The application of condensate water as an additional cooling media intermittently in condenser of a split air conditioning

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Abstract. The condensate water produced by indoor a split air conditioning is usually not utilized and thrown away into the environment. The result of measurement shows that the temperature of condensate water produced by split air conditioning is quite low, that is 19-22 °C at the rate of 16-20 mL / min and it has PH balance. Under such conditions, Air Condensate produced by split air conditioning should still be recovered as an additional cooling medium on the condenser. This research will re-investigate the use of condensate water as an intermittent additional cooling of the condenser to increase the cooling capacity and performance of the air conditioning system. This research is done by experimental method whose implementation includes; designing and manufacturing of experimental equipment, mounting measuring tools, experimental data retrieval, data processing and yield analysis. The experimental results show that the use of condensate water as an intermittent additional cooling medium on split air conditioning condenser can increase the refrigeration effect about 2%, cooling capacity about 4% and 7% of COP system. Experimental results also show a decrease in power consumption in the system compressor about 3%

1. Introduction

Air conditioning (AC) split type which cooled the room is increasingly used in the hotels, offices, and households. With air conditioning system, the air in the room can be conditioned in accordance with the needs of both its temperature, humidity and cleanliness so that a comfortable condition can be obtained. With comfortable conditions, people will be able to perform better, creative and more productive.

One of the concerns in choosing an AC unit is that the used of power consumption and the cooling capacity. Power consumption is a major concern in vapor compression cycles of air conditioning systems which is used air-cooled condensers. The air-cooled condenser temperature is depends on ambient air temperature directly. In high environmental temperatures conditions, the condenser temperature and refrigerant pressure will be increase respectively, and the power consumption of AC units will be increase as well. Higher condenser temperatures caused the cooling capacity and the coefficient of performance (COP) of the AC unit system lower et al [1]. An attempt to increase the COP system is by lowering the temperature of the condenser

The condensate water produced by the indoor AC split type is usually piped out through the pipe and thrown away into the environment. From the condensate water measurement, it was found that the temperature was quite low between 19 - 22 °C and the production rate was between 16 - 20 mL / min. Its also has pH balance et al [2]. This low condensate water temperature could be re-utilized. One of which is used as an additional cooling medium on the condenser. By utilizing condensate water as an additional coolant on the condenser is expected to reduce condensing temperature on the condenser.
Decreasing condenser temperatures will certainly decrease energy consumption and improve performance of AC system units.

Recently, improvements in AC system performance are continuing to gain greater benefits with less energy usage. Hajidavalloo [3] investigated the use of a media pad to cold air condenser (evaporative cooler) in AC Window. It was reported that the power consumption can be reduced about 16% by using evaporative cooler and increase total performance about 55%. And also Hajidavalloo et al [4] and Kamlesh kumar et al [5] investigated the use of a cellulose media pad to cold air condenser (evaporative cooler) in air-cooled refrigeration system. It was reported that the power consumption can be reduced about 20% by using evaporative cooler and increase total performance about 50%. Aditya P Sawant et al [6], investigated the use of evaporative cooling in condensers by using a Khus-khus media pad and cellulose bounded on the AC window which made COP of the system increase approximately 18% and can save energy raised into 13%. Meanwhile, the experimental analysis of K.R.Aglawe et al [7], informed that the COP of the system increased and the pressure of condenser reduced into 20% respectively. Its pressure ratio also reduced in about 18%

A review of the evaporative cooling application of in split type air conditioners has been also performed using a paper media pad et al [8]. The results showed that the lower the temperature of the input, the pressure of the condenser and evaporator are lower, which is increase the COP of the system up to 20%. Kulkami M M et al [9] and Tianwei Wang et al [10] also conducted an evaporative cooling investigation on the split AC condenser, which concluding that there was a 22% increase in COP of the system and its energy consumption decreased into 16.7%. Evaporative cooling like spraying cold water from the conditioned space into the condenser cooling air increases the performance of the refrigeration cycle especially if this water at low temperature as possible [11,12,13,14]. The usage of evaporative cooling with axis stove as a media pad on condenser of the split AC has been done investigated et al [15]. From the research it was found that by using evaporative cooling on the condenser, the COP and EER of the system can be increased up to 20%. Sastra Negara et al [16] investigated the utilities of condensate water as pre-evaporative cooling at AC split 1 Pk. The investigation showed that cooling capacity increased around 12 ÷ 18%. From this point of view, it can be interpreted that simply wasted condensate water is still feasible to be used as a cooling medium on a split AC condenser.

2. Methodology

The split type of air conditioning application has a cooling capacity of 9000 Btu / hr which is made by Panasonic electric. Condensate storage tube is made and placed above the condenser and equipped with level control. Then it is connected to the drip tube placed above the condenser fins as shown in Figure. 1. If the condensate water in receiver tank full, it will begin to drip on to the surface of the condenser fins by opening the distribution valve. Once the condensate water is at the lowest level in the receiver tank, the distribution valve closes and the storage process of condensate water take place.

The compressor power consumption measuring instrument uses a digital AC clamp power meter (Kyoritsu, with 1.5% accuracy). The refrigerant pressure of the evaporator output is measured by bourdon tube pressure gauge which is suitable for refrigerant system with the 5 psi accuracy level. In this study pressure drop in both condenser and evaporator were ignored due to the effect on the end of the result was not significant. The temperature of the refrigerant, the air circulation of the evaporator and the condensate water at predetermined measurement points were recorded with the K type thermocouple. Test data is recorded every single minute for approximately 2.5 hours operational system.

Equation (1) to (4) are used to calculate the desired parameter. Equation (1) is used to calculate the compressor power consumption. Mass flow rate, cooling capacity and system performance are calculated by using equation (2), (3) and (4) respectively et al [17].

\[ W_p = V.I.\cos \varphi \]  \hspace{1cm} (1)
In all aquation, subscript (1), (2), (3) and (4) are each used to express the evaporator, compressor, condenser and capillary tube output conditions.

\[
\dot{m} = \frac{W_k}{h_1-h_3}
\]  
\[
Q_r = \dot{m} (h_1 - h_2)
\]  
\[
COP = \frac{Q_r}{W_k}
\]

Figure 1. Experimental design and instrument tool positions

3. Result and Discussion

Test procedure is carried out intermittently between using and without using condensate water. At the first time, the test is done without condensate water, then after the condensate water tank is full continued by using condensate water, respectively. Three repetitions is required during test. Recording data started after the steady state condition system which is estimated after 10 minutes operates. Test data is recorded every minute for approximately 2.5 hours (three periods) of operational system. The obtained data expressed in Table 1.

| Parameter                          | unit | AC/a | AC/b | AC/c | AC/d |
|------------------------------------|------|------|------|------|------|
| Condenser inlet temperature (T2)   | °C   | 79,4 | 78,8 | 79,1 | 78,2 |
| Condenser exit temperature (T3)    | °C   | 32,0 | 30,9 | 31,6 | 30,4 |
| Evaporator inlet temperature (T4)  | °C   | 15,7 | 15,3 | 15,7 | 15,0 |
| Compressor inlet temperature (T1)  | °C   | 23,5 | 24,1 | 22,8 | 24,0 |
| Condensing temperature (Tc)        | °C   | 40,8 | 39,9 | 41,9 | 40,8 |
| Evaporator pressure                | psi  | 175  | 165  | 175  | 170  |
| Condensate water temperature       | °C   | 21,2 | 20,1 | 20,1 | 20,3 |
| Evaporator inlet air temperature   | °C   | 29,9 | 29,9 | 29,9 | 30,0 |
| Evaporator exit air temperature    | °C   | 18,5 | 18,4 | 18,3 | 18,2 |
| Compressor electric current        | A    | 2,77 | 2,64 | 2,71 | 2,64 |
Mollier-Chart program is used to plot the data into P-h diagram. On P-h diagram, the value of enthalpy can be founded. The amount of enthalpy at each measurement position is used to calculate; Refrigeration effect, mass flow rate, cooling capacity and coefficient of performance (COP) system. Calculations are performed for both condition system, by using or un-using condensate water. One of the experiment results on P-h diagram can be seen in Figure-2. The graph show that condenser and evaporator pressure is decreasing while the condenser output temperatures are decreasing in which can increase the effect of refrigeration system. As can be seen in Table-1, as an additional cooling medium on the condenser is used in the system, the consumption of electric current which is used by the compressor was declined. Once the electric current decreases then the compressor power consumption will decrease respectively. If compressor power consumption is low and the refrigeration effect was increased, then the COP of the system will increase respectively.

| Voltage electric current | Volt | 225 | 225 | 228 | 227 | 227 | 227 | 227 |
|--------------------------|------|-----|-----|-----|-----|-----|-----|-----|
| AC                       | Air Conditioning condenser without condensate water |
| ACcd                    | Air conditioning condenser with condensate water |

Figure 2. P-h diagram of system with and without condensate water

Figure 3. Temperature conditions of state point on the system
Figure 3 shows the experiment result of temperature conditions on state point when the system used condensate water as an additional cooling to the condenser. It appeared that there was a slight decrease in the temperature of refrigerant entering condenser (T₂) and decreasing evaporator temperature (T_{evap}). On the order hand, there is a slight increase in the temperature of the evaporator output (T₁).

**Figure 4.** Refrigeration effect of the system during the operating period

Figure 4 shows that the refrigeration effect is increased during the period of condensate water as an additional cooling medium on the condenser. There is 2 % (in average) enhancement of refrigeration effect for the system using condensate water as additional cooling on condenser compared to the system without using condensate water as additional cooling on condenser.

**Figure 5.** Variation of Compressor power during the operating period

Figure 5 shows that the compressor power consumption decreases during the period of condensate water use as an additional cooling medium on the condenser. In average, there 3% decreased of power consumption of compressor in condenser which is used condensate water compared to the system without using condensate water. Decrease power consumption of compressor will certainly affect the amount of COP system.
As shown in Figure-6, by increasing refrigeration effects and decreased power consumption on the compressor can enhance COP of the system into 7% in average. The average cooling capacity during condensate water usage increased by 4% as well.

4. Conclusion
Based on of this study, can be concluded that by utilizing condensate water from the air conditioner (AC) system as an additional cooling medium intermittently on the condenser, the refrigeration capacity of the system increase in about 4%. The utilization of condensate water as an additional cooling medium intermittently on the condenser can also reduce the energy consumption of the AC system approximately 3%. The results of the study indicate 7% enhancement in the coefficient of performance (COP) of the system.

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