Increasing Efficiency of Domestic Refrigerator By Using Refrigerant 'R134a'

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Abstract- *Refrigerator-freezers are one of the major energy consuming appliances in the household environment, and so more attention should be paid in improving their efficiency throughout the world. A certain additives are provided by a company Infinity HVAC, which can be used in the refrigeration and air conditioning system. These additives are a chemical solution which helps in improving the performance of the system and reducing the energy consumption of the system by removing oil fouling from the inner surface of the evaporator and condenser. The system used in this work is 165 litre domestic refrigerators with R134a as a working refrigerant. Experimental results have shown that the COP is increased by 7 % and energy consumption is increased by 4.48 %*

Keywords- Performance additive, Refrigerator, COP, Energy efficiency ratio, R134a

I. INTRODUCTION

Currently the refrigerators used widely are with R600a as refrigerant, prior to that refrigerators were with R12 as refrigerant. The switch over from refrigerant R12 to R600a was due to global policies for reducing the impact of the refrigerants on the environment i.e. to reduce the global warming potential and to reduce the ozone depleting potential. There was no significant changes in energy efficiencies due to switch over as the switch over had no such objective.

In this project with the aim of increasing efficiency of domestic refrigerator by application of refrigerant R134a, the selection of refrigerant was done based on the desirable properties of refrigerant and the selected refrigerant i.e. R134a required some technical changes. The design of components to be replaced to make refrigerator compatible with refrigerant R134a were carried out with the reference of research papers and reference books.

Usually for increasing the energy efficiency of refrigerator the focus was on two main technical parameters i.e. the latent heat of evaporation for refrigerating effect and for compressor work depending upon pressure ratio. Along with all other parameters, both the parameters mentioned before were significantly in the direction for higher energy efficiencies. Thus the implementation of refrigerant R134a was carried out and the aim of this project i.e. increasing the energy efficiency of refrigerator by application of refrigerant R134a was achieved.

1 Refrigerants:

For an ideal refrigerant for minimum power consumption the following properties are required to be high: Latent heat, Critical temperature, Liquid thermal conductivity, Vapour density, Vapour specific heat. Following refrigerant properties were recommended to be low: Liquid viscosity, Molecular weight. And was the reason for selection of R134a over the existing refrigerant R600a. Refrigerant R134a, or isobutane, is a possible replacement for other refrigerants, which have high impact on the environment, in domestic refrigerators. It has zero ozone depletion potential ODP and a negligible global warming potential GWP. Furthermore it is a substance which is a part of petrol gases from natural sources. Because of the availability of isobutane all over the world it has been discussed widely for replacement with older refrigerants. R134a are a possible refrigerant for this application, with good energy efficiency, but with a very different characteristic in several points, which implies the design to be made or adopted for this refrigerant.Thus taking into consideration various parameters whose comparison is shown in below table with the ideal properties of a refrigerant it can be concluded that R600a is a possible alternative for the existing refrigerant R134a it can be concluded that implementation of R600a in refrigerators will lead to reduction in power consumption of refrigerators which will also help in accomplishing our aim i.e. "Reduction in power consumption of domestic refrigerator by application of refrigerant R600a.

What is Refrigeration? Refrigeration is defined as the process of removing heat from a body or enclosed space so that the temperature first lowered and then maintained at level below the temperature of surrounding. The equipment used to maintain the required temperature is called refrigerating equipment.

1.1.1 Types of Refrigeration system There are two types of refrigeration system 1. Vapour Compression Refrigeration system (VCRS) 2. Vapour Absorption Refrigeration system (VARS)

1.1.2 VCRS system The below diagram shows the refrigeration circuit. The Main four processes are Evaporation, Compression, Condensation and Expansion.

1.1.3 Components of Refrigeration system 1. Compressor 2. Condenser 3. Expansion valve 4. Evaporator

1. Compressor

It compresses the refrigerant. The compressor receives low pressure gas from the evaporator and converts it to high pressure gas. As the gas is compressed, the temperature rises. The hot refrigerant gas then flows to the condenser.

2. Condenser

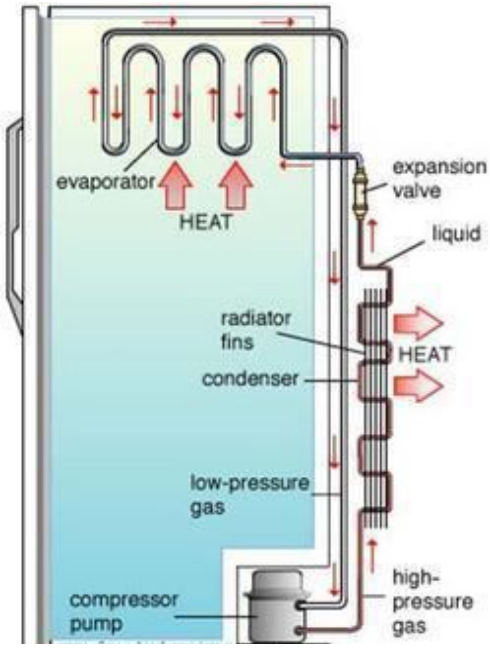
A condenser is a device or unit used to condense a substance from its gaseous to its liquid state, by cooling it. In so doing, the latent heat is given up by the substance, and will transfer to the condenser coolant

3. Expansion Valve:

Its function is to meter the amount of refrigerant to be supplied to evaporator and to reduce the pressure up to evaporator pressure such that liquid can vaporise at the evaporator coil.

4. Evaporator

An evaporator is used in an air-conditioning system to allow a compressed cooling refrigerant, to evaporate from liquid to gas while absorbing heat in the process. It can also be used to remove water or other liquids from mixtures.



Experiment set up, Methodology: Refrigerator Model Details

Brand	Godrej
Model name/year	Boyce
Freezer Capacity (liter)	170
Fresh Food Compartment Capacity (liter)	230
Power Rating	160W
Current Rating	0.9A

This Section provides the information about the how I was developed the experiment set up and how I will carry out the test procedure the during experiment. First the experiment test ring developed from the refrigerator model. To perform the experiment and develop the test ring 230L refrigerator is selected. and Fig. shows the line diagram of test ring and connection point of pressure and temperature measurement. Now from the experiment test ring there 6 point of temperature measurement and 2 point of pressure measurement. Two point of pressure measurement one of the one point in suction side and another point is in discharge line. The pressure gauge are used for the pressure measurement so compound gauge is fitted on discharge line due to high pressure and vacuum gauge is fitted on suction line due to low pressure as shown in the fig. Now there five pointis is temperature measurement so one the point of temperature measurement is in evaporator means in the freezer compartment of refrigerator. One point is for the measurement of food storage cabinet. And point is located on the compressor inlet, compressor outlet, condenser inlet and

condenser outlet. So now for the temperature measurement digital thermometer are used. Ammeter is also used for the current measurement. So this the procedure of the experiment set up Now for the test procedure the evacuation and vacuuming is done by the another compressor. And vacuum is done up to the 25in/hg. This is required for the cleaning of the lines by removing moisture, air and oil. Now after that the refrigerant is charged by the charging system and when the evaporator temp. set at 10oc and 1st I charged the R 600a and collected the data like pressure and temperature every 15 minutes during the running the refrigerator and also collected the data various evaporator temperature. After collecting the data R 600a is removed and refrigerator are charged by another alternative refrigerant like R 290, R 134a, R 152a and mixture of the different refrigerant and collected the data. After collecting the experimental data I found different parameter like COP, Refrigerant effect, Compressor power, Volumetric cooling capacity, mass flow rate , compressor power per ton, compression ratio etc. and then compare this data each other to the refrigerant and find the alternative refrigerant which gives the better performance in compare with R 600a.

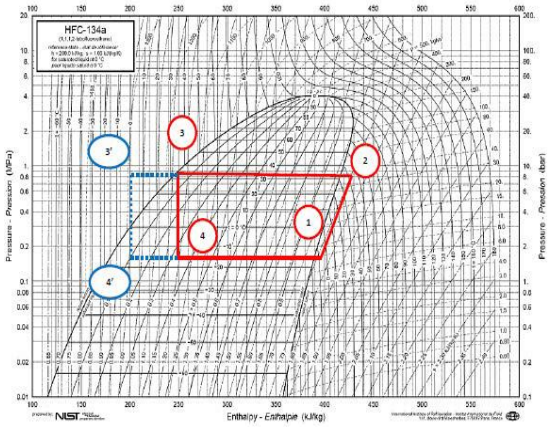
II. CALCULATION

1. Compressor Work done (w) = (h2 – h1) KJ/Kg 2. Refrigerant effect Per Kg (RE) = (h1 – h3) KJ/Kg Where, h1 =Specific Enthalpy at the inlet of compressor (KJ/Kg)
2. h2=Specific Enthalpy at the outlet of compressor (KJ/Kg) h3 =Specific Enthalpy at the outlet of condenser (KJ/Kg)
3. h4 = Specific Enthalpy at the inlet of evaporator (KJ/Kg)
4. COP =Refrigerant effectCompressor work done

Mass flow rate = 3.517RE 5. Compression ratio = Discharge pressure Suction pressure 6.Compressor power per ton = Mass flow rate × Compressor work done

Volumetric refrigerant efficincy = REVg1 = 113.340.04944 = 2942.15kg/m3

Notes:- Values of h1, h2, hf3, h4 are calculated by using pressure enthalpy diagram related to the various alternative refrigerant during calculation.



III. RESEARCH CONCLUSIONS

From the ethnographic research material presented above the following conclusions are made and targets set.

It was established that refrigerators are globally significant energy consumers mainly due to high quantity of refrigerators and the long running time of each domestic refrigerator. Looking at LCA data it was shown that the usage cycle of a refrigerator uses more energy in one year than the entire life cycle of the appliance. Hence, looking at improving efficiency of the domestic refrigerator in it usage phase is a viable eco sustainability improvement project.

Linking the power consumption and other refrigerator end-of-life concerns back to CO2 emissions provides a common scale for assessing the environmental impact of different options in the project as well as the environmental evaluation of the final product. The target user of the Super-Efficient Refrigerator is defined geographically as cold climate countries with high energy cost. Also, based on kitchen modifications required to fit a Super-Efficient Refrigerator, it was shown that there is a reasonable size market of half a million new homes a year in the US alone that can be targeted. From these new homes two personas emerge. 67% are the professional builders who decide the type and price of the refrigerator they spec for the new house and 33% are the owner builders making the same decision

IV. ADVANTAGES

- Reduction in power consumption from 1.56 units to 1.13 units for 24 hours by about 28% has been achieved.
- The operating pressures have reduced to almost half than the previous one, this means that there will be 50% less chances of leakage which is desirable and will increase the reliability of the system.

- The refrigerant (R134a) used is a natural refrigerant, its Ozone Depletion Potential (ODP) is zero and has negligible (433.33 times less than the previous refrigerant) Global Warming Potential (GWP).
- The experimental setup along with normal use as a refrigerator can also be used for experimental verification of vapour compression refrigeration cycles.
- The quantity of refrigerant required is less than the previous one and in comparison with the quantity required total expenses towards refrigerant 14.57% less than the previous refrigerant.
- While brazing no harmful emissions were emitted which was a result of proper selection of brazing rod were complying with EU norms.

V. DISADVANTAGES

- Refrigerant used is a highly inflammable refrigerant.
- During brazing operation there are chances of leakage of the joints brazed when performed by any unskilled person or in a careless manner which is not applicable in our case.
- Refrigerant (R134a) and brazing cans require careful handling due to their inflammable nature.
- Improper handling of the brazing setup during the brazing process can cause damage at many things like wiring of refrigerator, any to any other objects kept nearby etc. and it may also lead to fire hazards further leading to injury and causalities.
- The brazing setup cannot be shut down instantaneously. There is time delay for about 10 seconds even after completely turning off the flow control valve and during this period if new user is handling the brazing setup the users panic during this time may also lead to accidents.
- There are chances of spark in few components of refrigerator which may lead to fire when the refrigerant leaks and the next topic deals with overcoming the same disadvantage.

VI. CONCLUSION

- Refrigerant R600a is a refrigerant with good potential for application in domestic refrigerators taking into considerations its higher energy efficiencies (about 28% more) over other refrigerants (e.g. R134a).
- Refrigerators with R600a as refrigerant will have reduction in raw material (heat transfer tubes) cost of up to 50% as the operating pressures of this refrigerant are almost 50% lesser then the currently used refrigerants.
- Safe implementation of refrigerant R600a can be carried out successfully as mentioned previously in this report and also the quantity of refrigerant required is less than the previous one it will further boost safety.
- The refrigerant R600a has zero Ozone Depletion Potential (ODP) is zero and has negligible Global Warming Potential (GWP), which will help in reducing the side effects caused by those potential factors.
- As this refrigerant is available globally the harmful pollutants emitted during the transportation will also be reduced.

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