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Vapor compression refrigeration system with air and water cooled condenser: Analysis of thermodynamic behavior and energy efficiency ratio

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Abstract: This study presents the analysis of thermodynamic behavior and energy efficiency of a vapor compression refrigeration system with two types of condensers: air-cooled (ACC) and water-cooled (WCC). The main objective is to assess the system performance by comparing the Coefficient of Performance (COP) and Energy Efficiency Ratio (EER) under both condenser configurations. During a 12-hour test period, data on refrigerant pressure, temperature, and electrical energy consumption were collected and analyzed. The results show that the WCC system outperforms the ACC system, showing a 5.7% increase in heat rejection and a 4.2% increase in cooling capacity. In addition, the WCC system exhibits a lower compressor duty cycle and consumes less electrical energy, resulting in a higher total EER of 5.658 compared to ACC of 1.945. These findings suggest that integrating a water-cooled condenser into a refrigeration system can significantly improve energy efficiency and reduce operating costs, making it a viable option for commercial applications in tropical regions.

Keywords: air cooled condenser; water cooled condenser; energy efficiency; coefficient of performance; energy efficiency ratio; thermodynamic behavior

1. Introduction

In recent years, cooling systems have become essential in tropical regions due to the growing demand for thermal comfort in commercial and residential buildings [1]. Tropical regions face the challenge of high temperatures year-round, which significantly increases energy consumption for cooling [2]. Unfortunately, cooling systems contribute substantially to greenhouse gas emissions, directly impacting global warming [3], [4], [5], [6] Therefore, improving energy efficiency through sustainable cooling system design and supporting thermal system engineering is urgently needed [7], [8], [9], [10] Increasing energy efficiency in cooling systems can significantly reduce electricity consumption and ultimately reduce carbon emissions, which are key factors in mitigating climate change [11], [12], [13].

In addition to environmental impacts, energy efficiency is closely related to conserving natural resources and benefiting the economy. In many countries, energy sources still primarily depend on fossil fuels, which are limited and non-renewable. Energy efficiency in cooling systems can help reduce this reliance as well as lower energy costs for consumers [14], [15]. More efficient cooling systems can save significant energy, ultimately, lowering operational costs and enhancing economic competitiveness [16], [17], [18]. By switching to more environmentally friendly and efficient technologies, the negative impacts of using energy-intensive cooling systems can be reduced. Implementing such technologies not only reduces carbon emissions but also minimizes health risks associated with air pollution [19], [20], [21], [22].

The refrigeration system, on the one hand, produces a cooling effect through the evaporator to enhance thermal comfort in a cooled room. On the other hand, heat removed by the condenser is released into the environment. At the same time, the demand for warm water in a reservoir, for activities like bathing, washing, and other thermal comfort needs, is increasing. Many households install both cooling and heating systems to achieve comfort in two conditions: a cool room and warm water in the reservoir. As a result, the electricity load increases significantly. However, the heat waste generated by the AC system, which is typically discharged into the environment, has not yet been optimally utilized.

The integration of air conditioning systems with water heaters was explored by Aziz et al. [23]. The use of an Air Source Air Conditioning Water Heater (ASACWH) is claimed to be far more efficient than conventional electric water heaters. This technology not only produces hot water but also provides a cooling effect for rooms, thus increasing overall efficiency. In another approach, combining an air conditioner with a water heater using coils has shown significant potential for improving energy efficiency [24]. However, neither study reported on the mechanisms for adding or removing water from the reservoir. Sivaram [25] also developed an innovative water heater that utilizes waste heat from the outdoor unit of a split-type air conditioner, achieving dual functionality by simultaneously cooling rooms and heating water. This research highlights the importance of energy conservation in the context of challenges facing conventional energy sources. Experimental results showed that the system can produce 88 liters of hot water per hour at a temperature of up to 52°C, demonstrating its potential to meet household hot water needs while still functioning as an air conditioner. However, once the water temperature reaches 37°C, the system's COP begins to decline and becomes lower than that of conventional air conditioners as the water temperature continues to rise.

The utilization of waste heat from the condenser cooling water in air conditioning (AC) systems to improve the efficiency of heat pump water heaters has also been extensively researched by Nhựt & Thái [26]. In this study, two heat pump water heater systems were tested: one using heat from the environment (air to water/ATW) and the other using heat from the condenser cooling water (water to water/WTW). The experimental results showed that the COP of the WTW system fluctuated between 5.7 and 6.7, significantly higher than the ATW system, which fluctuated between 2.5 and 3.2. Recently, Wiriyasart & Kaewluan [27] investigated waste heat recovery from air conditioning units to improve the thermal efficiency of water heaters. By using a double-tube heat exchanger to transfer heat from the AC to the water heating system, the thermal efficiency of the water heater is increased by 12% to 180%, much higher compared to conventional systems.

From the literature reviewed, all studies discuss system performance in terms of COP, except for the last reference [27], which specifically addresses efficiency. However, none of them report the performance of cooling and heating systems while considering the compressor duty cycle. In fact, during the operation of an AC system, the compressor does not run continuously but rather operates in an on-off cycle, forming a duty cycle. Additionally, previous research has not considered the energy consumption required to operate supporting components of the AC and heater systems, such as the evaporator fan, water pump, and other electrical equipment. Therefore, in this study, we compare the performance of an AC system with a water-cooled condenser, which produces warm water, to that of an air-cooled condenser system. By comparing these configurations, the research aims to determine the potential energy savings and operational benefits of integrating water-cooled condensers, particularly for applications in tropical regions. Performance calculations are not limited to COP but also take into account all components consuming electricity to run the system, so the total EER is a more representative parameter. In this study, both the air-cooled and water-cooled systems were tested over 12 hours to obtain more comprehensive data, representing the ambient air temperatures in the morning, during the hot midday, and in the afternoon.

2. Material and methods

2.1 Experimental setup

In our present study, a small-scale vapor compression air conditioning system was constructed in a research apparatus, as shown in Figure 1. A compressor (1) was installed to increase the refrigerant pressure and push it into the condenser (2). A dryer (3) was installed between the condenser and the expansion valve (4) to filter impurities from the refrigerant. The low-pressure refrigerant leaving the expansion valve then passes through the evaporator (5) and returns to the compressor. The evaporator is installed in a 1.2 x 1.2 x 1.8 m cooled chamber with a total volume of 2,592 m^3. The condenser is designed to be cooled alternately by air (A) or water (W). When the condenser is cooled by air (air-cooled condenser, ACC), an electric fan draws air through the condenser fins and exhausts it into the environment. When water is used (water-cooled condenser, WCC), an electric water pump (1) circulates water from the cold reservoir (8) through the condenser fins which are fully immersed in a box (7), then discharges the water into the warm reservoir (9). The system was tested for 12 hours, from 08:00 to 20:00.

Refrigerant R134a is used with a total mass of 0.44 kg. During the working cycle, the refrigerant's pressure and temperature were recorded using a pressure transducer and a thermocouple. As presented in Figure 1, P1 and T1 represent the pressure and temperature of the refrigerant entering the compressor, while P2 and T2 represent the pressure and temperature of the refrigerant leaving the compressor or entering the condenser. P3 and T3 indicate the pressure and temperature of the refrigerant entering the expansion valve, and P4 and T4 indicate the pressure and temperature of the refrigerant entering the evaporator. Additionally, T5 and T6 are the temperatures of the air entering and leaving the condenser, respectively. T7 and RH7 refer to the temperature and humidity of the air in the cooled chamber, whereas T8 and RH8 denote the temperature and humidity of the air in the test environment. When the system works with WCC mode, a cold and warm reservoir are measured by T9 and T10, respectively. A speed sensor is also installed on the compressor to measure its rotation, which is connected to a data logger (11) and then displayed on the DAQ master (13) in a personal computer. All temperature, pressure, and humidity data are recorded every 10 seconds, while the compressor rotation is logged every second. The data logger and personal computer communicate via the SCM-US48I converter (12). Technical data for the test equipment is presented in Table 1.

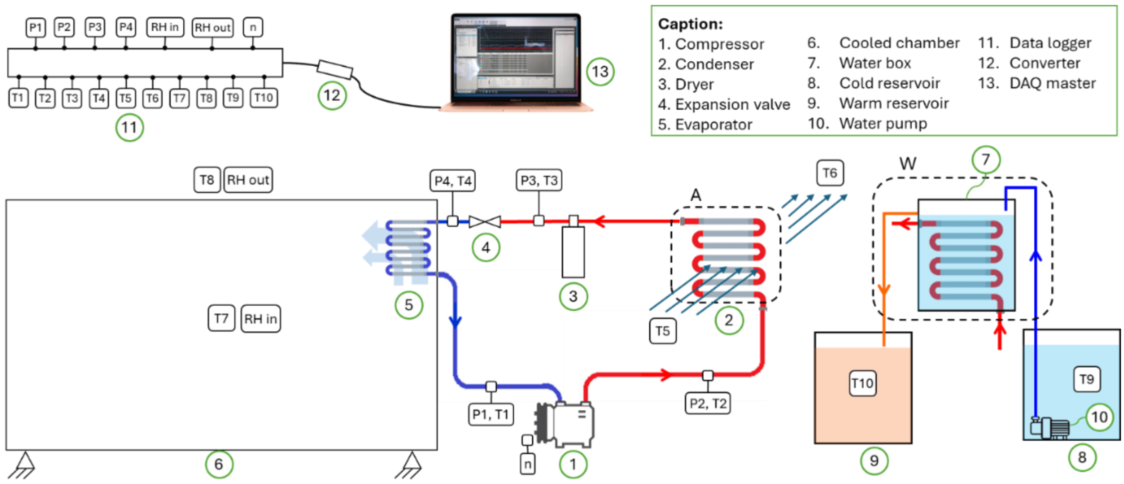

Figure 1. Experimental setup

Table 1. The accuracy of temperature, pressure, humidity and speed sensor

No	Sensor	Accuracy
1	Temperature sensor, RTD	PV ±0.2%
2	Pressure sensor, PSAN	FS ±0.2%
3	Humidity sensor, THD-R-C	±3%RH (30 to 70% RH, at room temp.)
4	Speed sensor, MP5W pulse meter	FS ±0.05%

PV: Present Value, FS: Full Scale

2.2 System description

In the vapor compression refrigeration system, as presented in Figure 1, the compressor (W_c) converts electricity into refrigerant pressure isentropically from specific state point (1) to (2). In addition to the compressor, an electric blower is installed in the evaporator box to push air across the evaporator fins as W_{ee}. During ACC mode, an electric fan works to circulate air across the condenser fins as W_{ec}. Meanwhile, during WCC mode, a water pump works to circulate water across the condenser fins as W_{ep}. Therefore, in this study, the total system power (W_{in}) is the sum of the work of the compressor, electric blower, condenser fan, or water pump at times according to Equations (1) and (2).

During ACC mode,

$$W_{in,a} = W_c + W_{ee} + W_{ec} \tag{1}$$

During WCC mode,

$$W_{in,w} = W_c + W_{ee} + W_{ep} \tag{2}$$

During ACC mode, the air is sucked from the environment by the electric fan and pushed back into the environment, so it does not produce further benefits, so the refrigeration effect is obtained in the evaporator (q_{ev}) as cooling power. Meanwhile, during WCC mode, in addition to getting q_{ev}, warm water is also obtained which can be further utilized as q_c. The cooling effect in the cooled chamber and the heating effect in the condenser are calculated by Equations (3) and (4), where $\dot{m}_r$ is the mass flow rate of refrigerant and h is enthalpy.

$$q_{ev} = \dot{m}_r\,(h_1 - h_4) \tag{3}$$

$$q_c = \dot{m}_r\,(h_2 - h_3) \tag{4}$$

Assuming that the heat exchange in the condenser occurs with an efficiency of 85% due to evaporation and mechanical losses, then q_c in Equation (4) becomes Equation (5), where $\dot{m}_w$ is the mass flow rate of water, C_{pw} is the specific heat of water (kJ/kg°C), and T is the water temperature.

$$q_c = \dot{m}_w\,C_{pw}\,(T_{10} - T_9) \times 85\% \tag{5}$$

When the condenser is cooled with water, the system gains two benefits: the cooling effect of air in the chamber cooled by the evaporator and the heating effect of water in the reservoir by the condenser, as q_t. In common calculations, the performance of a refrigeration system is calculated by COP, which compares the cooling effect (q_{ev}) with the compressor work (W_c) without including the work of the electric blower on the evaporator (W_{ee}) and the electric fan on the condenser (W_{ec}) or the water pump (W_{ep}). In fact, the refrigeration system will not work without the air flow across the evaporator and the coolant flow across the condenser. Therefore, in this research, all the energy used to make the system work normally is included in the thermodynamic analysis to calculate the EER, as formulated in Equations (6) and (7).

$$EER_{ACC} = \frac{q_{ev}}{W_{in,a}} \tag{6}$$

$$EER_{WCC} = \frac{q_{ev} + q_c}{W_{in,w}} \tag{7}$$

3. Results and discussion

3.1 Pressure behavior

Figure 2 (a and b) shows the behavior of refrigerant pressure over 12 hours of testing with the condenser cooled by air (a) and water (b). Meanwhile, Figure 2(a' and b') highlights the first hour of testing to provide a clearer view of the refrigerant pressure dynamics within the system. The refrigerant pressure trend in the evaporator appears relatively consistent in both ACC and WCC modes, unaffected by ambient temperature, as indicated by the black and gold curves in Figures 2a and 2b as well as in 2a' and b'. However, the refrigerant pressure trend in the condenser reveals a significant difference. By comparing the blue and magenta curves in Figures 2a and 2b as well as in 2a', and 2b', it was found that the trend of refrigerant pressure follows the trend of ambient temperature (red dashed curve). Furthermore, a comparison of the average refrigerant pressure with ACC and WCC mode is presented in Table 2.

Table 1. Comparison of average refrigerant pressure in ACC and WCC modes

Specific state point	Average pressure of refrigerant (bar)		Pressure difference (bar)
	ACC	WCC	
P1 (entering compressor)	2.53	2.54	+0.01
P2 (entering condenser)	9.92	8.50	-1.42
P3 (entering expansion valve)	9.68	8.26	-1.42
P4 (entering evaporator)	2.36	2.38	+0.02

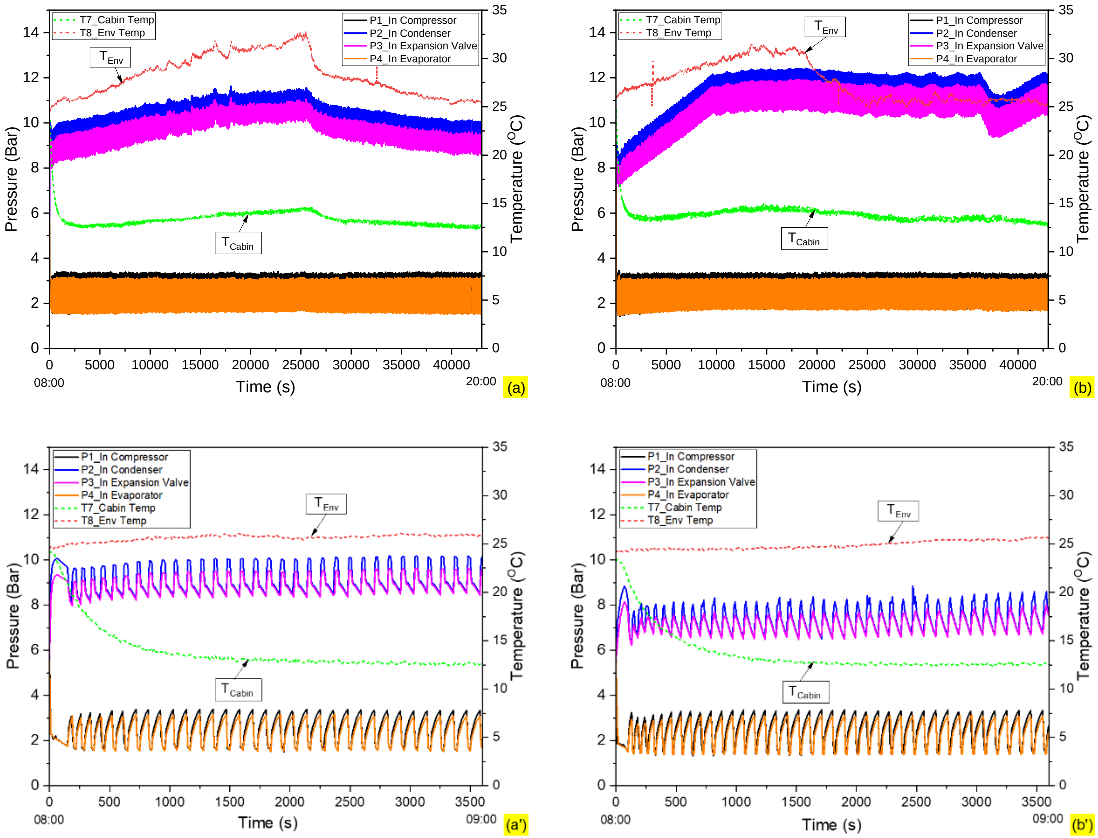

Figure 1. Refrigerant pressure comparison: (a) ACC mode recorded for 43000 seconds, (b) WCC mode recorded for 43000 seconds, (a') ACC mode recorded for 3600 seconds, and (b') WCC mode recorded for 3600 seconds

By observing Figure 2 and Table 2, the refrigerant pressure exiting the compressor with WCC mode is also relatively lower by 1.42 bar compared to ACC mode. This indicates that the compressor work with WCC mode is lighter, and the electrical load is lower to produce relatively the same temperature in the cooled chamber (dotted green curve). In the two different cooling systems, there is the same pressure drop in the condenser of 0.24 bar. This is a normal phenomenon, although theoretically, the condensation process occurs at constant pressure, the friction between the refrigerant and the inner wall of the condenser pipes causes a pressure drop [28], [29], [30], [31]. However, an interesting phenomenon can be observed from this work, where the refrigerant pressure leaving the evaporator is higher than entering the evaporator, by 0.16-0.17 bar. Theoretically, the evaporation process occurs at constant pressure, with a tendency for pressure drop due to friction of the refrigerant with the inner walls of the evaporator pipes. The increase in refrigerant pressure in the evaporator is thought to be due to the presence of sensible heat transfer, where the refrigerant vapor receives heat from the air passing through the evaporator fins. When the refrigerant absorbs heat and begins to evaporate, if sensible heat is added, the temperature and pressure of the refrigerant can increase under non-ideal conditions [32].

3.2 Temperature behavior

Figure 3 (a and b) shows the refrigerant temperature behavior during 12 hours of testing with ACC (a) and WCC (b) modes. Meanwhile, Figure 3(a' and b') presents a closer look at the first hour of testing to more clearly observe the dynamics of refrigerant temperature in the system, in both transient and steady-state conditions. The refrigerant temperature trend in the evaporator appears to be relatively the same for both ACC and WCC, unaffected by ambient temperature, as shown by the black and gold curves in sides a and b (or a' and b'). However, there is a significant difference in the refrigerant temperature trend in the condenser. When comparing the blue and magenta curves on sides a and b (or a' and b'), it is clear that the refrigerant temperature trend follows the ambient temperature trend (shown by the red dashed curve). Further comparison of average refrigerant temperatures for ACC and WCC is provided in Table 3.

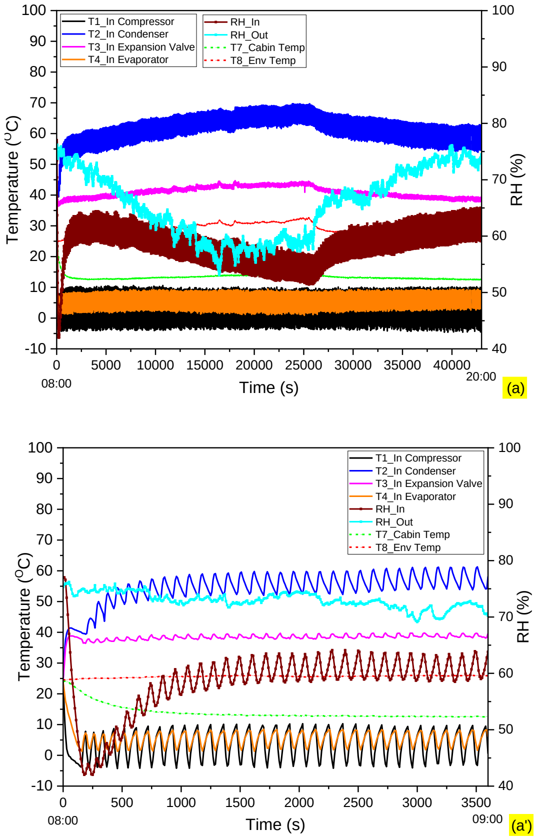

Figure 2. Comparison of refrigerant temperature: (a) with ACC recorded for 43000 seconds, (b) with WCC recorded for 43000 seconds, (a') with ACC recorded for 3600 seconds, (b') with WCC recorded for 3600 seconds

Table 2. Comparison of average refrigerant temperature with ACC and WCC

Specific state point	Average temperature of refrigerant (°C)		Temperature difference (°C)
	ACC	WCC	
T1 (entering compressor)	4.15	5.06	0.91
T2 (entering condenser)	61.34	59.52	-1.82
T3 (entering expansion valve)	40.82	36.81	-4.01
T4 (entering evaporator)	5.71	5.02	-0.69

Referring to Figure 3 and Table 3, the refrigerant temperature exiting the compressor with WCC mode is also relatively lower by 1.82 °C compared to ACC mode throughout the test. The heat transfer from the refrigerant to the environment is also better with WCC mode, where the refrigerant temperature in the condenser (T3 – T2) is reduced by 22.71 °C while in ACC mode it is only 20.51 °C. The refrigerant temperature with WCC mode in the condenser is 4.01 °C lower compared to ACC mode which also reduces the refrigerant temperature when entering the evaporator.

3.3 Thermodynamic analysis

In this study, we analyzed 10 compressor on-off cycles during the peak ambient temperature, recorded at 14:00. From these cycles, we collected the average pressure and temperature data while the compressor was operating, as shown in Table 4. The enthalpy values were obtained from the interactive p-h diagram provided by FlyCarpet Inc [33]. Since the thermocouples were not installed directly at the inlet and outlet of the expansion valve, the refrigerant temperature data at these points were also sourced from FlyCarpet Inc., assuming the expansion process to be isenthalpic. Additionally, the p-h diagrams for both systems are presented in Figure 4. The red cycle curve represents the air-cooled condenser cycle, while the blue one represents the water-cooled condenser cycle.

Table 3. Refrigerant properties pada specific state point

Specific state point	Air cooled condenser			Water cooled condenser		
	T (°C)	P (bar)	h (kJ/kg °C)	T (°C)	P (bar)	h (kJ/kg °C)
Entering compressor	2.53	1.82	403.611*	3.13	1.68	404.559*
Entering condenser	66.68	11.25	446.449*	65.44	10.10	447.074*
Entering expansion valve	42.09*	10.75	259.942*	37.53*	9.51	252.742*
Entering evaporator	-12.712*	1.80	259.942*	-13.831*	1.72	252.742*

*Obtained from FlyCarpet Inc

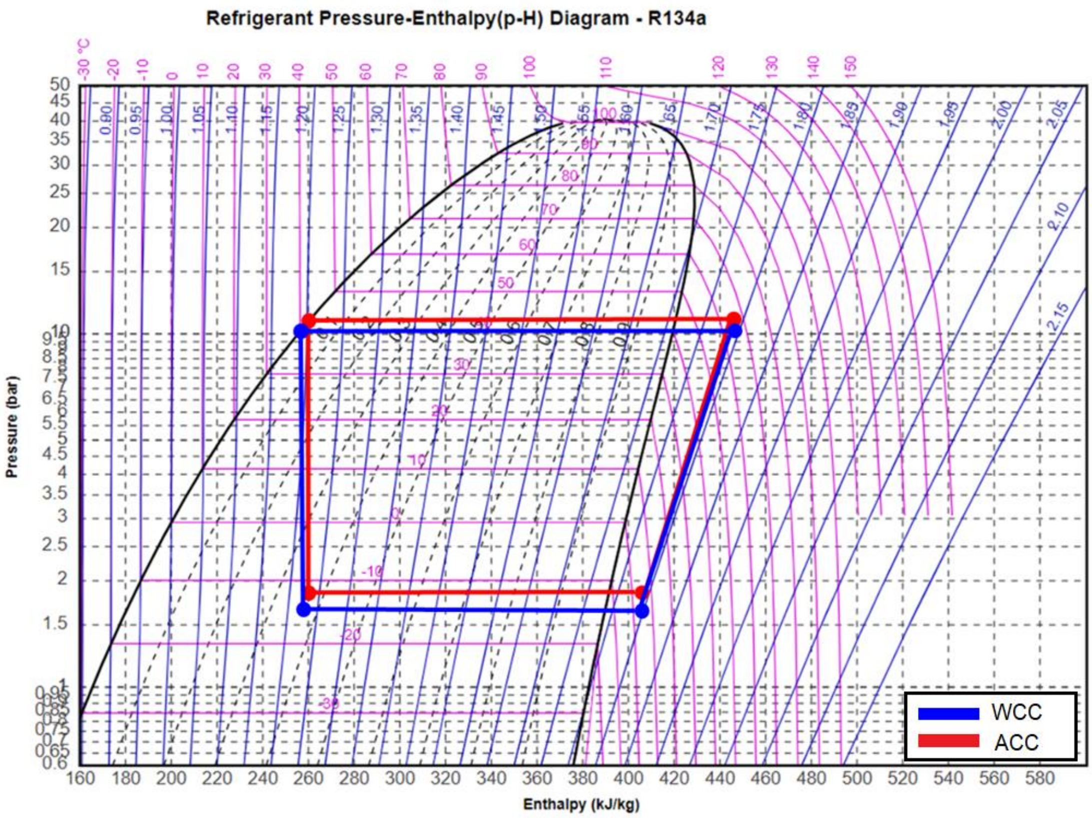

Figure 3. p-h diagram of ACC and WCC modes

To calculate the cooling power, the mass flow rate of the refrigerant must be determined. In this research, since no refrigerant flowmeter was installed and the compressor efficiency was unknown, the mass flow rate of the refrigerant was calculated from the heat exchange process in the condenser when the system was operating with WCC mode. Based on the test data, the average water temperature entering (T9) and leaving (T10) the water box was 27.75°C and 38.07 °C, respectively. The mass flow rate of water ($\dot{m}_w$) was measured at 0.0243 kg/s. With a specific heat of water (C_{pw}) of 4.18 kJ/kg°C, the heat transfer rate (q_c) was calculated to be 1.05 kJ/s. Using Equations (4) and (5) along with the enthalpy data in Table 4, and assuming 85% of the heat released by the refrigerant is absorbed by the water, the mass flow rate of the refrigerant ($\dot{m}_r$) was found to be 0.0081 kg/s. With the known values of $\dot{m}_r$, the other parameters in both working modes can be calculated, as presented in Table 5.

Table 4. The compression work, heat rejected, heat absorbed, and COP of ACC and WCC modes

Mode	Compression work, W_c (kJ/s)	Heat rejected, q_c (kJ/s)	Heat absorbed, q_{ev} (kJ/s)	COP (q_{ev}/W_c)
ACC	0.348	1.167	1.515	4.354
WCC	0.345	1.223	1.579	4.571
Improvement	-0.8%	5.7%	4.2%	5.0%

In this study, in addition to producing cooling power in the cooled chamber, it also produces water heating that can be further utilized. The profiles for temperature and water heating power during the 12-hour test are presented in Figure 5. The red curve shows the water heating power (qc) and the solid and dashed blue curves represent the inlet and outlet water temperatures of the condenser box, respectively. The trend of water temperature also follows the ambient temperature, as presented in Figure 2(b) which affects qc. On average, the heating power generated during the 12 hour test is 1.048 kJ/s. Therefore, by summing qc and qev as the benefits of the system, then qt with WCC mode is 2.627 kJ/s and produces a total COP of 7.606.

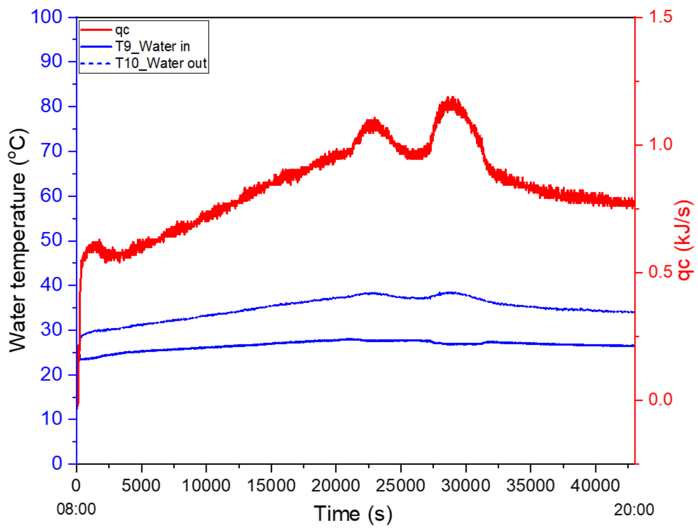

Figure 4. Profile of temperature and heating power in condenser box

3.4 Total energy efficiency ratio (TEER)

Although system performance is typically assessed by calculating the COP, the compressor does not operate continuously throughout the test. The compressor shuts off when the cooled chamber temperature is reached and turns on again when the chamber temperature rises. From the test results, it was obtained that the compressor duty cycle with ACC mode was 35.17% and with WCC mode was 33.05%. With a 12-hour test, the compressor worked for 4.22 hours and 3.96 hours, for each operating mode. The results of measuring the compressor current and voltage were 2.9 A and 220 V (0.638 kW). Meanwhile, the water pump power (W_{ep}) was 23 Watts, and the electric fan power in the evaporator (W_{ee}) and blower (W_{ec}) were 33.12 and 46.8 Watts. When the system works in ACC mode, the compressor and condenser fan turn on and off according to the compressor duty cycle while the evaporator fan is on throughout the test. Meanwhile, when the system works in WCC mode, the compressor turns on and off according to the compressor duty cycle while the evaporator fan and water pump are on throughout the test. Therefore, the *TEER* formula is presented in Equation (8) and the results are presented in Table 6.

$$TEER = \frac{Total\ useful\ work\ (kWh)}{Total\ work\ (kWh)} \tag{8}$$

Table 5. Total energy efficiency ratio (TEER)

No	Parameter	Formula	Operation mode	
			ACC	WCC
1	Operation duration (hour)	-	12	12
2	Compression power (kW)	-	0.294	0.296
3	Compressor power (kW)	-	0.638	0.638
4	Compressor efficiency (η)	(2)/(3)	0.545	0.541
5	Compressor duty cycle (%)	-	35.17	33.05
6	Condenser fan power (kW)	-	0.047	0
7	Evaporator fan power (kW)	-	0.033	0.033
8	Water pump power (kW)	-	0	0.023
9	Useful cooling effect (kW)	-	1.515	1.579
10	Useful heating effect (kW)	-	0	1.048
11	Total useful load (kW)	(9)+(10)	1.515	2.627
12	Total useful work (kWh)	(11)*(1)	6.395	18.125
13	Compressor work (kWh)	(3)*(5)*(1)	2.693	2.530
14	Condenser fan work (kWh)	(6)*(5)*(1)	0.198	0
15	Evaporator fan work (kWh)	(7)*(1)	0.397	0.397
16	Water pump work (kWh)	(8)*(1)	0	0.276
17	Total work (kWh)	(13+14+15+16)	3.288	3.204
18	TEER	(12)/(17)	1.945	5.658

3.5 Potential applications

The warm water produced during the operation of a refrigeration system has numerous practical applications, particularly in commercial and industrial settings. One of the most obvious uses is for domestic and commercial water heating. The warm water generated by the water-cooled condenser can be directly utilized for bathing, washing, and other household needs. By integrating this system, users can reduce the energy demands of conventional water heaters, thereby lowering energy costs. On a larger scale, this system can be incorporated into Heating, Ventilation, and Air Conditioning (HVAC) systems in commercial buildings, such as hotels and offices. By combining space cooling with water heating, buildings can repurpose the warm water from the cooling system to heat rooms or facilities like swimming pools. This approach increases overall energy efficiency, reducing both electricity consumption and environmental impact.

In industrial applications, warm water can be used for drying or sterilization. For example, in the food, pharmaceutical, or textile industries, the water temperature is sufficient to dry products or even carry out sterilization processes. By using this waste heat, industries can improve operational efficiency without the need for additional energy sources. Moreover, industries that require large volumes of hot water, such as food processing, chemical, or manufacturing can integrate this system into their production processes. Producing warm water from the cooling system not only improves energy efficiency but also reduces the carbon footprint of industrial operations.

4. Conclusion

The results of this study indicate that a vapor compression refrigeration system with a water-cooled condenser (WCC) performs better than one with an air-cooled condenser (ACC). In WCC mode, the refrigerant operates at lower pressure and temperature, resulting in reduced electrical energy consumption and a more efficient system overall. The Coefficient of Performance (COP) for the WCC and ACC were 4.57 and 4.35, respectively. Additionally, the WCC mode exhibited a 5.7% increase in heat rejection and a 4.2% increase in heat absorption compared to the ACC mode. The compressor duty cycle in the WCC system was also lower, indicating that the compressor required less operating time. Over a 12-hour test period, the WCC produced 18,125 kWh of useful energy, while the ACC produced 6,395 kWh. With total system work of 3,204 and 3,288 kWh, the corresponding TEER values were 5,658 and 1,945, respectively. These findings have significant implications for improving energy efficiency in cooling systems. The use of water-cooled condensers can reduce electrical energy consumption, making them suitable for commercial-scale applications by lowering operational costs and enhancing energy efficiency. Furthermore, the heat generated by the condenser can be repurposed, such as for heating water, which further increases the system's overall efficiency. In other words, this system offers dual benefits: efficient cooling and the utilization of waste heat for other applications. In the long term, these results can serve as a foundation for the development of more efficient and energy-saving cooling systems, both for industrial and domestic use, particularly in tropical regions where higher ambient temperatures affect cooling system performance.

Author's declaration

Author contribution

Muji Setiyo: Conceptualization, Conceived and designed the experiments, Performed the experiments, Analyzed and interpreted the data, Wrote the original and revised paper. **Retno Rusdjijati**: Conceptualization, Wrote the research proposal; **Ilham Habibi**: Conceived and designed the experiments, Performed the experiments. **Muhamad Latifur Rochman**: Conceived and designed the experiments, Performed the experiments, Analyzed and interpreted the data. **Bagiyo Condro Purnomo**: Analyzed and interpreted the data. **Fungky Dyan Pertiwi**: Performed the experiments, Wrote the original and revised paper. **Budi Waluyo**: Conceptualization, Conceived and designed the experiments. **Rifky Ismail**: Wrote the revised paper. **Aditya Kolakoti**: Data validation.

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Competing interest

The authors declare no competing interest.

Ethical clearance

This research did not involve human or animal subjects.

AI statement

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