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STUDY OF TWO STAGE EVAPORATIVE SYSTEM AS A WATER COOLER

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ABSTRACT - It is proposed to develop a single compressor two evaporator system with individual expansion valve to maintain 5˚C and 10˚C temperature. The refrigerating effects of refrigerant R134a and R32 at varying evaporating temperature for condensing temperature of 55°C can be studied. Refrigerating effect increases as the evaporating temperature increases for R134a and R32 refrigerants. This is due to the increase in latent heat of the refrigerant. A very high value of latent heat is desirable because the mass flow rate per unit of capacity is less. When the latent value is more, the efficiency and capacity of the compressor are increases. This reduces the power consumption and also reduces the compressor displacement requirements that permit the use of smaller and more compact size equipment.

Keywords: Refrigerating Effect, Evaporating Temperature, Refrigerants.

I. INTRODUCTION

Refrigeration is a technology which absorbs heat at low temperature and reduce temperature below the surrounding by rejecting heat to the surrounding at higher temperature. A vapor compression cycle is used in most household refrigerators and refrigerator–freezers and freezers in which total cooling load is carried at one temperature by single evaporator but in many applications like large hotels and food storage and food processing plants, food products are stored in different compartment and at different range of temperatures. Therefore, there is need of multi evaporator vapor compression refrigeration system to maintain different temperature. The systems under vapor compression technology consume large amount of electricity, this problem can be reduced by improving performance of vapor compression refrigeration system.

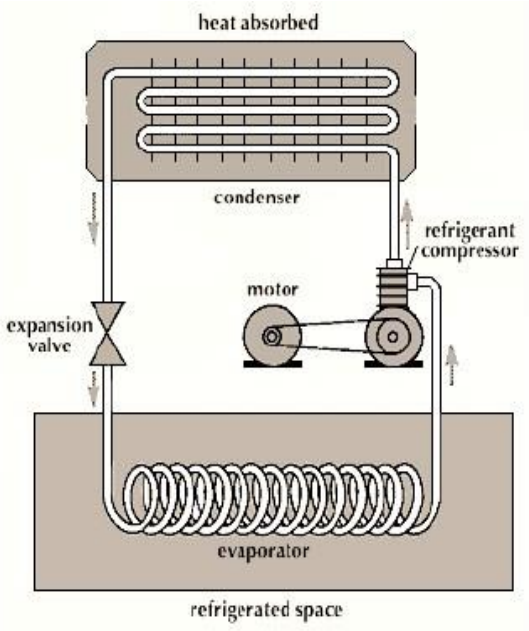

Fig. 1 Vapor Compression Refrigeration Cycle

Refrigeration system is based on the Clausius statement of 2nd law of thermodynamics. Statement, ―It is impossible to construct a system which, operating in a cycle, will produce no affect other than the transfer of heat from a cooler to a hotter body. The vapor compression refrigeration system is shown in Fig1. It consists of four major components compressor, expansion valve and condenser and evaporator

During the cycle refrigerant circulates through four stages continuously. The first stage is known as Evaporation and in this stage refrigerant cools the enclosed space by absorbing heat. Next, during the second stage, the pressure of the refrigerant is increased, which increases the temperature above that of the surroundings. As this hot refrigerant circulate through the next stage, Condensation, the natural direction of heat flow allows the release of heat into the surrounding air.

II. EASY OF USE

This paper deals with to develop a single compressor and two evaporator systems with two expansion valve to maintain 5˚C and 10˚C temperature. The refrigerating effects of R134a and its potential alternative R-32 at varying evaporating temperatures and compare them.

III. LITERATURE REVIEW

The replacement refrigerants studied in the analysis R152a, RE170 and R600a possess a commendable performance coefficient (COP) compared to CFC12 and CFC22 and R134a. In the experiment condensation temperature is kept at 50°C while the evaporating temperature ranged from -30°C to 10°C. HC290/HC1270 (20/80 by wt.%) and HC290/HC600a (40/60 by wt.%) and RE170 refrigerant blends was regarded as the most suitable replacement among refrigerants tested for R12, R22 and R134a.[1]

For selection of environment friendly refrigerant compare between R12, R152a and R134a Experimentally the performances of three ozone friendly Hydrofluorocarbon refrigerants R12, R152a and R134a. R152a refrigerant found as a drop in replacement for R134a in vapor compression system. [2]

Three capillary tubes with different length and different inner diameter were selected as test sections. The capillary tube lengths were 889mm, 559mm, and 508 mm for R-22 and the COP of Capillary tube 889mm was 32% efficient than capillary of length 559mm and 40% efficient than capillary 508mm for 39°C outdoor temperature. [3]

Analysis can be conveniently useful to compare the thermal performance of different Nano particles (i.e. Al2o3,Tio2) based Nano fluid as a secondary fluid in a Vapor Compression Refrigeration System. The influence of input variables on the output of the system is presented. This type of model can also be used to design various Components Viz. Evaporator, Compressor, Condenser and Throttle Valve for Vapor Compression Refrigeration Systems for any desired cooling capacity. [4]

Plain Fin and Tube Evaporator Using CO2 as A Refrigerant having properties of Fluid inorganic, non-toxic, non-flammable, but inefficient in thermodynamics [5]

In this project, two zoetrope blend refrigerants were selected to be tested as alternative refrigerants for R-22 in the window type air conditioner system viz., R-407C and R-407A to acceptable pressure and temperature ranges and better thermal properties. The drop in technique of R-22 by R407C and R- 407A improved cooling capacity up to (4.5%)for R407C and (7.5%) for R407A respectively. R-407A consist lower power consumption than that experienced with R-22 tests by (2%). R-407C showed (9%) higher consumed power than that of R-22 by. R-407C and R-407A showed a significant increase in EER by (4%) and (7.5%) R-407C exhibited decrease in mass flow rate than that experienced with R-22 tests by (5%). [6]

The alternative refrigerants investigated in the analysis RE170, R152a and R600a have a slightly higher performance coefficient (COP) than R134a for the condensation temperature of 50˚C and evaporating temperatures ranging between -30˚C and 10˚C.Refrigerant RE170 instead of R134a was found to be a replacement refrigerant among other alternatives. [7]

A small capacity vapor compression refrigeration system is used for the tests to be conducted with three different expansion devices and R407C as refrigerant. study the performance characteristics comprise of cooling capacity (Q), power consumed by the compressor (W), refrigerant flow rate (m) and the coefficient of performance (COP) of the vapor compression refrigeration system with respect to different expansion devices like thermostatic expansion valve and capillary tubes with different diameter and length and analyze that capillary tube have more cooling capacity. [8]

IV. PROBLEM STATEMENT

R134a HFC is used in water cooler and other vapor compression system. R134a is having zero ozone depletion potential (ODP) and almost same thermodynamic properties as R12, but it has a high Global Warming Potential (GWP) of 1300.

In certain applications, R22 is problematic when system is working at lower pressure and lower discharge temperature HFCs have no ozone depletion problem associated with them, but their global warming potentials are relatively high. For example R12 (ODP= 2400), R22(1810), R134a(1300), R152a(120), R32 (675). A large amount of energy must be rejected to the environment in the condenser when used of R134a and R22 in an air conditioning system.

V. COMPONENT DESCRIPTION

- Evaporator I

This evaporator is designed for 0.15TR capacity to get the temperature of 5°C

Specific heat capacity at constant pressure Cp= 4.187KJ/Kg k

Consider,

Initial temperature of the solution T_{hi} =28 °C

Final temperature of the solution T_{ho} =5 °C

Hence change in temperature ΔT =23 °C

Load on evaporator

Q = 0.15× 210 = 31.5 KJ/min

We know that

$$Q = \frac{ms \times Cp \times \Delta T}{t}$$

$$31.5 = \frac{ms \times 4.187 \times 23}{60}$$

$$ms = 19.6\ kg$$

- Compressor

Manufacturer: Emerson Climate Technologies (India) Limited

Model: KCE444HAG.1phase

Refrigerant: R134a

Evaporating temperature: 7.2 ˚C

Condensing temperature: 55 ˚C

Displacement: 12.5 cm^3/rev

Refrigerating capacity (Q_0) : 1055Watt

Power: 450watt

Electrical rating: 230V; 50Hz; 1PH.

Suction pressure for R134a: 2.75bar

Discharge pressure for R134a: 13.51bar

- Condenser

Height of fins, H: 0.254 m
Width of fins, W: 0.0508 m
Finned length, L_{fin}: 0.2794m
Number of fins per m, N_{fin}: 472
Thickness of fin, t_{fin}: 0.5×10^{-3} m
Number of rows, Nr: 3
Number of Passes N_p: 11
Outer radius of tube, r_o: 4.76×10^{-3} m
Inside radius of tube, r_i: 4.415×10^{-3} m
Thickness of tube, t: 0.71×10^{-3} m

- Expansion Devices

A capillary tube is used as expansion device; it is a long, narrow tube of constant diameter. Typical tube diameters of refrigerant capillary tubes range from 0.5 mm to 3 mm and the length ranges from 1m to 6 m.

- Fan

An axial flow fan is selected to match the system capacity. It is an air conditioning and industrial process applications fan. The specifications of fan are as follows:
Type: Axial flow type.
Model: 2508
Capacity: 74.6W (1/10 hp)
Speed: 1075 RPM

VI. STUDY

Our review paper deals with, the study that different alternative to CFCs these are HCFCs such as R22, R123, R124, etc. next generation is HFCs for example R32, R134a,. Focus of recent paper shifted from HFCs to HCs like R134a, R32 also blending is quite popular way of comparing new refrigerant and conventional.

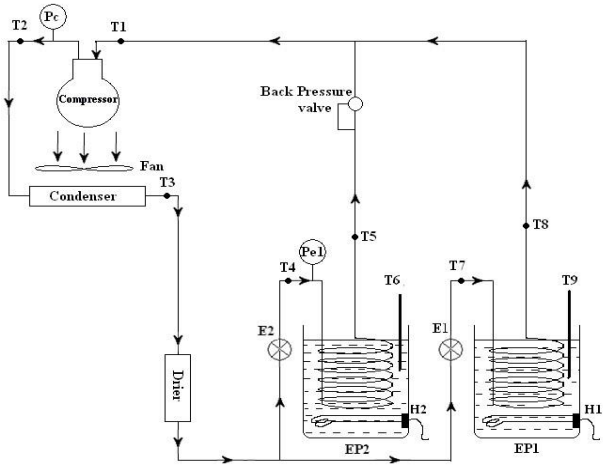

Fig.1: Schematic Layout of the Experimental Setup

EP1and EP2- Evaporator 1 and Evaporator 2
E1 and E2- Expansion valve 1 and 2
H1 and H2- Heater

VII. ACKNOWLEDGMENT

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