Hydrodynamic, Thermal and Optical Evaluation of Ceramic Foam Solar Absorbers

Antonio L. Avila-Marin[1*], J. Fernandez-Reche[1], L. Alonso-Pardo[1], A. Ferandez-Garcia[1], I. Cañadas[1], R. Enrique[1], F.Zaversky[2], X. Randez[2], A. Fuessel[3], W. Pritzkow[4], J.A. Carballo[1], D. Sanchez-Señoran[1]

[1] CIEMAT – Plataforma Solar de Almeria (PSA), Ctra. De Senes km 4.5, E-04200 Tabernas, Almeria, Spain
[2] CENER – Solar Energy & Storage, Ciudad de la Innovacion 7, E-31621 Sarriguren, Pamplona, Spain
[3] Fraunhofer Institute for Ceramic Technologies and Systems IKTS, Winterbergstr. 28, 01277 Dresden, Germany
[4] Walter E.C. Pritzkow Spezialkeramik, Adam Opel Str. 6, 70794, Filderstadt, Germany
*Correspondence: Antonio Avila-Marin, antonio.avila@ciemat.es

Introduction & Objectives

- Development of advanced solar receivers (> 565ºC) is essential for enhancing the efficiency and reducing LCOE/LCOH of CST technologies.
- ASTERIx-CAESar project aims: high-temp operation (> 700ºC) with open volumetric receiver together with Brayton cycles.

Facility Description

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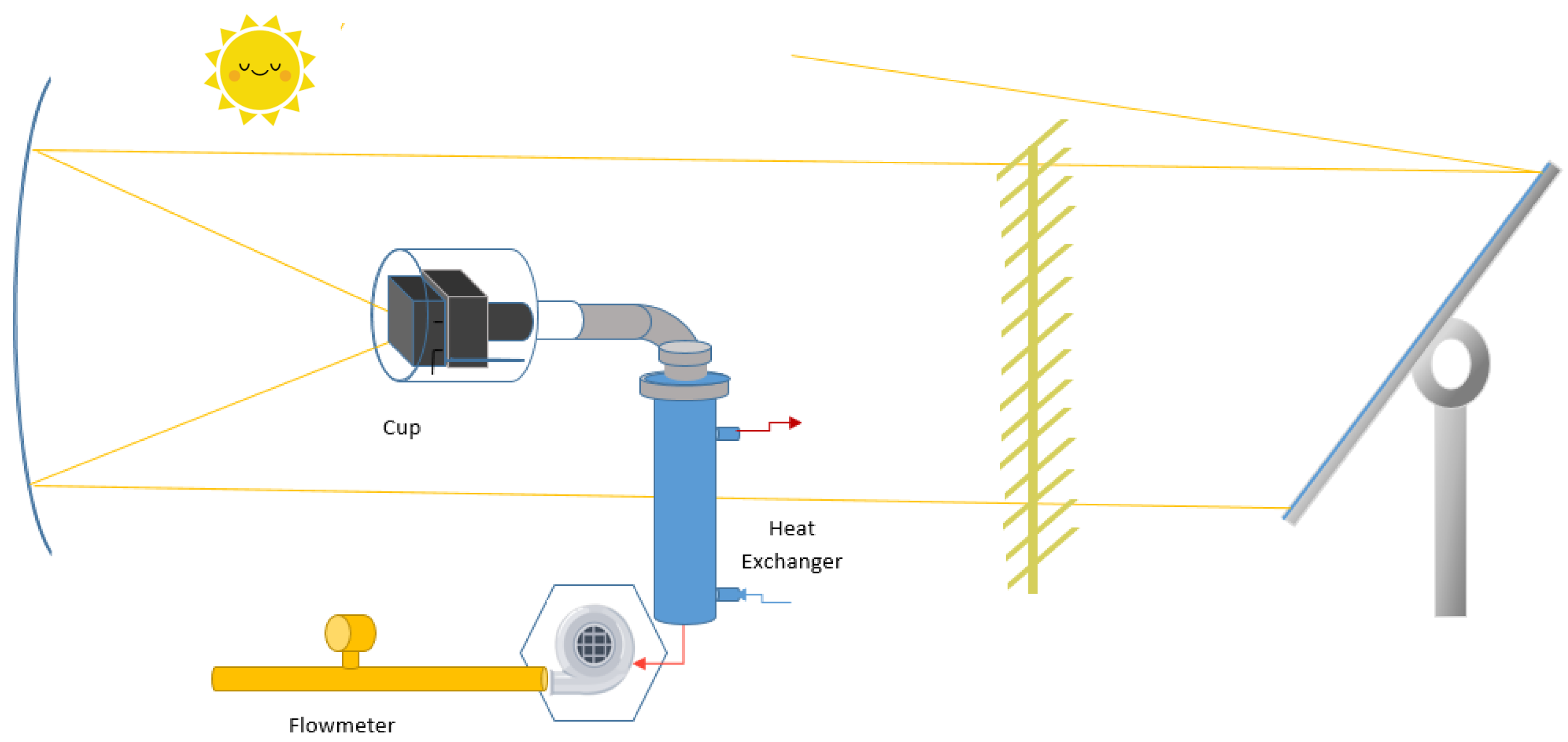
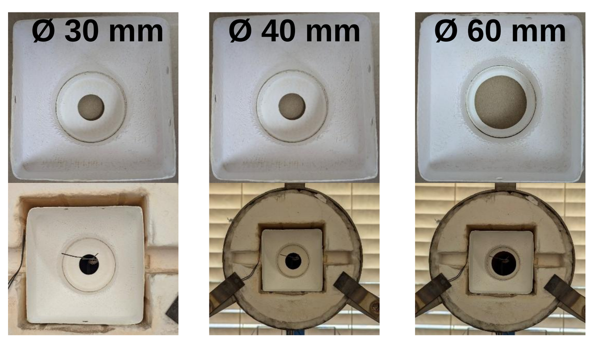


Fig. 1. Solar Furnace Test-bed sketch

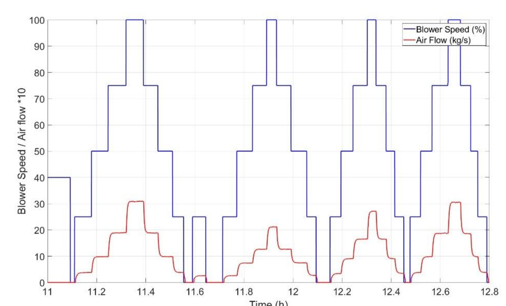
Experimental Methodology

- Study of the hydrodynamic, thermal and optical behavior of 9 different absorbers together with a cup with 3 different outlet orifices.
- Sequential experimental methodology structured in 3 phases:
  1. Cold flow tests
  2. Thermal performance assessment
  3. Optical characterization

COLD FLOW TESTS

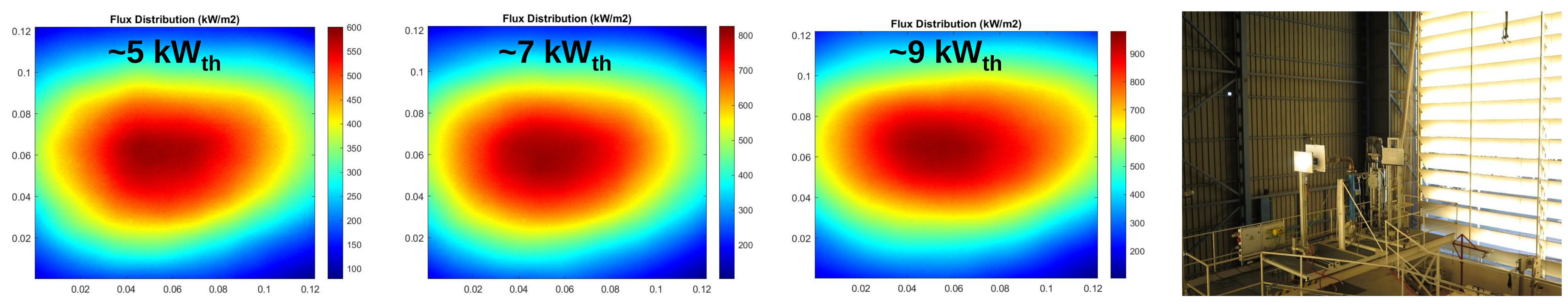


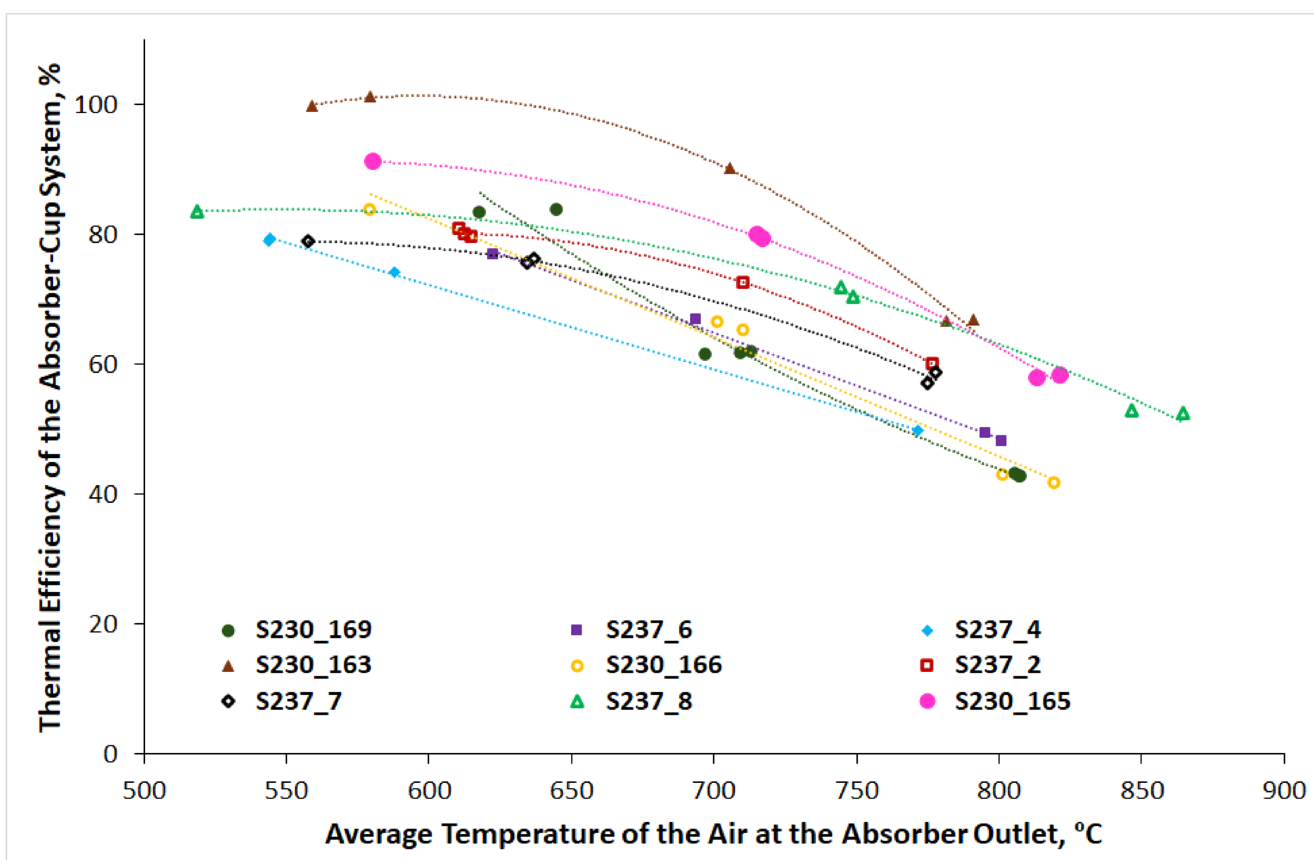
Speed	Ø 30mm	Ø 40mm
100%	30.8%	11.1%
75%	31.7%	11.3%
50%	24.4%	7.1%
25%	31.6%	10.5%



THERMAL PERFORMANCE ASSESSMENT

3 Shutter Apertures of the Solar Furnace: ~5-7-9 kW_{th} and 3 Temperatures: 600-700-800ºC

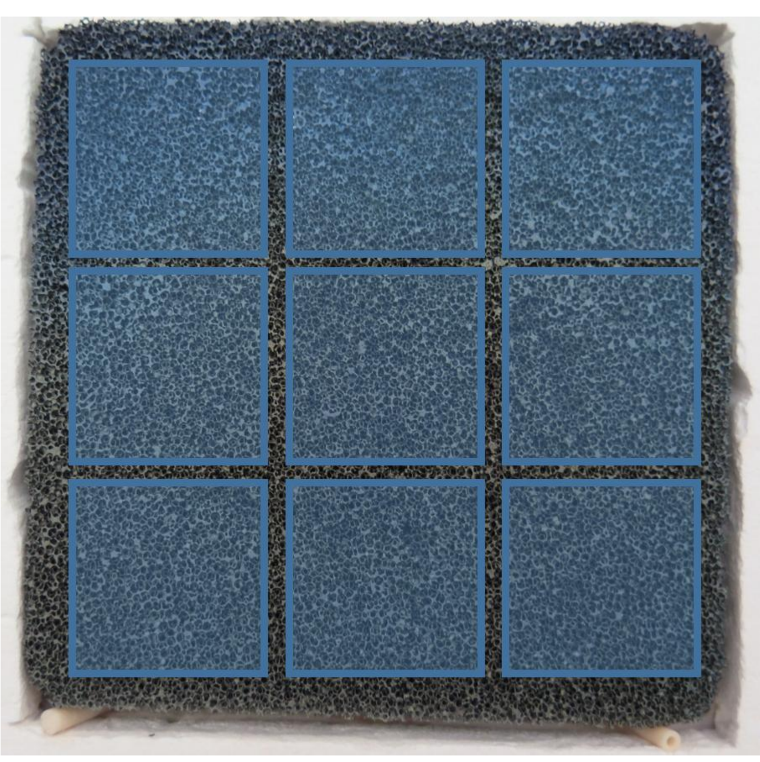




Shutter 25

Ranking	ф, %
S230-163	91.1
S230-165	90.1
S237-8	90.3
S237-2	88.0
S237-7	87.4
S237-6	90.3
S230-166	88.1
S230-169	86.8
S237-4	87.5

OPTICAL CHARACTERIZATION



Absorber	S230-169	S237-6	S237-4
Average solar absorptance before testing	0.964	0.967	0.970
Average solar absorptance after testing	0.965	0.969	0.971

The solar absorptance and thermal emittance of the different absorbers was done before the tests and is now ongoing after the first experimental test campaign.

Future Works

A second experimental campaign is ongoing within the framework of the ASTERIx-CAESar project, which aims at demonstrating the integration of advanced receivers in a Brayton cycle. This new campaign will concentrate on the best-performing absorbers identified so far, tested under higher solar flux conditions with peak values close to 1.5 MW/m². To investigate the influence of geometry on thermal and fluid-dynamic behavior, three different outlet cup diameters will be evaluated (30 mm, 40 mm, and 60 mm). The resulting dataset will not only provide insights into absorber performance at challenging operating conditions, but will also serve as the basis for the validation of a detailed numerical model, enabling accurate predictions across a wide range of operating scenarios.

Conclusions & Outlook

- The preliminary cold-flow tests performed without the absorber indicate that reducing the outlet cup diameter leads to a significant decrease in air mass flow. For instance, the 30 mm outlet shows reductions of around 24–32% depending on the operating blower speed, while the 40 mm outlet results in more moderate reductions of about 7–11%.
- In terms of thermal performance, the absorbers with higher porosity demonstrated the best results. The ranking obtained confirms that sample S230-163 (91.1% porosity) achieved the highest performance, followed by S230-165 (90.1% porosity) and S237-8 (90.3% porosity).
- Finally, the optical characterization carried out so far shows that variations in solar absorptance between the tested samples are almost negligible, suggesting that material differences in this property are not a critical factor for overall performance.

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