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CALCULATION OF COEFFICIENT OF PERFORMANCE IN VAPOUR COMPRESSION REFRIGERATION SYSTEM BY USING R600 REFRIGERANT

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ABSTRACT

This Synopsis deals with experimental investigation by using R600 refrigerant and to calculate the value of COP. We have all experienced a sensation of heat when passing behind a functioning refrigerator or air conditioner. The cause of this phenomenon is the air condenser, a heat exchanger made up of tubes with air fins attached to the back of the device. This is where the cooling fluid condenses by releasing its heat into the ambient air. To limit the system's energy consumption, humidification processes were initiated. The principle consists of saturating the ambient air in contact with the exchanger by projecting fine water droplets. Humidification of the air intensifies the heat exchange on the air side and reduces the cooling fluid's condensation temperature. This lowers the compression rate in the cooling cycle and improves the compressor's consumption of electrical power

INTRODUCTION

Refrigeration may be defined as the process to achieve and keep an enclosed space at a temperature lower than its surrounding temperature. This is done by continuous extraction of heat from the enclosed space whereas the temperature is below than that of the surrounding temperature. Nowadays refrigeration is something that is indispensable in our daily life. One of the most important applications is the preservation of perishable foods and keeps the food in fresh condition. There is no doubt that food, is just like air and water are necessities for livings. People often utilize refrigeration to chill their drinks, making it more scrumptious. In additional, refrigeration also being used in providing thermal comfort to people by means of air conditioning process. Historically, it is generally agreed that the first refrigeration machine was introduced in 1755 which was made by Scottish professor William Cullen. However, he did not use his discovery for any practical purpose. In the following 50 years, an American inventor, Oliver Evans, designed the first refrigeration machine. An American physician, John Gorrie, built a refrigerator based on Oliver Evans' design in 1844 to make ice to cool the air for his yellow fever patients. A German engineer named Carl von Linden patented not a refrigerator but the process of liquefying gas in 1876 that is part of basic refrigeration technology. Generally refrigeration systems can be classified in 3 main cycle systems which are vapor compression refrigeration system, vapor absorption refrigeration system, and gas cycle refrigeration system. However the vapor compression refrigeration system is the most widely used in the refrigeration process. It is adequate for most refrigeration applications. The ordinary vapor compression refrigeration systems are simple, inexpensive, reliable and practically maintenance free.

OBJECTIVES

The main objective of this report is to improve the configuration of the refrigerator test rig to a simpler configuration. and the effect of the charge quantity of the refrigerant on the refrigeration system. Finally, obtain the optimum *COPr* by using the data collected from the experiment. To be able to do this, the exact locations of the points of interest at where the data (temperature and pressure) should be collected must be identified correctly.

SCOPES

Literature Study

The literature study is mainly focused on the fundamental of working principle of vapor compression refrigeration cycle. The working principle of each of the 4 main components, compressor, condenser, expansion device and evaporator are also in the region of concerned.

LITERATURE REVIEW

THE SECOND LAW OF THERMODYNAMICS

There are 2 classical statements of second law of thermodynamics which are the Kelvin-Planck statement and the Clausius statement. Both of Kelvin-Planck and Clausius statements are 2 equivalent expressions of the second law of thermodynamics. For refrigerators or heat pump, Clausius statement is being related to which is expressed as “It is impossible to construct a device that operates in a cycle and produces no effect other than the transfer of heat from a lower-temperature body to a higher temperature body” (Cengel, 2008).

There is commonsense that heat does not naturally transfer on its own from a colder medium to a warmer medium. The Clausius statement simply means that if a cyclic device that transfers heat from a colder medium to a warmer medium will be impossible to be achieved or construct, unless this cyclic device produce a net effect on other (Cengel, 2008).

For an example, a cyclic device that transfers heat from a cold medium to a warmer one has long been constructed which is the domestic refrigerator. A domestic refrigerator is in complete compliance with the Clausius statement of the second law of thermodynamics. The Clausius statement simply states that a refrigerator cannot operate unless its compressor is driven by an external power source, such as an electric motor. In this case, the compressor leaves a trace in the surroundings by consuming some energy in the form of work by the electric motor so that to transfer heat from the colder body to a warmer one (Cengel, 2008).

REFRIGERANTS

Over the last decade, the choice of refrigerant used in a refrigeration system has been becoming a worldwide issue as mainly in response to the environmental issues of “holes in the ozone layer” and “global warming or greenhouse effect”. Previously people had no much discussion on the selection of refrigerant. The refrigerants chosen were all based on the capability of heat absorption and releasing of the fluids, which depends on the latent heat of vaporization of the fluids. As the majority of applications could be met by the well known and well tested fluids, R-11, R- 12, R-22, R-502 and ammonia (R-717). However only ammonia can be considered environmental friendly today, but still it is not readily suited to commercial or air-conditioning refrigeration applications because of its toxicity, flammability and attack by copper. The ozone layer beyond the atmosphere provides a filter for ultraviolet radiation, which is harmful to us. The ozone depletion potential of the refrigerants such as R-11, R-12, R-114, and R502 is due to the emissions into the atmosphere of chlorofluorocarbons (CFCs). The Montreal Protocol in 1987 agreed that the production of hydro chlorofluorocarbons (HCFCs) would be phased out by 1995 with a consumption cap, followed by a 35 % reduction in consumption beginning in 2004 and alternative fluids developed (Trott, 2000). The phaseout of HCFCs is earlier in some European countries, with for example Germany having a phaseout of R-22 in new equipment starting in 2000, and Sweden banning HCFC use for new equipment after 1997, and service after 2001 (Murphy, 1998).

VAPOR COMPRESSION REFRIGERATION SYSTEM

Ideal vapor compression refrigeration cycle

The Temperature-Entropy ($T - s$) and Pressure-Enthalpy ($p - h$) diagram for the ideal vapor compression refrigeration cycle are shown in Figure 2.1.

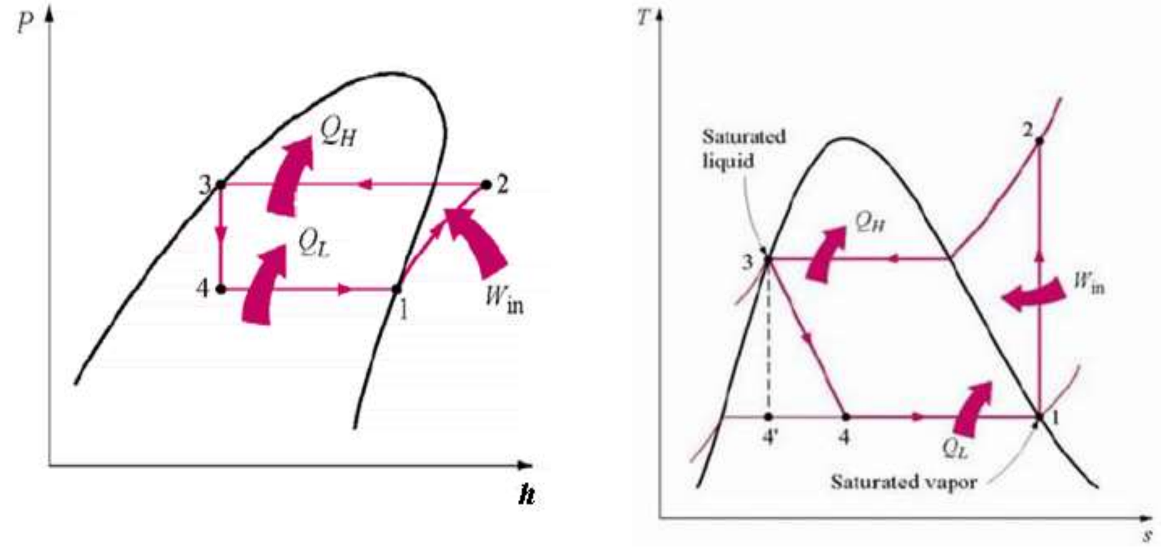


Figure 2.1: (a) T □ s and (b) p □ h diagrams for the idea vapor compression refrigeration cycle
Source: Cengel and Boles (1998)

The vapor compression refrigeration system is the most common refrigerationsystem that is being used nowadays. It is widely used for all purpose refrigeration. It iscommonly used for all industrial purposes from a small domestic refrigerator to big airconditioning plant. The vapor compression refrigeration system is an improved type ofsystem of air refrigeration system. In this system, a particularly suitable working fluid isused to run the whole system and we called this working fluid as refrigerant. Therefrigerant used is circulating throughout the system alternately condensing andevaporating without leaving the system (Khurmi, 2006).

Vapor Compression Refrigeration System

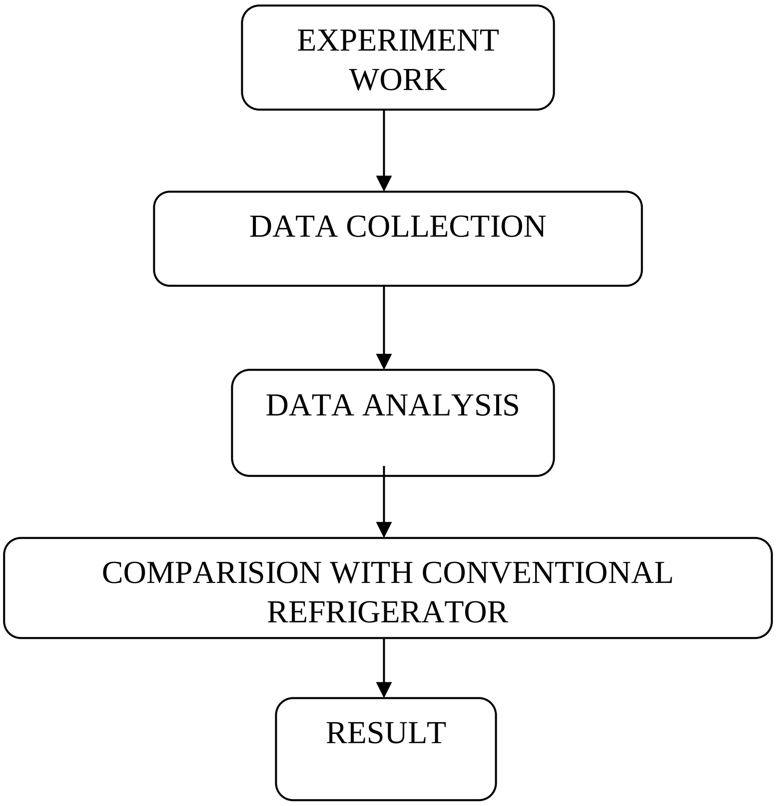
A vapour compression refrigeration system is an improved type of air refrigeration system in which a suitable working substance, termed as refrigerant, is used. It condenses and evaporates at temperatures and pressures close to the atmospheric conditions. The refrigerants, usually, used for this purpose are ammonia (NH_3), carbon dioxide (CO_2) and sulphur dioxide (SO_2). The refrigerant used, does not leave the system, but is circulated throughout the system alternately condensing and evaporating. In evaporating, the refrigerant absorbs its latent heat from the brine (salt water) which is used for circulating it around the cold chamber. While condensing, it gives out its latent heat to the circulating water of the cooler. The vapour compression refrigeration system is, therefore a latent heat pump, as it pumps its latent heat from the brine and delivers it to the cooler. The vapour compression refrigeration system is now-a-days used for all purpose refrigeration. It is generally used for all industrial purpose from a small domestic refrigerator to a big air conditioning plant.

METHODOLOGY

DESCRIPTION OF THE TEST RIG:-

Refrigeration test rig consists of a hermetically sealed compressor, air-cooled condenser, capillary and an evaporator. The evaporator cools the water in a calorimeter. A heater is provided in the calorimeter, whose output can be varied by a dimmer stat. Separate pressure gauges are provided to measure Condenser & Evaporator pressures. Five suitable thermometers are provided to measure temperatures at various locations (refer the Layout). Two energy meters are provided to measure energy supplied to compressor and heater. Suitable H.P.L.P. cutout, Voltmeter and ammeter are provided in the unit.

FLOW-CHART



REFRIGERATION SYSTEM TEST RIG

3.3.1 SPECIFICATIONS:

1. Cooling capacity: 30 kg of ice in 24 hours.
2. Insulation: PUF Insulation
3. Number of ice cans: 12
4. Size of tank: (0.83*0.345*0.345) m3.
5. Height of the tank: 0.27 m
6. Size of the ice can: (0.325*0.116*0.078) m3.

EQUIPMENT

COMPRESSOR

The low pressure and temperature vapour refrigerant from evaporator is drawn into the compressor through the inlet or suction valve A, where it is compressed to a high pressure and temperature. This high pressure and temperature vapour refrigerant is discharged into the condenser through the delivery or discharge valve B

CONDENSOR

The condenser or cooler consists of coils of pipe in which the high pressure and temperature vapour refrigerant is cooled and condensed. The refrigerant, while passing through the condenser, gives up its latent heat to the surrounding condensing medium which is normally air or water

RECEIVER

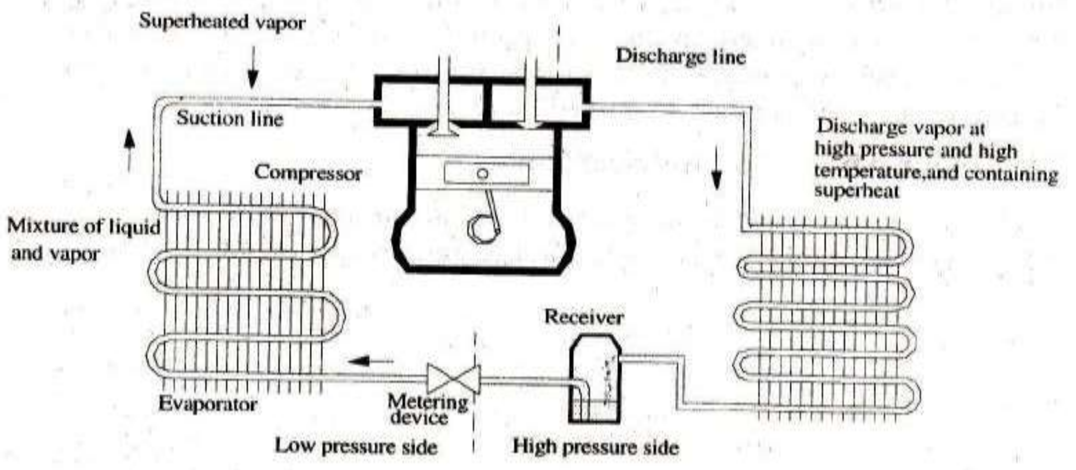
The condensed liquid refrigerant from the condenser is stored in a vessel known as receiver from where it is supplied to the evaporator through the expansion valve or refrigerant control valve.

EXPANSION VALVE

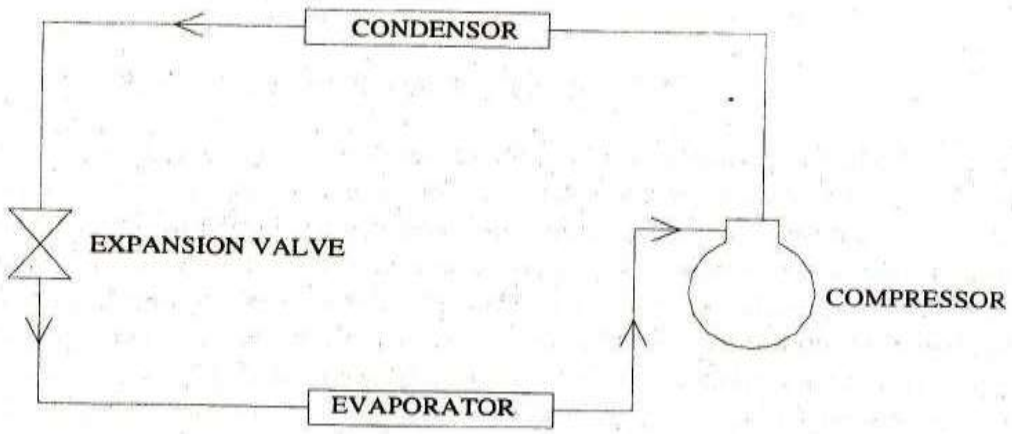
It is also called throttle valve or refrigerant control valve. The function of the expansion valve is to allow the liquid refrigerant under high pressure and temperature to pass at a controlled rate after reducing its pressure and temperature. Some of the liquid refrigerant evaporates as it passes through the expansion valve, but the greater portion is vaporized in the evaporator at the low pressure and temperature.

EVAPORATOR

An evaporator consists of coils of pipe in which the liquid-vapour refrigerant at low pressure and temperature is evaporated and changed into vapour refrigerant under high pressure and temperature to pass at a controlled rate after reducing its pressure and temperature. Some of the liquid refrigerant evaporates as it passes through the expansion valve, but the greater portion is vaporized in the evaporator at the low pressure and temperature



Vapour compression refrigerator (Schematic diagram)



OBSERVATION TABLE

Sr. no.	Description	Symbol	Reading
1	Condenser pressure	Pc	bar
2	Evaporator pressure	Pe	bar

3	Condenser inlet Temp.	Tci (T1)	°C
4	Condenser outlet Temp.	Tco(T2)	°C
5	Evaporator inlet Temp.	Tei(T3)	°C
6	Evaporator outlet Temp.	Teo(T4)	°C
7	Time Taken for 10 revolution of energy meter of compressor	Tc	sec
8	Time Taken for 10 revolution of energy meter of heater	Th	sec
9	Temp. of water	T5	°C

CALCULATION & EXPECTATION OUTCOMES
CALCULATIONS

$$\text{Theoretical COP} = \frac{\text{Theoretical refrigerating effect}}{\text{Theoretical Compressor Work}}$$

$$= \frac{He_o - He_i}{Hc_i - Hc_o} =$$

$$\text{Carnot COP} = \frac{T_{Low}}{T_{Low} - T_{High}} =$$

$$T_{low} = (t_{saturation} \text{ corresponding to } P_e) + 273 = \qquad k$$

$$T_{high} = (t_{saturation} \text{ corresponding to } P_c) + 273 = \qquad k$$

Actual COP -

R_{act} = Actual Refrigerating heat = heat produced by heater

$$R_{act} = \frac{10}{N_H} \times \frac{3600}{T_h} \text{ KW} = \underline{\hspace{4cm}} \text{ KW}$$

$$W = \text{actual energy supplied to compressor} = \frac{10}{NC} \times \frac{3600}{TC} \text{ KW} = \underline{\hspace{3cm}} \text{ KW}$$

$$\text{Actual COP} = \frac{R_{act}}{W} = \underline{\hspace{3cm}}$$

EXPECTED OUTCOMES

We are going to use R600 to find the COP at different temperature in series. It is a new refrigerant which is launched in the market.

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