B4: Phase changes in liquid metals for direct energy conversion

A. Onea, N. Díez de los Ríos Ramos, W. Hering, A. Weisenburger, M. Lux, J.L. Palacios, R. Stieglitz

LIMTECH Meeting, 10–11.11.2014, Ilmenau
Hybrid concept*: AMTEC & CSP

A & CSP:
- HTF + storage fluid: Na
- Plant size: ~ 100 MWth
- Loading time: 6 – 8 h
- Storage time: 16 – 18 h

- Storage tank*: 200 – 550 °C
- AMTEC: > 600 °C

AMTEC cluster
- Electrical output: ~ 2 MWe
- Nr. BASE elements: ~ 30k
- Current density: ~ 1 A/cm²
- Open issue: power loss

*Hering et al., E2C, Maastricht, 2012
ATEFA Facility: Status (1)

- Stand: in construction

See Poster: Nerea Diez de los Rios Ramos
## ATEFA Facility: Status (2)

<table>
<thead>
<tr>
<th>Components</th>
<th>Stand</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na, Ar valves,</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Vacuum pump</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Control unit, instrumentation, trace heating</td>
<td>✓</td>
<td>2nd tank in progress</td>
</tr>
<tr>
<td>Na tank</td>
<td>✓</td>
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<table>
<thead>
<tr>
<th>Test cell</th>
<th>Stand</th>
<th>Remarks</th>
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<tbody>
<tr>
<td>Mo deposition</td>
<td>✓</td>
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</tr>
<tr>
<td>Metal-ceramic brazing</td>
<td>In progress</td>
<td>First tests 11.2014</td>
</tr>
<tr>
<td>Frame</td>
<td>In progress</td>
<td>01.2015</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Assembly framework</th>
<th>Stand</th>
<th>Remarks</th>
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</thead>
<tbody>
<tr>
<td>Frame machining</td>
<td>In progress</td>
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<tr>
<td>Assembly frame</td>
<td>02.2015</td>
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<thead>
<tr>
<th>AMTEC lab</th>
<th>Stand</th>
<th>Remarks</th>
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<tbody>
<tr>
<td>Ar supply</td>
<td>✓</td>
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<tr>
<td>Glove-box operable</td>
<td>✓</td>
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<tr>
<td>Melting facility</td>
<td>✓</td>
<td>First tests 11.2014</td>
</tr>
</tbody>
</table>

| First tests | 03.2015 | Exp. campaign 04.15 |
AMTEC cell – Structural & thermal analysis

Test case | Analysis | Results
---|---|---
T & S distribution (1000°C, 2 bar) | Steady state | No failure at operating range (safety factor ~3)
T & S distribution (forced convection) | Transient | No failure
T & S distribution ($\Delta T_{\text{BASE}} = 300°C$) | Steady state | No failure
Failure pressure | Steady state | ~0.7 MPa at upper brazing

Inconel
Brazing: Ni
Niobium
Brazing: Ni
BASE
BASE sputtering (Mo)*

*Alfons Weisenburger, KIT - IHM, alfons.weisenburger@kit.edu
BASE sputtering (Mo)

1 keV 700 14.10.2014 Mo-Sputtern 60mA, Querschnitt

1 keV 5000 14.10.2014 Mo-Sputtern 60mA

20 keV 1300 21.10.2014 Mo-Sputtern 102mA, 24h

1 keV 5000 22.10.2014 Mo-Sputtern 102mA, 24h
BASE sputtering (Mo)

Presently: third electrode is sputtered

Magnetron sputtering

Teflon – cover

Unsputtered β-alumina

Mo – sputtered layer
HEMCP infrastructure

- 8- shape loop for long term material and corrosion tests
- High efficient intermediate HX
- Temperatures:
  Cold loop: 700 K (SS)
  Hot loop: 1000 K (Inconel)
- Mass flow rate: ~300 kg/h
- Design: ready
- Acquisition phase: started
  - Na-pump
  - Universal traction facility
- Construction start: End 2014
- Set into operation: Spring 2015

Initial design: Pascal Hinkerohe
Future Material testing

- Creep fatigue / stress corrosion cracking
- W-compounds and metal-ceramic joints
- Up to 1000 K in vacuum furnace

→ **Unique:** in situ tests with flowing sodium
Contents

1. AMTEC clusters for A&CSP
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   a) Status
   b) Test cell - Structural analysis
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3. SOdium Loop for TEst Materials and Corrosion (SOLTEC – HAC)