Steam Generation Heat Pump

Fuji Electric

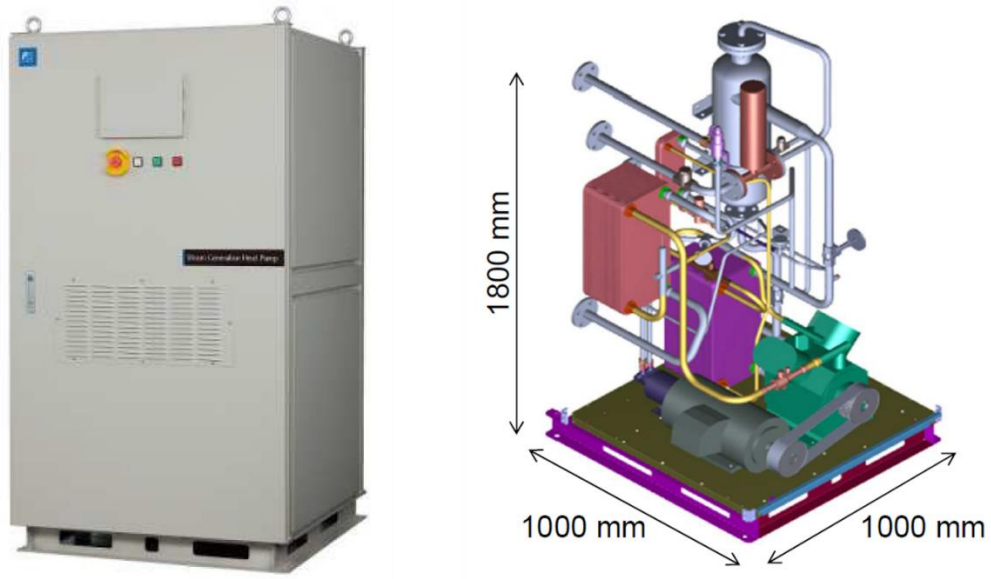

Figure 1: External appearance and element configuration

Summary of technology

The steam generation heat pump was commercialized in 2015. This heat pump can be used as an alternative to the low-pressure steam boiler used for heating processes. The heat pump is expected to install near each heating process. Generally, steam boiler is installed at the energy center located far from each process, and the steam is distributed with long pipes. This causes a lot of heat loss from steam pipes. Installing the heat pump near the process can reduce the heat loss as well as effectively recover the waste heat from the process. For the easy installation near the process, this heat pump is made compact.

The system has a steam generation part and a heat pump cycle part (see Figure 2). The heat pump lifts the heat from the heat source water (60-80°C) and sends the heat to the feed water. The feed water is preheated at the subcooler and evaporated at the condenser. The water is sent to the steam separator in the form of wet steam. Saturated steam (up to 120°C, 0.1 MPaG) from the separator is controlled with the pressure regulator and supplied to a heating process. While saturated water from the separator is mixed with the preheated feed water and returned to the condenser.

For the working fluid of the heat pump, R245fa is selected because of its high critical temperature of 154°C. The compressor is a reciprocating type. The subcooler improves the heat pump cycle efficiency as well as preheats the feed water.

To achieve the compactness, the condenser needs to be smaller. In an existing steam generation heat pump (SGH120 by KOBELCO), saturated steam is generated by decompressing a pressurized water in a flash tank. The pressurized water is heated by refrigerant in the condenser. The condenser needs a larger size because the pressurizes water has a relatively small heat transfer coefficient. In addition, the pressurized water needs to be circulated at a relatively large flow rate, and a pump for pressurized water circulation is required.

On the other hand, the present system selected a two-phase heating method in the condenser. Thanks to the higher heat transfer coefficient of the evaporation of water, the heat transfer area is reduced by 75%, and the condenser can be made compact. The water mass flow

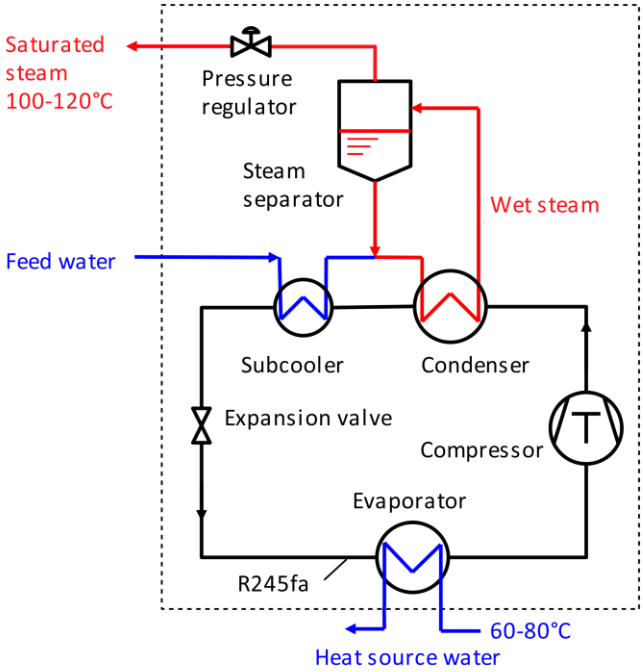

Figure 2: System configuration

Table 1: Performance

$T_{source,in}$ [°C]	$T_{source,out}$ [°C]	$T_{sink,in}$ [°C]	$T_{sink,out}$ [°C]	$COP_{heating}$ [-]
80	70	20	120	3.5
70	62	20	120	2.8
60	54	20	120	2.5

rate is also decreased. Without using a circulation pump, wet steam is sent to the steam separator by a thermosiphon effect.

The rated COP is 3.5 under the heat source water temperature of 80°C and the steam supply temperature of 120°C (see Table 1). The rated heating capacity per unit is 30 kW (45 kg/h of steam), and up to 10 units can be integrated.

Project example

This steam generation heat pump was installed at a cleaning process before painting in a vending machine production factory. The heat pump uses the cleaning wastewater as a heat source and generates steam for heating the cleaning water. To ensure the stable heat source, a wastewater tank was also installed. Compared to the conventional system with steam boiler, this heat pump can reduce energy cost and CO_2 emissions by 52% and 46%, respectively. It should be noted that the reduction effects are values for the part where the heat pump was applied, not for the entire process.

FACTS ABOUT THE TECHNOLOGY

Heat supply capacity: 30 kW/unit (Max. 10 units)

Temperature range: Heat source water 60-80°C, Feed water 10-80°C, Steam 100-120°C

Working fluid: R245fa

Compressor technology: Reciprocating

Specific investment cost for installed system without integration:

TRL level: TRL 9

Expected lifetime: 10 years

Size: Weight 850 kg, Footprint 1.0 m^2

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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.