ATEFA facility for performance evaluation of an Alkali Metal Thermo-Electric Converter (AMTEC)

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**Motivation AMTEC in Space**
- Flexible heat source
- Direct conversion of heat to electricity
- AMTEC net fuel consumption = 0
- High expected AMTEC efficiency (~ 40 %)
- Static system
- Modular connection

**AMTEC technology**
- Key process: Na-ionization (Δp across BASE)
- Issues:
  - Ceramic-metal joint
  - Electrode sputtering
  - Overvoltage losses
  - Power degradation (BASE, electrode)

**AMTEC Test Facility (ATEFA)**
- Facility for efficiency and performance evaluation of AMTEC
- Sodium system (800 °C, 1.5 bar)
- Argon system controls: \( p_{\text{Na}}, i_{\text{Na}} \)
- Safe design (handling of Na)
- Ceramic-metal joint developed for 800°C
- Electrode-sputtering achieved (TiC, TiN, Mo)
- Data acquisition and control system finished
- Automatic operation during steady state

**Overvoltage losses in AMTEC**
The overvoltage losses can be separated into ohmic losses \( \xi_r \) (20%) and polarization losses in the cathode \( \xi_c \) (80%).

**Characteristics curve of AMTEC**

<table>
<thead>
<tr>
<th>Variable</th>
<th>AMTEC @ INR 1993</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V )</td>
<td>0.4 – 1.2 V</td>
</tr>
<tr>
<td>( I )</td>
<td>0.5 – 1.5 A/cm²</td>
</tr>
<tr>
<td>( P )</td>
<td>0.5 – 1.5 W/cm²</td>
</tr>
<tr>
<td>( \eta_{\text{AMTEC}} )</td>
<td>~ 20 %</td>
</tr>
<tr>
<td>( T_{\text{Na}} )</td>
<td>600 – 1000 °C</td>
</tr>
<tr>
<td>( p_{\text{Na}} )</td>
<td>1 Pa – 0.1 MPa</td>
</tr>
</tbody>
</table>

**Operation principle of AMTEC**

**Transport process in the cathode**

And depend mainly on the morphology:
- Internal resistance of the cell
- Cathode:
  - Grain size
  - Porosity
  - Thickness
- Current collector structure

**ATEFA facility**

**AMTEC test cell**