Innovative Air-Cooled Package Air Conditioner for Data Centers Reduces Energy Use by 50%


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1. Abstract

In recent years, there has been an increasing trend in energy consumption by the data centers. The energy consumption of the data center is 20 times or more the office. In addition, the air conditioning system consumes the energy of 30-50% at the entire data center, so there is a strong demand for higher energy efficiency in data center air conditioning.

It is difficult to reduce the energy of air conditioning systems by half by improving the efficiency of the refrigeration cycle, as has been done up to now. We therefore, developed a new advanced air conditioner that effectively uses the outside air as the cold source in a free-cooling cycle in addition to improving the refrigeration cycle. The free-cooling cycle is a heat transport technique that uses a refrigerant pump that consumes a small amount of energy compared to a compressor to circulate the refrigerant in place of the compressor.

Cavitation within the refrigerant pump caused by the temperature of the refrigerant near the boiling point has hindered practicality of the free-cooling cycle. We have achieved a practical free-cooling cycle by developing a heat transport technique that suppresses cavitation and a control method that averts cavitation.

2. Technical Description

The air conditioner that we developed automatically switches between operating cycles according to the season. In seasons when the outside air temperature is high the system operates in the compression cycle; in seasons when the outside air temperature is low, it operates in the free-cooling cycle (Fig. 1). In cold seasons, the operating efficiency is high as the result of free-cooling cycle operation in which the refrigerant pump is used (Fig. 2). From calculations based on climate data, the decrease in annual energy consumption compared to conventional computer room air conditioners is estimated to be 54% for Sapporo and 42% for Tokyo. The energy-saving effect for each operating cycle calculated from the climate data for Sapporo is shown in Fig. 3.

The compression cycle technology for achieving the energy savings described above includes 1) use of a pressure release valve to prevent over-compression, 2) use of an asymmetric scroll, and 3) use of a DC inverter motor.

The pressure release valve prevents the over-compression that occurs in the region of medium to low compression ratios, enabling operation at the correct compression ratio.

The asymmetrical shape of the scroll teeth suppresses compression loss between the compressor intake and outlet.

The use of the DC inverter motor reduces motor loss.

The free-cooling cycle technology for suppressing cavitation includes 1) development of an anti-cavitation refrigerant pump, 2) a cavitation prevention control, and 3) cycle switching technology.

In developing the refrigerant pump, we clarified the characteristics related to the occurrence of cavitation by testing different types of actual refrigerant pumps. The results show what types and shapes of refrigerant pumps are suitable for use in the free-cooling cycle.

The cavitation prevention control keeps the refrigerant in a super-cooled state at the pump intake by controlling the rotation speed of the fan of the outdoor unit, which is on the intake side of the refrigerant pump, according to the outside air temperature and refrigerant characteristics.

The cycle switching control was designed to implement cycle switching for energy-efficient operation without interfering with the cooling of the IT equipment during switching. Through experiments and field testing, we achieved a smooth cycle switching control method.

3. Conclusion

The air conditioner for IT facilities that we developed was introduced to the market under the product name “FMACS-V hybrid” in December, 2011, and successively made available in all areas of Japan. Further expansion of sales is planned to contribute to energy savings in the data centers.

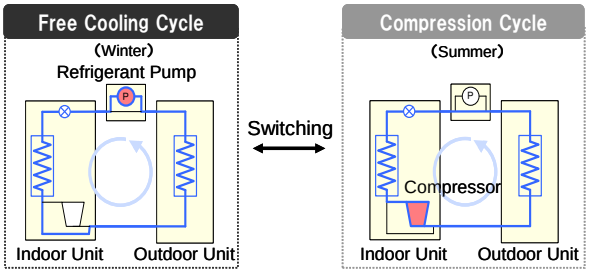

Fig.1 Operating states of new air conditioner

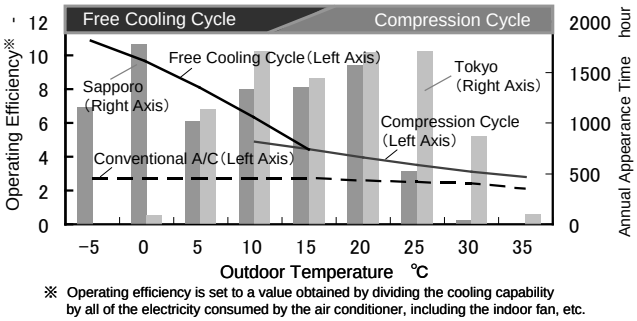

Fig.2 Air conditioner characteristics with respect to outdoor temperature

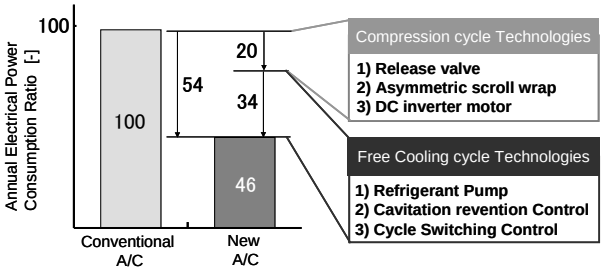

Fig.3 Energy-saving effect of each operating cycle (Sapporo)

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