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PERFORMANCE OF DOMESTIC REFRIGERATOR USSING R-404A TO REPLACE R-134A

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ABSTRACT

In this work, an experimental work was investigated on the R-404A which is eco friendly refrigerant and has zero ozone depletion potential and low global warming potential than R-134a used in a domestic refrigerator without any system reconstruction. The refrigerator performance was then investigated using energy consumption test and freeze capacity test. The results indicate that R-404A work normally and safely in the refrigerator. The refrigerator performance was better than the pure R134a, thus R-404A refrigerant in domestic refrigerators is feasible and can replace the R-134a.

Keywords: Domestic refrigerator, Performance characteristics; R-404A, R134a, Energy saving

INTRODUCTION

Refrigeration may be defined as the process to achieve and keep an enclosed space at a temperature lower than its surrounding temperature. This is done by continuous extraction of heat from the enclosed space whereas the temperature is below than that of the surrounding temperature.

Most of the domestic refrigerators today are running based on the vapor compression refrigeration system. It is somewhat analogous to a reverse Rankine cycle. The vapor compression refrigeration system contains four main components which are compressor, condenser, expansion device, and evaporator.

In response to the international protocol agreements many experimental and theoretical studies is been carried out to replace R-12 and R-134a from a domestic refrigeration system.Exergey analysis of R-413A as a replacement of R-12 in domestic refrigeration system is done by **MigyalPadillaet.al.[2010]**,12 tests is taken out [six for each refrigerant] evaporator temperature range is kept constant from [15 to -10^{o}c].The performance of R-413A was better than the R-12.**B.O.bolaji et.al[2010]** reported the experimental study of R-152a and R-32 to replace R-134a in a domesticrefrigeration system, the pull down time by R-152a and R-134a achieved earlier than R-32,cop of R-152a was 4.7% higher than than the R-134a and cop of R-32 was 8.5% lower than the R-134a.**Shengshan Bi et.al[2010]** analysed the performance of domestic refrigerator by using nano-refrigerants Tio2 with R-600a,the results showed that less power is consumed when nano refrigerant is mixed with R-600a and system performance was better when nano refrigerant is used miscibility of oil and compressor life is also increased.**Ching-Song Jwo et.al[2008]** reported the experimental investigation of hydrocarbon refrigerants [R-290 and R-600a] with 50% component ratio to replace R-134a,they analysed that cop ofhydrocarbon refrigerant was higher than the R-134a,pwer is saved up to 4.4% and mass of refrigerant is reduced up to 40%.**M Mohan Raj et.al[2008]** reported the experimental study of R290/R-600a mixture as an alternative to R-134a in domestic refrigeration system, refrigerant composed of R-290 and R-600a in a ratio of 45.2:54.8 by weight, overall performance was increasedmiscibility of oil is also increased with R290/R600a.**M Fatouh et.al.[2006]** assement of propane and commercial butane mixture as possible alternatives to replace R-134a from domestic refrigerator the performance characteristics of system predicted over a wide range of evaporator temperature[-35 to -10oc] and condensation temperature [40 to 60oc].finally the results confirmed that the propane/iso-butane/n-butane mixture with 60% propane is the best drop in replacement for R-134a in domestic refrigerator. **Mao-Gang He et.al.[2004]** reported the performance of mixing of the HFC152a/HFC125 in domestic refrigeration system. The theoretical performance showed that HFC 152a/HFC 125 mixtures in the composition of 0.85 mass fraction of HFC152a has same performance as with R-12.

Experimental system:

The experimental domestic refrigerator was GL-195RL4 type manufactured by L G Electronics India Pvt.Ltd.,which was a single door multicontrolled refrigerator.

13 digital sensors and 2 pressure gauges were placed on the freezer compartment, fresh food storage compartment, and refrigeration system pipeline and detailed arrangement can be shown in fig.1,the power consumption was measured by a digital watt meter.

METHODOLOGY

Before starting the experiment leaks were checked with the help of soap solution. The refrigerator was first charged with 60 g of R134a and tested at the intended various conditions. The experiment was repeated for 80 g, 100 g and 120 g of R134a. Tests were carried out the same way with R404A refrigerants by following the same procedures. The tests with R134a were carried out so that they can be used for comparison purposes.

Calculations:

Refrigeration effect is given by Eq.[1]:

$Q_{evp}=m(h_1-h_4)$ (KW) ………(1)

Where, m=mass flow rate(gm.),h_1=enthalpy of refrigerant at outlet of the evaporator(Kj/Kg) and h_4= enthalpy of refrigerant at inlet of the evaporator(Kj/Kg).
The compressor work done is given by Eq.[2]:
$W=m(h_2-h_1)$ (KW) ....(2)

Where, h_2 is the enthalpy of refrigerant at the outlet of the compressor (Kj/Kg).

The COP is calculated at the steady-state when the minimum temperature is achieved in the cold cabinet and it is obtained as the ratio between the refrigeration capacity (Qevap) and the compressor work per second W:

$COP=\frac{Qevp}{W}$ ..……(3)

RESULTS AND DISCUSSIONS

1. EFFECT OF REFRIGERENT CHARGE ON ENERGY CONSUPTION

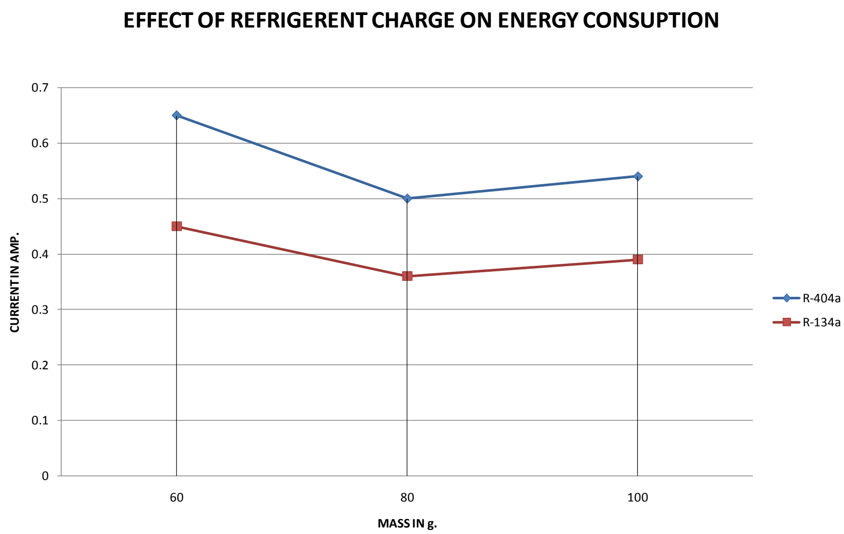

Fig:2 varition of current under different charge of refrigerants

Fig. 2 shows the effect of the refrigerant charge on the energy consumption. The curves show that the power consumption reduces as the refrigerant charge increases until it reached the minimum power consumption, and it increases thereafter as the refrigerant charge increases. As shown in the figure, the average optimal refrigerant charge, which corresponds to the minimum power consumption, for the three refrigerants, was 80 g. The average power consumptions of 0.40 amp and 0.55 amp were obtained during the test for R134a, and R-404A, respectively.

2. Discharge pressure at 100gm of refrigerant charge:

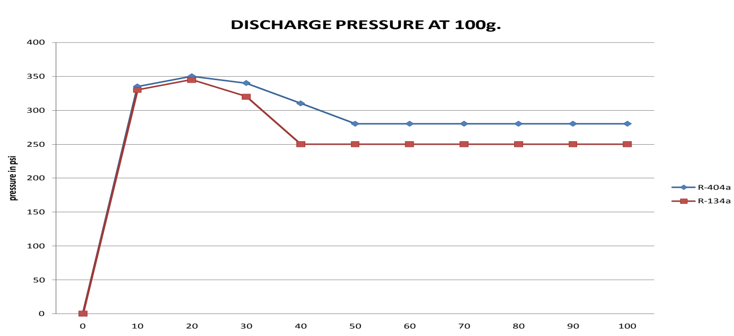

Fig:3 vartion of discharge pressure under five minute interval

Fig. 3 shows the variation of discharge pressure with time for 100 g refrigerant charge. As shown in the figure, the maximum short-time discharge pressure within the first 20 min of starting the compressor runs up to 330 to 350 psi, after which the pressure reduced and stabilized. At steady-state conditions the discharge pressures for R134a and R404A were 250 and 280 psi, respectively.

3.COP of refrigerants at different gm.

Fig. 4 shows the effect of refrigerant charges on the system COP. The COP increases with refrigerant charge for all the refrigerants. Increase in refrigerant charge increases the quantity of refrigerant in the system, which increased the cooling capacity and also the COP of the system (Eq. (3)). Average COP of R-134a was higher than the R-404A.

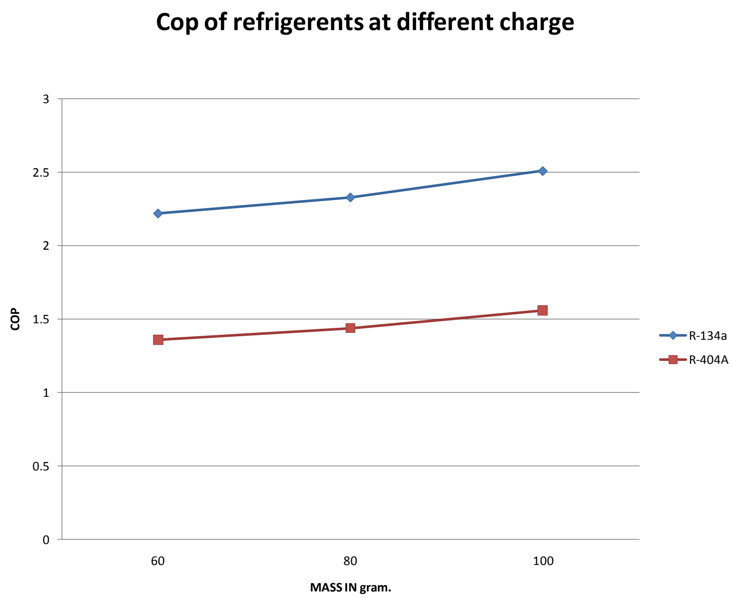

Fig 4: value of COP under different mass charge.

CONCLUSION

A. The average COP obtained using R404A is higher than that of R134a.
B. Discharge pressure of R404A is about the same with that of R134a,which means it has almost same miscibility of oil and compressor life.
C. R134a offers lowest energy consumption. The compressor consumes 4.0% and 3.2% less energy when R-134a was used than when R-404A in the system, respectively.
D. The performance of R134a in the experimental refrigerator closely follows that of R404A. Generally, the system performed better with R404Aa than R134a . This shows that R-404A can be used as replacement refrigerant for R134a in domestic refrigerator.

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