Design and Development of Vapour Compression Refrigeration System Using Liquid Heat Exchanger

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Abstract— The objective of the research paper is to test the performance of the vapour compression system using liquid heat exchanger. The main purpose of our project is to increase the coefficient of performance (COP) of the system with reduction in global warming potential (GWP) and with zero ozone depletion potential (ODP) and minimum energy consumption using liquid heat exchanger. In our project we are using blend of two refrigerant i.e R600a and R290 in various proportion and the another refrigerant used is HFO-1234yf, with the help of liquid heat exchanger and in both the cases of refrigerant we calculated that the COP of the system had increased and global warming potential and energy consumption were reduced with zero ozone depletion potential as compared to the current used refrigerant R134a and existing vapour compression refrigeration system. As liquid heat exchanger involves cooling and heating process the load on compressor is reduced and more cooling effect with minimum energy consumption and less harm to environment. As compared to the current refrigerant R134a which global warming potential(GWP) i.e. 4 with zero ozone depletion potential(ODP). So by using HFO-1234yf and another blend of R134a and R290 we had increased the COP and reduced the GWP of the system and thus we have successfully fabricated and tested the vapour compression system using liquid heat exchanger.

Keywords: Vapour Compression Refrigeration System, Refrigerant, Liquid Heat Exchanger, C.O.P, Power Consumption

I. INTRODUCTION

Refrigeration is the process of removing heat from an enclosed space or from a substance in order to maintain a lower temperature than surrounding. In refrigeration system refrigerant plays an important role, refrigerant is the cooling medium filled in compressor which flows in the refrigerator. All other properties would be meaningless if the refrigerant decomposed or react to form something else. Refrigerant should have low and it should be non –flammable and ODP should be zero with low GDP.

Figure.1 Shows simple vapor compression Refrigeration system. The analysis of thermodynamic cycle is shown in Figure.2 In this cycle, a circulating refrigerant such as Freon enters the compressor as a vapor. At point 1-2, at constant entropy the vapour is compressed and exits the vapor at a high temperature. Now at point 2-3 and to point 4, the vapor traveling from the condenser, cools the vapor until it starts condensing, and then condenses the vapor into a liquid by removing additional heat at constant pressure and temperature. At points 4-5, the liquid refrigerant flows through expansion valve and then pressure abruptly decreases, causing flash evaporation and auto-refrigeration of, typically, less than half of the liquid.

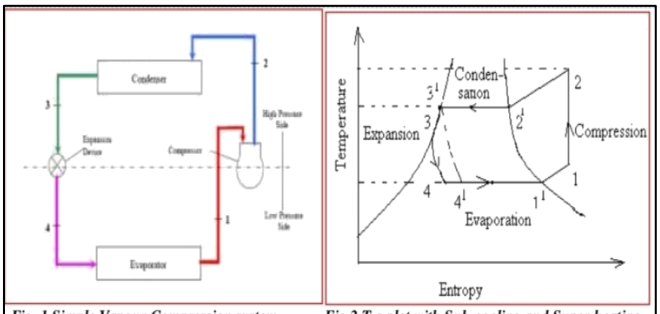


Fig. 1 Simple Vapour Compression system *Fig.2 T-s plot with Sub-cooling and Super heating*

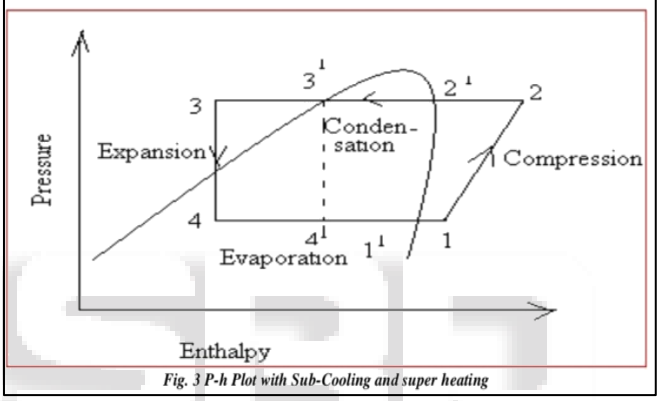


Fig. 3 P-h Plot with Sub-Cooling and super heating

A. Necessities of Refrigeration

1) Domestic-In domestic for storing the food and other material to keep it in well condition,
2) Commercial-For human comfort
3) Cold storage-For storing fruits and agricultural products,
4) Ice factory-To produce ice for various use,
5) In transportation
6) For storing medicines and human organs and death bodies.

B. Major Elements of Refrigeration System and their Functions

1) Condenser

Condensation changes gas to a liquid form. It is used to condense gaseous substance to liquid through cooling process. The latent heat is released by substance and transferred to surrounding environment. To regain the liquid refrigerant the high pressure vapour in the condenser will be cooled this time with a little heat.

2) Compressor

The use of compressor's is to pull the low-temperature and low-pressure vapour from the evaporator, through a suction line. The vital function of compressor is to increase the pressure by transform a low-temperature vapour in to a high temperature vapour, Its main function is to circulate the refrigerant.

3) Evaporator
An evaporator is used to turn any liquid material into gas like water into gaseous form. In this process, heat is absorbed. Evaporator is situated after expansion valve.
4) Expansion Valve
Expansion valve is commonly placed at the end of the liquid line and before the evaporator. Keeping the refrigerant super-heated, expansion valve controls the amount of refrigerant to flow into evaporator. The valve is reached by liquid refrigerant after it has been condensed. As it is reducing the pressure of the refrigerant, its temperature decreases to a Level below its atmosphere. This liquid will then be pumped into the evaporator.
5) Heat exchanger
The function of heat exchange is to transfer heat between two or more fluids. In both cooling and heating processes heat exchanger is used. To prevent mixing of fluid or they may come in direct contact a separate solid wall is present in heat exchanger.

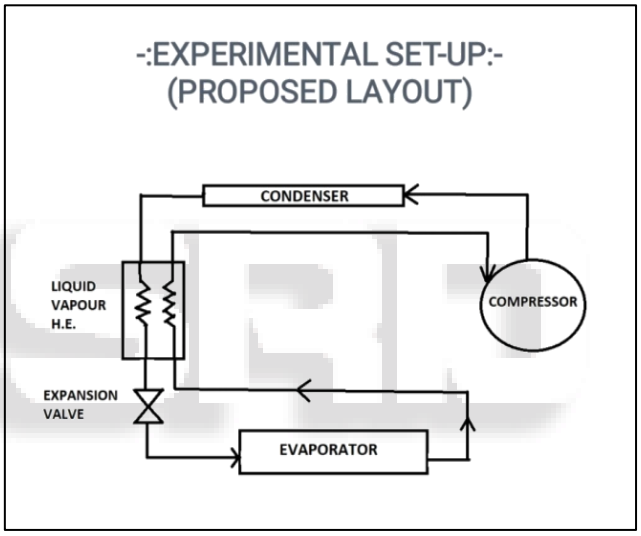
II. Literature Review

[1] From this study they conclude that, an ideal vapour compression refrigeration system is used for the performance analysis of alternative new refrigerant mixtures as substitutes for CFC12, HFC134a, and CFC22. After comparing the performance coefficients (COP) and pressure ratios of the tested refrigerants and impacts of ozone layer depletion and global warming in environment, refrigerant blends of HC290/HC600a(40/60 by wt.%) and HC290/HC1270 (20/80 by wt.%) are found to be the most suitable alternatives among refrigerants tested for R12 and R22 respectively. The refrigeration efficiency, the performance coefficient (COP) of the system, increases with increasing evaporating temperature for a constant condensing temperature in the analysis. All systems including various refrigerant blends were improved by analyzing the effect of the superheating/sub cooling case. Better performance coefficient values (COP) than those of the non-superheating/ sub cooling case are obtained as a result of this optimization.

[2] From this study they found that as per the Kyoto and Montreal protocols, the harmful refrigerants are to be phased out and are to be replaced with alternate environmental friendly refrigerants. To evaluate different environmental friendly refrigerant is the main objective of this paper. On the basis of collecting information, the following conclusions may be drawn. HFCs can replace R-22 without any modification in the system. Despite having the advantage of zero ODP, the system delivers the poor performance with increased energy consumption as compared with R-22. Without any system modifications HCFs can be replace by R22. With reduction in energy consumption the COP of the system is improved. As compare to pure refrigerant the system delivers the better performance, the energy consumption is also reduced. However optimum blend composition for Research work for deciding the concentration of blends has to be undertaken to have better performance of the system.

[3] They concluded after their study that project invested an ozone friendly, energy efficient, user friendly, safe and cost effective alternative refrigerant for HFC134a in domestic refrigeration systems. On the performance of HCs and blends of HCs as refrigerants the conclusions and results obtained are, the energy consumption of the pure HCs and blends of HCs is about similar to the energy consumption of refrigerator when HFC134a is used as refrigerant. The compressor consumes 2% and 3% less energy when Butane and Iso-butane were used than that of HFC-134a at 28°C ambient temperature. • HCs and mixture of HCs offer lowest inlet refrigerant temperature of evaporator. For low temperature application HCs and blends of HCs is better than HFC-134a. Thus it indicates the possibility of using HCs as an replacement of HFc-134a in the existing refrigerator system. Chemical and thermodynamics properties of hydrocarbon meet the requirement of a good refrigerant. The final conclusion is that butane and isobutene can be used in the existing refrigerator-freezer without modification of the components.

III. Methodology



In our work, we use the Liquid heat exchanger after the condenser in order to reduce the load on compressor and also along with that we take Hydro-Fluoro-Olefin(hfo-1234yf) and the blend of R600a and R290 which results in the reduction in the Global Warming Potential(GWP) & Ozone Depletion Potential(ODP)

IV. Conclusions

From the work, we conclude that by using Hydro-Fluoro-Olefin(hfo-1234yf) as the refrigerant we get very low GWP i.e.;4 with zero ODP. It has low toxicity, excellent COP and Capacity. Also it doesn't have glide temperature. This characteristic property will results in the increase in COP of the system & reduce in the energy consumption of the system. The blends of R600a & R290 results in neglisible Green House Effect, strong cooling performance, low toxicity, high solubility with conventional lubricants and ester oils due to their individual characteristic properties.

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