Enhancing performance of wall mounted split air conditioner using capillary tube in a tube heat exchanger

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Abstract. The high cost of electricity rates has affected the demands of the public for the availability of energy-efficient air conditioning systems. This study aims to obtain data on improving performance of air conditioner using capillary tube in tube heat exchangers. Tests were carried out on a wall mounted split AC capacity of 9000 Btu/h which was modified using a heat exchanger with capillary tube in tube heat exchanger. The results showed that the installation of a capillary tube in tube heat exchanger on a wall mounted split AC resulted in an increase RE and COP of 13.2% and 14.9%, respectively. In addition, the room cooling time in the TiTHX capillary mode testing is shorter. So it has implications for lighter compression work and saves the power consumption required by AC.

1. Introduction

Nowadays, many people spend their daily activities on the inside [1]. Air Conditioner (AC) is an electronic equipment that plays an important role in creating comfortable conditions in the room. The wall mounted split air conditioner is widely used in residential areas. AC is the biggest energy consumer in a building. In general, the energy requirements for an AC system are about half of the total energy consumption in buildings [2,3]. The level of electricity consumption in the largest in Indonesia is dominated by the AC system, especially in areas that have hot and humid climates such as Jakarta and Surabaya [4]. Conditions elsewhere are not much different, the energy consumption of HVAC systems in the United States consumes about 50% of building energy [5]. In Europe, around 40% of energy consumption is used in commercial buildings and homes [6]. Furthermore, in Middle Eastern Countries, more than 70% of energy consumption is used to support HVAC systems [7]. The use of air conditioning systems to create thermal comfort in residential, commercial and industrial environments has an impact on high energy consumption, especially in summer. Air conditioning energy savings will obviously have a considerable impact on the total consumption figures. An understanding of energy efficiency in AC systems is essential to protect the environment from the negative effects of air pollution generated by electrical equipment and to protect consumers from the high price of electricity bills.

One solution to improve the performance of an AC system can be done by using a heat exchanger. Refrigerant as it flows in the evaporator and suction line has a low temperature of cooled room temperature. After leaving the compressor the refrigerant flows in the condenser and liquid line with a temperature higher than the ambient air temperature, thus the refrigerant exits the condenser and enters the expansion device at a higher temperature than when inside the suction line. The difference in
temperature on both sides can be used as a heat exchanger. Installing a heat exchanger on an AC system is one way to lighten the work of the compressor in the system so that it will have an impact on reducing compressor power and electricity consumption [8]. Specifically the installation of heat exchangers in the cooling system is very effective to: improve system performance, cool the liquid refrigerant to prevent the formation of gas bubbles in the inlet to the expansion valve, and vaporize all liquid refrigerant coming out of the evaporator to prevent liquid from entering the suction channel compressor [9].

Based on literature studies, several researchers have applied the use of heat exchangers in various types of cooling systems with different types and sizes. First, the implementation of suction liquid heat exchanger is used to predict the benefits to be gained by the refrigeration system [10]. The results of his research explained that the use of a suction liquid heat exchanger will provide protection to the cooling system components and ensure that refrigerants to the expansion valve are in the form of liquid and refrigerants to the compressor in the form of vapour. Second, the use of suction liquid heat exchangers with various types of refrigerants in the cooling system will also affect the capacity of the system. It depends on a combination of operating conditions and fluid properties, such as: heat capacity, latent heat, and coefficient of thermal expansion [11,12]. Finally, the use of liquid-suction heat exchangers in low-capacity air conditioning rooms with R290 provides an advantage in increasing the energy efficiency of AC systems [13]. However, some problems are still found. The natural refrigerants that are made from hydrocarbons have flammable properties and the advantages of suction liquid heat exchangers installation rely on the combination of operating conditions and the properties of the fluid [12].

This study aims to obtain data on improving performance of air conditioner using capillary tube in tube heat exchangers. Tests were carried out on a wall mounted split AC capacity of 9000 Btu/h which was modified using a heat exchanger with capillary tube in tube heat exchanger. The use of heat exchanger is intended to lighten the work of the compressor so that it can reduce the electricity consumption needed.

2. Material and experimental method

Figure 1 shows the installation scheme of an experimental device used to obtain data on the improvement of AC system performance. The test was carried out on a unit of AC Elba EA90a with a capacity of 9000 Btu/h installed in a room. Component of tube in tube heat exchanger consists of copper pipe (Artic) with a thickness of 0.6 mm along 10 m, capillary pipe (Onda) Ø 0.07 "along 50 cm, flare nut and double naple copper size 1/4" and 3/8 "and 1/4 "copper T joint. The measuring instrument used consisted of four manifold gauge units (Robin air), four temperature sensor units (Elitech), and a clamp meter (Krisbow). Two pressure gauges and two temperature sensors were placed on the inlet and outlet of the compressor to measure the suction and discharge pressures-temperature. While the remaining tools are installed in the TiTHX inlet and outlet. Data collection is done when the system is in a steady condition that is when the room temperature starts from 27 C to 20 C and the working fluid used as primary refrigerant is R-410A.

The testing procedure is carried out for two conditions, first the operation of the AC system with a standard refrigeration cycle (baseline) and secondly the operation of the AC system uses the refrigeration cycle with a capillary tube in the tube heat exchanger (modification). Data was collected four times for each condition. The stages of testing conducted in this study are the first to calibrate all measuring instruments. Next, vacuum and check the leakage of the AC system and continue filling the refrigerant into the AC system. After that, record the ambient temperature when testing is done. Next turn on the AC system to begin the testing process which is carried out when the room temperature reaches 27 C to 20 C where observations are made every 1 C decrease. Finally, the testing process is repeated three times on different days.
3. Results and discussions
The results obtained from testing the performance of wall-mounted split air conditioners under two operating conditions: Standard mode and TiTHX Capillary mode. Tests have been carried out under load conditions of 27°C to 20°C with an ambient temperature of 31°C in a cooling cycle operating mode.

3.1. Refrigerating effect
Figure 2 shows the results of the refrigerating effect (RE) of the wall mounted split AC under two testing conditions. In general, the RE generated by the system using standard mode has a lower value than the TiTHX Capillary mode.

In the standard mode, the RE generated when the room temperature 27°C was 63.70 Btu/lb. Then, this decreased gradually to 62.20 Btu/lb when the room temperature was 21°C. After that, it is slight increase to 62.80 Btu/lb when the room temperature was 20°C. On the other hand, in the system which used TiTHX Capillary mode, the RE generated when the room temperature 27°C was 68.50 Btu/lb. Further, this gradually decreased to 67.70 Btu/lb when the temperature of the room temperature was
25 C. After that, it is gradually increase to 71.10 Btu/lb when the room temperature was 20 C. Based on the results, there is an increase in the RE of 13.2% in the TiTHX Capillary mode. The impact of using capillary tubes in tube heat exchangers on AC systems is that the aspect ratio of pressure becomes greater and the amount of heat able to be absorbed by the refrigerant in the evaporator is more thereby increasing the cooling capacity.

3.2. Coefficient of performance

Figure 3 presents the coefficient of performance systems (COP) of two mode conditions of the wall mounted split AC testing. In the standard mode, the COP decreased along with the decreasing room temperature. At first, the obtained COP was 4.79 when the room temperature was 27 C; the COP of was obtained 4.52 when the room temperature was 20 C. Furthermore, when the AC system uses the TiTHX Capillary mode, the COP obtained at the initial condition is 5.19. Next, COP has decreased gradually to 5.06 at room temperature 24 C. Then, COP has significantly increased to 5.21 at room temperature 23 C. After that, COP has decreased until the end of the test temperature with a value of 5.19. These results indicate that the use of Capillary TiTHX on the wall mounted split AC increased 14.9% value of COP. The high value of COP indicates that the system worked properly. The COP is influenced by the amount of heat which can be absorbed by the refrigerant flowing in the evaporator (refrigerating effect) and the compression work performed by the compressor when it compressed the low temperature-pressured refrigerant vapor to high temperature-pressured refrigerant vapor. If the value of the refrigerating effect is big and the value of compression work are small, the COP obtained will be large. The bigger the value of the refrigeration effect and the smaller the value of the compression work, the value of COP obtained will be better.

![Figure 3](image)

**Figure 3.** The COP of a wall mounted split AC under standard mode and TiTHX capillary mode.

3.3. Room cooling time

In Figure 4 the chart shows the time for cooling the room from 27 C to 20 C. The duration of the cooling time in the standard mode as a whole is 204 minutes, while in the TiTHX Capillary mode is 166 minutes. The cooling time in the TiTHX Capillary mode is shorter, this is influenced by the performance of the system parameters at each change in room temperature. The high value of the refrigeration effect produced in the TiTHX Capillary mode impacts the amount of heat absorbed in the room. The compression work performed by the compressor in the Capillary TiTHX mode is lower than the compression work in standard mode. This affects the compression work which compresses the vapour from evaporating pressure to condensation pressure becomes shorter.
Figure 4. The room cooling time of a wall mounted split AC under standard mode and TiTHX capillary mode.

4. Conclusions
Research on the use of capillary tube in tube heat exchangers to improve the performance of wall mounted split air conditioners has been carried out. To show the improvement of the performance of the AC system, the test was carried out in two different conditions. The results showed that the installation of a capillary tube in tube heat exchanger on a wall mounted split AC resulted in an increase in RE and COP of 13.2% and 14.9%, respectively. In addition, the room cooling time in the TiTHX capillary mode testing is shorter. So it has implications for lighter compression work and saves the power consumption required by AC.

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