Development and Evaluation of Advanced Heat Pumps

Background and Objective

Heat pumps are attracting attention in and outside Japan as an effective technology to promote energy conservation and reduce CO_2 emissions. Much research and development is carried out to improve efficiency, to use low-GWP (global warming potential) refrigerants, and to expand applications to a wide variety of thermal demand.

In this project, we aim to develop and evaluate highly efficient, compact, and low-priced heat pumps using low-GWP refrigerants for residential hot water supply, room heating, industrial process heating and so on. We wish to contribute to the launching and popularization of heat pumps attractive to end users.

Main results

1 Efficiency evaluation for residential heat pump water heaters

With our test facility for the development and evaluation of residential heat pumps, we have evaluated the energy consumption efficiency of a residential heat pump water heater with CO_2 refrigerant, Eco-Cute, under various operating conditions with the parameters of hot water demand, heat source air temperature/humidity and so on. We will make efficient use of these results to set performance evaluation standards of heat pump water heaters.

2 Elucidation of commercial heating tower's frosting/defrosting characteristics

With our new test facility for the development and evaluation of industrial and commercial heat pumps, we have elucidated the frosting/defrosting[*1] characteristics of a commercial heating tower[*2] (Fig. 1) under various operating conditions with the parameters of heat source air temperature/humidity and so on, through some defrosting methods. Moreover, we have devised a new defrosting method with a shorter period and reduced energy consumption for defrosting. We will make efficient use of these results to improve performance and to expand the applicable regions of heating towers.

3 Efficiency evaluation for industrial heat pump steam generators

With our new test facility, we have evaluated steam discharge rate and system COP[*3] of an industrial heat pump steam generator, SGH165[*4] (Fig. 2), under various operating conditions with the parameters of inlet temperature of heat source water, steam discharge pressure and so on (Fig. 3). Moreover, we have elucidated technical problems for the expansion of heat pump steam generators through inquiries to end-users, plant engineering companies, manufactures and so on. We will make efficient use of these results to improve the performance of heat pump steam generators and to develop new related technologies.

*1: Frosting is the freezing of water contained in cold outside air on the surface of a heat exchanger. As frost become a thermal resistance and an obstruction of air flow in a heat exchanger, defrosting, in other words, the melting of frost, is essential to the operation of a heating tower and air source heat pump.

*2: A heating tower is a heat exchanging system in which brine, referring to antifreeze solution, absorbs heat from cold outside air. A water source heat pump chiller can generate hot water for room heating through using air source heat in combination with a heating tower. Moreover, it plays the role of a cooling tower when a water source heat pump chiller generates cold water for room cooling. There is one in operation at the Tokyo Sky Tree and so on.

*3: The system COP is a kind of energy consumption efficiency defined as heat output of generated steam divided by electric power input, exceeding 1 by using waste heat of hot drainage.

*4: SGH is an abbreviation of Steam Grow Heat pump and applicable to industrial heating processes, for example, sterilization, concentration, drying, distillation and so on. There are two SGHs; SGH120, which generates 120℃ steam, and SGH165, which generates 165℃ steam, through the recovery of waste heat from drainage in factories. These are in operation at some factories which manufacture bioethanol, medicine and so on.

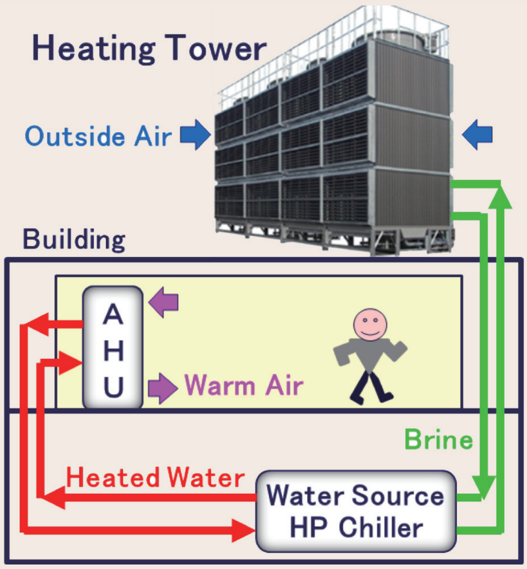

Fig. 1: Commercial heating tower

In a heating tower, brine, referring to antifreeze solution, absorbs heat from cold outside air. A water source heat pump chiller absorbs heat from brine and generates heated water. In an air handling unit, heated water releases heat to indoor air to warm a room.

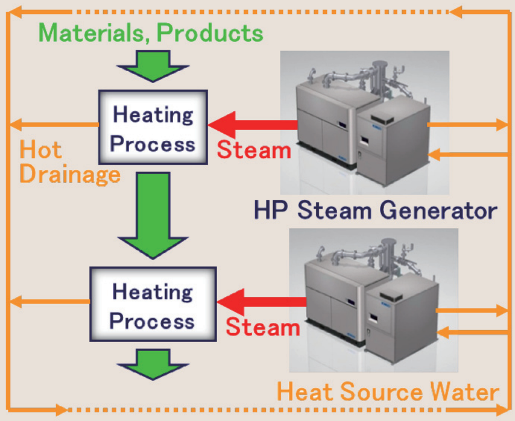

Fig. 2: Industrial heat pump steam generator

Steam condenses and converts to drainage after being used in various heating processes in factories. Efficient use of energy is possible by recovering waste heat of drainage. The higher the temperature of drainage, the higher the efficiency of the heat pump steam generator.

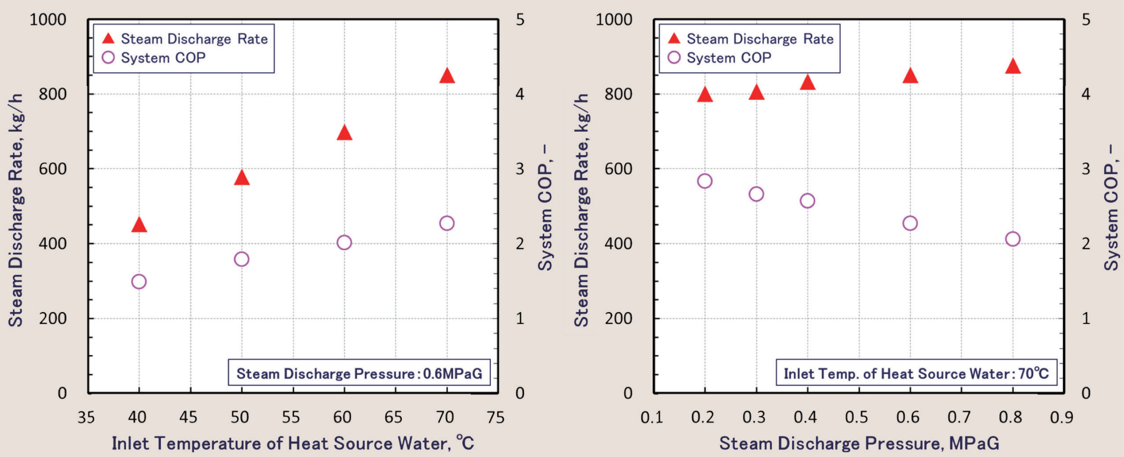

Fig. 3: Performance test results of the heat pump steam generator SGH165

The figure to the left indicates the impact of inlet temperature of heat source water on steam discharge rate (▲) and system COP (◯), while the figure to the right the impact of steam discharge pressure on the same two points. The condition for basic performance of the SGH165 is that the steam discharge pressure is 0.6MPaG (saturated steam temperature 165℃) and inlet temperature of heat source water is 70℃.