Weel & Sandvig

Figure 1: WS Turbo Steam: Here as a one stage direct drive turbo compressor working on steam (R718) in a closed loop process heat pump system with condenser "Process Heater" and evaporator "Process Cooler".

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.

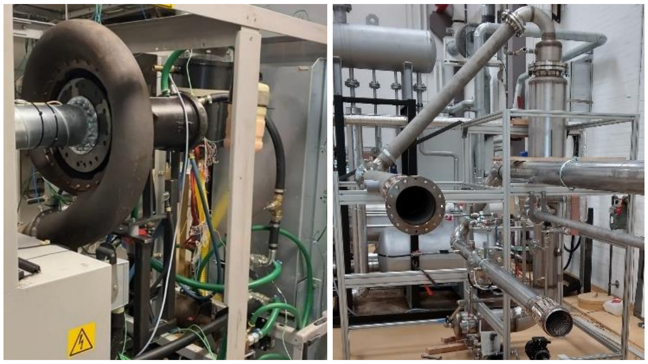

Figure 2: Left: Turbo compressor and high speed motor. Right: Steam test rig before compressor installation.

Table 1: Performance.

$T_{source,in}$ [°C]	$T_{source,out}$ [°C]	$T_{sink,in}$ [°C]	$T_{sink,out}$ [°C]	$COP_{heating}$ [-]
100	99	120	120	10.0
100	99	150	150	5.0

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.

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 m^2

Compressor module incl. frequency drive: Weight 700 kg, footprint 2 m^2.

Contact information

Weel & Sandvig - Energy and Process Innovation Aps
mwh@weel-sandvig.dk
+45 2671 0046

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.