INSTITUTE OF ENGINEERING

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LAB REPORT

LAB NO: 4

SUBJECT: Thermodynamics.

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Department of Applied science.

Title : Heat Pump
Objectives
The purpose of this experiment is
→ To study about the various components of the heat pumps.
→ To study basic principle of vapor compressor refrigerator Cycle
→ To find COP of Heat Pump.

Relevant Theory.
Heat pump
It is a device that transfers the heat from the low temperature reservior to the high temperature reservior in order to maintain the temperature of a specified space higher than the surrounding by consuming energy.
The performance of a heat pump is measured by its coefficient of the performance, which is defined as the ratio of desired effect to the work supplied.
Refrigerator
It is a device, operating on a cyclic process, which takes heat from a low temperature reservior at T_L (desired Space) and delivers it to a high temperatouve T_H (Surrounding) with the help of external work. Refrigerator maintains the temperature of a desired Space lower than that of the surroundings. Performance of the refrigerator is also ~~maintained~~ measured by its coefficient of performance, and in case of refrigerator, desired effect is the amount of heat taken out from the desired space.
The ideal vapour compression cycle is represented below in which heat is taken from a constant low temperature source at T_L and is rejected to a constant higher temperature sink at T_H.
Saturated vapour at 1 is compressed isentropically from a a low pressure P_1 to a higher pressure P_2. Superheated vapor at state 2 is passed into a condenser and heat is rejected at constant pressure to a cooling medium so that the vapour condenses and become saturated liquid at state 3. The high pressure saturated liquid is throttled from P_3 to P_4 and the resulting very wet vapor is passed into an evaporator at state 4. In the evaporator, the vapour evaporates at low temperature taking in heat from the low temperature heat reservoir and reaches state 1. The cycle now repeats.

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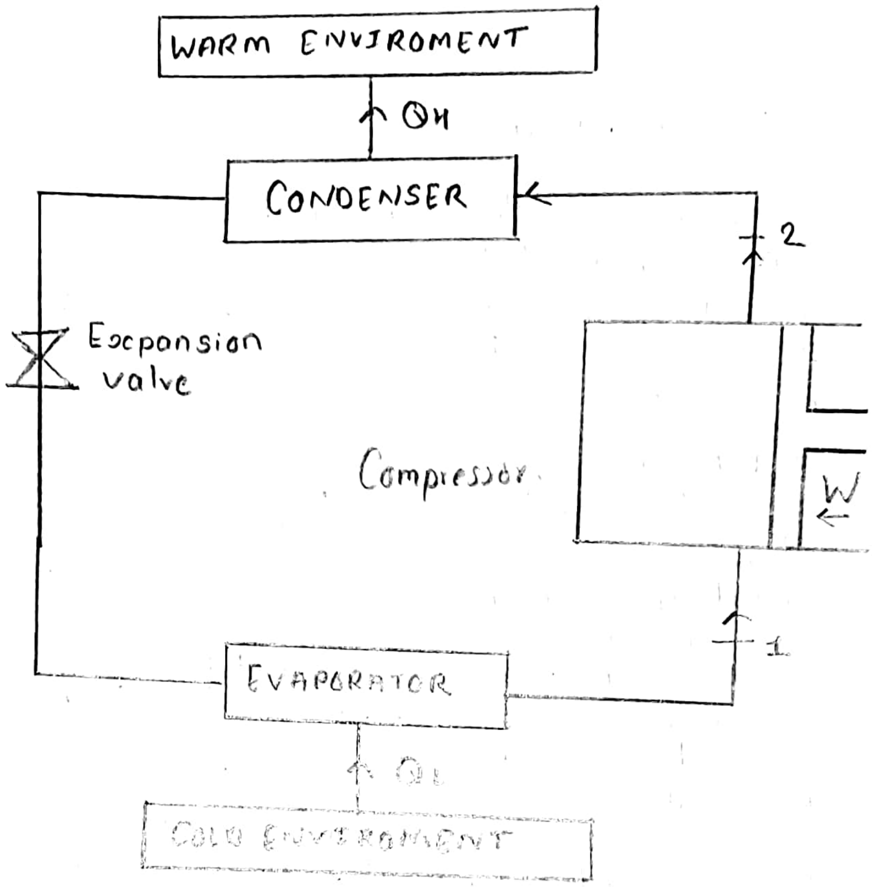
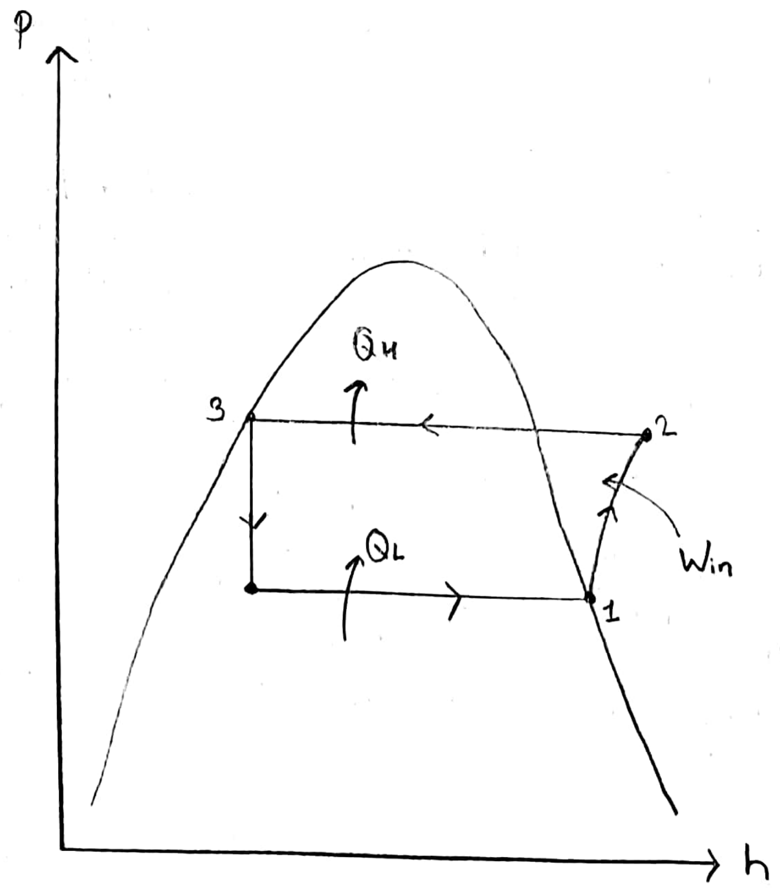

WARM ENVIROMENT
QH
CONDENSER
2
Expansion valve
Compressor
W
1
EVAPORATOR
QL
COLD ENVIROMENT


P
QH
3
2
QL
Win
1
h

There are some differences regarding the practical cycle and the ideal cycle. The practical cycle differs from the idealized cycle in the following ways.

1) Due to friction, there will be a small pressure drop between the compressor discharge and expansion valve inlet, and between the expansion valve outlet and the compresser suction.

2) The ~~compressor~~ compression process is neither adiabatic nor reversible. (There will usually be a heat loss from the compressor and, obviously, there are friction effects.)

3) The vapour leaving the evaporator is usually superheated. (This makes possible automatic control of the expansion valve and prevents compressor damage by ensuring no liquid enters the suction valve.

4) The liquid leaving the condenser is usually sub-cooled, ie it is reduced below the saturation temperature corresponding with its pressure. (This improves the COP and reduces the possibility of formation of vapour due to the pressure drop in the pipe leading to the expansion valve.).

5) There may be small heat inputs or losses to or from the surroundings to all parts of the circuit depending upon their temperature relative to the surrounding.

Second law of Thermodynamics

The second law of thermodynamics states that it is impossible to transfer heat from a region at a low temperature to another at a high temperature without expenditure of energy. Heat pumps and refrigerators are the example machines which transfer heat energy fom low to a high temperature region consuming energy.

The vapour compression refrigeration cycle finds application in countless industrial and domestic situation throughout the world. In the majority of these application, the emphasis upon measuring (maintaining) a product or air steam at a low temperature whilst rejecting the heat extracted to a sink at a higher temperature. However the vapour compression refrigeration cycle may be equally be utilized to upgrade heat from low grade source to ~~hig~~ atmosphere, river, soil so that it may be discharged at a more useful higher temperature for some application. This application may be space heating or water heating.

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Equipment Description

Refrigerant vapor generated by absorbtion of low grade heat in either the air or water source evaporator is drawn into compressor. This extraction of heat from the air or water reduces the temperature of air or water flowing leaving the unit.

The workdone on the gas by the compressor increases the pressure and temperature of the refrigerant vapour. This hot high pressure gas flows to a concentric tube water condenser.

In the condenser, the gas is desuperheated and then condensed at essentially constant temperature. Before leaving the condenser, the liquid refrigerant is slightly subcooled below the saturation temperature for the condensing pressure and then this liquid flows to a liquid receiver.

The liquid receiver gives a large volume, into which excess refrigerant can flow during operating conditions. In addition to the receiver ensures that liquid is always available for the changes in demand due to evaporator loading.

The compressor motor has winding resistance losses, internal friction and the compression process is not isentropic. All of these condition results in some of the electrical energy input being covered into heat. The compressor and the motor are contained within the hermetically sealed steel casing and run in oil which during normal operation is wormed by circulating around the casing and collects at the base of the unit. During normal operation some oil will be carried out around the system and under certain conditions may appear in variable area flow meter as a discoloration to the flow. This is quite normal and will dissappear during the normal running process.

As the compressor is designed specifically for heat pump uses, a copper heat transfer coil is located at the base of the compressor within the oil reservior. By passing the cold water from the main supply through this coil before the water is transferred to the condenser normally waste heat from the oil can be added to that given up to condenser.

Subcooled liquid at high pressure passes through a panel mounted flow meter to a thermostatically controlled expansion valve. On passing through the valve the pressure is reduced to that of the evaporator and the two phase mixture of the liquid and vapor begins to evaporator within the selected evaporator.

Control of the heat pump is by variation of the condensing temperature by the source air (or water) temperature and flow rate, and by variation of condensing temperature by the flow rate of the condenser water.

The range of the source temperature can be extended directing warmed air from a fan heater at the air intake or by warmed or chilled water to the source water inlet.

Revelant system temperature can also be measured by the Alcohol thermometer.

Condenser and evaporator pressure are indicated by panel mounted pressure garges. Water and refrigerant flow can be visualized by flow meters and indicator on the panel respectively.

Observation

1) Compressor electrical power input (w) = 312 W
2) Cooling water inlet temperature (t_5) = 16 °C
3) Compressor cooling water outlet temperature (t_6) = 24 °C
4) Condenser water outlet temperature (t_7) = 28 °C
5) Condense water mass flow rate (m_c) = 20 kg/sec.

Calculation.

$$COP = \frac{m_c . C_p . (T_7 - T_5)}{W}$$

$$= \frac{20 \times 4.18 \, (T_7 - T_5)}{312} \qquad [C_p = 4.18 \text{ kJ/kgk}]$$

$$= \frac{20 \times 4.18 \, (28-24)}{312}$$

$$= 3.21538$$

Discussion and Conclusion.

With the help of our theoretical knowledge, we performed the experiment in order to calculate the COP of the heat pump. We also studied about the various components of the heat pump ~~and~~ the basic principle of vapor compression refrigeration cycle. Here, We donot Calculate the efficiency of of the heat pump instead we calculate the COP (coefficient of performance) because while calculating the efficienrey, the value ~~will be~~ obtained will be greater than One which is inappropriate.

The refrigerator ~~produces~~ uses the CFC's (chloro fluoro carbon) which are the reason for the ozone layer depletion. The hydrocarbon is used as a refrigerand because hydrocarbon donot deplete the ozone layer depletion. ~~but the~~ But the Chlorofluorocarbon deplets and also ~~the~~ affect the green house gases ~~and~~ greenhouse effets.