Solar Expanding-Vortex Particle Receiver (SEVR)

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Solid particle solar receivers are attracting growing interest because of their potential to achieve outlet temperatures of over 800˚C, which exceeds that of the current molten salt receivers. In power cycles, particles also offer potential for sensible and/or chemical storage, while they are also an inherent component of many chemical processes including gasification and minerals processing.

Why using Solar Vortex Receiver technology?

Potential benefits:

- ✓ Highest efficiency among several solar receiver-reactors
- ✓ Successful demonstrated at lab-scale (e.g. gasification)
- ✓ Relevant to several reactors (e.g. flash calciners, entrained flow)

Potential challenges:

- x Particle deposition onto the window
- x Limited understanding of the mechanisms controlling particle deposition
- x Residence time distribution independent of particle size

Objective

- To develop a particle receiver with outlet temperature of >**800˚C** with **85%** thermal efficiency at design point;
- To devise alternative configurations to mitigate current issues;
- To obtain a detailed understanding of:
  - ➢ Flow-field within a SVR [1] and SEVR [2]
  - ➢ Dependence of the vortex structure on geometry
  - ➢ Mechanisms responsible for particle deposition

Solar Expanding-Vortex Particle Receiver

Key features:

- Vortex at the opposite end of chamber to aperture (Figure 1);
- Conical inlet to reduce swirl intensity at the aperture (Figure 1);
- It can be oriented vertically or horizontally.

Methodology

Experimental:

- Single phase velocity: Cobra probe in air (f = 1.25 kHz). Particle Image Velocimetry (laser diagnostic);
- Two-phase deposition: High precision balance (10^{-4} g).

Numerical:

- CFD Analysis - RANS approach, two-way coupling.

Conclusions

- The SEVR mitigates the disavantages of SVR (Figure 3):
  - ➢ Particle deposition rate on window is reduced by > 10 times;
  - ➢ Large particles are preferentially recirculated within the chamber (Figure 1)
- Particle deposition is inhibited by inhibiting fluid flow through the aperture. This occurs for $d_{vmax,ap}/d_{ap} > 1$ (low S_{ap}, Figure 3);
- Key parameters: Vortex core at the aperture plane and cone angle.

Flow-field and particle trajectories analysis

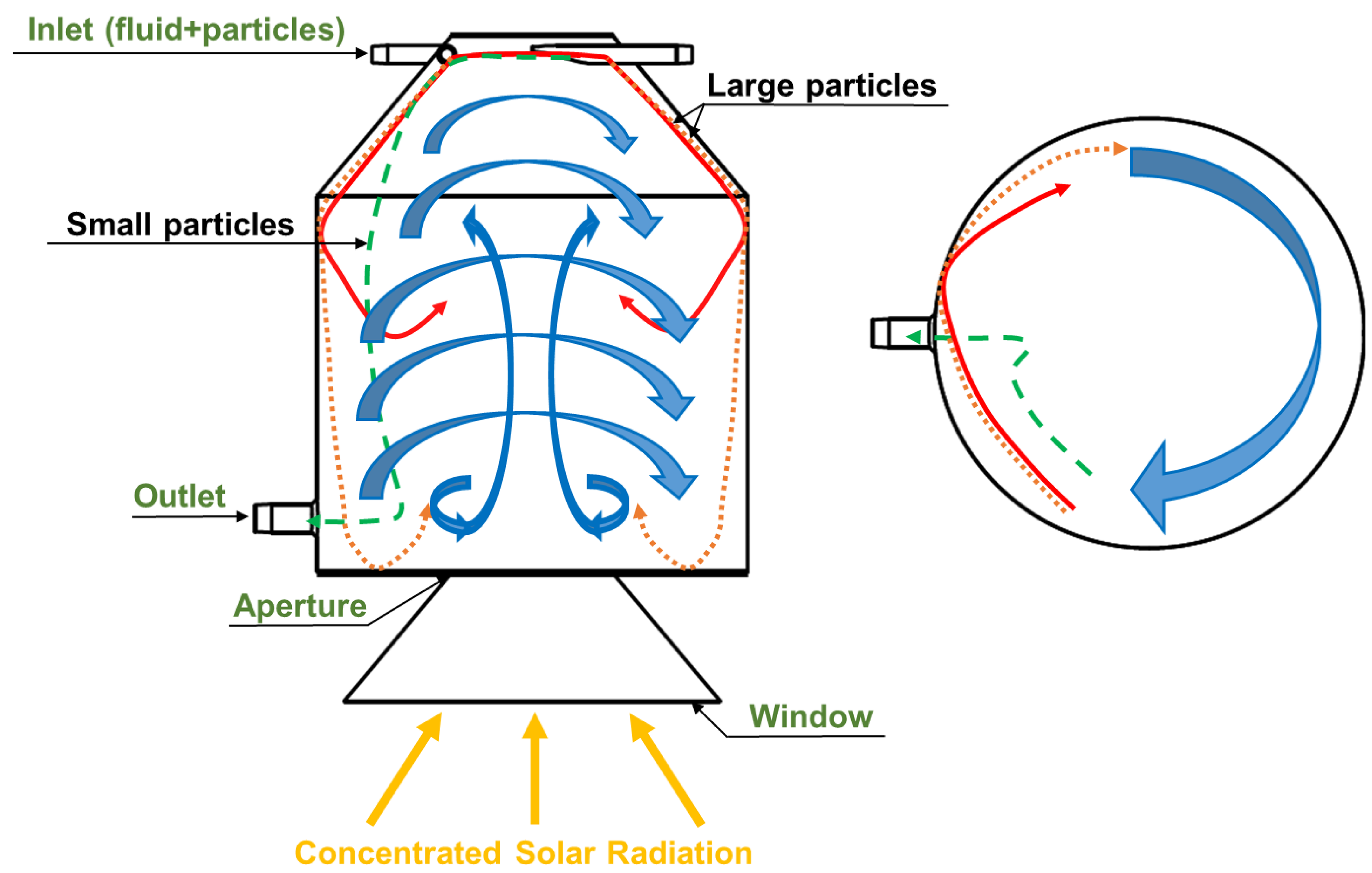

Figure 1: Simplified representation of the 3D flow-field and particle trajectories of an SEVR [3].

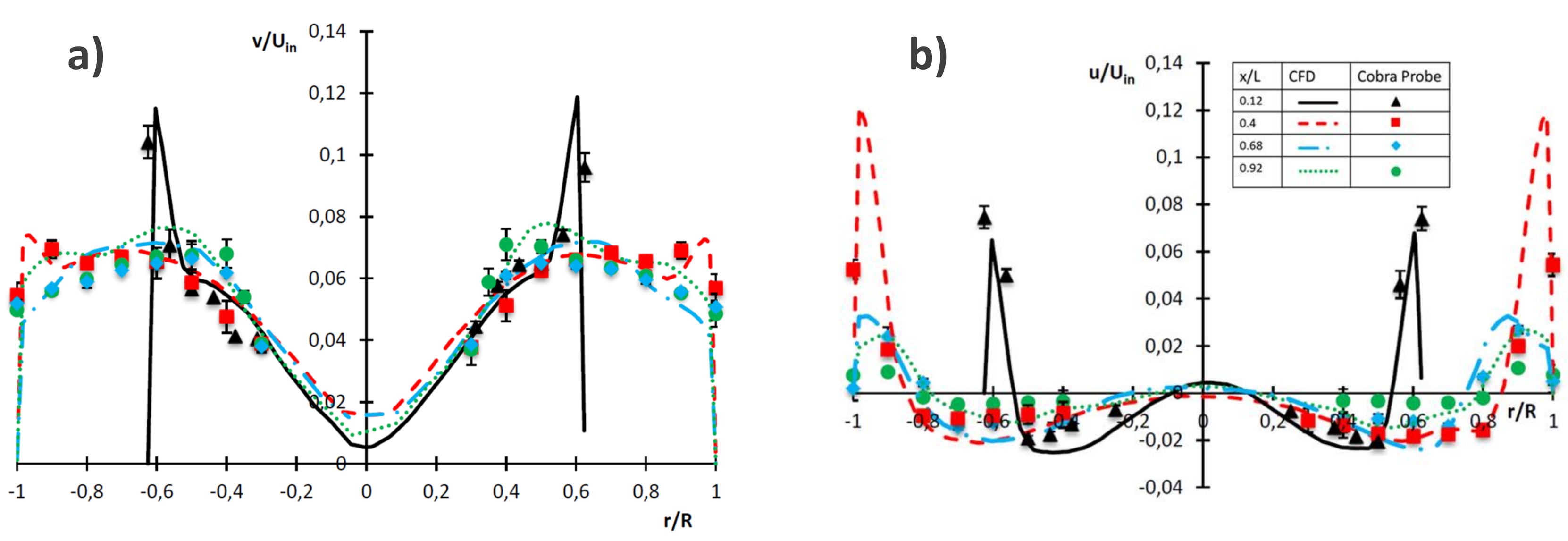

Figure 2: a) Tangential and b) axial velocity profiles within an SEVR [4].

Particle deposition analysis

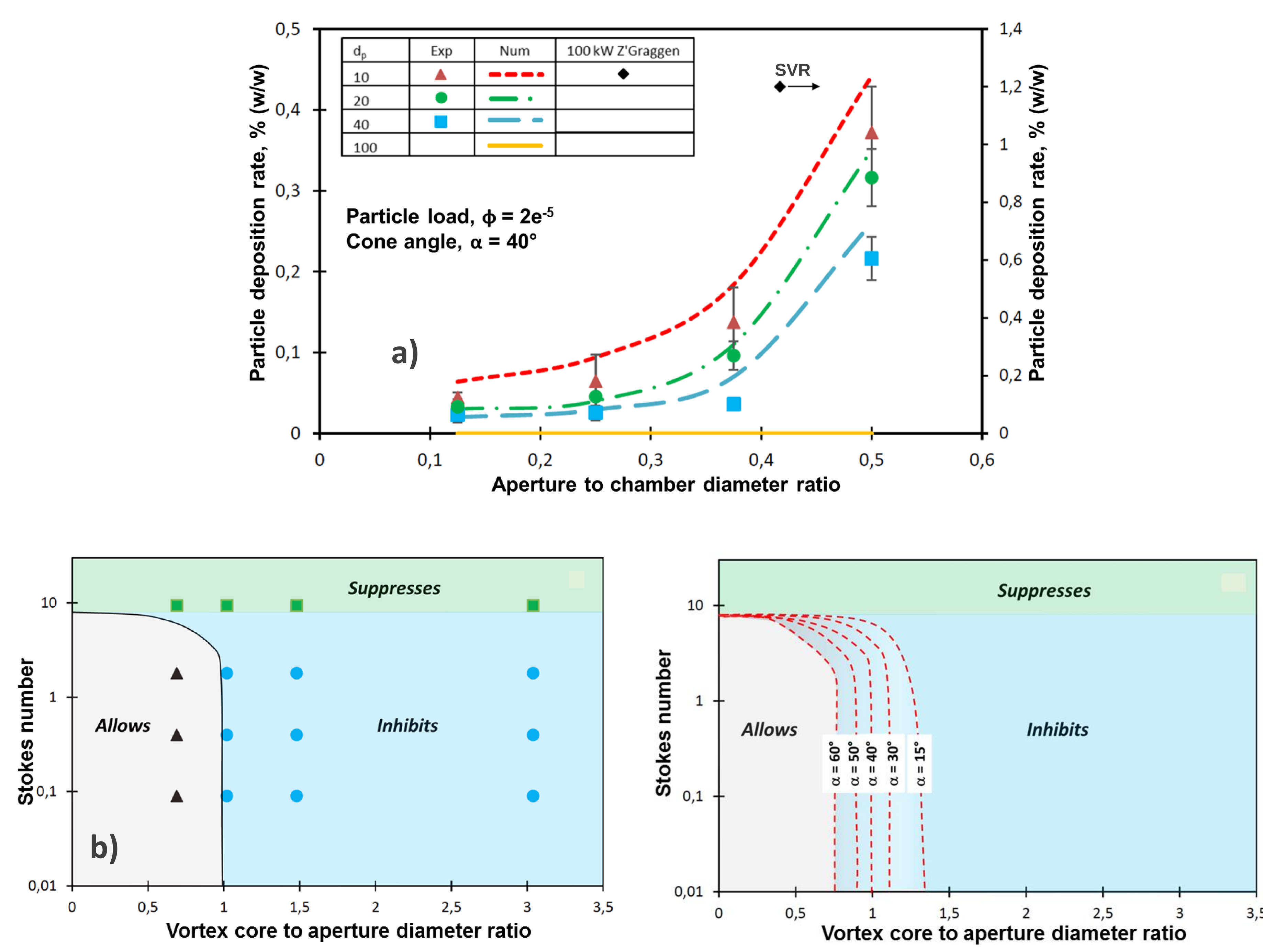

Figure 3: a) Measured and calculated particle deposition rate and b) regime diagram identifying the conditions under which particle deposition is inhibited [4].

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