ETES CO_2 Heat pump

MAN Energy Solutions

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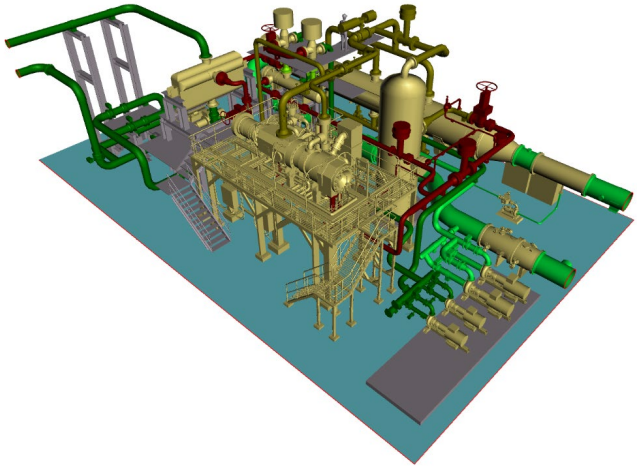

Figure 1: Typical heat pump system general arrangement

Summary of technology

The MAN high temperature industrial heat pump system has been derived from the Electro-Thermal Energy Storage technology developed originally by ABB and further developed by MAN Energy Solutions. The working fluid is CO_2 operated in an optimized trans-critical heat pump cycle.

The system is customized to the specific customer requirements for several applications in three frame sizes (small-middle-large) depending on the duty varying between 10 to 50 MW thermal supply capacity per unit. Typical applications are for district heating plants and process industry applications demanding medium to high supply temperatures (up to 150°C).

The design and heat pump layout is fully customizable and adapted to each project or specific site requirement. The main piece of equipment is a hermetically sealed centrifugal turbo-compressor driven by high speed electrical drive incl. VSD (variable frequency drive).
The overall system is closed and emission-free. An expander stage is integrated for optimal performance. The rotating parts on magnetic bearings makes the system oil-free and maintenance friendly (no wear and tear parts hence low specific OPEX resp. maintenance effort).

The static process equipment parts (i.e. heat exchangers) are optimized resp. customized to reach the required duty and performance while complying the specific space requirements. Special compact heat exchangers are therefore applied on the sink side.

The performance of the system (i.e. COP) depends mainly on the temperatures applied, primarily the supply and return temperature on the sink side, secondly the temperature level of the source medium (mainly water).

A pilot system of 5MW heat supply capacity was successfully tested at the MAN production & testing facility in Zurich in 2020 and two units have been sold in 2021 for a district heating application.

Due to the use of CO_2 as refrigerant, the source medium temperature cannot be elevated much more than 40°C, however a temperature lift up to 150-170°C can be achieved with the single-stage heat pump system. The system takes benefit of the favorable compressing properties of CO_2 and its outstanding heat transfer capacities when compressed to supercritical conditions (i.e. above 78.4 bar).

The units can be combined with storage tanks making the system even more flexible in operation (daily charging / discharging cycles typically).

Start-up and shut-down times are very short due to active magnetic bearing technology. Likewise dynamic or fast load change capability for grid stabilization purpose can improve the overall operational profitability of the heat pump system.

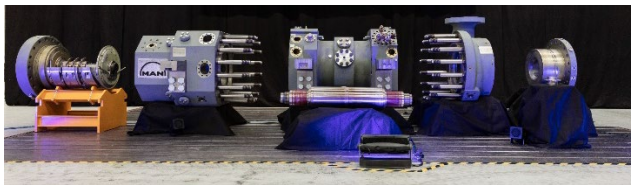

Figure 2: Compressor HOFIM™ dismantled

Table 1: Performance for different conditions

$T_{source,in}$ [°C]	$T_{source,out}$ [°C]	$T_{sink,in}$ [°C]	$T_{sink,out}$ [°C]	$COP_{heating}$ * [-]
10	7	40	110	3.05
2	-1	30	95	3.25
20	17	50	150	2.85

**) calculated (i.e. predicted) values*

Project example

Two heat pump units will be installed in the city of Esbjerg in Denmark by end of 2022 for replacing the current coal-fired power plant by mid 2023 for a carbon neutral district heating supply of all neighboring communes. The installed units have an overall thermal supply capacity of >50MW with a COP>3.

Similar project are under development mainly in Europe but also worldwide.

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.

FACTS ABOUT THE TECHNOLOGY

Heat supply capacity: from 10 MW to 50 MW per unit

Temperature range: sink temperature up to 150°C, source temp. from -20° up to 40°C, max. temperatur lift of approx. 170 K

Working fluid: CO_2

Compressor technology: centrifugal turbo-compressor (hermetically sealed) with integrated expander

Specific investment cost for installed system without integration: 300 – 500 €/kW (thermal supply capacity)

TRL level: 7-8 (prototype tested in 2020, project in execution in 2021)

Expected lifetime: approx. 35 years

Size: from 100 m^2 (smallest unit) to 250 m^2 (biggest unit) with max. 10 kN/m^2

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