VOCOREC – DESIGN AND PERFORMANCE OF THE TWO-STAGE VOLUMETRIC CONICAL RECEIVER

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Outline

- Motivation
- Design Features
- Performance Simulation
- Outlook
Motivation

Open volumetric receivers
  + Low technical complexity
  + High robustness
  + Simple integration of heat storage
  + Air: no temperature limits, non-toxic, available
  - Challenges: efficiency, specific costs

HiTRec design
  • Demonstrated at Juelich Solar Tower 1.5 MWₑ
  • Design seems to approach inherent limits
    ($T_{\text{hot}}$, structure cooling demand, insulation, piping expense)
Design Features

• Open cavity with conical inner shape

• Two-stage air heating up to 700…800 °C
  1) Outlet absorber (metal wire mesh)
  2) Main absorber (metal wire mesh)

• Well-insulated separation of hot and warm air

• Modularity:
  ▪ Hexagonal cross-section
  ▪ Module aperture area ~ 0.1…2.3 m²
Air Return Ratio (ARR)

CFD investigation:
- ARR = percentage of exhausted air that is sucked back in
- Aperture area 1m²
- Mass flow 0.8 and 1.6 kg/s
- Various tilt angles

- Modules in cluster
- Tilt angle = 25°

- Various sizes: aperture area from 0.1 to 2.3 m²
**Performance Simulation and Module Size Variation**

$E$: Monte-Carlo raytracing

$T_{\text{air}}, T_{\text{absorber}}, \eta$:  
Thermal simulation with inhouse code “Voreco”

$T_{\text{structure}}, \varepsilon$:  
Thermomechanical simulation with ANSYS

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<th>Size 1</th>
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<th>Size 3</th>
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<tbody>
<tr>
<td>Aperture area [m²]</td>
<td>0.13</td>
<td>0.53</td>
<td>1</td>
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<tr>
<td>length [mm]</td>
<td>380</td>
<td>726</td>
<td>1000</td>
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<tr>
<td>Specific cost [€/m²]</td>
<td>33'878</td>
<td>23'708</td>
<td>25'024</td>
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<tr>
<td>Solar power into aperture [kW]</td>
<td>128.1</td>
<td>519.7</td>
<td>930.1</td>
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<tr>
<td>Flux density in aperture [MW/m²]</td>
<td>0.983</td>
<td>0.988</td>
<td>0.930</td>
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<td>Air return ratio [%]</td>
<td>92.7</td>
<td>88.7</td>
<td>86.4</td>
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<td>Air inlet temperature receiver [°C]</td>
<td>27</td>
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<td>27</td>
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<tr>
<td>Air temperature after outlet absorber [°C]</td>
<td>556</td>
<td>580</td>
<td>593</td>
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<tr>
<td>Air outlet temperature receiver [°C]</td>
<td>700</td>
<td>700</td>
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<tr>
<td>Max. Absorber Temp. [°C]</td>
<td>893</td>
<td>901</td>
<td>903</td>
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<td>Spec. mass flow [kg/m² s]</td>
<td>1.237</td>
<td>1.158</td>
<td>1.108</td>
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<tr>
<td>Thermal efficiency [%]</td>
<td>88.6</td>
<td>85.4</td>
<td>83.6</td>
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Absorber temperature for 800 °C hot air
Outlook

- Fundamentally new and simple design of a OVR
- Two stage heating, Conical cavity, Hexagoanal modules
- Simulation of $E, ARR, T_{air}, T_{absorber}, \epsilon, \eta$
- $\Rightarrow \eta = 88 \ldots 81\%$ at 700 °C
- Prototype and testbench was constructed for Synlight
- Compare simulations and measurements
- Scale-up, Clustering, Further increase of hot air temperature
THANK YOU FOR YOUR ATTENTION

Let’s talk!