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Study of Air conditioner system cooling by water with Heat recovery to Supply hot water for human living

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Abstract: To reuse the heat resource discharged from the condenser system of an air conditioning cooler with water, we carried out the fabrication and the installation of heat exchanger to recover part of the waste heat of the refrigerant cold to hot water heating. After manufacturing a complete model, the input/output parameters were measured in certain period timesand conditions. By evaluating and comparing the data obtained as employing the simulation, the effected parameters were released bythe experimental process. The results showed that the ability to recover the heat of the actual system achieved 36%, hot water temperature reached 41^0C and supllied to the living conditions that do not affect the working of the system.
Keywords: Heat recovery; air conditioning; hot water; heat exchanger.

1. Introduction

Currently, the demand for air conditioning and hot water in civil field as consumption power is quite large [1, 2]. Therefore, the development of systems that use energy sparingly play key and strategical role to the economic development of the country. With his reason, this issue is attractive to scientists.

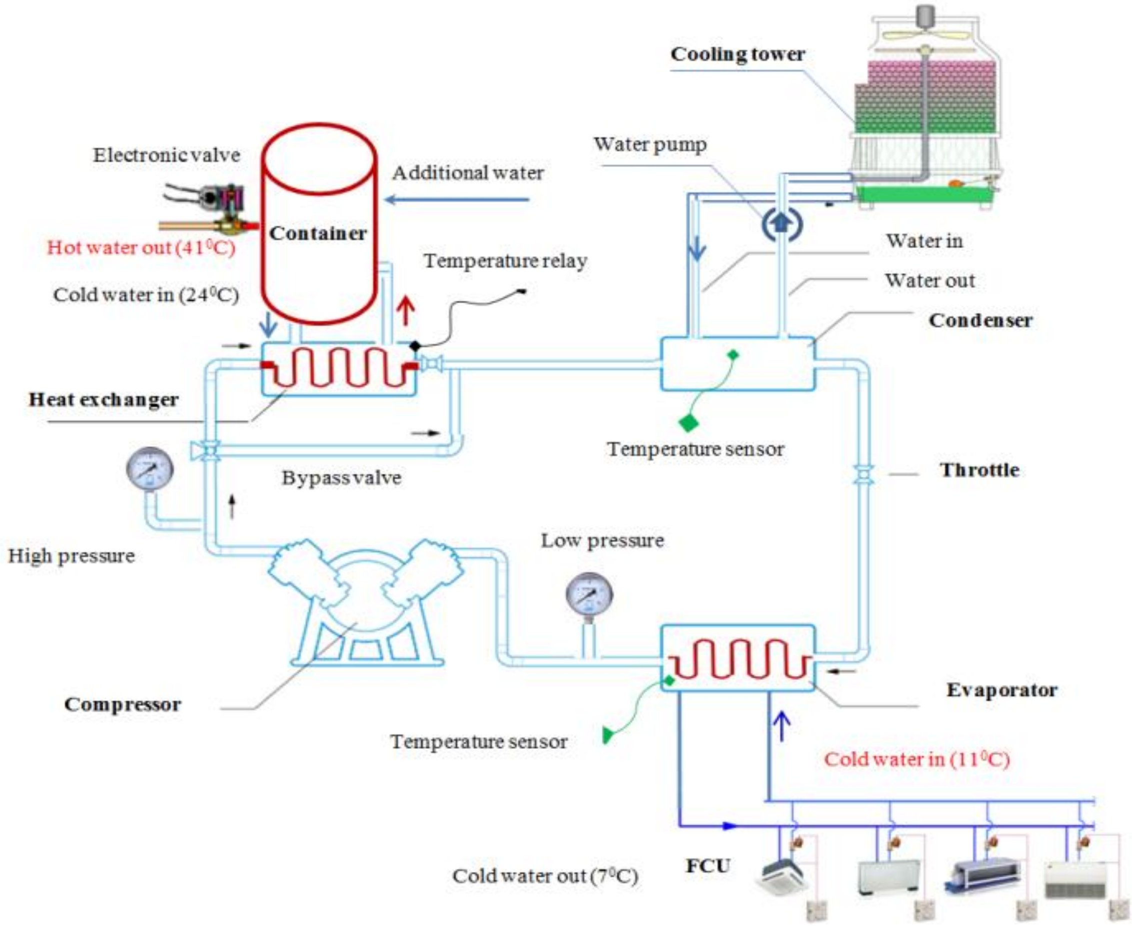

Figure 1: The principle diagram of air conditioning system with waste heat recovery

Furthermore, using direct heating equipment with electricity, although there are many advantages, they are not significantly effective in energy. For this reason, we planned to product and examine the system air conditioner style cooled by water, which recovered waste heat from the coolant to heat the hot water for supplying human activities. This will bring the high efficiency in consuming energy and significantly contribute to reduce the use of power sources available, to meet the development needs of industrialization and modernization of the country and protect the environment.

Water-cooled air conditioning system with a water temperature of approximately 7^0C gives the FCU (Fan Coil Unit) and AHU (Air Handling Unit) cools air in the room, and we design heat exchanger to revoke this heat that supplies hot water of41^0C for human living. The remaining excess heat will discharge into the environment through the cooling tower, which helps to increase the system's working efficiency. The main parts of the system include compressors; heat exchanger equipment; condensate; evaporation tank; saving equipment; cooling tower; gauges; water pumps; control devices; pipeline system; sensors. In the design and fabrication model, the condensate temperature of R22 refrigerant is surveyed in the range $(45 \div 50)^0$C corresponds to the pressure $(17 \div 18)$ bar and boiling temperature of the lips achieved from $(-5 \div 0)^0$C corresponding to the pressure $(4 \div 6)$ bar.

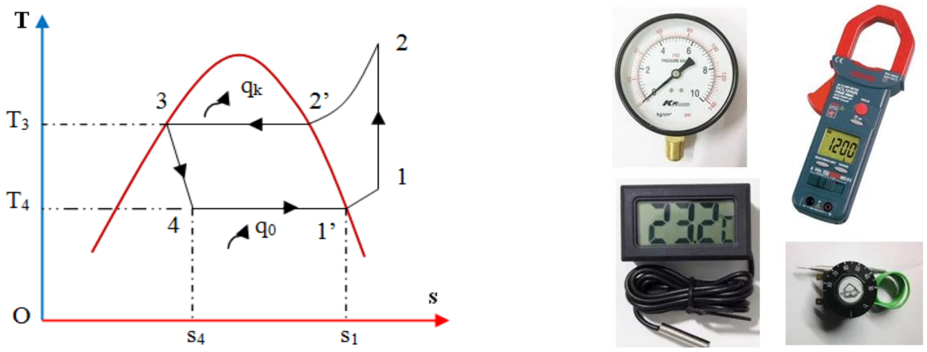

Figure 2:T-s graph of air-conditioning systems and measuring equipment

* When the waste heat is not recovered (without water in the bottle of the heat exchanger), the by-pass valve opens, there frigerant goes directly to the condenser. At this time, the entire amount of heat in the refrigerant is discharged to the water in the condenser and then is taken to the cooling tower.

* When the waste heat is not recovered, the water valve opens to the heat exchanger. Here, the refrigerant passes through heat exchanger (valve by pass closed) and then to a condenser, water receives heat coming primarily from super heated steam, until it reaches the required temperature that is installedat41^0C (but still lower than the temperature of refrigerant'scondensation).The temperature relay force, then,to valve opened for hot water drawing out the heat exchanger, providing to living process. In the model, we calculate the percentage of heat exchange are a between two devices and arranged logically so that most of superheat of refrigerant is used to heat the water, the rest is saturated steam condenses at the condenser. Energy efficiency index of retractable conditioning is calculated as follows: $\eta = \frac{Q_{th} + Q_0}{L_{mn}}$, with L_{mn}- the compressor; Q_0- average revenue from its heat evaporates; Q_{th}- heat obtained from the heat exchanger. Observation on the graph T- s and η found expression can try blowing the entire amount of heat from condensers q_k if the hot water temperature provides valuable living below the condensation temperature of theair cooling system with water [2]. On the other hand, through survey research types such as R22 refrigerant; R134a; R32; R502 ... We find that the higher the value of the refrigerant η was,the lower the condensing temperature was [4]. However, the effective recovery is not maximized because it is influenced by many other factors such as condensing pressure, type of refrigerant, compressor ... The waste heat recovery coefficient is realistically calculated based on the amount of heat that the hot water in heat exchanger received versus the amount of power consumed by the air-conditioned [3]. This result would be carried out in the experimental model.

2. Experimental method

The air conditioner model is designed and manufactured in order to recover a part of heat Q_{th} ranging of 25% ÷ 50% of the waste heat from the air conditioner [2].

While the air conditioning systems with water cooling and heat recovery are consistent with the large constructions.With the input parameters as hot water flow choose M = 11 liters,the water 's cold temperature at

$t_1 = 24^0C$; the hot water temperature $t_2 = 41^0C$; time $\tau = 2$ machine operating hours was selected. The refrigerant used in the system is R22 and specific heat of water C_n = 4186 J / kg^{0}K; condensing temperature $t_k = 45^0C$; evaporation temperature $t_0 = 0^0C$ is set-up. Based on the graph T- s, the table lookup and interpolation of results is performed to identify the parameters at state nodal points of the cycle as follows: the heat needed to raise 11 liters of water from a temperature t_1 to t_2 during time τ is (ignoring losses): $Q_k = \frac{M.C_n(t_2 - t_1)}{\tau}$, W. Replace the data, we get the required heat result of the system is Q_k = 108 (W); separate cooling capacity of the cycle: $q_0 = i_{1'} - i_4$ = 158 (kJ/kg); condensing heat capacity separately: $q_k = i_2 - i_3$ = 192 (kJ/kg); refrigerating capacity of the compressor: $Q_0 = Q_k \frac{q_0}{q_k} = 89$ (W).And, the heat exchange area of the condenser is: $F_k = \frac{Q_k}{q_k} = \frac{Q_k}{k_k.\Delta t_k}$; (m^2). According to earlier studies cited from [1, 5] select the average temperature difference logarithmic $\Delta t_k = 6^0K$; Q_k- condensing heat capacity; the heat transfer coefficient k_k=745 W/m^2.K.The calculation, therefore, resulted in F_k = 0,024 m^2. The heat exchange area of the average evaporation: $F_0 = \frac{Q_0}{q_0} = \frac{Q_0}{k_0.\Delta t_0}$; (m^2). According to [1, 5] select the average temperature difference logarithmic $\Delta t_0 = 7^0K$; Q_0- refrigerating capacity of the compressor; heat transfer coefficient k_0 = 356 W / m^2.K. Hence, the result is F_0 = 0,035 calculated m^2.

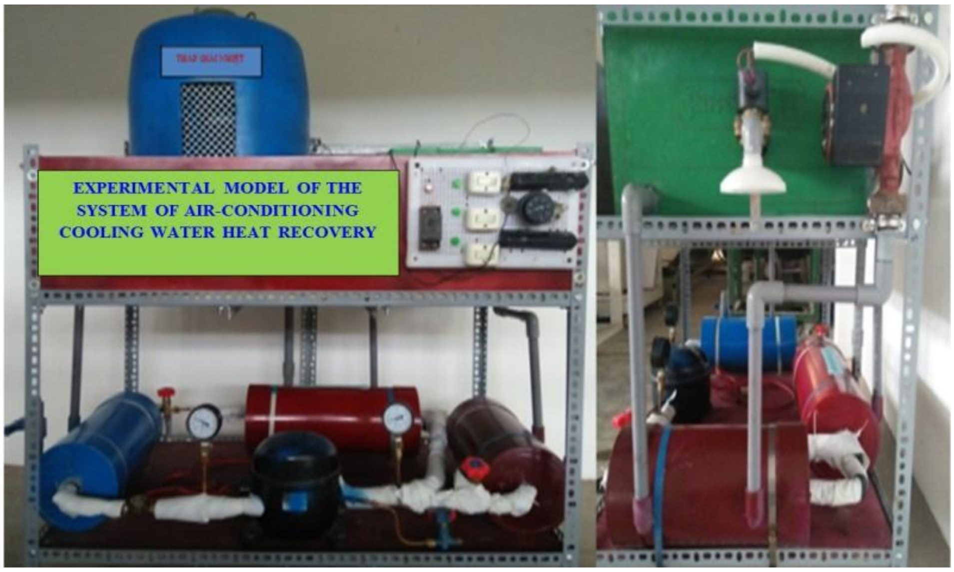

Figure 3: Experimental model

The models are manufactured with hermetic compressor capacity of 185W; condenser with 10 liters of capacity; Evaporation in8-liter of bottle; throttling device; two circulating water pump power 55W; 40W fan cooling tower; plumbing systems; water temperature measuring equipment, amperage and condensing pressure of the refrigerant; 20liters of hot water tank is insulated and other ancillary equipment. All parameters of the device are originally consistent with the data selected, work safety and stability. The system is equipped with a by-pass valve installed to models, which are able to operate in two modes and does not collect waste heat recovery.

3. Results and Discussions

3.1. The change in average temperature of the water when heat recovery over time

When the system starts operating, the water temperature increased rapidly due to water at low temperatures (24^{0}C).Hence, most of the waste heat from the refrigerant (superheated steam from point 2 to 2'shown on the graph T-s) absorb the water, and we can see that it is a conditioning, cooling water [3]. When the water temperature increases, the temperature, and pressure of the refrigerant condenses increase. Until the water temperature rose nearly by the condensing temperature of the refrigerant, the amount of heat that water received started falling. Also, when the water temperature in condenser pressure increases, leading to the increment in the refrigerant condenses. However, when the hot water temperature is greater than 41^{0}C (close to the condensation temperature of refrigerant), the temperature irelays reiforce to open solenoid valve to bring the water into containers providing for the load temperature, to ensure the conditioning system operates safely, the rest were sent to a condenser for cooling. These values were measured continuously during the experiment and shown in Figure 4.

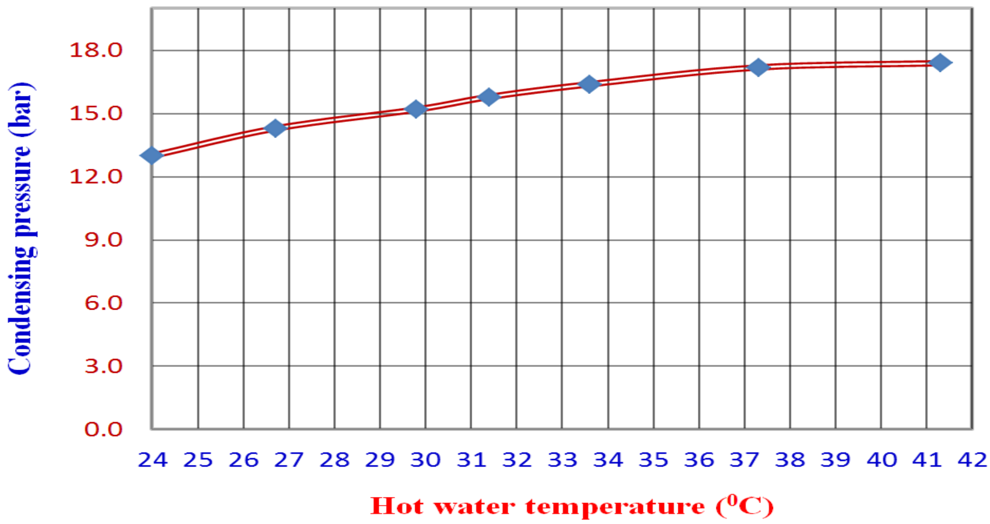

Figure 4: The change in average temperature of the water when heat recovery over time

3.2. The change in pressure of the refrigerant condensing temperature hot water

When the average water temperature in the heat exchanger increases, the condensing pressure of refrigerant increases. However, when the water temperature is greater than 41^{0}C, the pressure is back to increase and stabilize at values close to the one of the system's pressure under normal running mode(do not waste heat recovery). This is explained by the heat exchanger waste heat recovery is in series with the condenser cooling water. Therefore, if the temperature of hot water in the average is higher than the condensing temperature corresponding to the condensing pressure, the refrigerant condenses in the condenser of the freezer. At this time, the system operates at stable pressure of condensate corresponding to the value of the air conditioner with water cooling.

In fact, the heat load in the room and the ambient temperature outside is always changing up.Hence, the condensing pressure of the refrigerant also is changed. For this reason, when these parameters change, the condensing pressure also decreases and/or increases and is shown in Figure 5.

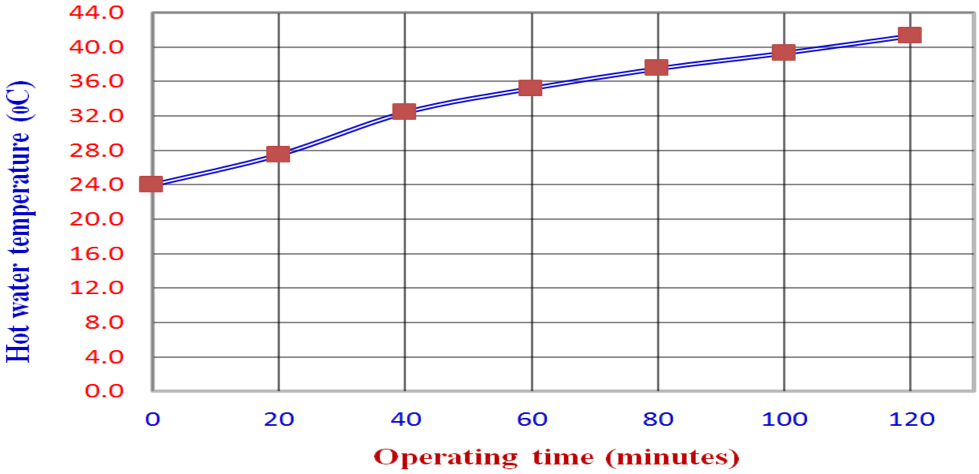

Figure 5: The change in pressure of the refrigerant condensing temperature hot water

3.3. The change in current intensity over time operated in two cases

In case of the waste heat recovery unavailable, the amperage is relatively stable during the conditioning operation. In constrast, with waste heat recovery, when the new system begins an operation, the amperage value according to the norms (because the temperature of the water in this time is low). As the water temperature increases, the amperage increases, but does not exceed the air conditioner's operating value when no waste heat is recovered [3]. So, this can be confirmed that with an air conditioner with heat recovery would has saved energy part when the water temperature in the storage container was at less than 41^{0}C.

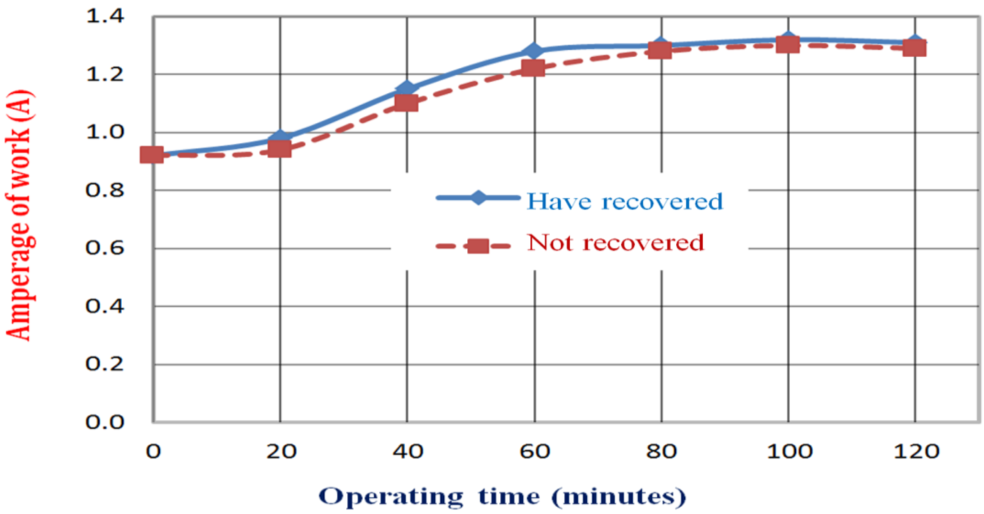

Figure 6: The change in current intensity over time operated in two cases

Through measurements from the experimental parameters, the waste heat recovery was found in a new case, the amperage was unstable compared to normal operating mode. This is explained in the case of waste heat recovery connected in series to add the heat exchanger. So the hindrance pipeline increases (refrigerant first heat exchange with the water in the heat exchanger, then go through the condenser of the system). The compressor temperature is higher than the case without heat recovery. However, due to high-pressure steam line after the waste heat from the compressor to the water in the heat exchanger, so the temperature of the compressor still does not exceed the permitted level. Results that change the amperage in the two cases are shown in Figure 6.

4. Conclusion

Experimental results show that two cases with recovered and no heat recovery were pointed out, the amperage difference is mainly due to the increased consumption of compressors. However, the total power consumption for the system considered negligible increase (power consumption device such as fans, pumps in the two cases is the same). So, with the above figures, if the hot water use (with 11 liters of water from the temperature 24^{0}C to 41^{0}C), instead of using resistance to heat, power was consumed about 240W. This illustrates that the utilization of the air conditioning waste heat recovery part to the hot water supply has brought high economic efficiency [4].However, in this study, we focus on the ability to heat from the empirical model compared to theoretical calculations in terms of power consumption. To assess to affecting factors to process heat recovery without considering the investment cost of initial installation, cost of equipment, structure and operation of complex systems air conditioner fitted additional heat exchanger. This issue, we will calculate in detail the system of conditional widely implementation in practice.

On the other hand, when the average temperature of the hot water is less than 41^{0}C, the actual amount of waste heat recovery is in consideration. When the hot water temperature up to 45^{0}C, the waste heat recovery decreases, the average water temperature is, then, increasing. This means that an air conditioning system operates effectively when the hot water temperature is wisely used at smaller values 41^{0}C corresponds to a working pressure of 17.5 bar.

We've combined the process of establishing in the theoretical basis and practical modeling of air conditioning. So the air conditioning combined with the hot water supply is to save energy. During the research process, we directly make energy efficiency after the calculation simulation is based on the input conditions of the refrigerant capacity of the compressor, the area condenser and fly as well as the parameters slightly different calculation. After comparison, the comparison between theoretical research and empirical evidence. Results showed that the ability of the heat recovery system from air conditioner actually achieved 36%. From this energy exchanges for providing hot water instead of using resistors or other energy sources.

References

[1]. JP Holman, Heat Transfer. Tenth Edition, McGraw-Hill International Edition, Year 2009.

[2]. Le Nguyen Minh Education Technical Thermodynamics. Educational publishers, Year 2009.

[3]. Bui Ngoc Hung, Waste heat recovery from the central air conditioning using the hot water heating to save energy. Vietnam Mechanics magazine, No. 1 + 2, pages 165-172, Year 2015.

[4]. Nguyen Cong Vinh, Ho Tran Anh Ngoc, Research on manufacturing and testing the heat recovery from anair conditioning to provide the simultaneous heat - cold energy. Journal of Science and Technology University of Danang, ISSN: 1859-1531; Vol. 17; No 1.2, Year2019; pp: 65-69.

[5]. Nguyen Duc Loi, Pham Van Tuy, the cold technique exercises. Educational publishers, Year 1998.