Ministry of Higher Education and Scientific Research

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وزارة التعليم العالي والبحث العلمي

جامعة الانبار

كلية الهندسة

قسم الهندسة الميكانيكية

الكــراس التــعريفي لتجـــــــــارب

مختبـــــــــر التثليج

إعداد:

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المحتويات

الفصل الاول (تجارب المختبر)	
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٢	اسم التجربة
٣	الهدف من التجربة
٤	المعدات المستخدمة في التجربة
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٨	اسم الجهاز
٩	وصف الجهاز
١٠	طريقة استخدام الجهاز

(Experiment 02)

Name of the experiment:

Heat pump

The goal of the experiment:

- **Identify the parts of the heat pump**
- **Finding the energy gained, the energy lost and the coefficient of performance**

Introduction

Most refrigeration processes are currently carried out using steam compression systems, including, among other applications, food storage and transportation, industrial food containers and central air conditioning. The heat pump is the mechanism of its main work extracting the waste from a heat reservoir with a low temperature and pumping it to a heat reservoir whose temperature is high at a useful temperature, and this temperature may be suitable for heating a place or providing hot water for domestic use or otherwise. The absorbed energy at low temperature can be saved for use at high temperature by equipping mechanical work to a compressive refrigeration, and the heat pump is the name given to the system when the system works in this way.

The used device

Figure 1 shows a diagram of the device used to conduct this experiment, manufacturing by Hilton company, mechanical heat pump using R512, which is specially designed for the laboratory so that students can understand the basic processes that take place in the compression refrigeration cycle and consist of the following parts.

Compressor

It is of the closed hermetic type with a rotational speed of about 2800 rpm and the volume of displaced gas is 8.85 cm^3 per cycle.

Condenser

It is two concentric tubes, the R-12 refrigerant passes into the outer tube while the cooling water flows in the inner tube and in a direction opposite to the direction of the flow of the refrigerant.

Expansion device

It is a thermostatic expansion valve by which manual calibration of the degree of freezing can be performed Evaporator.

Evaporator

The evaporator used in this unit is a finned copper coil with a fan to warm air on it and a basin at its base to collect condensate water on its pipes

Measuring devices

It includes a measure of electrical power consumed by the unit, a mass flow meter of water during the condenser, another to measure the mass flow of the refrigerant, as well as a digital meter connected to a set of thermocouples to measure temperatures in different points of the cycle. In addition, there are two pressure gauges on the high and low pressure sides of the cycle.

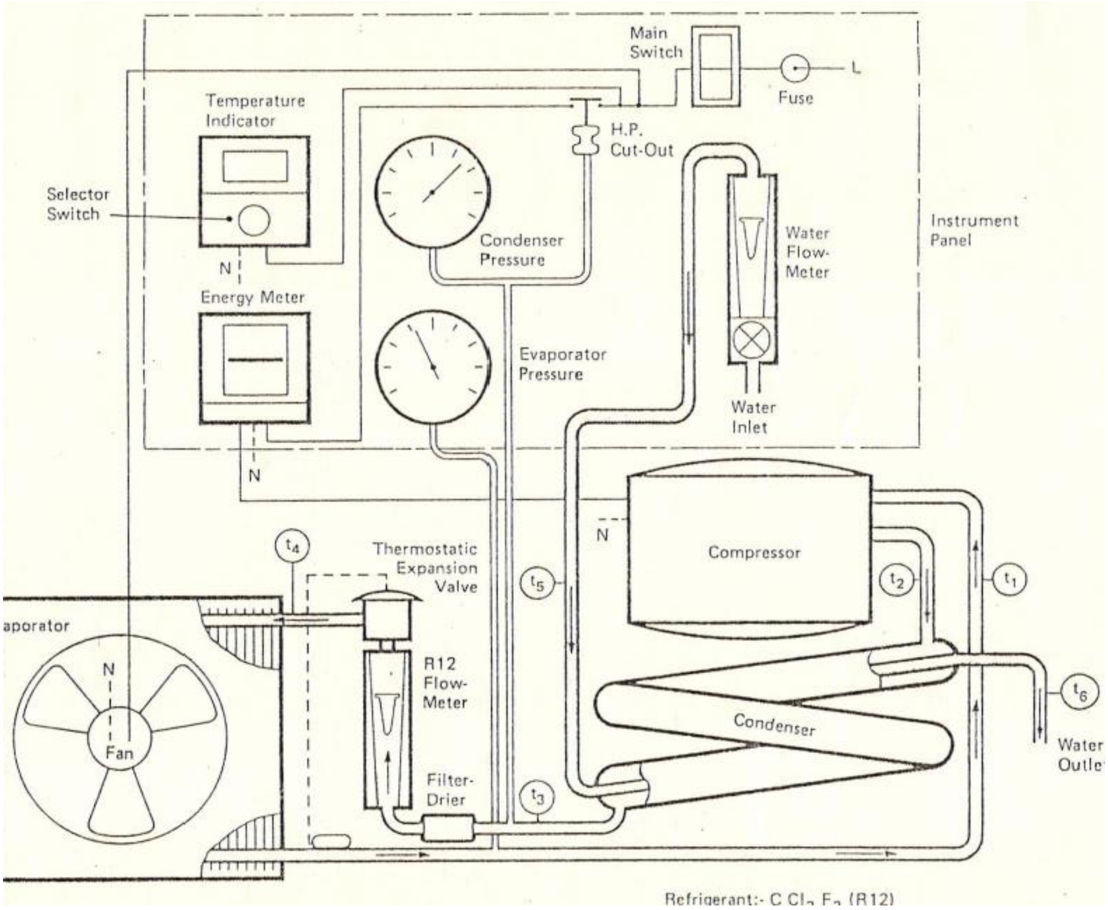

Figure 1. Mechanical heat pump

Test method

1- Open the condenser water to about 0.8 of the maximum value of the flow rate.
2- Press the circuit switch to turn on the compressor.
3- Leave the unit running until it reaches the steady state and then record the readings shown in the table.
4- Reduce the flow rate of the condenser water so that the temperature of the outgoing water increases (t_6) about 6 ^{O}C and leave the unit to reach the steady state and then record the required readings.
5- Repeat step 4 several times until you reach (t_6) to my mobile 55 ^{O}C.

Note: The above steps are carried out at a constant temperature of the laboratory air, and the same steps can be repeated at an air temperature about 5-10 degrees higher than the previous one (this is possible by directing hot air to the unit).

- ## The calculations

First method

1- **Calculation of electrical power consumed in the unit**

$$P_{elec.} = \frac{C}{\tau} \quad Watt$$

C: is a constant depends on the electrical power meter Since the number of cycles of the scale disk is equal to **150** cycles per kW and since 1 watt-hour equal to **3.6 * 10 ^{6}** joules, the measurement constant is equal to **C=3.6 * 10 ^{6} /150** joules per cycle.

τ : One cycle time for the electric meter disk.

2- **The rate of heat rejection in the condenser**

$$\dot{Q}_H = \dot{m}_w \, cp \, (t_6 - t_5) \quad Watt$$

Cp: specific heat of water **J/kg. K**

$\dot{m}_w$ **:** mass flow rate of water **kg/s**

3- **Coefficient of performance**

$$C.O.P_H = \frac{\dot{Q}_H}{P_{elect.}}$$

Second method

1- Using the pressure-enthalpy **(p-h)** diagram of the refrigerant **R12**, the enthalpy values of the refrigerant must be found at different points of the cycle h_1,h_2,h_3, and h_4, where these symbols indicate the enthalpy of the refrigerant entering and leaving the compressor, entering the expansion valve and entering to the evaporator respectively

2- Calculation of heat transferred from the icing fluid in the condenser

$$\dot{Q}_c = \dot{m}_r \ (h_2 - h_3) \quad Watt$$

The result is compared with the heat transferred to the water (**step 2 above**) and the reason for the difference, if any,

3- Compression work calculation

$$P_w = \dot{m}_r \, (h_2 - h_1) \quad Watt$$

4- Coefficient of performance calculation

$$C.O.P_H = \frac{\dot{Q}_{Cond.}}{P_w} = \frac{h_2 - h_3}{h_2 - h_1}$$

- ## The discussion

1- Draw the curve of the relationship between the rate of heat transferred to water $\mathbf{Q_H}$ and the electrical power consumed $\mathbf{P_{elec.}}$ and the performance factor **C.O.P** (all on the vertical axis) and condensing temperature ($\mathbf{t_6}$) (on the horizontal axis)

2- Discuss in detail the difference between the results obtained from the two methods

- ## The readings

The readings		1	2	3	4	5
Time of one cycle of the electrical meter disk τ (s)						
Refrigerant R-12	Water mass flow rate m_r (kg/s)					
	Refrigerant temperature at compressor inlet t_1 (°C)					
	Refrigerant temperature at compressor outlet t_2 (°C)					
	Refrigerant temperature at condenser outlet t_3 (°C)					
	Refrigerant temperature at evaporator inlet t_4 (°C)					
	Evaporator pressure P_e (kN/m^2)					
	Condenser pressure P_c (kN/m^2)					
Condensing water	Mass flow rate of water m_w (kg/s)					
	Inlet water temperature in condenser t_5 (°C)					
	Outlet water temperature in condenser t_6 (°C)					

- ## The calculation

The readings		1	2	3	4	5
First method	Electrical power consumption in compressor P_{elect} (kW)					
	Heat rejection $Q_{H.}$ (kW)					
	Coefficient of performance $C.O.P._H$					
Second method	Compressor work P_w (kW)					
	Heat rejection in condenser $Q_{Ref.}$ (kW)					