SkaleUP

Skala Fabrikk AS

Figure 1: Skala Fabrikk - SkaleUP Cascade HTHP
Picture: SINTEF Energi AS, Christian Schlemminger

Summary of technology

The SkaleUP Cascade HTHP is a unit for a) simultaneous ice and process hot water production or b) utilization and upgrade of low temperature waste heat, i.e. from dry-coolers.

The heat pump is decided as a classical cascade cycle where hydrocarbons are applied to give an optimal performance, while having a high temperature lift of 70 K to 135 K. This high lift enables applications in new designed heating and cooling systems, as well as the retrofit in already existing pressurized process hot water supply systems.

The heat pump is constructed modularly on frames enabling an installation in a 10 feet shipping container or in a machinery room. One module simultaneous provides up to 0.3 $MW_{heating}$ at 115 °C and 0.15$MW_{cooling}$ at 0 °C, process cooling may be realized down to -20 °C with reduced capacity.

The vapor compression cycles with their standardized components, such as semi-hermetic compressors, plate heat exchangers etc. are having service cost and lifetime of classical chillers.

On the heat source side, process ice or chilled water, heat transfer fluid for a dry-cooler circuit or water-based process waste heat streams can be connected. As heat sink a direct implementation in the pressurized process hot water supply system of the plant is favorable. However, heat source and sink side can also be utilize secondary circuits as water/glycol mixtures. A simple process diagram as depicted in Figure 2 indicates the possible implementations. When installing the HTHP in ice water production mode, additional cooling capacity for e.g. production expansion will be available.

The applied natural refrigerants R290 and R600 are classified are nontoxic, having a very low GWP and zero ODP. Working pressures are below 25 bar_a.

Performance data is given in Table 1. COPs were calculated in two ways: for a) simultaneous ice- and process hot water production a combined $COP_{Combined}$ was calculated, taking both heat source and sink into account.

For b) utilization and upgrade of low temperature waste heat the heating $COP_{Heating}$ is considered.

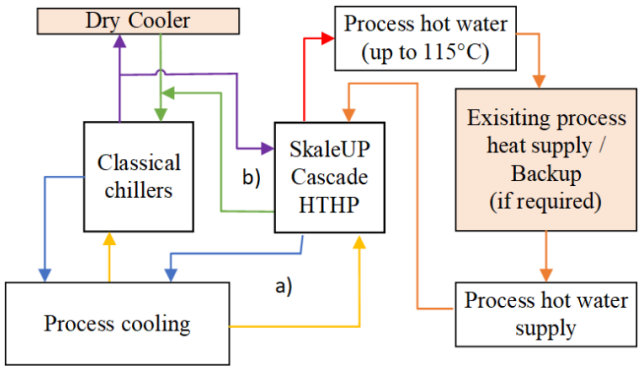

Figure 2: Simplified process diagram of the SkaleUP Cascade HTHP. Connection a) ice water production, b) dry cooler waste heat recovery.

Table 1: Performance estimate, relevant COPs for applications in bolt numbers.

$T_{source, in}$ [°C]	$T_{source, out}$ [°C]	$T_{sink, in}$ [°C]	$T_{sink, out}$ [°C]	T_{lift} [K]	COP heating	COP combined
-15	-20	95	115	135	1.9-2.0	**2.7-2.9**
4	0.5	95	115	115	2.2-2.4	**3.3-3.5**
12	6	95	115	109	2.4-2.6	**3.6-3.8**
25	15	95	115	100	**2.7-2.9**	4.1-4.3

Project example

Simultaneous supply of ice at 0.5 °C water and process hot water at 115 °C as retrofit of a dairy. The SkaleUP HTHP was integrated with a secondary loop water/glycol circuit at heat source side. The ice water return of the dairy was cooled down from 5 °C to 0.5 °C. As heat sink the process hot water return is utilized directly and heated up from 95 °C ±5 K to 110 °C ±5 K. The evaluated $COP_{combined}$, considering heat sink and source side was 3.4 ±0.3. This results in a Carnot-efficiency of the combined heat source and sink of 54 %.

The operation compared to a classical ice water production with NH_3-chillers ($COP_{cooling}$ = 4.5) and process heat supplied by gas burners (efficiency 90 %) indicates a primary energy saving of about 60 %. Using a CO_2-lean energy mix with e.g. 22 gCO_2/kWh_{el} results in a green house gas emission reduction of up to 94 %.

FACTS ABOUT THE TECHNOLOGY

Heat supply capacity: simultaneous up to 0.3 $MW_{heating}$ and 0.15$MW_{cooling}$ per module

Temperature range:
Cycle design tailor made to application, Soruce inlet 25°C to -15°C, Sink outlet 95°C to 115°C, Temperature lift 70 K to 135 K

Working fluid: Natural
R290 (Propane), R600 (n-Butane)

Compressor technology: piston (semihermetic)

Specific investment cost for installed system without integration: 500 €/kW to 700 €/kW thermal supply capacity (sink + source)

TRL level: TRL7 (system prototype demonstration in operational environment)

Expected lifetime: 15 years.

Size: 4.200 kg incl. 10 foot shipping container for 0.3 $MW_{heating}$ at 115 °C and 0.15 $MW_{cooling}$ at 0 °C

Contact information

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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.