Institute of Solar Research

# Comprehensive numerical tool for performance evaluation and design of porous ceramic microstructures in solar thermal application

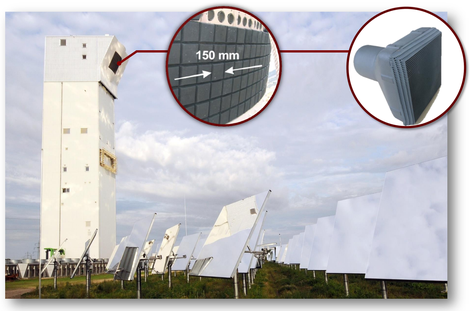

**Raffaele Capuano [1]; Thomas Fend [2]; Bernhard Hoffschmidt [2]**

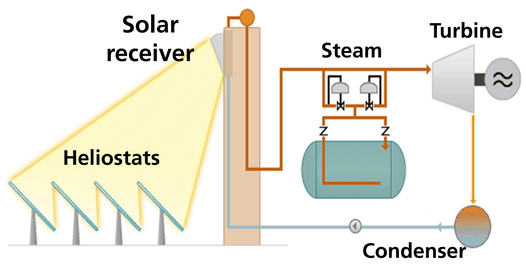
*[1] - German Aerospace Center - Karl-Heinz-Beckurts-Str. 13, 52428 Jülich, Germany*
*[2] - German Aerospace Center - Linder Höhe, 51147 Köln, Germany*

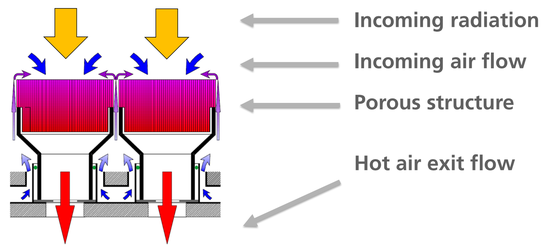
Contact: Raffaele.Capuano@dlr.de


## Introduction & main aim

Porous ceramic structures like extruded monoliths, foams and combined micro-shapes have been tested during the last years as thermal absorbers in open volumetric solar receivers to be used in solar tower power plants.




- In order to have high efficiency, material structure parameters and coefficients (porosity, specific surface area, optical properties) must be optimized.
- Numerical optimization has to be carried out for the designing procedure.
- Due to the complexity of the structure, numerical simulation can be computationally heavy and slow → optimized numerical approach needed

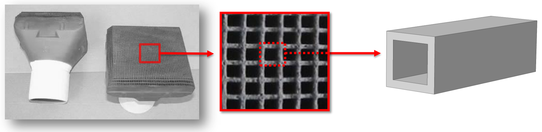
## Scientific approach

Comprehensive numerical tool: discrete models for effective properties evaluation + *continuum-based* numerical simulation for absorber performance evaluation

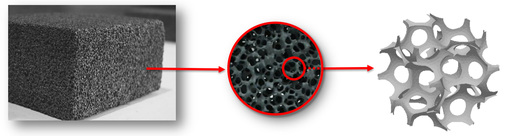
### **Discrete numerical tool s-** Effective properties evaluation

Discrete representation of porous absorber unit element.

Carbon-based Honeycomb Monoliths – Single channel

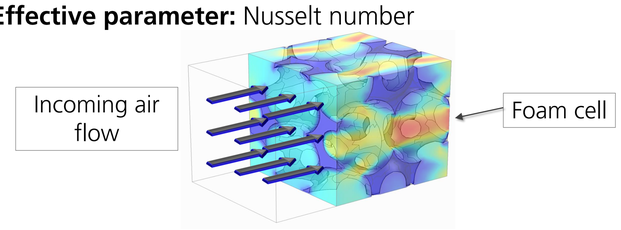


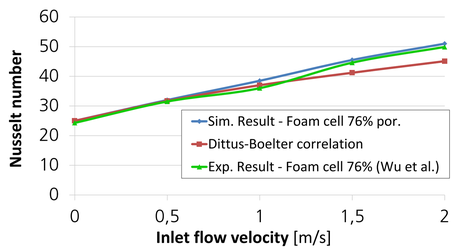
Carbon-based foams – *Weaire* & *Phelan* foam cell



#### Convective heat transfer analysis

**Effective parameter:** Nusselt number

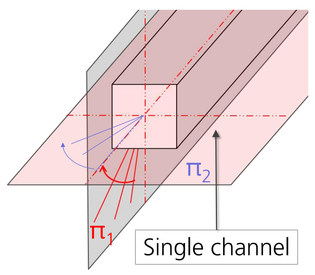


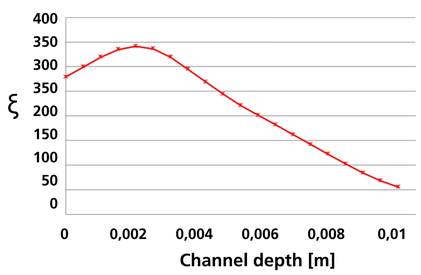

#### Radiative heat transfer analysis

**Effective parameter:** Extinction coefficient

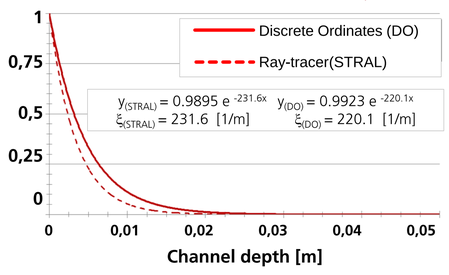
**Irradiation directions**




**Extinction coefficient (ξ)**

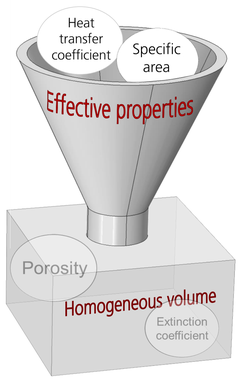


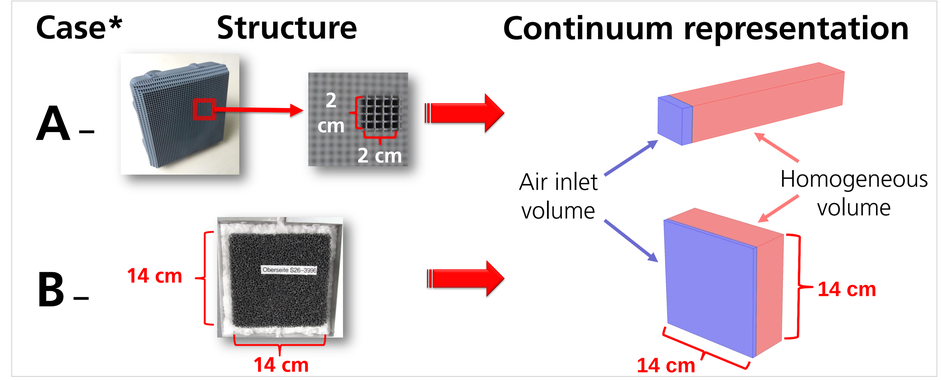

**Attenuation curve**



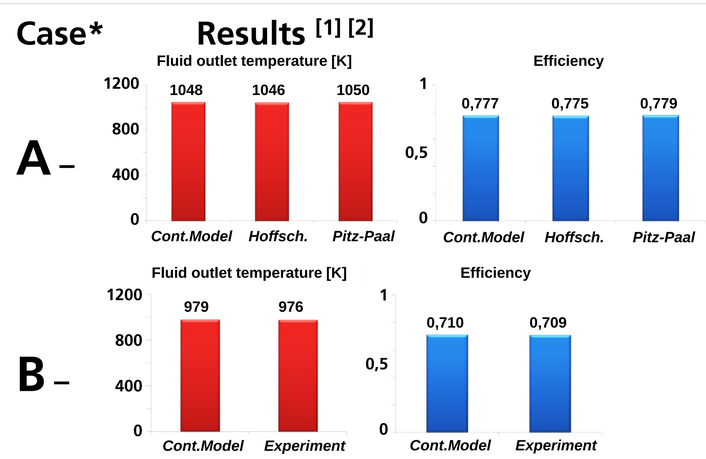

### **Continuum-based numerical tool –** Absorber performance evaluation

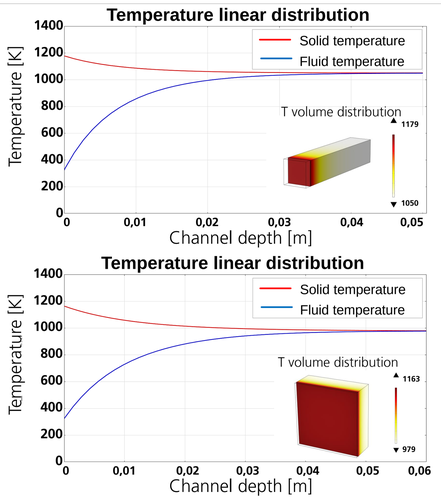
Homogeneous representation of porous absorber by means of effective properties.




**Case*** **Results** [1] [2]




** Different environmental conditions*

## Conclusions

In the present work, a comprehensive numerical tool for the design and optimization of porous structures has been developed leading to a faster and computationally lighter complete numerical simulation. With the combined use of continuum and discrete approach, it is now possible to predict with a good approximation the thermodynamic performances of ceramic absorbers and, furthermore, to optimize their shape in order to reduce the losses and to enhance the heat transfer efficiency in high temperature solar applications.


## Acknowledgements

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## References


[1] Hoffschmidt, B.: *Vergleichende Bewertung verschiedener Konzepte volumetrischer Strahlungsempfänger*, Deutsches Zentrum für Luft- und Raumfahrt e.V., RWTH Dissertation,1996.

[2] Pitz-Paal, R.: *Entwicklung eines selektiven, volumetrischen Receivers für Solarturmkraftwerke-Parameterunterschungen und exergetische Bewertung*, Dissertation. DLR-Forschungsbericht,1993.


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