21/11/21

EXPERIMENT – 6

Objective

To study and understand the working principle & and components of a Refrigerator.

Theory :

Refrigeration : It is defined as the art of producing and maintaining temperature in a span below atmospheric temperature.

It is used to remove heat continuously from a source sink and maintain the temperature below atmospheric temperature and reject heat to the sink.

Artificial methods of obtaining refrigeration :

1. Vapour compression cycle
2. Vapour absorption cycle
3. Air or Gas cycle refrigeration
4. Steam jet refrigeration.
5. Non - conventional methods.

Working of the Refrigerator

→ For obtaining ~~heat~~ refrigeration, heat is to be removed from a substance or space maintained at a lower temperature. In order to absorb this heat at a lower temperature,

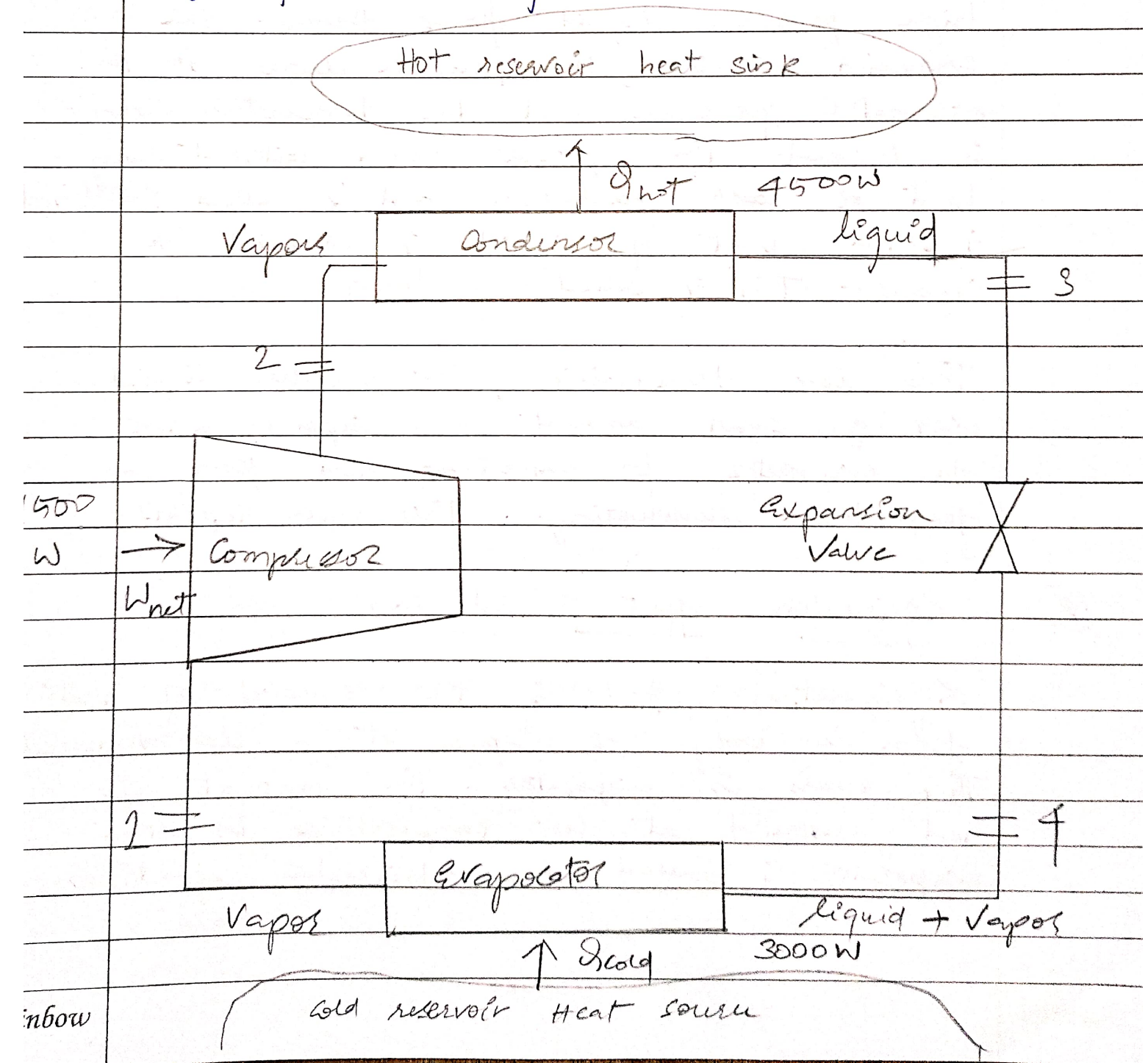
The working medium, the refrigerant liquid, has to boil at the temperature lower than the space temperature so that it absorbs the latent heat from the refrigerated space. The heat exchanger placed inside the refrigerated space is called evaporator as the refrigerant liquid evaporates here. The pressure of the refrigerant liquid has to be low enough so that it can boil at lower temperature.

The vapour coming from the evaporator is at a ~~too~~ low temperature and a low pressure. In order to reuse the same refrigerant in the evaporator, it has to undergo a cyclic process. A compressor is used to raise the temperature and pressure.

The compressor achieves 2 functions - it continuously sucks and removes vapour from the evaporator thus maintaining a low pressure in the evaporator, and it also raises the temperature and pressure of the vapour so that it can reject heat in the ~~compressor~~ condensor.

Due to the high pressure after compression, the condensing temperature of the refrigerant increases above the surrounding ambient temperature. Condenser is also a heat exchanger like the evaporator. The high temperature high pressure vapour flows on one side

and ambient air or water flows on the other side. The temperature of refrigerant vapour is higher than the surrounding medium. (ambient air/water) so it rejects heat to this medium and gets cooled down to its situration temperature and further rejection of heat condenses it to a liquid. At the outlet of the condensor, the refrigerant is high temperature, high pressure liquid.



This high temperature high pressure liquid is made to flow through a restricted path which causes the pressure drop.

Expansion device device is the component used to create ~~obs~~ obstruction to flow of liquid and also to meter the refrigerant flow through the evaporator in response to varying ~~load~~ load. The expansion device could be a capillary tube or a thermostatic expansion valve. When the high temperature high pressure liquid flows through the expansion device, its pressure drops to the evaporator pressure and the temperature also is lowered. The process occurs without any heat or work exchange and is called throttling. A small part of liquid is converted to vapour - This is called flashing.

This low temperature, low pressure liquid with a small amount of vapour enters the evaporator for extracting heat from low temperature surrounding. This cycle repeats.

(2) Refrigeration effect and COP.

Refrigeration effect is the removal of heat from a body or space at a low temperature. This occurs in evaporator. The amount of heat extracted at low temperature in the evaporator is called the refrigeration effect.

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Work is required to be done on the refrigerant to compress it. The net work input is the net work required for the compression. The performance of a refrigeration system can be evaluated by taking a ratio of refrigeration effect to net work input. This is termed as coefficient of performance or COP.

2. (A) Theoritical Simple Saturated Vapour Compression cycle.

→ The four processes in a theoritical vapour compression cycle are:

(1) 1 – 2 : Reversible adiabatic or isentropic compression of refrigerant vapours

(2) ~~1 – 2 – 3~~

2 – 3 : Reversible adiabatic compression of refrigerant vapor.

(3) 3 – 4 : Irreversible expansion at constant enthalpy – (Throttling)

(4) 4 – 1 : Reversible heat absorbtion at constant pressure. (vaporation from liquid to vapour)

Heat rejected in condensor =

$$q_R = q_2 - q_3 = (h_2 - h_3)$$ ... on unit basis.

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Refrigeration Effect : = Heat absorbed in the evaporator.

$$q_A = q_4 - q_1 = (h_1 - h_4)$$

Net work input, W_{in} = Heat Rejected − Heat absorbed

$$= q_R - q_A = (h_2 - h_3) - (h_1 - h_4)$$

$$= (h_2 - h_1)$$

$$COP = \frac{\text{Refrigeration Effect}}{\text{Net Work input}} = \frac{(h_1 - h_4)}{(h_2 - h_1)}$$

(★) Domestic Refrigerator

Basic components are:

(1) Evaporator and compressor

(2) Condensor

(3) Expansion device

(★) Conclusion :

The working and applications of a refrigeration rig were studied and understood in detail.

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(*) Questions

Q.1. Define Refrigerant, COP and Tons of refrigeration.

Ans. (1.) Refrigerant: A refrigerant is a working fluid used refrigeration cycle of air conditioning systems and heat pumps where in most cases they undergo a repeated phase transition from a liquid to a gas and back again. Refrigerants are heavily regulated due to their toxicity, flammability, and contribution of CFC and HCFC refrigerants to ozone depletion and that of HFC refrigerants to climate change.

(2.) COP: The performance of a refrigeration system can be evaluated by taking a ratio of refrigeration effect to net work input. This is termed as co-efficient of Performance or COP.

$$COP = \frac{\text{Refrigeration effect}}{\text{Net Work input}} = \frac{h_1 - h_4}{h_2 - h_1}$$

(3) Tons of Refrigeration: (TOR) or (RT)

is a unit of power used in some countries (North American) to describe the heat extraction capacity of refrigeration and air conditioning equipment equipment.

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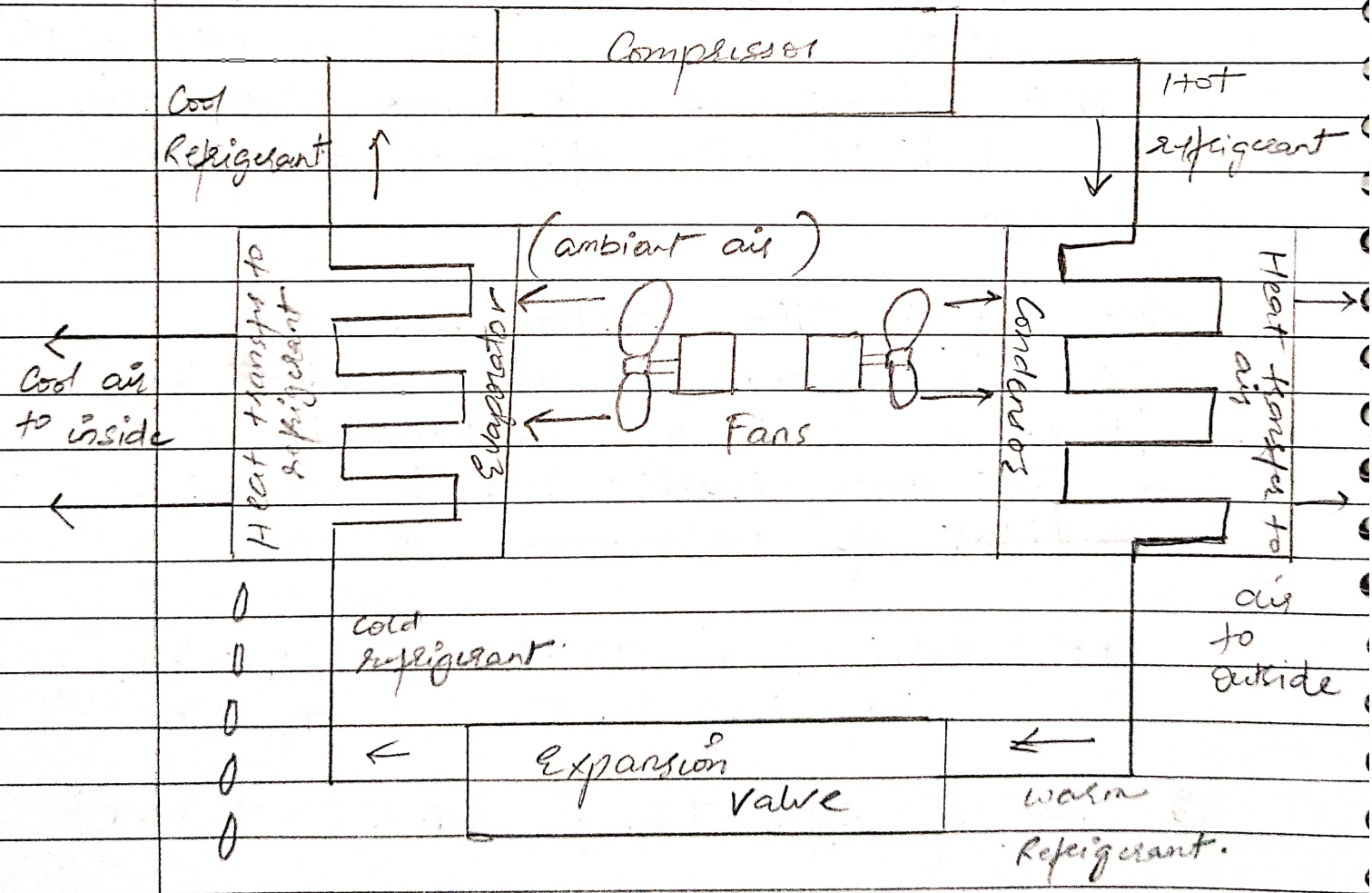
It is defined as the rate of heat transfer that results in the freezing or melting of 1 short ton (2000 lb, 907 kg) of pure ice at 0°C (32°F) in 24 hrs.

Q.2. Explain with a neat sketch the working of an Air conditioner.

Fig :2 : Working of a ~~refrigerator~~ Air conditioner.



When you turn on an air conditioner and set the desired temperature say 20° celsius, the thermostat installed in it will detect that there is a difference between the temperature of the room air and the temperature you have chosen.

This warm air is sucked in through a grill at the bottom of the indoor unit, which then flows through some pipes through which the refrigerant, i.e a coolant, flows. The refrigerant fluid absorbs the heat and itself becomes a hot gas. Thus, heat is removed from the air that falls on the evaporator coils. Note that the evaporator coil not only absorbs heat, but also pushes moisture out of the incoming air, which helps to dehumidify the room.

This hot refrigerant gas is then passed on to the compressor located on the outside unit, which then compresses the gas thereby increasing its temperature and pressure. This hot high pressure gas then reaches the condensor.

The refrigerant enters the condensor as a hot gas but quickly becomes a cool liquid as the heat from the hot gas is quickly dissipated into the environment through metal fins. As a result the refrigerant loses its heat as it leaves the condensor and becomes a cool liquid. This flows through an expansion valve, a

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- Tiny hole in the system's copper tube, which controls the flow of the cool liquid refrigerant into the evaporator, so that the refrigerant then arrives at a point where its journey began.