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Increasing of COP in vapour compression refrigeration system by reducing compressor work through induced diffuser between evaporator and compressor for same refrigeration effect

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Abstract—

The purpose of this undertaking is to show that the COP ofvapour compression refrigeration system can be increased by installing a diffuser between the evaporator and the compressor . The sphere of diffuser is gradually decreasing, thereby pressure sensation raise . Already pressure overhead refrigerant is then sent to the compressor. In this way the work done of compressor is reduced for the same refrigeration effect and also energy is conserved. The experimental solution from vapour refrigeration system with R290 refrigerant set up (at Thermal laboratory , NEC Erode) was taken where the variables like suck pressure of compressor, delivery pressure of compressor, temperature of evaporator and condenser are noted down. After calculation the COP was found to be increased from 6 .94 to 7.446 when diffuser was used.

Index Terms:VCR system, COP, Diffuser.

I. INTRODUCTION

Refrigeration is the process in which the temperature is maintain below that of surrounding. Simply the removal of heat from the object to be cooled. We know that heat passes from hot body to cooler one until they acquire same temperature. Preservation of food items and medical supplies requires maintaining certain temperature which is accomplish by refrigeration.

In 1755 Prof.William Cullen showed that a liquid is capable of absorbing large amount of heat as they boil and evaporate. He demonstrated it by placing water in contact with ether under a receiver of a vacuum pump. Due to low pressure of vacuum pump and high evaporation rate of ether,water was frozen.

This unconscious process deals with two thermodynamic concepts, the vapour pressure and the latentheat .Saturation pressure means liquid and its vapour remains in thermal equilibrium .and depends on temperature alone. For an instance take pressure cooker,when pressure raised water stared to boil at higher temperature.

The second concept of refrigeration is that the evaporation of liquid requires latent heat during evaporation. If latent heat is remove, the liquid gets cooled. The temperature of ether will remain invariable as long as the vacuum pump maintains a pressure equal to saturation pressure at the desired temperature. This requires the removal of all the vapors formed due to vaporization of liquid. If a lower temperature is desired, then a lower saturation pressure will have to be maintained by the vacuum pump.

The portion of the modern day refrigeration system where cooling is produced by this method which is called as evaporator. If this process of cooling is to work continuous then the vapors have to be condensed to the liquid state by recycling. The condensation process requires heat rejection to the surroundings. By increasing its pressure it can be condensed at atmospheric temperature.

The process of condensation was learned in the second half of eighteenth century .U.F. Clouet and G.Monge liquefied SO2 in 1780 while Vant-Marumand Van Troostwijk liquefied NH3 in 1787. Hence, a compressor is required to maintain a high pressure so that the evaporating vapour can condense at a greater temperature than that of the surroundings. Oliver Evans in his account book "Abortion of a Young Steam Engineer's guide" published in Philadelphia in 1805 described a closed refrigeration system to produce ice by ether under vacuum. Jacob Perkins, an American living in England actually designed such a system in1835. The apparatus described by Jacob Perkins in his letters patent specifications of 1834. In his manifest"I am enabled to use volatile fluids for the purpose of producing the cooling or freezing of fluids, and yet at the same time constantly condensing such volatile fluids, and bringing them again into operation without wastage"

II. RELATED WORK

[1].In 1805, the American innovator Oliver Evans depicted a shut VCR cycle for the creation of ice by ether under vacuum. Warmth can be expelled from nature by reusing vaporized refrigerant, where it would travel through a compressor and condenser and would in the end return to a fluid shape so as to rehash the refrigeration procedure over.

[2].Yuri built up another type of the ejector vapor pressure refrigeration cycle, which utilized an inner warmth exchanger and intercooler to upgrade the execution of the cycle .Results acquired demonstrated that there were increment of 8.6% and 8.15% in coefficient of execution and second law effectiveness esteems separately of the new ejector-vapor pressure refrigeration cycle when contrasted with the ordinary ejector-vapor pressure refrigeration cycle with R125. It was additionally noticed that there was an augmentation of 21% in the COP of the new ejector-vapor pressure cycle contrast with the ordinary vapor pressure framework.

[3].Selvaraju investigated an ejector with condition amicable refrigerants. Vapor ejector refrigeration is a warmth worked framework utilizing second rate vitality, for example, sun based vitality, squander warm from mechanical procedures, and so forth., and it could agreeably be worked at generator temperature as low as 650C. Results that were found had demonstrated that among the chose working liquid, R134a given a superior execution and higher basic entrainment proportion in examination with different refrigerants.

[4].Bergender explored new regenerative cycle for vapor pressure refrigeration cycle which portrayed a novel way to deal with the Rankin vapor pressure cycle for cooling and refrigeration. Results acquired had meant that the weight on the ejector expanded by 15-16% and model accomplished vitality sparing of 16%. Akintuinde got the approval of an outline display for vapor pressure refrigeration framework created by Akintuinde. This model was utilized to outline a VCRS(vapour pressure refrigeration framework).

III. WORKING PRINCIPLE

As in the current refrigeration cycle, cycle starts from the evaporator channel, the low-weight fluid grows, retains warm, and dissipates, changing to a low-weight gas at the evaporator outlet.

After this compressor directs this gas from the evaporator builds its weight, and releases the high-weight gas to the condenser.

In the condenser, warm is expelled from the gas, which at that point gathers and turns into a high weight fluid. Between the condenser and the evaporator an extension gadget found. Here, the weight of the liquid gets expanded and temperature is kept up in normal way. Henceforth stream of refrigerant into the evaporator is completely controlled by the weight differential over the development gadget.

As the high-weight fluid refrigerant enters the evaporator; it is subjected to a much lower weight because of the suction of the compressor and the weight drop over the development gadget. In this manner, the refrigerant has a tendency to extend and vanish. Keeping in mind the end goal to vanish, the fluid must ingest warm from the air ignoring the evaporator than the traditional iceboxes and cooling impact is accomplished speedier. At the point when the coveted air temperature is come to and the indoor regulator or chilly control will break the electrical circuit to the compressor engine and stop the compressor.

A diffuser is joined after evaporator with the goal that weight of refrigerant ascents essentially before pressure process. As the air temperature going through the evaporator rises, the indoor regulator or frosty control changes the electrical circuit. The compressor begins, and the cycle proceeds.

IV. EXPERIMENTAL SETUP

A refrigeration system is a combination of different physical components contains evaporator, a condenser, a compressor and an expansion valve. The evaporator is the space that needs to be cooled by the refrigerant; the compressor compresses the refrigerant from the low pressure of the evaporator to the pressure at the condenser. Now at the condenser heat gained by the refrigerant is rejected and the high pressure refrigerant is expanded into the low pressure evaporator by the expansion valve. This is a very simple representation of the various units in a vapour compression refrigeration system. The performance of refrigeration systems vary according to the purpose and the type of refrigerant used.

4.1 Description of equipment

A) COMPRESSORTwork of a compressor in a

Persistently draw the refrigerant vapor from the evaporator, evacuate the vapor from the evaporator and too to raise its temperature and weight to a point such that it (vapor) can be condensed with accessible condensing media, so that a moo weight and moo temperature can be kept up in the evaporator, thus due to this refrigerant can bubble extricating warm from the refrigerated space. At that point the compressor has to raise the weight of the refrigerant to a esteem at which it can condense by dismissing warm to the cooling medium in the condenser.which it can condense by

g warmFig-1: Compressor used in experiment

B) CONDENSER

A substance undergo phase changes from its gaseous to its liquid state by cooling it.

Fig-2: Condenser used in experiment

In this process, the latent heat is given up by the substance, and will transfer to the condenser coolant. Condensers are a type of heat exchangers which have various designs and come in many sizes ranging from rather small (hand-held) to very large industrial scale units used in plant processes. In this heat exchanger section, the refrigerant goes through multiple tube passes, which are surrounded by heat transfer fins through which cooling air can move from outside to inside the unit. Sometimes in this a fan used inside the condenser unit near the top, which is covered by some grating to keep any objects from accidentally falling inside on the fan.

C) THROTTLING DEVICE

The throttling device obstructs the flow of liquid; cold liquid is reduced with the help of this device, in this case the throttling device is a capillary tube. The capillary tube has an length of 2m(approx.) and an inside diameter of around 0.6mm , so it offers considerable resistance to flow. The effective throttling at the inlet the refrigerant should be high pressure liquid. The throttling device restricts the flow of refrigerant which cause a tremendous pressure drop due to drop in pressure the boiling point of refrigerant is lowered and it start to evaporate.

Fig-3: Throttling device used in experiment

D) EVAPORATOR

The liquid refrigerant from the expansion valve enter into the evaporator where it boils and changes into vapour.

Fig-4: Evaporator used in experiment

The function of an evaporator is to absorb heat from the surrounding location or medium which is to be cooled, by means of a refrigerant. The temperature of the boiling refrigerant in the evaporator must always be less than that of the surrounding medium so that the heat flows to the refrigerant. The evaporator becomes cold and remains cold due to two reasons :

i. The temperature of the evaporator coil is low due to the low temperature of the refrigerant inside the coil.

ii. The low temperature of the refrigerant remains unchanged because any heat absorbs is converted to latent heat as boiling proceeds

E) DIFFUSER

Diffuser is the static device of increasing cross-sectional area. It raises the pressure of flowing fluid by converting its kinetic energy of refrigerants into the pressure energy. Diffuser is make with the help of sheet metal operation and metal plate is required.

Fig-5: Diffuser used in experiment

F) REFRIGERANT(R290)

A refrigerant is a substance or mixture, usually a fluid, used in a heat pump and refrigeration cycle. In most cycles it undergoes phase transitions from a liquid to a gas and back again. As according to our need we are taking R290 as my refrigerant and here, there are some properties which are given below:-

i. Acceptable Exposure Limit,AEL=1000PPM

ii.Flammable: ignition limits between 1.7 and 10.9% by volume in air

iii. Ozone layer depletion : 0

iv. Global warming potential : 3

v. High solubility with conventional lubricants and ester oils.

V. METHODOLOGY

The schematic diagram of the vapour compression refrigeration system with diffuser at condenser outlet is shown in figure 6. The system consists of two flow lines one is simple vapour compression refrigeration system flow line without diffuser and other is flow line with diffuser. Three pressure gauges are installed at diffuser outlet, at compressor outlet and at capillary outlet to measure the pressure of the refrigerant at diffuser outlet and pressure in simple VCRS flow line. Thus we can calculate the pressure with and without diffuser. The both lines can be opened or closed with the help of flow control valves. A constant refrigeration effect is maintained throughout the experiment. The experiment is performed by taking with and without diffuser and compared with each other.

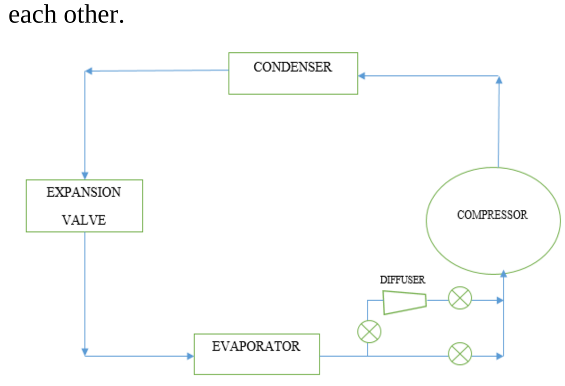

Fig-6:Schematic Diagram of Set Up

Fig-7: Image of the experimental set up installed at NEC thermal lab

VI. EXPERIMENT DATA

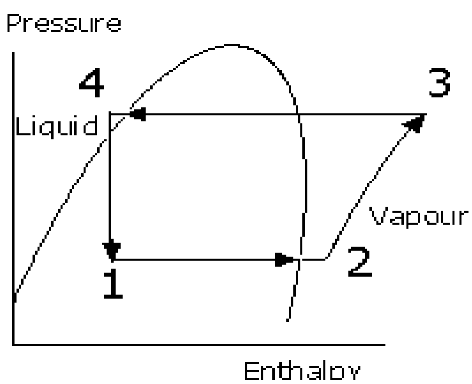

Fig-8: p-h diagram

6.1 Data for Existing system

Table 1

P1(psi)	P2(psi)	P3(psi)	P4(psi)
75	175	175	75

1 psi = 6.895 kPa
So, P1 = 75 psi = 5.1675 bar
P2 = 175 psi = 12.0575 bar
P3 = 175 psi = 12.0575 bar
P4 = 75 psi = 5.1675 bar
Using R290 property chart,
h3= 610.93kj/kg
S2 = S3= 2.3445kj/kg
h1= 296.38kj/kg h4 = h1 =571.4368kj/kg
hence , COP=-$\frac{h2-h1}{h3-h2}$ =$\frac{571.4362-296.38}{610.93-571.4362}$ =6.96

6.2 COP of proposed system

Table 2

P1(psi)	P2(psi)	P3(psi)	P4(si)
73	165	165	73

P1 = 73 psi = 5.0297 bar
P2 = 165 psi = 11.3685 bar
P3 = 165 psi = 11.3685 bar
P4 = 73 psi = 5.0297 bar
Using R290 property chart,
h3 = 607.34 kj/kg
h1 = 285 kj/kg
h2= 569.1786kj/kg
h1 = h4 = 569.1786kj/kg
hence , COP= -$\frac{h2-h1}{h3-h2}$ =$\frac{569.1786-285}{607.34-569.1786}$ =7.446

VII MERITS

a) Simple construction and efficient.

b) Low power consumption.

c) Simple Easy to operate.

d) Maintenance cost low.

e) High efficiency.

VIII APPLICATION

a) It is used to preserve food items, fruits, vegetables fresh for several days from being spoilt,

b) Gas Turbine Air Inlet Cooling,

c) Reflux chillers

d) Vent gas /solvent recovery chillers

e) Brine / Water chillers

f) It can be also used for preservation of dairy products, Blood plasma and antibiotics are manufactured using a method called freeze drying,

g) It can be used to “preserve fishes and meat” in ship containers for several days during travel in the sea

IX CONCLUSION

The proposed project shows that decreased in compressor work and increase in COP of vapour compression refrigeration system.This was achieved mainly by introducing a diffuser, where the refrigerant pressure is raised before compressor process.

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