**Summary of technology**

- Turbo compressor operating in steam (R718) either as open system (direct on process steam/water) or as a closed water/steam loop and process heat exchangers (see Figure 1).
- The system as 1-stage or cascaded in multi-stages.
- Compressor is driven directly by a 100 kW high speed (70 krpm) PM electric motor.
- Most relevant applications are upgrading excess heat sources with temperatures from 80 -110 °C with temperature lift of 20 - 25 °C as 1-stage and up to 55 °C as 2-stage application.
- COP: Typically COP will be between 5 and 13 depending on required temperature lift.
- Technology consists of high efficient advanced 3D centrifugal compressor and high speed drive.
- Lubrication: Ceramic bearings are oil lubricated with an external oil loop. There are no contact between steam and lubricating oil system.
- Performance: Examples (see Table 1) of COP for one and two stage operating are based on compressor map (measured in air and conversion to steam).
- Development status: Weel and Sandvig is in the phase of laboratory demonstration (own test rig) at Technical University of Denmark (see Figure 2).
- Process heat exchangers will be specified according to process media, etc.
- Systems will be based on a few standard compressor units with various trim on impellers.
- Startup time: From hot system approximately 5 minutes.
**Annex 58**

**High-Temperature Heat Pumps**

www.heatpumpingtechnologies.org/annex58/

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**Table 1: Performance.**

<table>
<thead>
<tr>
<th>T_{source,in}</th>
<th>T_{source,out}</th>
<th>T_{sink,in}</th>
<th>T_{sink,out}</th>
<th>COP_{heating}</th>
</tr>
</thead>
<tbody>
<tr>
<td>°C</td>
<td>°C</td>
<td>°C</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>99</td>
<td>120</td>
<td>120</td>
<td>10.0</td>
</tr>
<tr>
<td>100</td>
<td>99</td>
<td>150</td>
<td>150</td>
<td>5.0</td>
</tr>
</tbody>
</table>

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**FACTS ABOUT THE TECHNOLOGY**

- **Heat supply capacity:** 1 MW to 5 MW
- **Temperature range:** Maximum supply (sink) temperatures 145–160 °C. Temperature lift 20 °C (one stage) and up to 55 °C. Source temperature 80 °C – 110 °C.
- **Working fluid:** Water (R718).
- **Compressor technology:** Turbo.
- **Specific investment cost for installed system without integration:** 150 - 250 €/kW heat supply.
- **TRL level:** From TRL 4 (Technology validated in lab) to TRL 9 (Actual system proven in operation).
- **Expected lifetime:** 20 years.
- **Size of 100 kW power unit:** Compressor with motor: Weight: 100 kg, footprint 0.5 m²
  
  Compressor module incl. frequency drive: Weight 700 kg, footprint 2 m².

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**Example: Efficient electrification of drying in superheated steam**

Combustion of fuel for heat supply in drying (with related emission of green house gases) can be eliminated by converting e.g. a tunnel dryer to use superheated steam (instead of hot air) in combination with a heat pump.

- In this case the dryer now operates with steam heated to an inlet temperature of 145 °C and a steam exit temperature of 110 °C. Demand for reheating recirculated steam is 1080 kW.
- With a two-stage steam turbo compressor heat in excess steam from dryer exit can be extracted to be used for reheating the recirculated steam to 145 °C. Electric power demand to compressors is 200 kW corresponding to a COP of 5.3.
- Simple payback is estimated to approximately 3 years assuming annual operation of 5000 hours, specific cost of heat and electricity of 38 €/MWh and 60 €/MWh, respectively.

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All information were provided by the supplier without third-party validation. The information was provided as an indicative basis and may be different in final installations depending on application specific parameters.