Study of the Effect of Refrigerant Collection Tank on the Performance of the Evaporator in the Refrigeration System

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Abstract:- To enhance the coefficient of performance (COP) for the evaporator within the cooling cycle, we initially designed, assembled, and executed the fundamental pressure cooling cycle. Subsequently, we introduced a novel component, the coolant group tank, strategically placed directly in front of the evaporator. The essential elements of the basic pressure cooling cycle encompass the compressor, condenser, expansion valve, and evaporator. Additional components include a thermostat, liquid flow meter, pressure gauge, temperature gauge, filter, examination valve, and the aforementioned cooling tank. Following the successful installation of the cooling cycle, we will activate the system and commence the collection of critical data, such as pressure and temperature readings at designated points throughout the process, to facilitate calculations and assess the performance of the evaporator. The experiment was replicated using the same cooling cycle; however, this time, we isolated both the cooling collection tank and the examination valve prior to gathering the necessary temperature and pressure data at specific locations within the system. We then recalculated to verify the evaporative performance. A comparative analysis of the data obtained from the first experiment, which yielded a COP of 7.5, and the second experiment, which achieved a COP of 9, revealed that the evaporative coefficient of performance was significantly higher when utilizing the coolant group tank compared to operating the cooling cycle without it.

Keywords:- *Evaporator C.O.P, Refrigerated Liquid Collection Tank, Refrigeration Cycle.*

I. INTRODUCTION

The refrigeration cycle in compression refrigeration system consists of four main parts, namely evaporator, compressor, condenser and expansion device respectively [1]. This cycle operates at the saturation condition of the refrigerant charged in the refrigeration circuit. It is a theoretical cycle in which the refrigerant vapor exits the evaporator in the form of dry saturated vapor and enters the compressor at the saturation temperature corresponding to the evaporator pressure. The evaporator in the refrigeration system is a key component in any refrigeration or air conditioning system, playing an important role in the cooling process of air or materials. Its primary function is to extract heat from the environment or specific spaces, which contributes greatly to the refrigeration cycle [2]. Related references include studies on increasing the coefficient of performance of the evaporator in the refrigeration cycle by various methods. According to one study, adding PCM to the evaporator cabinet of a deep refrigeration system can increase the energy efficiency. Experimental results showed significant effects on the system performance, such as a 7.1% improvement in the coefficient of performance, a 6.7% reduction in daily energy consumption, and relatively smaller temperature fluctuations inside the freezer cabinet [3]. According to a different study, the efficiency of the system increases when the two evaporator stages are extended to 80-90% of their limit, allowing the compressor speed to be reduced without sacrificing cooling capacity [4]. Another study showed that the temperature of the refrigerant leaving the evaporator decreased by about 11.3%. However, the water flow rate (170 L/h) was found to be the best rate for improving the evaporator temperature [5]. Another study focused on the fact that the evaporator plays a major role in an indirect cooling system, so improving the efficiency of the evaporator is of great importance for improving the overall performance of the refrigeration system. The study concluded that reducing the condenser pressure and temperature increases the cooling effect and the coefficient of performance. Increasing the evaporator pressure and temperature also reduces the compressor work and increases the cooling effect and the coefficient of performance [6]. In another study The coefficient of performance (COP) was focused on by examining different condenser configurations and varying evaporator loads. The condensers analyzed included a standard household refrigerator condenser and a conventional copper tube condenser. The results indicate that the average COP for Case 1 and Case 2 improved by 20% and 14%, respectively, compared to a standard unloaded condenser design. In addition, it was observed that system performance was affected by evaporator load, with the COP showing an upward trend as evaporator load increased [7]. This research explores the possibility of improving the coefficient of performance of the evaporator using a refrigerant collection tank compared to operating the refrigeration cycle without a tank. The coefficient of performance, which is the ratio of the benefit of the refrigeration unit to the external work done on it using electrical energy, is the measure that allows us to evaluate refrigeration units and compare them with their different systems.

ISSN No:-2456-2165

II. MAIN PARTS

➢ *Compressor*

The function of the compressor is to raise the pressure of the dry gas from low pressure (evaporator pressure) to high pressure (condenser pressure).

Fig 1: Shows the Compressor

➢ *Condenser*

The function of the condenser in the refrigeration cycle is to receive the hot gas from the high compressor and cool it to remove the roasting heat or not and then the latent heat so that the refrigerant condenses back to saturated.

Fig 2: Shows the Condenser

➢ *Capillary Tube*

It is installed directly between the condenser and the evaporator inlet. To increase the tube's operating efficiency, the refrigerant flow rate must be equal to the compressor's vapor flow rate.

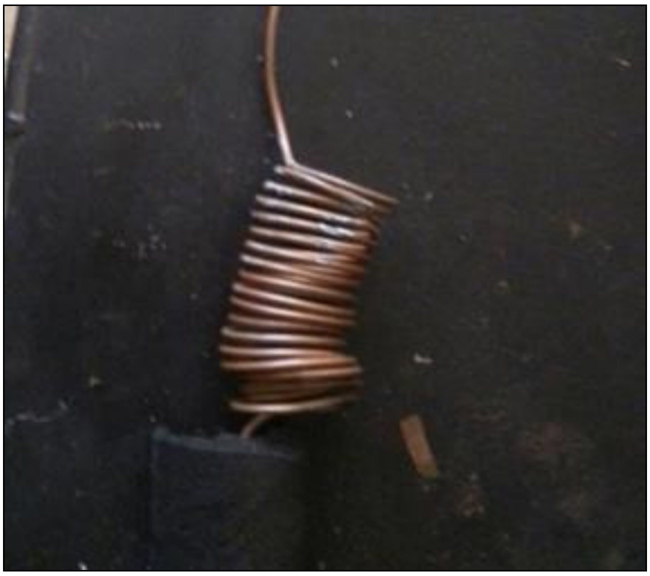

Fig 3: Shows the Capillary

➢ *Evaporator*

The function of the evaporator is to absorb the heat load of any space or product liquid subject to cooling.

Fig 4: Shows the Evaporator

III. SUB-PARTS

➢ *Thermostat*

Its function is to regulate and control the refrigerator's cold temperature by controlling the operating period, stopping the compressor, and giving the compressor rest periods.

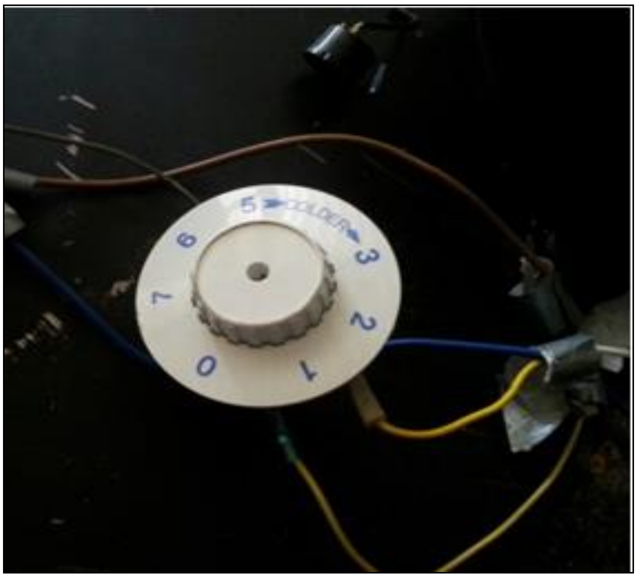

Fig 5: Shows the Thermostat

➢ *Indicator Bottle*

The indicator bottle is usually installed in the liquid pipeline of the cooling system. The indicator bottle shows bubbles if the amount of refrigerant inside the system is low. The presence of bubbles may also indicate the presence of obstructions in the system circuit in front of the indicator bottle, such as a partial blockage in the dryer, filter, or filter.

Fig 6: Shows the Indicator

➢ *Pressure and Temperature Gauge*

It is a pressure gauge consisting of two gauges, one blue and the other red, and each gauge has a valve of the same color.

Fig 7: Shows the Pressure & Temperature Gauge

➢ *Liquid Collection Tank*

The liquid tank increases the performance factor of the refrigeration cycle by passing the refrigerant in the liquid state only to the expansion valve and does not allow the refrigerant to pass in the gaseous form.

Fig 8: Shows the Liquid Collection Tank

ISSN No:-2456-2165

➢ *Non-Return Valve*

These valves are used to ensure that the refrigerant flows in one direction and prevents it from returning in the same line in order to preserve the basic parts of the refrigeration circuit, especially the compressor. Non-return valves are placed after the condenser and in the suction and discharge line for the compressor.

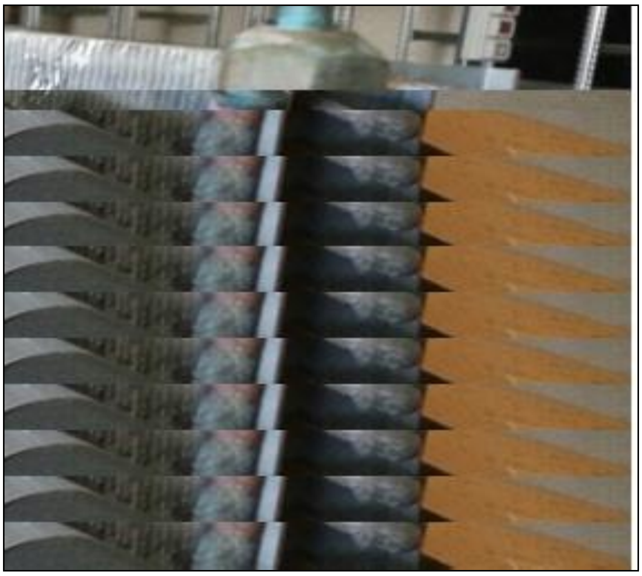

Fig 9: Shows the Non-Return Valve

IV. WORK STEPS

- A metal table with a base that measures 1.5 meters in length and 1 meter in width has been manufactured.
- The primary components of the system were securely affixed to the base.
- Various pipes of differing diameters and lengths were prepared, along with elbows and assorted connections (joints).
- We proceeded to weld a discharge line pipe with a diameter of 1/4 inch, establishing a connection with a nut, followed by the installation of a three-way connector and a valve to monitor the pressure in the discharge line prior to its entry into the condenser.
- A connection was welded using a 1/4 inch diameter pipe within the condenser.
- A statement bottle was positioned subsequent to the condenser, followed by the installation of a capillary tube functioning as an expansion valve.
- We constructed a tank designed to collect the liquid refrigerant while separating the vapor by modifying a section of the cylinder, sealing it, and applying heat using a copper piece. The tank was then fitted with three openings:
- The first opening serves as the inlet for the refrigerant mixture (vapor and liquid) arriving from the expansion valve.
- The second opening functions as the outlet for refrigerant vapor from the top of the tank, directing it to a non-return valve, which is subsequently connected to the pipe leading from the evaporator to the pressure system.
- The third opening, located at the bottom of the tank, facilitates the exit of liquid refrigerant, directing it towards the evaporator, as illustrated in Figure 10.

Fig 10: Shows the Tank to Collect the Liquid Refrigerant

The presence of valves to test the system without any loss in the amount of gas present in the system, Figure (11) Compression cooling system using a liquid collection tank and separating the vapor before entering the evaporator.

Fig 11: Shows the Tank to Compression Cooling System Using a Liquid Collection Tank

V. READINGS

The objective of developing the system is to evaluate its performance in scenarios both with and without a gas collection tank, thereby determining which configuration yields superior results. We conducted measurements in both scenarios.

ISSN No:-2456-2165

➢ *First Scenario (Measurements Without the Tank).*

Table 1: shows that the readings were taken without using the tank, and the room temperature was = (19)

Evaporator pressure EP	**Map (0.2)**
Condenser pressure CP	**Map (1.1)**
Evaporator exit temperature T1	**(-4) Co**
Condenser entry temperature T2	**(48) Co**
Condenser exit temperature T3	**(29) Co**
Evaporator entry temperature T4	**(-2) Co**

Following the collection of the readings, these data were utilized in conjunction with the psychrometric chart R 134a to determine the enthalpy values, as illustrated in chart number 2.

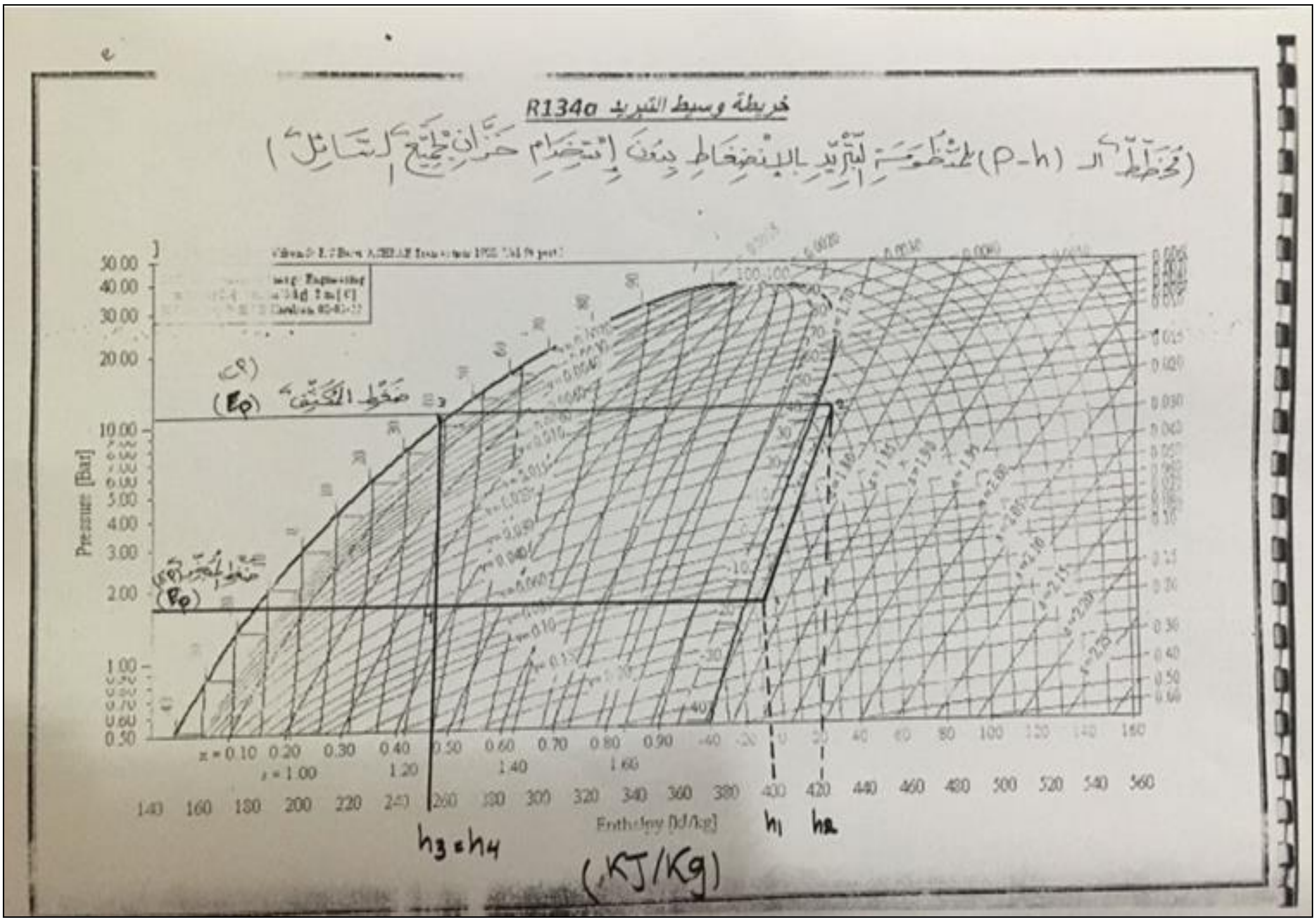

Chart 1: Shows the Readings were Applied to the Psychrometric Chart

Table 2: Shows the Enthalpy Values Obtained from the Psychrometric Chart

KJ/kg400	**H1**
KJ/kg420	**H2**
KJ/kg250	**H3**
KJ/kg250	**H4**

➢ *Second Scenario (Measurements using the Tank)*

Table 3: Shows Readings Taken using the Tank and the Room Temperature was = (19)

Map (0.107)	**Evaporator pressure EP**
Map (0.109)	**Condenser pressure CP**
(3) C°	**Evaporator exit temperature T1**
(46) C°	**Condenser entry temperature T2**
(24) C°	**Condenser exit temperature T3**
(-5) C°	**Evaporator entry temperature T4**

Following the collection of the readings, these data were utilized in conjunction with the psychrometric map to determine the enthalpy values, as illustrated in chart number 4.

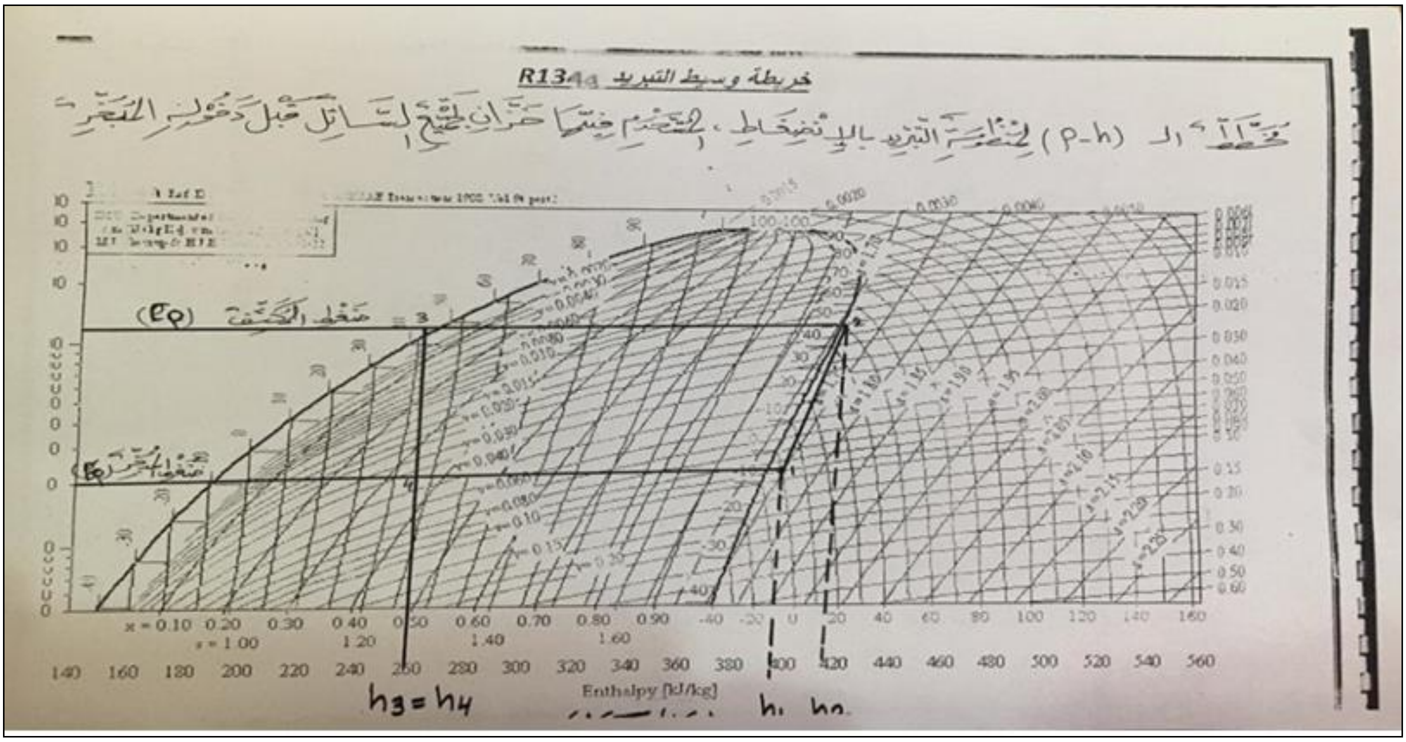

Chart 2: Shows the Readings were Applied to the Psychrometric Map Chart

Table 4: Shows the Enthalpy Values Obtained from the Psychrometric Chart

H1	**KJ/kg**395
H2	**KJ/kg**410
H3	**KJ/kg**260
H4	**KJ/kg**260

VI. CALCULATIONS

➢ *To Calculate the Performance Factor in Both Cases as Follows:*

- C.o.p = RE / WC
- RE = m· (h1- h4)
- h2- h1) (m· WC =

➢ *When the Tank is Not in Use*

- C.o.p = RE / WC
- RE = m· (h1-h4)
- RE = m· (400-250)
- RE = 1 (150)

➢ *Assuming the Mass Flow Rate* m· = **kg / s1**

- RE =150w
- WC = m· (h2-h1)
- WC = m· (420-400)
- WC = 1* (20)
- WC = 20 watt
- C.o.p = 150 / 20 = 7.5

➢ *In Case of Using the Tank*

- C.o.p = RE / WC
- RE = m· (h1-h4)
- RE = m· (395-260)
- RE = m· (135)

➢ *Assuming the Mass Flow Rate m·* 1= (*kg/s)*

- **WC = m· (h2-h1)**
- **WC = m· (410-395)**
- **WC = 1* (15)**
- **WC = 15 w**
- **C.o.p = 135 / 15 = 9**
- **watt135 RE =**

VII. CONCLUSIONS

➢ *We Arrive at the Following Conclusion:*

After assembling the compression refrigeration system, specifically the incorporation of three non-return valves, we conducted a series of charging and discharging procedures. This was accompanied by the collection of data and the execution of necessary calculations to ascertain the optimal performance of the evaporator under two distinct scenarios:

- The performance of the evaporator without the inclusion of a liquid collection tank.
- The performance of the evaporator with the liquid collection tank positioned prior to the evaporator.

Our findings indicate that the performance coefficient of the evaporator in the compression refrigeration system, when utilizing the liquid collection tank, surpassed that of the evaporator operating without it. Consequently, it is advantageous to implement the liquid collection tank prior to the evaporator.

It is important to note that variations in weather conditions may influence the readings obtained from the compression refrigeration system.

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