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To cite this article: J I Yoon *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **675** 012043

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Performance characteristics of portable air conditioner with condensate-water spray

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Abstract. In this research, a device for injecting condensate-water generated from the evaporator into the distributor on the top of the condenser was fabricated as a method for improving the efficiency of the portable air conditioner. To compare the efficiency, the condensation temperature, blowout air temperature, power consumption, cooling capacity, and COP of the system were measured. As a result of the experiment, the condensation temperature dropped by about 6.2 °C. Also, the power consumption of the compressor was reduced by about 0.16 kW and the cooling capacity increased by 0.2 kW. As a result, it was confirmed that the COP increased by about 16 % when the condensate-water was sprayed on the condenser.

Keywords: Portable air conditioner, Condensate-water, COP, Cooling capacity.

Introduction

The demand for air conditioners is increasing every year due to rising temperatures in summer in South Korea. In particular, the demand for the portable air conditioner is increasing in industrial plants or various fields requiring local cooling. Portable air conditioners use a method of absorbing ambient air and cooling the surroundings when the refrigerant evaporates. In addition, since the outdoor unit and the indoor unit are built in the main body, there is no need to install the outdoor unit separately, so the burden on the cost or installation space is less, but there is a disadvantage that the cooling capacity is lower than the existing system air conditioner. [1] A. Khalil et al. If the evaporator coil surface temperature is lower than the dew point temperature of the inlet air, condensation will occur on the coil surface. This is called surface cooling, which is why condensate-water is produced and humidity in the atmosphere is low. [2] A. H. Mahvi et al. Air conditioners produce an average of 36L of condensate-water per day. This amount of production is thought to be available in many ways. [3] S. Algarni et al. The study of air conditioning condensate-water recovery and application has addressed the need for building energy recovery and freshwater sustainability. [4] W. Akram et al. When using other water on earth, the scale is generated as impurities contained in water. Therefore, the application of condensate-water from the evaporator side of the refrigerator was studied. [5] John A. Bryant et al. The amount of condensate-water produced in the industrial building was quite high and the potential impact on the resulting condensate-water utilization and reuse technique was studied. [6] N. Nethaji et al. To utilize the condensate-water, an experiment was conducted to reduce the indoor circulation air temperature by installing a condensate-water drain pipe inside the wall of the building. As a result, experimental results showed that average indoor air temperature is get lowered to about 0.3~0.5 °C and achieved energy-saving about 7%. [7] I. N. Ardita et al. Codensate-water is reviewed as an additional cooling medium. As a result of the experiment, we found that the system air conditioner increased the cooling capacity by 4%, the COP by 7%, and decreased the power consumption by 3%.

When the air conditioner is running, condensate-water is generated as moisture in the air condenses on the evaporator. In the case of a system air conditioner, this condensate-water is removed through a drain pipe using a pump, but a portable air conditioner uses a method of manually removing



condensate-water by placing a separate reservoir under the evaporator for convenience of movement. The purpose of this study is to investigate the characteristics of system performance improvement as the condensate-water evaporates and the condensation temperature is lowered by spraying the condensate-water on the condenser.

2. Experiment apparatus and methods

The compressor of the portable air conditioner was Samsung Rotary Compressor, which was selected as the 48D199IT model. At rated conditions, the cooling capacity is 19,300 Btu/h, and power consumption is 1.8 kW. The condenser consists of 4 rows of 24 stages of 9.52 mm copper tubes. Aluminum fins have a 2 mm pitch. When water is sprayed on the fins, aluminum is corrosive, so the surface of the fins is coated with urethane, which has excellent corrosion resistance to prevent corrosion. The evaporator has a 9.52 mm copper tube arranged in 2 rows of 20 stages. The pin pitch is 2 mm, and the aluminum fin of the evaporator is coated with a urethane hydrophilic coating to prevent corrosion of the aluminum fin of the evaporator due to the condensation of moisture in the evaporator. The blower motor inside the portable air conditioner was selected as 220V, 1Ph, 60Hz with 0.5 kW.

Figure 1 shows a schematic and photograph of a portable air conditioner. A spray pump is installed in a reservoir of a portable air conditioner, and a distributor is installed at the top of the condenser.

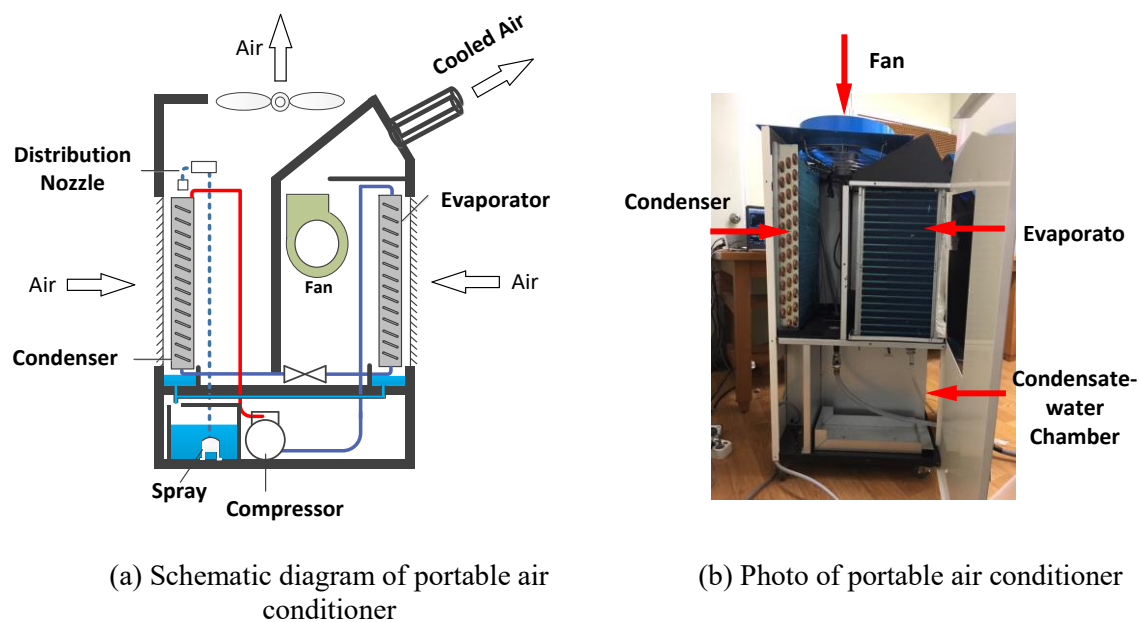


Figure 1. Device schematic diagram and photo.

Figure 2 is a photograph of the data acquisition and measurement equipment. The data were divided into a refrigeration cycle, and airside. The measurement data are as follows. In the refrigeration cycle, compressor suction and discharge temperature, inlet and outlet temperature of condenser and evaporator were measured using a T-type thermocouple.

The power meter was measured using Yokogawa's WT200 model, which measured the amount of power consumption. The data logger was also used Yokogawa's device, which collected all the necessary data from the experiment. Condenser side inlet/outlet air temperature and humidity are required to confirm cooling capacity and heat of condensation. For this purpose, the above data was measured from the airside. At this time, the thermocouple was fixed in the air using T-type thermocouple and humidity sensor using GHP-100T. To confirm the effect of the presence of the spray of condensate-water at a constant ambient condition, the experiment was conducted under the conditions of table 1.



Figure 2. Data acquisition device.

Table 1. Experimental conditions

	Values	Units
Refrigerant	R-22	-
Evaporator side air flow rate	0.21	kg/s
Condensate-water temperature	27±1	°C
Atmosphere temperature	26~38	°C

The same temperature and humidity conditions were applied to confirm the improvement of portable air conditioning performance through the injection of the condensate-water upper side of the condenser. Temperature and humidity conditions were maintained using a steady temperature and humidity room. Under these conditions, power consumption, atmosphere temperature, humidity, evaporator inlet and outlet temperature, and condensation temperature were measured. To compare the cooling capacity, through temperature and humidity of evaporator side inlet and outlet, enthalpy was measured via the Psy-Chart-SAREK [8] program proposed by the Society of Air conditioning and Refrigerating Engineers of Korea. The cooling capacity was calculated through the following equation (1). The power consumption was measured by a power meter, and using the cooling capacity calculated and the power consumption measured by the measuring device are written in equation (2) to compare the device coefficients of performance.

$$Q = G * (h_1 - h_2) [\text{kW}], \quad (1)$$

where Q = Cooling capacity [kW]; G = Evaporator side air flow rate [kg/s]; h_1 = Evaporator side inlet air enthalpy [kJ/kg]; h_2 = Evaporator side outlet air enthalpy [kJ/kg].

$$COP = \frac{Q}{AW}, \quad (2)$$

where Q = Cooling capacity [kW]; AW = Power consumption [kW].

3. Experimental results and discussion

Figures 3 and 4 are experimental data to confirm the influence of atmospheric temperature. The power consumption and COP of the portable air conditioner were analyzed according to the atmospheric temperature increased. Figure 3 shows that power consumption tends to increase by 0.6 kW on average as the figure 3 atmosphere air temperature increases. It seems to be the result of

decreased refrigerant circulation amount as the condensation temperature in the cycle increases with increasing atmospheric temperature.

Under the same experimental conditions, as shown in figure 4, the maximum COP decreases by 0.8 as the atmospheric temperature increases. It is thought that the cooling capacity is decreased due to the increase of power consumption and a decrease of refrigerant circulation amount caused by the rise of condensation temperature and decrease of refrigerant circulation.

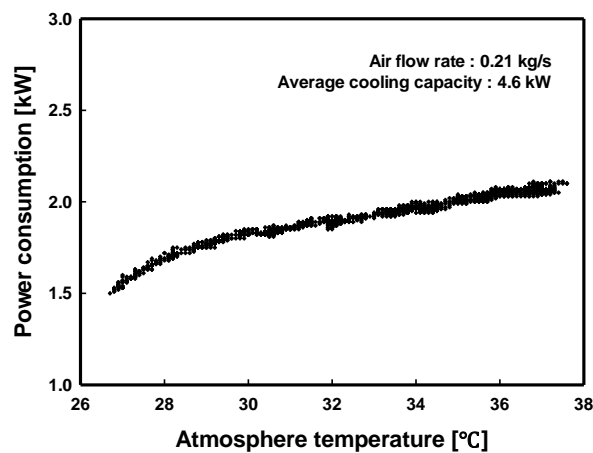


Figure 3. Power consumption according to the change of atmosphere temperature.

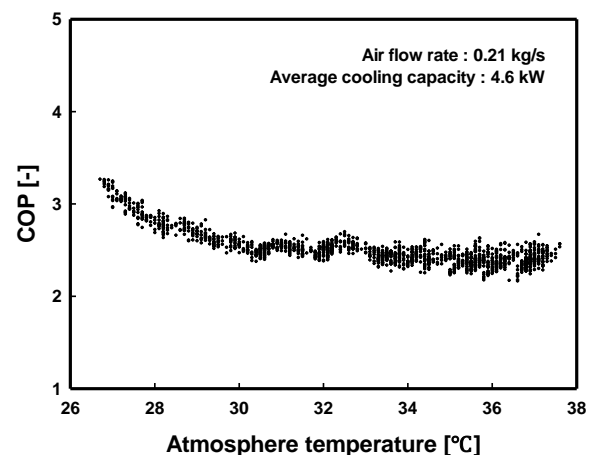


Figure 4. Coefficient of performance according to the change of atmosphere temperature.

Figure 5-8 are graphs of the performance characteristics of the experimental apparatus concerning table 1.

Figure 5 shows the temperature of condensing, discharge air according to spray pump on/off. When the condensate-water spray pump operates, condensation temperature decreased up to 6.2 °C, and the blowout air temperature of evaporator had no change. The condensation temperature is lowered through the heat exchange with condensate-water.

Figure 6 is a graph comparing the power consumption of the device and measured by installing a power meter. The average power consumption reduced about 0.16 kW when spraying the condensate-water on the condenser. Reduction of the compression ratio leads to the reduction of power consumption of the compressor. Figure 5 shows a result of decreasing compression ratio due to the decrement of condensation temperature.

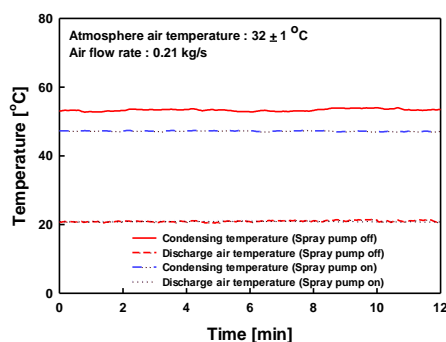


Figure 5. Condensing temperature and discharge air temperature according to change of time.

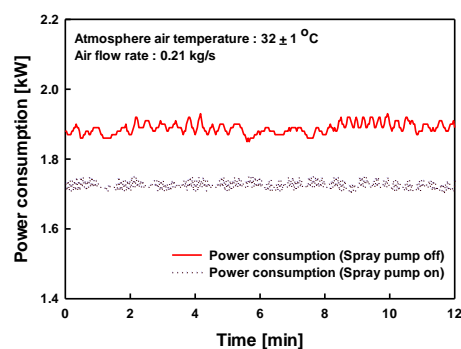


Figure 6. Power consumption according to change of time.

Figure 7 shows the change in cooling capacity according to the spray pump on/off. The cooling capacity increased by 0.2 kW compared to before the condensate-water injection. The increase in cooling capacity is thought to be because of the reduction of the condensation temperature of the cycle due to the injection of condensate-water and the increase of cooling capacity because of the increase of refrigerant circulation.

Figure 8 is a graph comparing the device coefficients of performance according to the condensate-water injection. COP was increased by 16% due to the reduction of the power consumption in figure 6 and the increase in cooling capacity in figure 7.

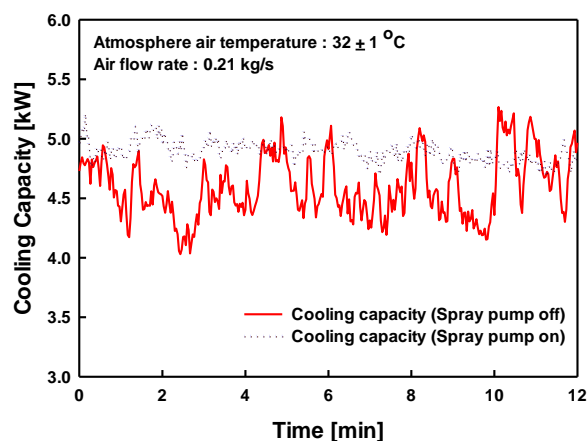


Figure 7. Cooling capacity according to change of time.

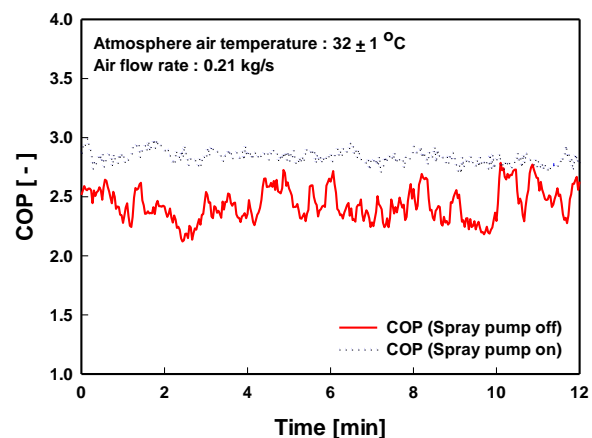


Figure 8. Coefficient of performance according to change of time.

4. Conclusions

In this study, the condensate-water generated from the evaporator of the portable air conditioner was injected to upper part of the condenser, and the following experiments were carried out to compare the condensation temperature, power consumption, cooling capacity and COP according to the presence or absence of spraying.

The condensation temperature was dropped by 6.2 °C under the experimental conditions when spraying condensate-water, and the compression ratio of the cycle was lowered, resulting in a 0.16 kW reduction in power consumption. Also, the cooling capacity was increased by 0.2 kW due to the increase of refrigerant circulation amount. The COP of the device showed a maximum of 16% higher compared to the non-operating spray pump experimental conditions. In the future, to improve the convenience of portable air conditioners research and experiment will be conducted.

References

- [1] Khalil A 1993 Dehumidification of atmospheric air as a potential source of fresh water *Desalination* **34** pp 587-596
- [2] Mahvi A H, Alipour V and Rezaei L 2013 Atmospheric moisture condensation to water recovery by home air conditioners *Am. J. Appl. Sci.* **10**(8) pp 917-923
- [3] Algarni S, Saleel C A and Mujeebu M A 2018 Air conditioning condensate recovery and applications - Current developments and challenges ahead *Sustainable Cities and Society* **37** pp 263-274
- [4] Akram W, et al 2018 *Recycling of condensed water from an air conditioning unit* (Rajshahi University of Engineering & Technology Press, Rajshahi)

- [5] Brayant J A and Ahmend T 2008 Condensate water collection for an industrial building in Doha, Qatar: An opportunity for water sustainability *Proc. 16th Symposium on Improving Building Systems in Hot and Humid Climates* (Plano, Texas, USA)
- [6] Nethaji N, Mohideen T and Nethaji M 2019 Energy conservation in room air conditioner unit by recovering cold energy from condensate *International Journal of refrigeration* **104** pp 95-102
- [7] Ardita I N and Subagia I W A 2017 The application of condensate water as an additional cooling media intermittently in condenser of a split air conditioning *Proc. 2nd International Joint Conference on Science and Technology* (Bali, Indonesia)
- [8] Psy-Chart-SAREK Ver. 2.0 2019 Society of Air conditioning and Refrigerating Engineers of Korea

Acknowledgments

Following are results of a study on the "Leaders in INdustry-university Cooperation +" Project, supported by the Ministry of Education and National Research Foundation of Korea

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