The Enhancement of Split Type Air Conditioner by Improving the Cooling System For Residence

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Abstract

This paper aimed to design an improved cooling system of a split-type air conditioner, to compare the performance of a normal commercial air conditioner and an improved one, and to study the potential of the investment in improving the cooling system. The system consisted of rotary compressors. Its capacity at 12000 BTU / hr. (1 ton of refrigeration) using the air-cooling system and R32 refrigerant. Was a working fluid in the system. It was installed in the testing room with 70 centimeters of wide, 95centimeter of long, and 110 centimeters of high, which was covered with high-quality insulation. The improvements included 1) adding an 80-watt cooling fan in series with the existing one. 2) Installing a 280-watt heat exchanger in series with the existing condenser. In this study, the cooling loads were set at 600, 800,1,000, and 3,000 watts with the incandescent lamp. The testing room temperature was constant at 25 degrees Celsius. It was found that 1) The coefficient of performance and the electrical power of the system by adding the 80-watt cooling fan were at 2.68 and 1.42 kilowatts while the electrical charge lessened by 4.75% and the payback period was 1.98 years. 2) The coefficient of performance and the electrical power of the system by installing the 16- watt heat exchanger in series with the existing condenser were at 6.82 and 3.95 kilowatts while the electrical charge lessened by 9.39% and the payback period was 2.65 years. 3) The coefficient of performance and the electrical power of the system by adding the 80-watt cooling fan with the 16-watt heat exchanger were at 8.98 and 4.16 kilowatts while the electrical charge lessened by 13.89% and the payback period was 2.39 years.

Keyword: spilt type air conditione, coefficient of performance, cooling system, energy saving

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Introduction

At present, the weather conditions in Thailand are increasing, causing a large number of air conditioners to be installed and it is likely to continue to increase. From data on the proportion of energy use in the industrial sector and residential buildings, it is found that energy use is more than 60%.

A large percentage of both types of buildings come from cooling and air conditioning systems, resulting in the demand for electricity in Thailand increasing. Due to this situation, air conditioners are now widely used in residences and offices. To adjust the internal temperature appropriately and create a comfortable feeling for residents. Usually, an air conditioner is a device. that is the top waste of electrical energy causing the country's electrical energy consumption to increase Therefore, there must be a need to reduce the amount of electrical energy used or help electrical equipment to work with maximum efficiency. This research is another approach that wants to increase the performance coefficient of air conditioners in order to reduce the amount of electrical energy used. The objective of this research is to design and improve the cooling system for split air conditioners. Conduct a comparative study of the performance coefficients of split air conditioning systems.

Methodology

In the case of improving the cooling system and normal system and study the pressure values for improving the cooling system of split air conditioners. Vapor compression refrigeration cycle It starts with the compressor's duty to suck in and compress the refrigerant by isentropic compression to increase the pressure and temperature of the refrigerant until it forms superheated vapor which is then sent to the condenser. The refrigerant flows through the condenser and condenses into a saturated liquid, causing the refrigerant leaving the condenser to drop in temperature. The constant pressure is then sent to the pressure reducing device. The refrigerant flowing through the pressure reducing device will have a lower pressure and temperature than the area that needs to be cooled and will flow into the evaporator. The refrigerant will then flow through the evaporator with a fan. It is used to absorb heat in a mixture with low vapor quality. The refrigerant will draw heat from the part that needs to be cooled, causing the refrigerant to evaporate and become saturated vapor, and the room temperature will decrease. The temperature of the coolant coming out of the evaporator will rise. The constant pressure then flows to the compressor again.

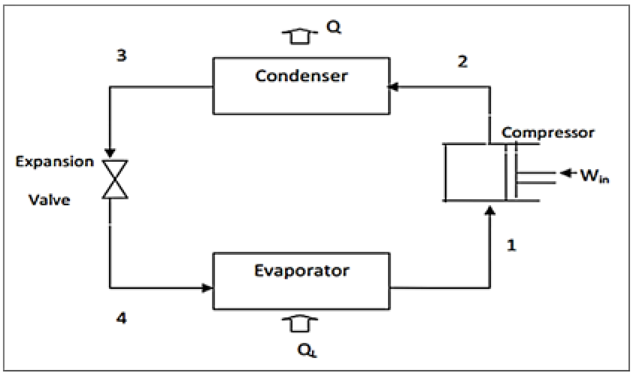

Figure 1. shows the vapor compression refrigeration cycle.

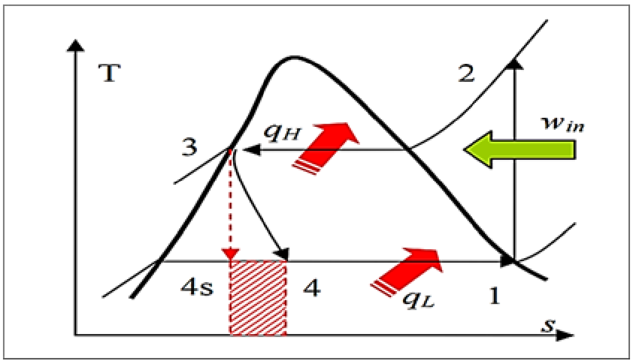

Figure 2. T-s Diagram of the vapor compression refrigeration cycle.

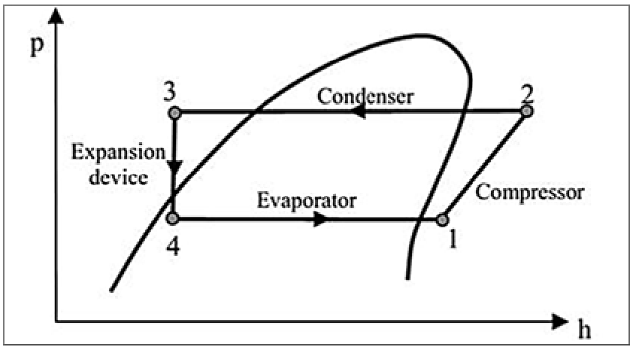

Figure 3. P-h Diagram of the vapor compression refrigeration cycle.

Compressor is a device that compresses refrigerant with low temperature and low pressure to a second state which has high height and high temperature. Pressing the vapor from state 1 to state 2 will compressing the refrigerant using an isentropic process. The energy generated by the compression of the compressor acting on the refrigerant is equal to

$$W_{com} = h_2 - h_1$$

When

W_{com} = Power supplied to the compressor (W)

h_1= Enthalpy of refrigerant before entering the compressor in units (kJ/kg)

h_2= The unit of enthalpy of refrigerant leaving the compressor is (kJ/kg)

Condenser is a device that releases heat or transfers heat and results in the refrigerant condensing. By releasing heat outside the system, that is, when the refrigerant flows through the condenser, heat will be transferred outside the system. The superheated vapor refrigerant gradually changes to liquid in state 3.

$$Q_{Cond} = h_2 - h_3$$

When

Q_{cond}= Amount of heat transferred out of the condenser (W)

h_2 = The enthalpy of the refrigerant leaving the compressor is (kJ/kg)

h_3 = Enthalpy of refrigerant leaving the condenser (kJ/kg)

Pressure reducing valve (Expansion Valve) reduces the pressure of refrigerant with high pressure values. to have a low blood pressure effect from high pressure state 3 to low pressure state 4 as shown in Figure 2., there is a change from liquid to a mixture of liquid and vapor. This is because refrigerants boil at low temperatures and pressures. Therefore, when the refrigerant expands through the pressure reducing valve, the temperature and pressure of the refrigerant decrease. In this process, the enthalpy value remains constant throughout the pressure reduction period from state 3 to 4 as shown in Figure 3.

Evaporator is a device that receives and changes heat from the liquid in the process. Forms a vapor and provides cooling in the area that needs cooling. Therefore, when cooling the refrigerant that is in a state of mixture between liquid and vapor. When flowing through the evaporator It will take in the heat and slowly Change state from vapor mixed with liquid to all vapor before entering the compressor at state 1 with the heat transfer equation as follows.

$$Q_{evap} = h_1 - h_4$$

When

Q_{evap}= Heat transfer to equipment

h_1 = The unit of enthalpy of the refrigerant before entering the compressor is (kJ/kg).

h_4 = Enthalpy of refrigerant vapor before entering the evaporator (kJ/kg)

Coefficient of Performance COP is a value used to express the efficiency of cooling as a comparison between the effect of cooling on the work given to the system or COP.

COP = Cooling power provided by the evaporator (Btu/hr)/ Power in the form of heat provided by the compressor (Btu/hr)

Cooling efficiency EER (Energy Efficiency Ratio) is a value showing the energy efficiency ratio of the chiller. This is used as a reference to compare the energy consumption of refrigeration and air conditioners. Currently in Thailand The Industrial Product Testing Center has tests to certify the standards of refrigeration and air conditioners from the EER value, which has units of Btu/hour Watt in the English system or watts (no units) in the SI system, with the higher the ratio, the higher the value. It will show more energy saving.

EER = Power used (power input) (watt) /Cooling output (Cooling output)(Btu/hr)

System design

The split type air conditioner with compressed air capacity of 1,2000 BTU per hour. air cooled Uses R-32 refrigerant as refrigerant. It is equipped with twin cooling fans and a heat exchanger behind the condenser. which in design The dimensions of the room used for the experiment were width, length and height 70 × 110 × 95 centimeters.

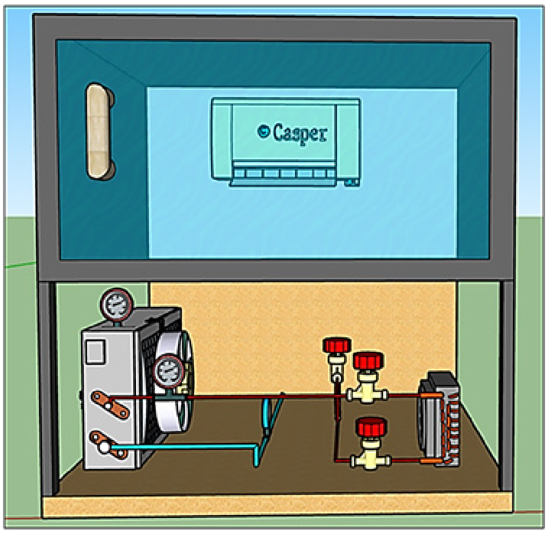

Figure 4. Air conditioning unit design (front)

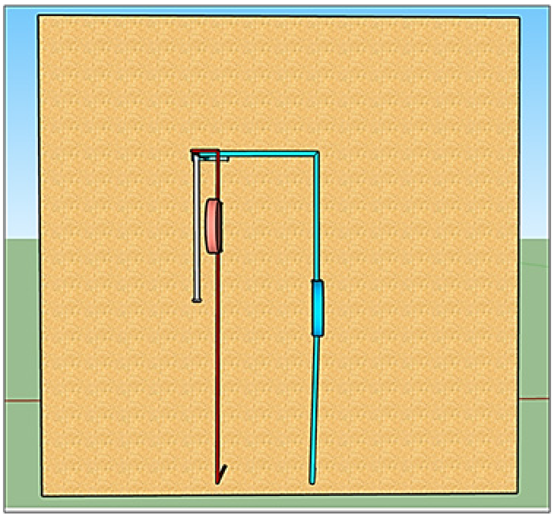

Figure 5. Air conditioning unit design (back) Installing the data acquisition tool.

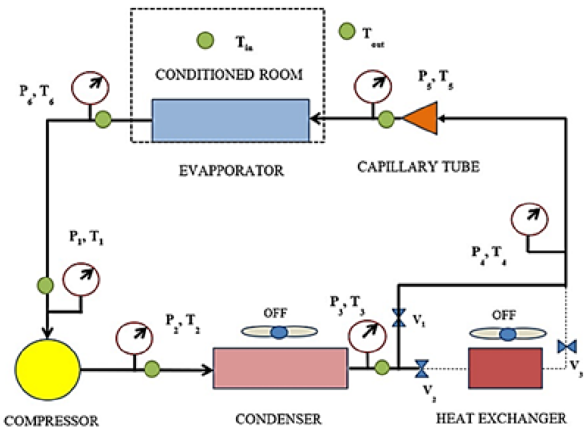

Figure 6. shows the cooling circuit and experimental measurement location before the improvement.

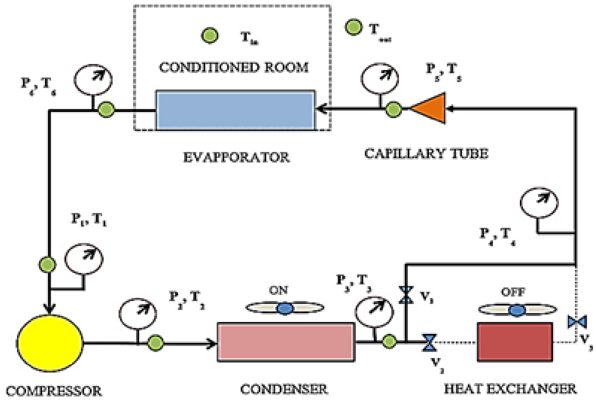

Figure 7. shows the cooling circuit and experimental measurement location after the improvement by installing the dual cooling fans.

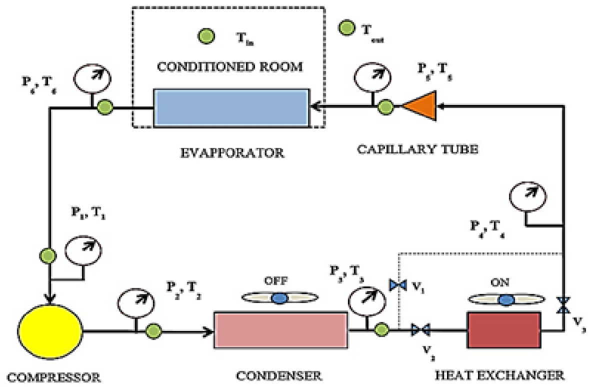

Figure 8. shows the cooling circuit and experimental measurement location after improvements by installing a heat exchanger behind the condenser.

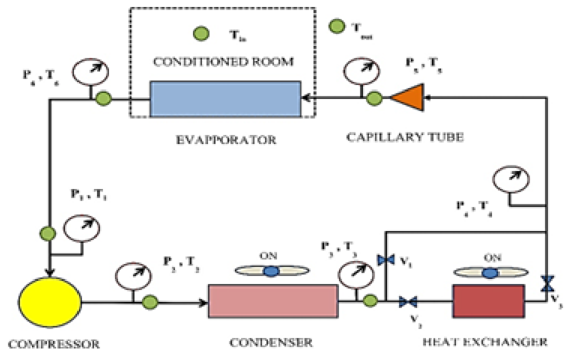

Figure 9. shows the cooling circuit and experimental measurement location after the modification by installing a pair of cooling fans together with a heat exchanger behind the condenser.

Results and discussion

It was found that the heat transfer rate of the condenser in all 3 cases was compared to the original air conditioner. The heat transfer rate of the condenser (Qcon) increases as follows. Installation of double cooling fans increased by 1.07 percent. Installation of heat exchange equipment behind the condenser increased by 1.07 percent. 2.26 and installing a pair of cooling fans together with a heat exchange device behind the condenser increased by 3.35 percent because installing a cooling fan resulted in the heat transfer coefficient increasing according to the speed of the cooling air. rising heat Installing a heat exchange device behind the condenser increases the heat transfer area between the refrigerant (R-32) inside the pipe and the air flowing through it.

Results of comparing the cooling rate of the air conditioner with the air conditioning load.

From Figure 11, it is found that the cooling rates of the air conditioners in all 3 cases are compared to the original air conditioners. The cooling rate of the air conditioner (Qevap) increases as follows. Installation of double cooling fans increased by 2.51 percent. Installation of heat exchange equipment behind the condenser increased by 2.51 percent. 1.16 and installing a pair of cooling fans together with a heat exchange device behind the condenser increased by 4.37 percent because installing a cooling fan resulted in the heat transfer coefficient increasing along with the speed of the cooling air. rising heat Makes the cooling rate of the air conditioner increase. As for installing a heat exchange device behind the condenser, it increases the heat transfer area between the refrigerant (R-32) and the cooling area. The results are Can reduce the temperature and pressure of the refrigerant before entering the evaporator. As a result, the heat exchange rate in the condenser increases, which increases the cooling rate.

Comparison results of cooling performance coefficients (COP) with air conditioning load.

From Figure 12, it is found that the cooling performance coefficient (COP) in all 3 cases is compared to the original air conditioner. The coefficient of cooling

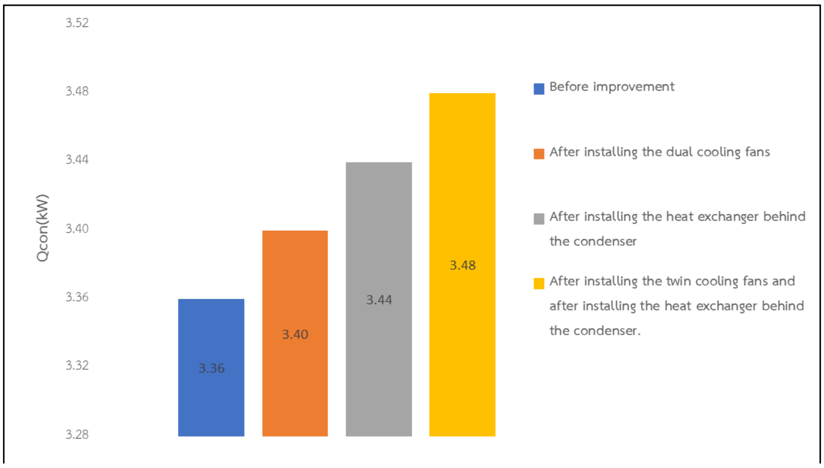

Figure 10. shows the heat transfer rate of the condenser with the air conditioning load.

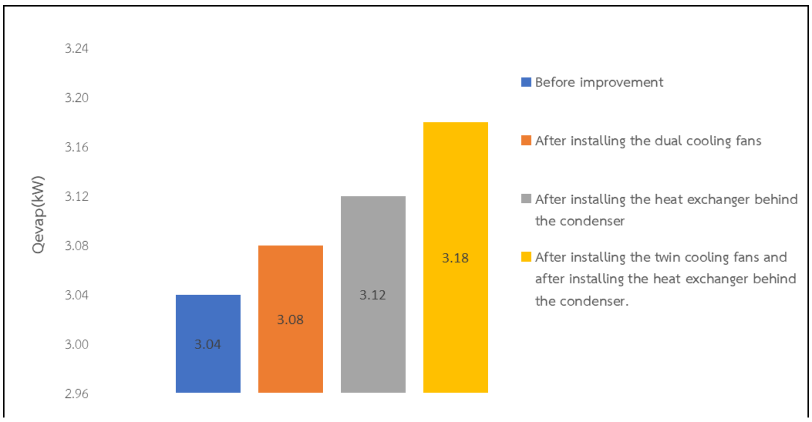

Figure 11. shows the cooling rate of the air conditioner and the air conditioning load.

performance (COP) increases as follows. Installation of double cooling fans increased by 2.68 percent. Installation of heat exchange equipment behind the condenser increased by 2.68 percent. 6.82 and the installation of a pair of cooling fans together with a heat exchange device behind the condenser increased by 8.98 percent due to the installation of a pair of cooling fans. Has an increased cooling performance coefficient. This is because the heat released from behind the condenser is dissipated faster by installing additional cooling fans. The cooling of the condenser is therefore better. Installing the heat exchanger behind the condenser has the highest cooling efficiency coefficient. Because there is more cooling space Can reduce the temperature and pressure leaving the condenser. cause condensation The results obtained That is, it will be possible to reduce the energy that must be fed to the compressor and increase the cooling rate, causing the cooling performance coefficient to increase accordingly.

Results of comparison of energy efficiency ratio (EER) with air conditioning load.

From Figure 13, it is found that the energy efficiency ratio (EER) in all 3 cases is compared to the original air conditioner. The Energy Efficiency Ratio (EER) increased as follows. The installation of dual cooling fans increased by 2.68 percent, the installation of heat exchange equipment behind the condenser increased by 6.82 percent, and the installation of dual cooling fans combined with heat exchange equipment behind the condenser increased by 6.8 percent. 8.98 percent.

Results of comparing the electrical power supplied to the air conditioning system with the air conditioning load.

From Figure 14, it is found that the electrical power supplied to the air conditioner system in all 3 cases is compared to the original air conditioner. The electrical power supplied to the air conditioning system is reduced as follows. Installations of dual cooling

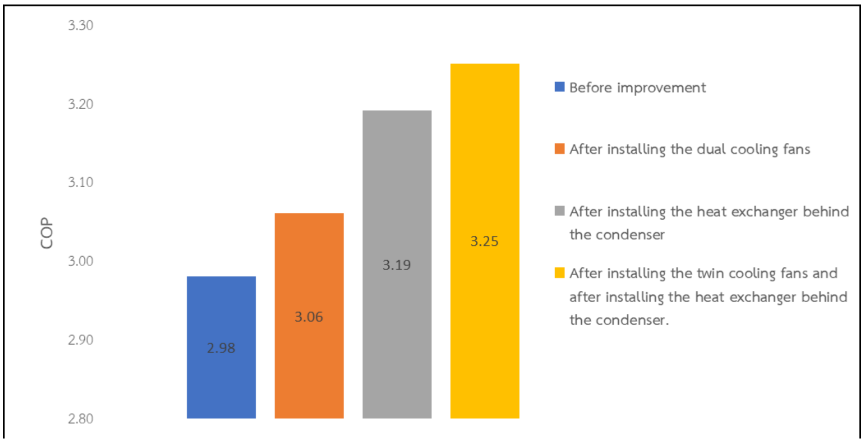

Figure 12. shows the coefficient of cooling performance (COP) with the air conditioning load.

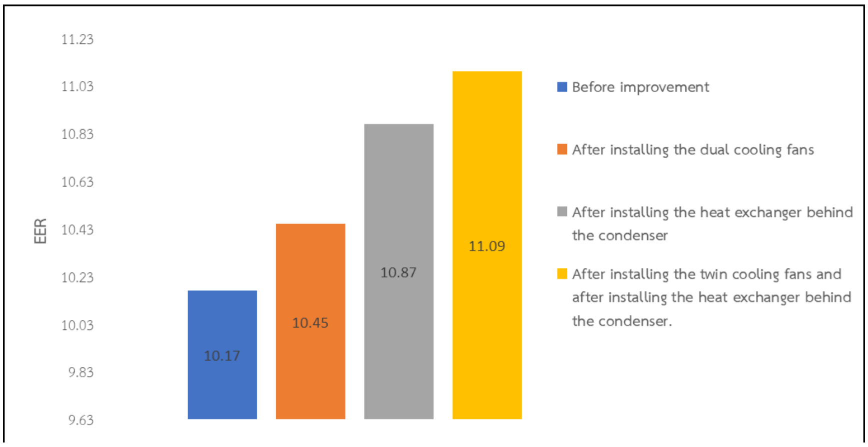

Figure 13. shows the energy efficiency ratio (EER) with the air conditioning load.

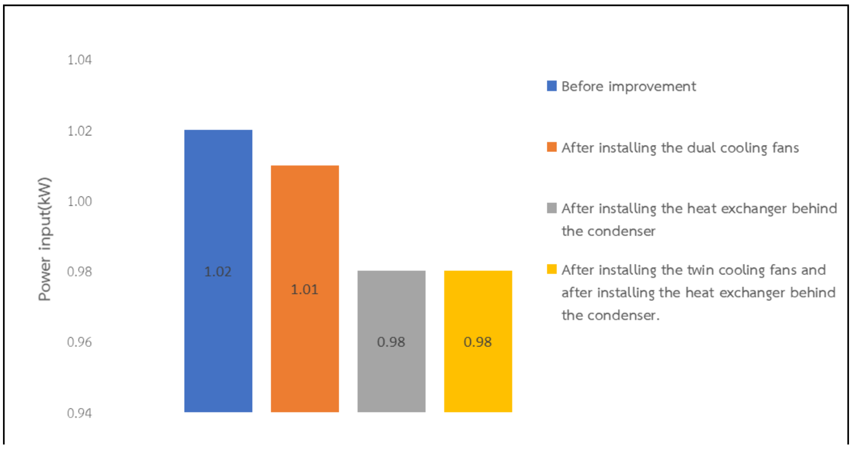

Figure 14. shows the electrical power supplied to the air conditioning system and the air conditioning load.

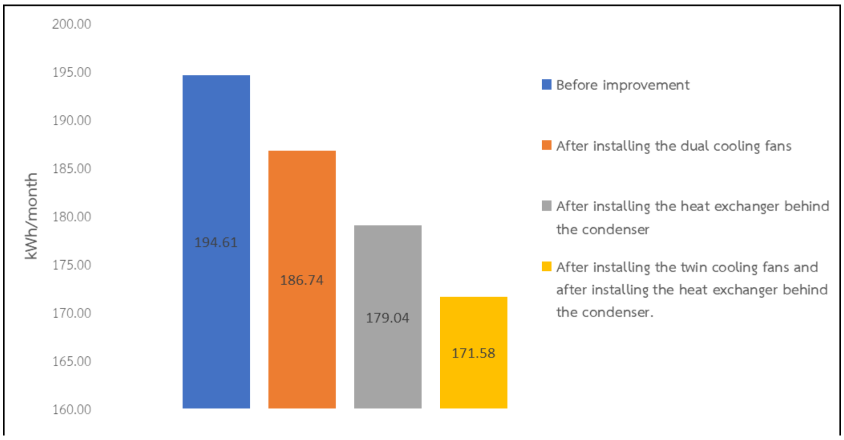

Figure 15. shows the electrical energy consumption for air conditioning for 8 hours and the air conditioning load.

fans decreased by 1.42 percent, installations of heat exchangers behind the condensers decreased by 3.95 percent, and installations of dual cooling fans and heat exchangers behind the condensers decreased by 3.95 percent. 4.16 percent.

Comparison results of electrical energy consumption of air conditioners with air conditioning load. Quantity: 8 hours

From Figure 15, it is found that the electrical energy consumption of the air conditioners in all 3 cases is compared to the original air conditioners. Electrical energy consumption of air conditioners decreased as follows: Installation of double cooling fans decreased by 100%. 4.04 Installation of heat exchange equipment behind the condenser decreased by 8.00 percent and installation of dual cooling fans with heat exchange equipment behind the condenser decreased 11.83 percent.

Results of comparing electrical energy consumption of air conditioners with air conditioning load for 16 hours.

From Figure 16, it is found that the electrical energy consumption of the air conditioners in all 3 cases is compared to the original air conditioners. Electrical energy consumption of air conditioners decreased as follows: installation of dual cooling fans decreased by 3.49 percent, installation of heat exchange equipment behind the condenser decreased by 7.61 percent, and installation of dual cooling fans as well. Heat exchange equipment behind the condenser decreased by 11.81 percent.

Results of comparing electrical energy consumption of air conditioners with air conditioning load for 24 hours.

From Figure 17, it is found that the electrical energy consumption of the air conditioners in all 3 cases is compared to the original air conditioners. Electrical energy consumption of air conditioners decreased as

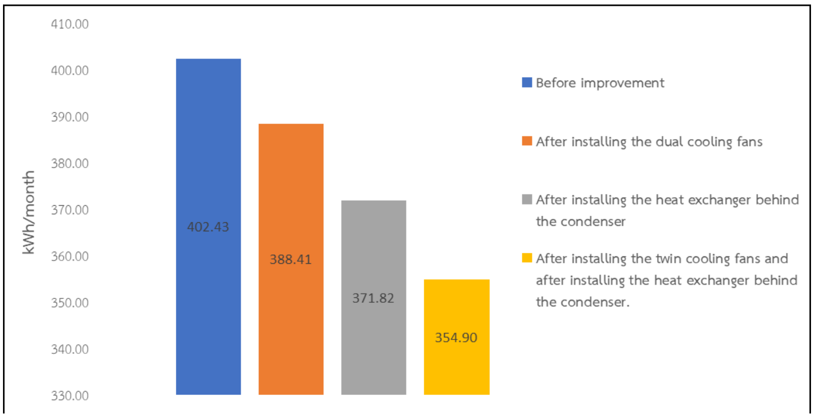

Figure 16. shows the electrical energy consumption of the air conditioner for 16 hours with the air conditioning load.

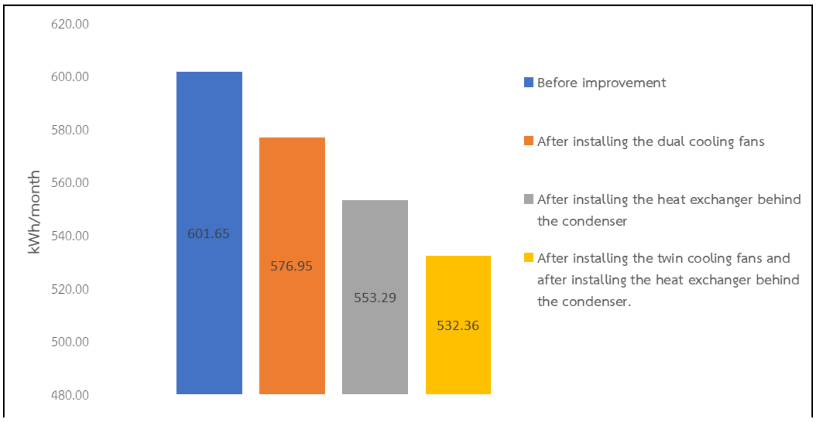

Figure 17. shows the electrical energy consumption of the air conditioner for 24 hours with the air conditioning load.

follows: Installation of double cooling fans decreased by 100%. 4.42 Installation of heat exchange equipment behind the condenser decreased by 8.34 percent, and installation of dual cooling fans with heat exchange equipment behind the condenser decreased by 11.81 percent.

Results of comparing the electrical energy used by air conditioners with the burden of air conditioning. Quantity: 8 hours

From Figure 18, it is found that the electrical energy used in all 3 cases of air conditioners is compared to the original air conditioners. The cost of electrical energy used by air conditioners has decreased as follows. The installation of dual cooling fans decreased by 4.75 percent, the installation of heat exchange equipment behind the condenser decreased by 9.39 percent, and the installation of dual cooling fans combined with heat exchange equipment behind the condenser decreased. 13.89 percent

Results of comparing the electrical energy used by air conditioners with the burden of air conditioning. Quantity: 16 hours

From Figure 19, it is found that the electrical energy used in all 3 cases of air conditioners is compared to the original air conditioners. The cost of electrical energy used by air conditioners has decreased as follows: Installation of dual cooling fans decreased by 3.81 percent. Installation of heat exchange equipment behind the condenser decreased by 8.25 percent, and installation of dual cooling fans with heat exchange equipment behind the condenser decreased by 12.77 percent.

Results of comparing the electrical energy used by air conditioners with the burden of air conditioning. Quantity: 24 hours

From Figure 20, it is found that the electrical energy used in all 3 cases of air conditioners is compared to the original air conditioners. The cost of electrical en-

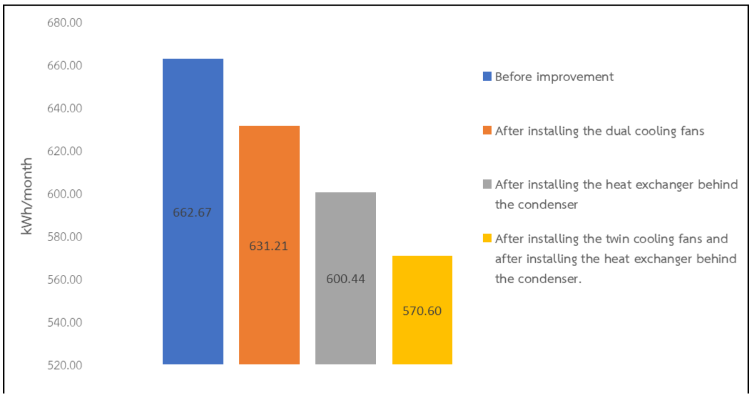

Figure 18. shows the electrical energy used by the air conditioner for 8 hours and the air conditioning load.

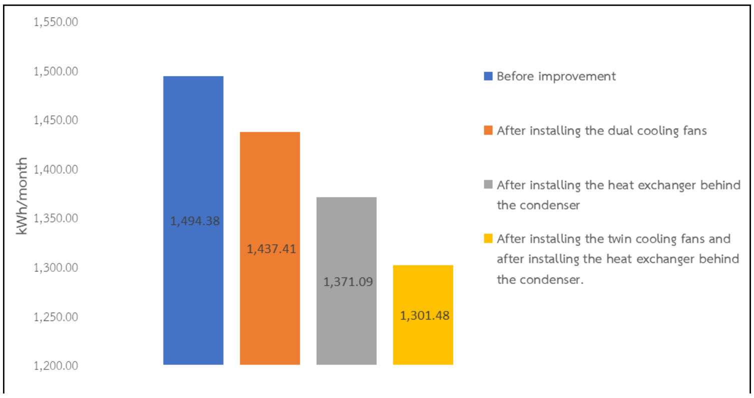

Figure 19. shows the electrical energy used by the air conditioner for 16 hours and the air conditioning load.

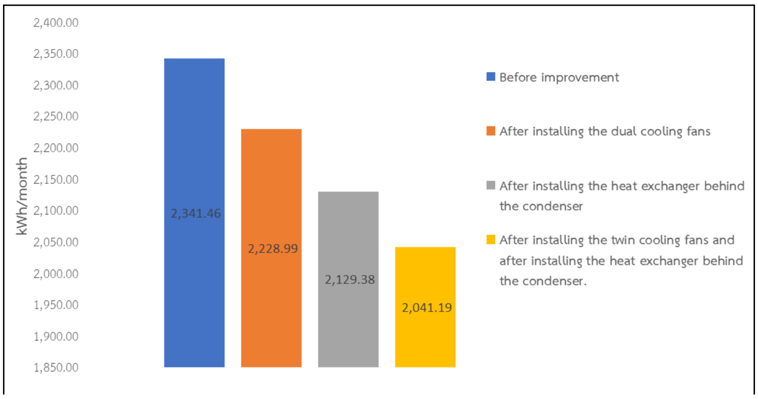

Figure 20. shows the electrical energy used by air conditioners for 24 hours and the air conditioning load.

ergy used by air conditioners has decreased as follows. The installation of dual cooling fans decreased by 4.80 percent, the installation of heat exchange equipment behind the condenser decreased by 9.06 percent, and the installation of dual cooling fans combined with heat exchange equipment behind the condenser decreased. 12.82 percent.

Conclusion

Results of comparison of payback period with air conditioning burden. Quantity: 8 hours

From Figure 21, it was found that installing a double cooling fan has an average payback period of 1.98 years, installing a hot exchange device behind the condenser has an average payback period of 2.65 years, and installing a cooling fan. Coupled with a heat exchanger behind the condenser, the average payback period is 2.39 years.

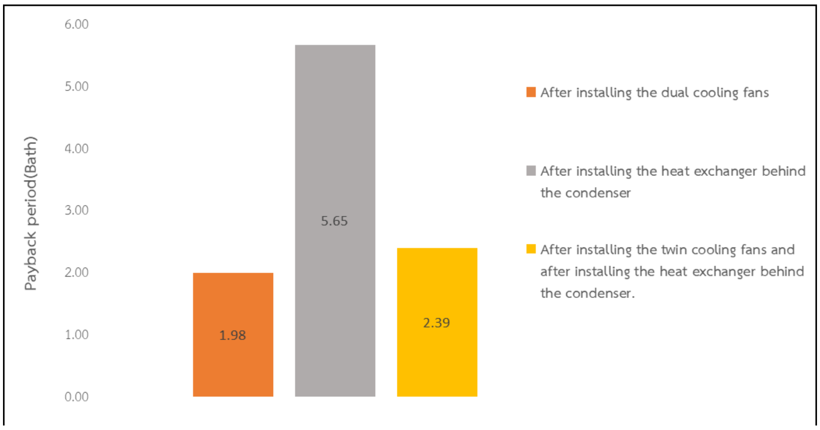

Figure 21. shows the payback period with air conditioning load of 8 hours.

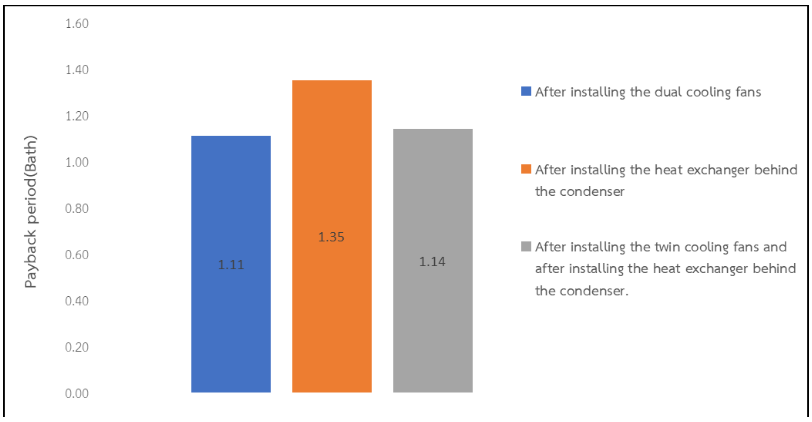

Figure 22. shows the payback period with air conditioning load of 16 hours.

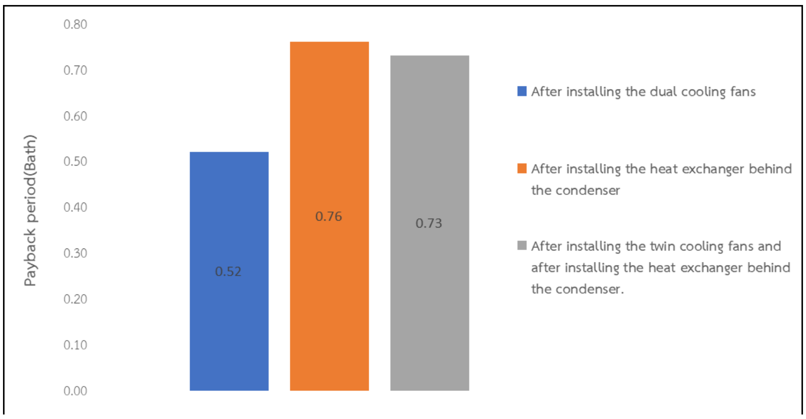

Figure 23. shows the payback period with air conditioning load of 24 hours.

Results of comparison of payback period with air conditioning burden. Quantity: 16 hours

From Figure 22, it was found that installing a pair of cooling fans has an average payback period of 1.11 years, installing a hot exchange device behind the condenser has an average payback period of 1.35 years, and installing a cooling fan. Coupled with a heat exchanger behind the condenser, the average payback period is 1.14 years.

Results of comparison of payback period with air conditioning burden. Quantity: 24 hours

From Figure 23, it was found that installing a double cooling fan has an average payback period of 0.52 years, installing a hot exchange device behind the condenser has an average payback period of 0.76 years, and installing a cooling fan. Coupled with a heat exchanger behind the condenser, the average payback period is 0.73 years.

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