Screw compressor high-temperature heat pump

Rank®

Figure 1: Rank® HTHP and compressor

Summary of technology

Rank® is a worldwide recognized company in the design and manufacture of Organic Rankine Cycles for different capacities and applications. Now, Rank® is using this valuable experience in extreme conditions to develop high-temperature heat pumps (HTHP) that can produce renewable heat up to 160 °C.

New Rank® HTHP systems are based on a single-stage cycle with an internal heat exchanger (IHX). However, a two-stage cascade cycle with IHXs can be assembled for covering larger temperature lifts.

The compressor is electrically driven, is based on a screw technology with a frequency inverter to be adapted to the customer's actual operation. The compressor is based on direct drive, avoiding gears or pulleys, minimizing the maintenance, and increasing electrical efficiency. Moreover, magnetic coupling ensures tightness and a-voids the possibility of leakage.

Lubrication used for the proper operation of the compressor is polyolester oil (POE oil) of a specific viscosity, fully compatible with organic working fluids and able to work at high temperatures while keeping the optimum properties.

Rank® HTHP systems can be used in various applications since we have different standard models (HP1 to HP4) adapted to the heat load. Our HTHPs can be designed and sized using our software if they do not suit the applications. The main Rank® HTHP applications include industrial processes (chemical, oil refinery, paper mill, etc.) or district heating.

Our HTHP prototype has been tested at a wide range of heat sink and source temperatures. The measured COP in the lab-scale prototype varied between 2.6 and 6.0, depending on the temperature lift. However, systems specifically designed for clients could reach remarkably higher COPs.

The development status is prototype demonstration (TRL 7), but our commercial department is in discussions for installing our technology in pilot plants for different applications.

Compact HTHP systems are based on plate heat exchanger technology; therefore, the condenser exchanges heat with a thermal oil heat transfer fluid. The evaporator revalorizes heat coming from water or thermal oil. These circuits can be used as intermediary circuits and then be connected to fan coils, among others

Figure 2: Rank® modular solution

Our machines operate through an automatic, efficient managing system without human intervention. Real-time data transmission via the internet allows predictive maintenance by server data analysis, online supervision (PC, mobile phone, tablet, etc.), and remote configuration of working parameters.

Table 1: Performance for the single-stage cycle with IHX HTHP prototype (experimentally measured in lab. prototype, not fully optimized for specific purpose)

$T_{source,in}$	$T_{source,out}$	$T_{sink,out}$	$COP_{heating}$
[°C]	[°C]	[°C]	[-]
84	70	103	5.9
101	70	122	4.6
102	72	130	4.0
115	70	130	3.7
100	90	160	3.0
116	95	160	2.8

Table 2: Case study for production of thermal oil.

$T_{source,in}$	$T_{source,out}$	$T_{sink,out}$	$T_{sink,out}$	$COP_{heating}$
[°C]	[°C]	[°C]	[°C]	[-]
100	70	130	110	3.6
100	80	130	110	4.5

Project example

A perfect application for our HTHP systems is district heating networks (DHN).

DHN are present in urban and industrial environments where each user is connected and uses heat at a given temperature. Heat is distributed at a particular temperature, but users' needs can differ.

HTHPs present in the installations of each client can upgrade the heat at useful levels with a high COP (2.6 to 5.9), adapting the temperature glide of the heat sink.

HTHPs, which local renewable energy sources can power and promote decarbonization in industries connected to district heating networks, independently of the distribution temperature, avoiding the need for fossil fuel boilers.

FACTS ABOUT THE TECHNOLOGY

Heat supply capacity: 120 kW to 2000 kW

Temperature range: useful heat inlet 80 °C to 120 °C and outlet 100 °C to 160 °C / heat source inlet 60 °C to 100 °C and outlet 40 °C to 80 °C

Working fluid: adaptable to the application R245fa, R1336mzz(Z), R1233zd(E)

Compressor technology: Screw

Specific investment cost for installed system without integration: 200-400 € per kW_t, but it varies between temperature levels and applications

TRL level: TRL 7 – prototype demonstration

Expected lifetime: 20 years (with the possibility of hiring Service to extend lifetime and ensure the highest energy performance)

Size: weight 5.5 to 8 tons / surface requried 5.2 to 13 m^2 / height 2.2 to 2.5 m

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