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''ANALYSIS OF ALTERNATIVE REFRIGERANT MIXTURES IN VAPOUR COMPRESSION REFRIGERATION SYSTEM''

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ABSTRACT

Refrigeration is a process for maintaining a temperature below the surrounding temperature. Tetrafluroethane R134 is commonly used as a refrigerant in domestic refrigeration after 2000, before that we are using halogenated refrigerants R12 in refrigeration which is very much responsible for ozone layer depletion which act as preventing us from ultraviolet radiation. After when we came to know about ozone layer we start replacing the halogenated refrigerant and shifted to Tetrafluoroethane R134a. After shifted to R134a we came to know that it has zero ozone layer depletion (OLD) but higher rate of global warming potential (GWP) and after Kyoto protocol global warming is serious issue as it increases the overall temperature of our surroundings and then we are finding some alternate refrigerants that can be used in place of Tetrafluroethane in domestic refrigerator. Here we see that the mixture of propane and isobutane (R290 & R600a) which is a pure hydrocarbon refrigerants and available in market in name easily and have almost the same thermodynamic property properties as of Tetrafluoroethane. Here we are calculating the various parameter like coefficient of Performance, Refrigeration effect, Compressor work from Tetrafluoroethane (R134a), Propane (R290), Isobutane (R600a) and from mixture of propane and isobutane (R290+R600a) at three different condition. In first condition we fixed the compressor outlet temperature, condensing temperature and varying the evaporator temperature, In second case we use sub-cooling effect and in third case we fixed the evaporator temperature and condensing temperature and varying the compressor outlet temperature and calculate all the parameters and draw all the graph and make a conclusion whether the mixture can be used in domestic refrigerator or not.

Keywords: Alternative refrigerants, Global warming potential, Ozone layer depletion and thermo-physical properties, R-290+R-600a refrigerant, Hydrocarbon refrigerant.

I. INTRODUCTION

Refrigeration is used for maintaining the temperature below to the surroundings. There are two types of plant power producing and power consuming, power producing are those which generate the electric power and consuming are those which consume electric power. Refrigeration is the power consuming plant which consumes electricity and creates the refrigeration effect. Heat is always flowing from higher temperature to lower temperature but in case of refrigeration heat is flowing from lower temperature to higher temperature for which we do some external work; the external work is in the form of electricity or power. There are number of applications like food processing industries, textile industries, in medical plant, in cold storages and also in some sectors, particularly food, drink, and chemicals it represents a significant proportion of overall site energy costs. For doing the performance analysis Carnot refrigeration cycle is used as a reference for finding the coefficient of performance of cycle.

Presently we are using tetrafluoroethane R134a as a refrigerant in domestic refrigerator. Tetrafluoroethane has a zero ozone layer depletion but higher global warming potential which effect the surrounding and very much responsible for increasing the global warming of earth. Due to increase in global warming of system it is very much necessary to study about the refrigeration systems that are used now days.

Vapour-Compression Refrigeration Systems

Vapour-compression refrigeration systems are the most normally used refrigeration systems used in domestic refrigerator and each system employs a compressor. In vapour-compression refrigeration cycle, four processes take place as follows: • Evaporation, • Compression, • Condensation, and • Expansion

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RESEARCH OBJECTIVE

Presently we are using tetrafluoroethane R134a as a refrigerant in domestic refrigerator. Tetrafluoroethane has a zero ozone layer depletion but higher global warming potential which effect the surrounding and very much responsible for increasing the global warming of earth. Due to increase in global warming of system it is very much necessary to study about the refrigeration systems that are used now days. the refrigeration instantly needs technical information how to minimize the global warming that is increased by the refrigerants finding some alternate refrigerant that can be used in place of refrigerant that are used currently.
The primary objective of this work is to discuss refrigeration cycles and their energy and Exergy analyses, some new refrigeration techniques for more efficient and effective refrigeration.

II. TECHNICAL APPROACH AND ANALYSIS

Methodology -Thermodynamic analysis of V.C.R. Cycle

The figure shows the schematic block diagram of vapour compression refrigeration cycle in which process 1-2 is isentropic compression in which the pressure and temperature of refrigerant increases in the next process that is in 2-3 there is constant pressure heat rejection, the temperature increases in compressor is above the surrounding temperature so that here in this process 2-3 heat transfer is take place from higher temperature to lower temperature and here the temperature drop takes place to surrounding temperature but the pressure is higher at that level in the next process 3-4 there is isenthalpic expansion in which pressure reduced to initial level, in the final process 4-1 there is constant pressure heat absorption from the surrounding space here refrigerant takes heat from surrounding space and evaporated which is also known as evaporator in case domestic refrigerator.

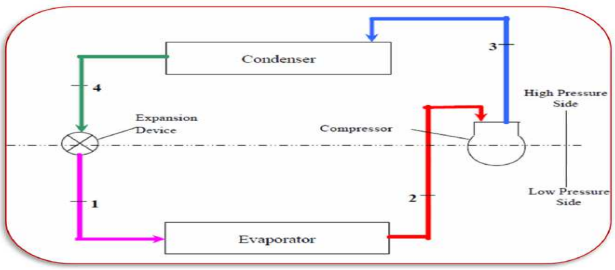

Figure: Fig. 01 Block diagram of vapour compression refrigeration cycle

Process 1-2 Isentropic compression
Process 2-3 Constant pressure heat rejection to surrounding
Process 3-4 Isenthalpic Expansion
Process 4-1 Constant pressure heat absorption from evaporator or from a particular space

C.O.P. =Q_ (Evap.)/W_ (Comp.) = (Refrigeration Effect)/ (Compressor Work).

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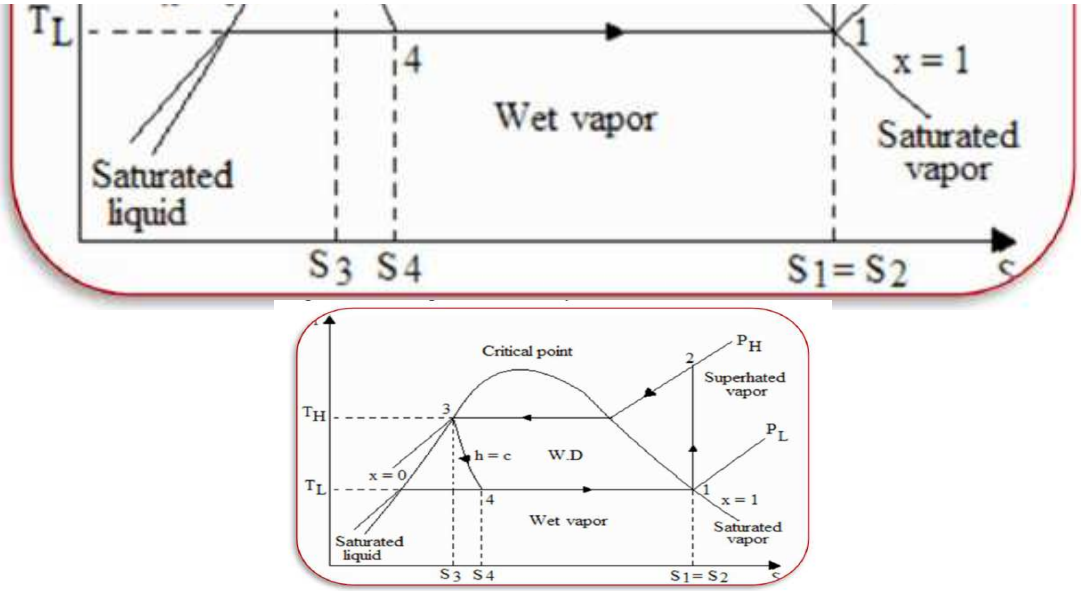

Figure: Fig. 02 T-S Diagram of V.C.R.system

Refrigeration effect or heat absorbed	$Q_{Evap.} = h_1 - h_3$
Compressor work	$W_{Comp.} = h_2 - h_1$
Condenser heat rejection to atmosphere	$Q_{Rej} = h_2 - h_3$
Isenthalpic expansion	$h_3 = h_4$

Study of Refrigerant

In earlier it has been proved that the role of chlorofluorocarbons CHC_S is very much in depletion of ozone layer which prevents us from the harmful ultraviolet radiation. Therefore we search for alternate refrigerants which have similar property to R12, then we found R134a which has almost similar property to R12 and also R134a has zero ozone layer depletion and have no effect on ozone layer and we started use of R134a as a refrigerant in vapour compression cycle. But R134a is more expansive and has high global warming potential. Then due to high global warming potential we search of another hydrocarbon refrigerants as alternative of R134a also the hydrocarbon refrigerants has low cost refrigerant and easily available in market and very much less global warming potential. Then after preparing the blend of hydrocarbon refrigerants propane and isobutane (R290+R600a) we see that this mixture has similar thermo physical property in range of -60ºC to +60ºC and has relative higher Coefficient of performance and refrigeration effect as compared to tetrafluoroethane (R134a)

III. RESULTS AND DISCUSSIONS

From the study of eco-friendly hydrocarbon refrigerants Care 30 which is a mixture of propane R290 and Isobutane R600a in a ratio of 50% of propane and 50 % isobutene which is a very similar property to that of R134a which are commonly used in household refrigeration system. In earlier we are using halogenated refrigerant R12 as a refrigerant in household refrigeration system but R12 is responsible for ozone layer depletion problem, that prevent us from the harmful ultraviolet radiation and act as a shield of earth, due to which after Kyoto protocol another halogenated refrigerant R134a was introduced which used as a refrigerant which has a zero ozone layer depletion but after some time and various studied we come to know it has a zero value of Ozone layer depletion but it has a high value of Global warming potential approximate 1300. Here refrigerant used is a mixture of propane and Isobutane which is similar property to R134a and having zero Ozone depletion problems and less than 3 Global warming potential. We are also separately used propane and isobutene as refrigerants in compression to R134a and mixture of propane & Isobutane in vapour compression cycle and calculate the coefficient of performance, refrigeration effect and compressor work.

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In third condition we changes our boundary condition and we fix the evaporator temperature to -5ºC instead of condenser as done in earlier two condition and continuously increases the condenser temperature from 40ºC to 60ºC by interval of 5ºC and see the effect of increasing temperature on coefficient of performance, on refrigeration effect and on compressor work and for compression graph are plotted between C.O.P. versus condenser temperature, refrigeration effect versus condenser temperature and compressor work versus condenser temperature

IV.CONCLUSION

The parameters that are evaluated in this work are coefficient of performance, refrigeration effect compressor work, evaporator temperature, compressor outlet temperature and sub-cooling in condenser. Here we are using four different refrigerants in which fourth one is the blend of two refrigerants propane and Isobutane (R290+R600a). In this work in the first condition the coefficient of performance from all refrigerants calculated at different evaporator temperature and taking compressor outlet and condensing temperature fix and in second condition the coefficient of performance from all refrigerants calculated at different condenser temperature taking evaporator temperature fix and in another condition taking effect of sub-cooling and following conclusion are made:

- As taking the condenser temperature fixed and decreasing the evaporator temperature the coefficient of performance and refrigerants start decreasing and compressor work start increasing but decrease in C.O.P. is more as compared to mixture of propane and Isobutane.
- As taking the evaporator temperature fixed and continuously increasing the compressor outlet temperature the coefficient of performance of all start refrigerant decreases but decrease in value of coefficient of performance is more in tetrafluoroethane (R134a) as compared to mixture of propane and Isobutane.
- When we are using a sub-cooling of -5ºC we see that the compressor work remain constant and the refrigeration effect of all refrigerant increases.
- The thermo physical property of tetrafluoroethane(R134a) and care 30 which is a mixture of Propane and Isobutane (R290+R600a) are approximately same and if we are using care 30 as a refrigerant we also obtained higher coefficient of performance and refrigeration effect and also the global warming potential of mixture is negligible as compared to tetrafluoroethane.

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