Screw compressor for water vapor heat pump technology

Svenska Rotor Maskiner International AB

Summary of technology

SRM is currently developing a steam screw compressor for applications in process industries. A prototype has been tested in the laboratory, while the full-scale system is under development and planned for full-scale demonstration in 2023/2024.

The steam screw compressor from SRM is a positive displacement compressor which was designed for steam system use. It is electrically direct driven by a frequency-controlled motor. Lubrication is provided by a separate oil skid in order to feed the bearings with oil. Sealing of the water steam against oil is performed by advanced labyrinth shaft seals. The system can be operated in open cycles, e.g. working between two steam distribution systems, or in a closed cycle.

For testing the prototype, the compressor was integrated with a closed cycle heat pump system and operated in a short period in the test laboratory. The heat pump system was heated and cooled by external water/glycol system for the test purpose.

The purpose of the prototype system was to demonstrate the application of a screw compressor in a heat pump system intended for large steam systems in paper and pulp industry as well as other energy intensive industries. The prototype system delivered heat to a stream being heated from 119 °C to 126 °C, while cooling a stream from 90 °C to 86 °C.

Figure 1: SRM prototype compressor skid
denser heat power was measured to 230 kW during this test, corresponding to a COP of 1.9. However, there were considerable losses from the compressor oil system and compensating these losses in full scale operation is expected to yield a COP of up to 2.7.

As a next step, the full-scale system is being developed with a nominal capacity of 2 MW at an evaporating temperature of 100 °C. The compressor is planned with a volume flow rate of 6000 m³/h and can operate at evaporation temperatures between 75 °C and 120 °C with a maximum pressure ratio of 10. This corresponds to condensing temperatures of up to 140 °C (for Tₑ = 75 °C). An overview of the expected performance in a closed cycle arrangement is shown in Table 1.

Table 1: Expected performance for full scale system

<table>
<thead>
<tr>
<th>Tsource,in [°C]</th>
<th>Tsource,out [°C]</th>
<th>Tsink,in [°C]</th>
<th>Tsink,out [°C]</th>
<th>COPheating</th>
<th>Qheating [kW]</th>
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</table>

The development and demonstration of the full-scale unit will be conducted in collaboration with DTI, MultiKøl og Energii, Verdo and a number of Danish partners and end-users between 2022 and 2025.

Project example

The system is most promising for applications in which heat is to be upgraded from above 90 °C. As many applications require heat to be upgraded from lower temperatures, it is likely to be applied in a cascade arrangement with an ammonia system. A typical application could be heat recovery from industrial excess heat to hot water or steam production. For these applications, there is a considerable potential, since it can replace boilers in an existing utility system with a minimum of required retrofitting. A possible system layout is shown in Figure 2. For this system, a COP of approximately 4.0 is expected.

FACTS ABOUT THE TECHNOLOGY

Heat supply capacity: Prototype: 250 kW, next model: 2 MW

Temperature range: 80 – 130 °C (prototype). Next model up to 165 °C

Working fluid: R-718 (water)

Compressor technology: Screw

Specific investment cost for installed system without integration: -

TRL level: 5, full-scale field demonstration expected for 2023/2024

Expected lifetime: 20 years

Size: compressor skid: 2.5 tonnes including frame and oil system. Footprint: 6 m²

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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.