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Study of Performance of a Household Refrigeration System with Different Refrigerants

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***Abstract*— This paper examines how the performance of a vapor compression refrigeration system is affected by changing the working fluid. A household refrigerator has been selected for the experimental investigation of performance under various refrigerants like Freon 12, Isobutene and Tetrafluoroethane. The results indicated that Tetrafluoroethane results in best performance over other two refrigerants by considerably reducing the compressor work.**

Keywords: Vapor compression, Tetrafluoroethane, Freon 12, Isobutene.

INTRODUCTION

Household refrigerators majorly work upon Vapour compression Refrigeration cycle. The main parts of the cycles are the evaporator, the compressor, the condenser and the expansion device. The objective of compressor is to pressurise of the refrigerant from the evaporator pressure up to condenser pressure. CFCs and HCFCs both have high ozone depleting potential and global warming potential which results in ozone layer depletion and global warming. Hence it is required to replaced them with eco-friendly refrigerants so as to protect the environment. R134a is the commonly used refrigerant for R12 due to its zero ODP, non-flammability, stability and similar vapours pressure as that of R12 [1–2]. The ODP of R134a is zero, but it has a relatively high global warming potential. A number of studies are being carried out which are concentrating on the application of environmentally friendly refrigerants in refrigeration systems. The issues of ozone layer depletion and global warming have led to consider the importance of using other hydrocarbon refrigerants such as propane, isobutene, *n*-butane or hydrocarbon blends as working fluids in refrigeration and air-conditioning systems.

I. REFRIGERATOR

A household refrigerator works upon vapor compression cycle. This cycle comprises of four basic processes:

1) Isentropic compression

2) Isobaric heat rejection

3) Isenthalpic expansion and

4) Isobaric heat extraction.

i) Isentropic compression process: - The vapour is dry and saturated at the start of compression it becomes superheated at the end of compression.

ii) Constant pressure heat rejection: - Heat is rejected through the compressor at constant pressure

iii) Isenthalpic expansion: - The vapour now reduced to saturated liquid is throttle through the expansion valve.

iv) Constant pressure heat extraction:-The dry saturated vapor is drawn by compressor from evaporator at lower pressure and then this vapor is compressed isentropically.

Figure 1: Experimental Setup

II. REFRIGERANT

1. FREON R12: - This refrigerant is CFC based and is also known as R12. The refrigerants chlorofluorocarbon (CFCs) and Hydro chlorofluorocarbon (HCFCs) both have high ozone depleting potential (ODP) and global warming potential (GWP) and con-tributes to ozone layer depletion and global warming.

2. TETRAFLUROETHANE: - this refrigerant is also known as R134a which is most commonly used replacement refrigerant for R12 because of having favourable characteristics such as zero ODP, non-flammability, stability and similar vapour pressure as that of R12. The ODP of R134a is zero, but it has a relatively high global warming potential.

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3. ISOBUTANE: - This refrigerant is also known as R600a which has zero ozone depletion and negligible global warning potential.it is a high purity isobutane which is derived from natural ingredients.

TABLE 1. PROPERTIES OF REFRIGERANTS

Refrigerant	R 600a	R 134a	R 12
Name	Isobutane	TetraFluro – Ethane	Chlorofluorocarbon
Formula	C_4H_{10}	CH_3CH_2F	CCL_2F_2
Critical Temp °C	135	101	112
Molecular W in kg/k mole	58.1	102	120.9
Normal Boil point	-11.6	-26.5	-29.8
Pressure at -25 °C in bar (absolute)	0.58	1.07	1.24
Liquid density kg/lit	0.60	1.37	1.47
Vapour density kg/m^3	1.3	4.4	6.0
Volumetric capacity k J/m^3	373	658	727

IV. LITERATURE REVIEW

1) Mihail-Dan & N. Staicovici investigated a method of improving the effectiveness of a mechanical vapors compression process and of its applications in refrigeration. It was shown that method can be improved of a polytrophic or an adiabatic mechanical vapors compression system.

2) Bilal Ahmed Qureshi & Syed M. Zubair, studied performance decrease of a vapour compression refrigeration system under fouling conditions. the result indicated that R717 performs the best in all cases. The paper is shows that the volumetric efficiency of R410A, R717 remained the highest under their respective operating condition. Performance degradation due to fouling in a simple vapour compression cycle is investigated for low, medium and high temperature applications.

3) K. Mani, V. Selladurai, did Experimental analysis of a new refrigerant mixture as drop-in replacement for CFC12 and HFC134a are Investigate that The refrigerants chlorofluorocarbon (CFCs) and hydro chlorofluorocarbon (HCFCs) both have high ozone depleting potential (ODP) and global warming potential (GWP) and con-tributes to ozone layer depletion and global warming.

4) Akintunde, M.A.et all Experimental study of R134a, R406 and R600a blends as alternative to Freon 12. The results show that R134a/R600a mixture in the ratio 50:50 can be used as alternative to R-12 in domestic refrigerators, without the necessity of changing the compressor lubricating oil. At of Te =-5°C and Tc =40°C , R-12 gives a COP of 2.08 while 50:50 blend of R134a/R600a gives a COP of 2.30 under the same operating conditions.

5) According to manual of company Danfoss Practical Application of Refrigerant R600a Isobutene in Domestic Refrigerator Systems is observed by Refrigerant R 600a, or isobutene, 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.

V. EXPERIMENTAL RESULTS

Refrigerants are charged one by one into the refrigerator. The refrigerator is initially provided with R12. Then after removing this refrigerant, R134a is charged into the system. After taking the observations the refrigerant is again replaced with R600a. For keeping the refrigeration capacity same 500 gm of water is kept into the freezer for all refrigerants. The thermostat is set to -1 degree Celsius so that ice formation can take place. The time is noted for all refrigerants when the compressor cuts off. The compressor has power rating of 1/6 hp.

Compressor Rating = 124.33 W

Power Factor = 0.82

Total power consumption by refrigerator with R600a = 3.86 kW

Total power consumption by refrigerator with R134a = 3.54 kW

Total power consumption by refrigerator with R12 = 4.72 kW

Power saving using R134a instead of R12 = 25%

Power saving using R600a instead of R12 = 18.22%

VI. CONCLUSION

- R-134a provides better refrigeration effect in comparison to R-12 and R-600a.
- By using R-134a the compressor work is reduced by 25%. And by using R-600a the compressor work can be reduced by 18.22%.
- As R-134a have zero ODP and zero GWP values so it does not affect the environment, whereas R-12 contains chlorine in its composition which severely affects ozone layer. In overall view the R134a refrigerant is found to be the best alternative which can be used in the refrigerator. R-600a can also be used as a good alternative to R-12 but it provides less COP in comparison to R-134a.

VII. FUTURE SCOPE

The suitability of the refrigerant with the lubricant oil of the compressor plays a very important role in maximising the performance of a refrigeration system. There is no single lubricant oil is accepted to be used with all refrigerants. Different lubricant oils with different refrigerants can be studied further in order to examine their effect on COP of the system.

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