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وزارة التعليم العالي والبحث العلمي

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كلية الهندسة

قسم الهندسة الميكانيكية

الكراس التعريفي لتجارب  
مختبر التثليج

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## **(Experiment 01)**

### **Name of the experiment:**

## **Refrigeration Demonstration Unit**

### **The goal of the experiment:**

- **Observing the boiling and condensation of the refrigerant in compression refrigeration cycle and the calculation of the performance coefficient**

- **Introduction**

For the purpose of clarifying the physical phenomena that occur in a compressive refrigeration cycle, the evaporator and condenser in this unit are made of a transparent material to facilitate the observation of the evaporation and condensation processes, which are the basis of the work of all compressive refrigeration cycles with wide uses. In this system, the refrigerant R-11 is used because its specifications that allow it to be used in an illustrative device of this type was used, and in practice this type is used with refrigeration cycles with centrifugal compressors. The R-11 refrigerant has a somewhat bright operating pressure compared to other types, as it can be condensed at normal temperatures and at a pressure slightly greater than atmospheric pressure

- **The used device**

Figure 1 shows a layout of the laboratory device used and prepared previously for illustrative purposes only, as it consists of the following basic parts:

### **1- Compressor**

In this experiment, a compressor of a special type called a diaphragm compressor was used, and there are no practical special applications for this type of compressor. As shown in Figure 1, this compressor has a special diaphragm that moves reciprocating motion by a special electric motor with a power of 0.25 horsepower at a rotational speed of 1425 revolutions per minute.

As for the reasons for choosing this type of compressor for this experiment, which are

- 1- It is not easy to failure due to misuse of the system, an object that enters the refrigeration in a state of liquidity
- 2- It does not need lubrication, which keeps the system uncontaminated from the impact of oil.

### **2-Condenser**

It consists of a thick glass cylinder with metal ends that have the ability to withstand a rather high pressure and allow watching the process of condensation of the refrigerant inside and to protect it from shocks put a transparent plastic cover and since the condensation process is to subtract the latent heat from the refrigerant, this glass cylinder has been provided with a heat exchanger in the form of a coil of chrome-plated copper tubes .Through this exchanger, water flows from an external source at room

temperature, absorbing the latent heat from the vapor of the refrigerant to convert it into a liquid formed in the form of droplets on the surface of the coil and then collects at the bottom of the cylinder.

As for the water passing inside the coil, its temperature will rise as a result of absorbing the latent heat, so the temperature of the water is measured at entry and exit with two mercury temperatures fixed with special rubber gaps, and there is another mercury thermometer to measure the temperature of the refrigerant inside the condenser. To measure the pressure of the refrigerant condensation inside the condenser, connect pressure gauge in two appropriate gradations to the upper end of the cylinder and also to this gauge a special electrical switch to protect the condenser from very high pressure.

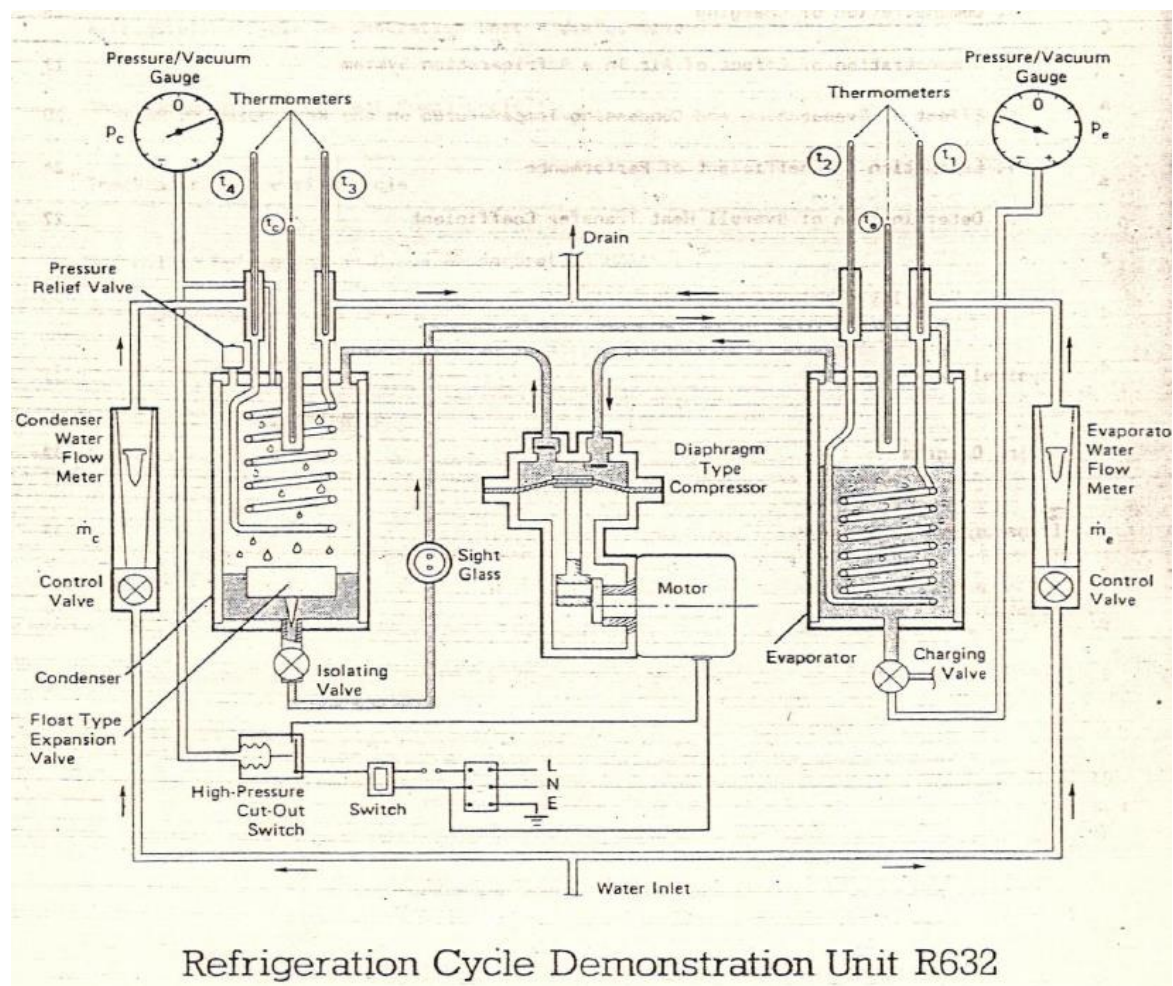


Figure 1 schematic of the lab device

### 3- Expansion device

The expansion valve used is part of the condenser and consists of a float operated needle valve valve installed in the pipe from which the refrigerant comes out evacuate the condenser rises cylinder causing the passage of the largest amount of it to the evaporator and with this work undermines the pressure of the refrigerant and there is also after the expansion valve another valve to control the amount of refrigerant flowing

#### **4- Evaporator**

It is quite similar to a condenser except that the process during which it takes place is a boiling process where the evaporation process can be clearly seen through the evaporator wall. In the evaporator, the refrigerant absorbs the latent heat of evaporation from a coil through which water to be cooled flows.

#### **5- Other components**

The system is equipped by the following components

- a- Electrical switch to operate the compressor.
- b- Control valves of water flow to the evaporator coil and condenser coil.
- c- Flowmeters for measuring water flow rates to the evaporation coil and condensing coil equipped with valves to control the rate of water flow through them.

#### **• Test method**

- 1- Make sure that the amount of refrigerant inside the evaporator is sufficient to cover the evaporation coil
- 2- Make sure that the thermometers are in the gaps designated for them and are well fixed
- 3- Open the valve for determining the flow of refrigerant to the maximum possible
- 4- Open the main valve for the flow of water and determine the amount of water flowing through the evaporation and condensation coil within reasonable limits
- 5- Connect the switch to the compressor and after a while we notice the start of the boiling process followed by the condensation process. Wait for a certain period during which to observe all the oysters, provided that it is not less than ten minutes, when the cycle has reached a stable state. We record the readings as shown in the attached readings and calculations table.
- 6- Change the flow rate of water through the evaporation coil towards more to increase the thermal load on the evaporator and repeat the process to obtain three or four separate readings
- 7- Disconnect the power supply from the compressor and wait for a certain period in which the temperatures are equal in mercury thermometers, then close the water main valve.

**Note:** The experiment can be performed by keeping the flow rate of water through the evaporation coil constant and changing the flow rate through the condensing coil to obtain different readings.

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#### **• The calculations**

To calculate the unit performance coefficient, we use the following equations with the neglect of heat transfer from the external slope of both the evaporator cylinder and the

condenser to the external environment, i.e. laboratory air, and these losses do not exceed 3% in any case.

$$\dot{Q}_e = m_e \dot{C}_p (t_1 - t_2) \quad kW$$

Where

$Q_e$  is the heat gain in the evaporator (kW)

$m_e$  is water flow rate through the evaporator (kg/s)

$t_2, t_1$  are water temperatures at inlet and outlet of the evaporating coil respectively ( $^{\circ}C$ )

$$\dot{Q}_c = m_c \dot{C}_p (t_o - t_1) \quad kW$$

Where

$Q_c$  is the heat loss in the condenser (kW)

$m_c$  is water flow rate through the condenser (kg/s)

$t_2, t_1$  are water temperatures at inlet and outlet of the condensing coil respectively ( $^{\circ}C$ )

Depending on the first law of thermodynamic of the heat cycle, the net heat gained or lost is equal to the network transferred during the cycle.

$$w_c = \dot{Q}_c - \dot{Q}_e \quad kW$$

$W_c$  is the add work in the compressor (kW).

Since the performance coefficient is equal to the ratio of the refrigeration product to the work spent in the compressor, we get

$$COP = \frac{\dot{Q}_e}{w_c}$$

### • The result and discussion

- 1- Demonstrate a sample of the calculations for one reading and then record the results in the table of readings and calculations
- 2- Explain the effect of changing the flow rate of water to the evaporator on the cycle performance coefficient.

- **The readings**

<b>The readings</b>		<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>
<b>The Evaporator</b>	Saturation temperature of the refrigerant $t_e$ ( $^{\circ}\text{C}$ )				
	Saturation pressure of the refrigerant $P_e$ ( $\text{kN/m}^2$ )				
	Mass flow rate of water $m_e$ ( $\text{m}^3/\text{s}$ )				
	Inlet water temperature $t_1$ ( $^{\circ}\text{C}$ )				
	Outlet water temperature $t_2$ ( $^{\circ}\text{C}$ )				
<b>The condenser</b>	Saturation temperature of the refrigerant $t_c$ ( $^{\circ}\text{C}$ )				
	Saturation pressure of the refrigerant $P_c$ ( $\text{kN/m}^2$ )				
	Mass flow rate of water $m_e$ ( $\text{m}^3/\text{s}$ )				
	Inlet water temperature $t_1$ ( $^{\circ}\text{C}$ )				
	Outlet water temperature $t_o$ ( $^{\circ}\text{C}$ )				

- **The calculation**

<b>The readings</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>
Heat gain in the evaporator $Q_e$ (kW)				
Heat loss in the condenser $Q_c$ (kW)				
Work added in the compressor $W_c$ (kW)				
Coefficient of performance COP				

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