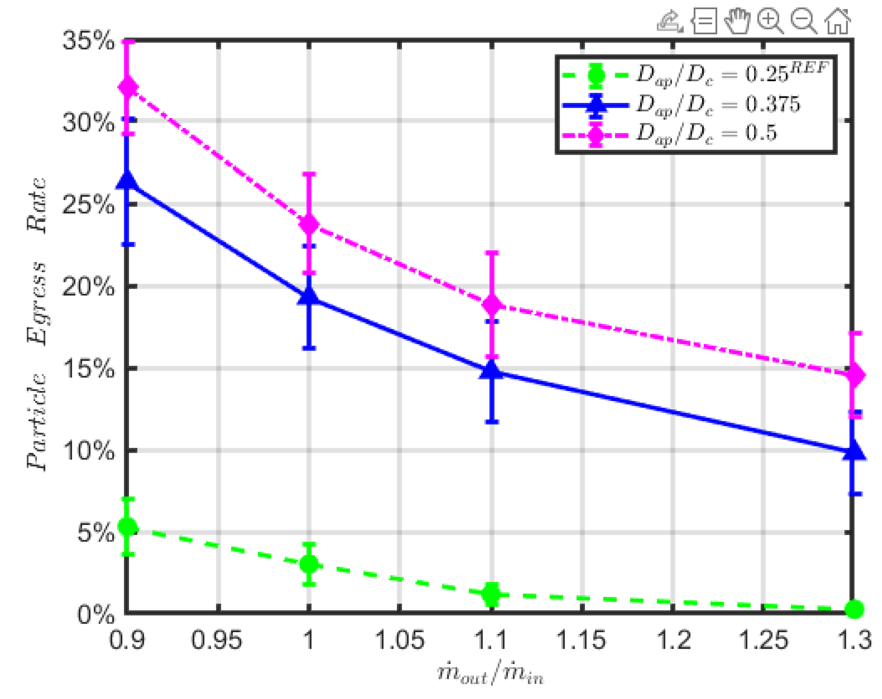
- Laser-based Mie scattering method for particle egress visualisation. Continuous Wave (CW) laser with a wavelength of 450 nm. CCD camera with an array of 2048*2048 pixels.
- Particle properties: PMMA density of 1200 kg/m^3; size: 80 micron, with narrow size distribution.

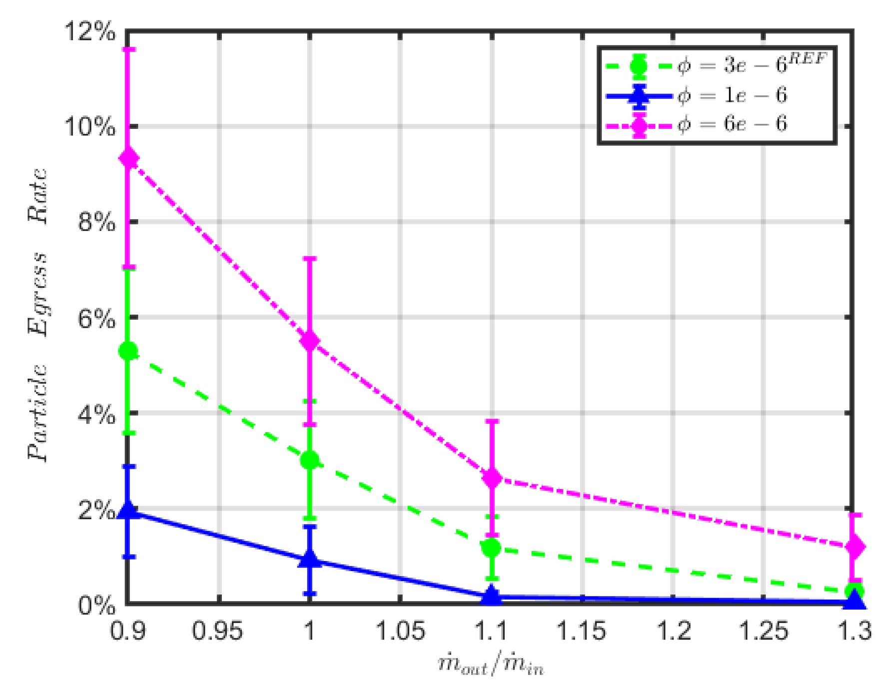
Results

- Higher outlet mass flow rate → Less particle egress;
- Higher inlet velocity → More particle egress, due to higher inertia of particles;
- Vertical orientation (aperture facing upwards) → Less particle egress, as particles lose momentum when hitting the wall around the aperture and are controlled by gravity;
- Aperture diameter larger than vortex core diameter → much more particle egress, due to the change of vortex core structure;
- Higher particle volume fraction → more particle egress, as more injected and more escaped.









Conclusion

- Increase of outlet mass flow rate will help mitigate particle egress but hardly reach zero of the current configuration. Higher outlet mass flow rate means more energy consumption in industrial scale.
- Operating conditions and geometric parameters will influence the particle egress passively. A combination of them is required to mitigate the particle egress.
- To mitigate the particle egress under various operating conditions, adding a secondary active control or change the design of the current configuration is essential, e.g. applying an air curtain or refine the design of the outlet.

Future Work

- Add secondary active control, e.g. air curtain or aperture suction, to mitigate particle egress;
- Vary the outlet size, number and direction to identify the feasibility of this passive control;
- Validate the CFD model for particle motion within the receiver.