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Performance study of domestic refrigerator using propane – butane as mixed refrigerant

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ABSTRACT

Domestic refrigerator designed to work with R-134a was used as associate investigation unit to assess the prospect of exploitation mixed refrigerants. The recital of the refrigerator exploitation mixed refrigerant was investigated and compared with the performance of refrigerator once R-134a was used as refrigerant. The result of condenser temperature and evaporator temperature on COP, refrigerating result was calculated. The energy consumption of the refrigerator throughout experiment with mixed refrigerant and R-134a was measured. The result shows the permanent running and cycling results showed that R134a with a charge of 100 g or mixed refrigerant with charge of 80 mg or additional satisfy the desired deep freezer air temperature of −18 °C. All-time low electrical energy consumption was achieved victimization mixed refrigerant with heat level is a smaller amount than -18oC. This mixture achieved higher volumetric cooling capacity and lower Freezer air temperature compared to R134a. Experimental results of the domestic refrigerator exploitation mixed refrigerant were comparing with those using R134a. During a final output may be a forceful change whereas employing a mixed refrigerant compared with R134a. This is often an indication of higher performance of mixed refrigerant as refrigerants. Once the results obtain during this experiment, it had been show a positive clue of using mixed refrigerant as refrigerants in domestic refrigerator.

Key Words: R134a Mixed refrigerant, chlorofluorocarbons, propane, Butane, Isobutane, COP, Energy consumption.

1. INTRODUCTION

Refrigerators are extensively used to store foods which deteriorate at ambient temperatures; spoilage from bacterial growth and other processes is much slower at low temperatures. Normal frost was disseminated and used in both commercial and domicile application in the middle-1800s to refrigerate food. The suggestion that cold could be produced by the forced evaporation of a impulsive liquid under reduced pressure had been previously pursued by Willam Cullen in the eighteenth century. A refrigerator is a cooling appliance comprising a thermally insulated screened-off area and a heat pump - element or perfunctory means - to transfer heat from it to the external atmosphere cooling the contents to a temperature below ambient. An apparatus described as a "refrigerator" maintains a temperature a slight degrees above the freezing point of water; a similar device which maintain a temperature below the freezing point of water is called a "freezer." The refrigerator is a fairly modern invention among kitchen appliances. It replaced the icebox, which had been a common domestic appliance for almost a century and a half earlier.

Chlorofluorocarbons (CFCs) and hydro chlorofluorocarbons (HCFCs) have many suitable properties, for example, non flammability, low toxicity and material compatibility that have led to their common widespread use by both consumers and industries around the world, especially as refrigerants in air conditioning and refrigerating systems. Results from many researches show that this ozone layer is being depleted. The general consensus for the cause of this event is that free chlorine radicals remove ozone from the atmosphere, and later, chlorine atoms continue to convert more ozone to oxygen. The presence of chlorine in the stratosphere is the result of the migration of chlorine containing chemicals. The chlorofluorocarbons (CFCs) and hydro chlorofluorocarbons (HCFCs) are a large class of chemicals that behave in this manner (Radermacher and Kim, 1996, Akash and Said, 2003).

Hydrocarbon for the most part propane, butane and isobutene are proposed as an environment benign refrigerant. Hydrocarbons are free from ozone depletion potential and have negligible global warming potential. Lee and Su (2002) conducted an experiment study on the use of isobutene as refrigerant in domestic refrigerator. The performance was comparable with those of CFC-12 and HCFC-22 was used as refrigerant.

Marketable fridge and freezer units, which go by many other names, were in use for almost 40 years prior to the common home models. They used noxious gas systems, which occasionally leaked, making them unsafe for home use. Practical household refrigerators were introduced in 1915 and gained wider acceptance in the United States in the 1930s as prices fell and non-toxic, non-flammable synthetic refrigerants such as Freon or R-12 were introduced. It is notable that while 60% of households in the US owned a refrigerator by the 1930s, it was not until 40 years later, in the 1970s, that the refrigerator achieved a similar level of penetration in the UK.

Refrigerant selection involves balancing conflicting requirements such as: ability to transfer heat, chemical stability, and compatibility with compressor lubricants, flammability, and toxicity. Akash and Said (2003) studied the performance of mixed refrigerant from local market (30%propane, 55% n-butane and 15% isobutene by mass) as an alternative refrigerant for CFC-12 in domestic refrigerator with masses of 50g, 80g and 100g. The result showed that a mass charge of 80g gave the best performance. Scientist and researcher are searching the environment benign refrigerant for the domestic refrigerator and freezer. Finally we decide to choose the mixed refrigerant as an alternate source of HFC-134.

2. EXPERIMENTAL SETUP & TEST PROCEDURE

This section provides a description of the facilities developed for conducting experimental work on a domestic refrigerator. The technique of charging and evacuation of the system is also discussed here. Experimental data collection was carried out in the research laboratory of our institution. The experimental setup of the test unit and apparatus is shown in the Fig.1.

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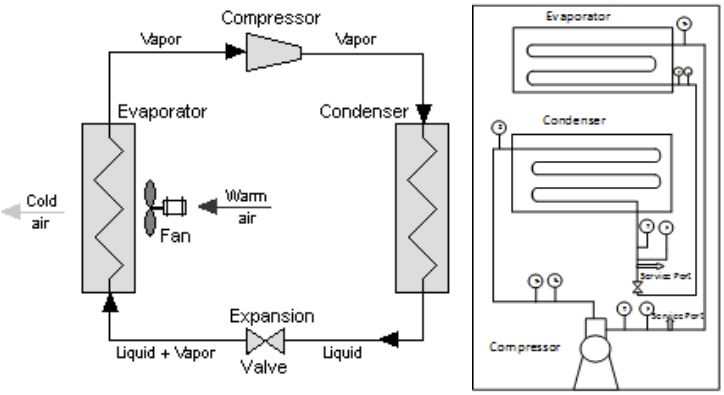

Figure 1

Schematic diagram of the investigation unit and apparatus

2.1. Experimental Style

The experimental setup of the household refrigerator used in the experiment is shown in Fig.1. The domestic refrigerator consists of an evaporator, wire mesh air-cooled condenser and hermetically sealed reciprocating compressor. The 165 liters domestic refrigerator of tropical class originally designed to work with HFC134a was taken for this study. The refrigerator was instrumented with one pressure gauge at the inlet of the compressor for measuring the suction pressure, one temperature sensor mounted at inside the refrigerator (freezer) compartment. As per the refrigerator manufactures recommendation quantity of charge requirement for HFC134a was 100 g. In the experiment, refrigerant charge is 10% higher due to the presence of instruments and connecting lines etc. To optimize the mixed refrigerant charge, the refrigerator is charged with 80g. The refrigerator was charged with 110 g of HFC134a and the base line performance was studied. After completing the base line test with HFC134a, the refrigerant was recovered from the system and charged with 80g of mixed refrigerant and the performance was studied. The refrigerant charge requirement with hydrocarbons is very small due to their higher latent heat of vaporization. During the experimentation the atmospheric is maintained at 28 ± 2ºC. The experimental procedures

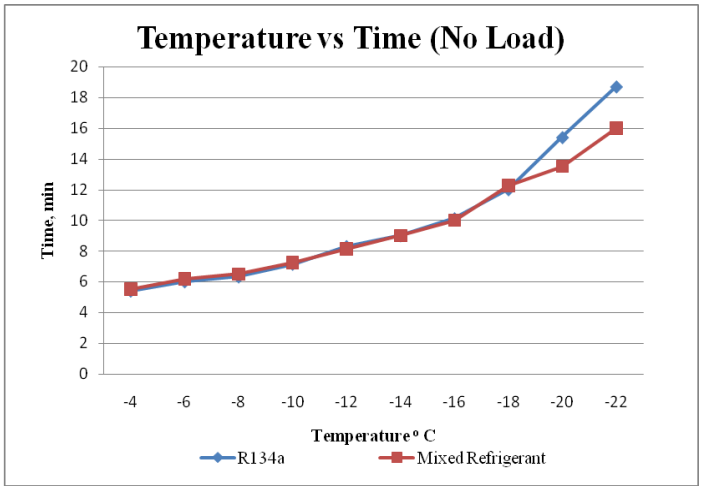

Figure 2

Observed value for R134a & Mixed Refrigerant – No Load (Temp. vs Time)

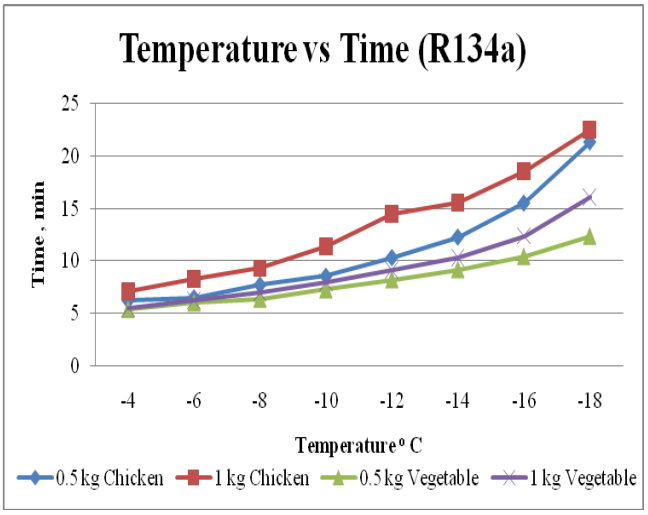

Figure 3

Observed value for R134a – Load (Temp. vs Time)

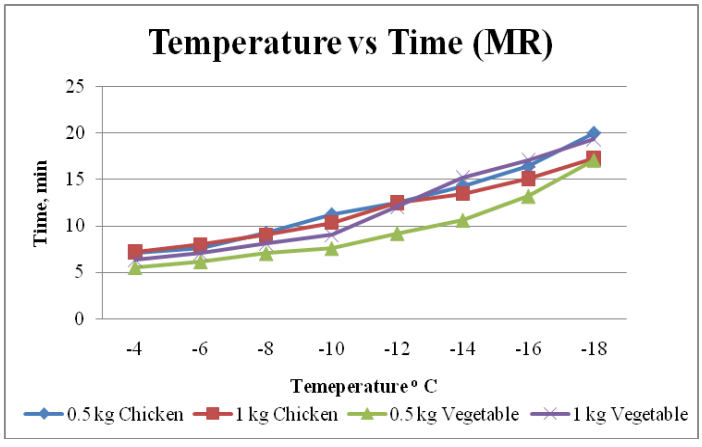

Figure 4

Observed value for Mixed Refrigerant – Load (Temp. vs Time)

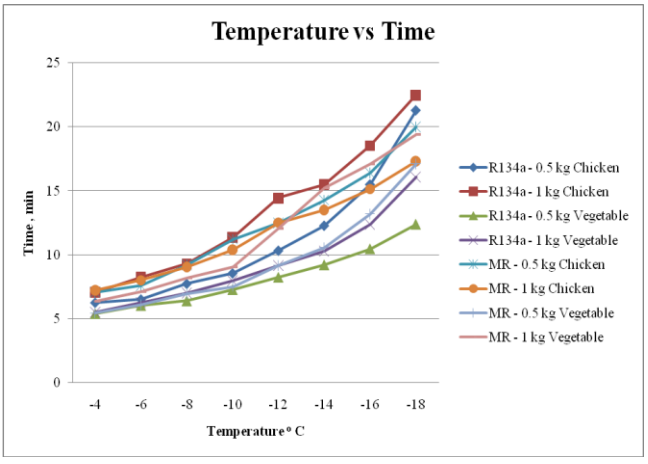

Figure 5

Observed value for R134a & Mixed Refrigerant – Load (Temp. vs Time)

were repeated and take the reading from the various modes of different loading conditions. Specially, we conduct the investigation is purely based on the vegetable and chicken in 0.5 and 1 kg load factor. Service port is installed at the inlet of expansion valve and compressor for charging and recovering the refrigerant is shown in Figure. Digital Temperature Indicator was used to measure the inside freezer temperature for this research.

2.2. Investigation Procedure

The system was evacuated with the help of vacuum pump to remove the moisture and charged with the help of charging system. The temperature inside the chamber was maintained at 25°C and 28°C. When the temperature and humidity inside the chamber was at steady state, the experiments were started. The experiment has been conducted on the domestic refrigerator at no load and load conditions.

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3. RESULTS AND DISCUSSION

From this section the comparison of the performance parameter of the refrigerants and energy consumption by the refrigerator was discussed this investigation deals with mixed refrigerant (hydrocarbon mixtures of propane, butane and isobutane) in order to assess their feasibility for replacing HFC-134a in refrigeration systems by comparing their relevant parameters.

The refrigerating effect is the main purposes of the refrigeration system. The liquid refrigerant at low pressure side enters the evaporator. As the liquid refrigerant passes through the evaporator coil, it continually absorbs heat through the coil walls, from the medium being cooled. During this, the refrigerant continues to boil and evaporate. Finally the entire refrigerants have evaporated and only vapor refrigerant remains in the evaporator coil. The liquid refrigerant still colder than the medium being cooled, therefore the vapor refrigerants continue to absorb heat. The experiment was performed on the domestic refrigerator purchased from the market, the components of the refrigerator was not changed or modified. This indicates the possibility of using mixed refrigerant as an alternative of HFC-134a in the existing refrigerator system. Freezer temperature was measured at the different time interval and also observed the lowest temperature level.

Fig.2 shows the observed values for R134a and mixed refrigerant at no load condition. For this observation temperature level reach up to -18ºC, R134a and mixed refrigerant take same time limit. But -20ºC and -22ºC, Mixed refrigerant gives better performance compare to sole (R134a) refrigerant.

Fig.3 shows the observed values for R134a at different load condition. i.e., 0.5kg, 1 kg Chicken and 0.5kg, 1 kg vegetables. For this observation, 0.5kg vegetable reach -18oC during a short period of 12 minute. But, 1 kg chicken can take maximum time of 23 minutes to reach -18ºC. Supported the higher than graph, we tend to observe vegetables is suddenly reaching the most {effective} cooling effect. When loading the chicken, lowest temperature was observed in maximum time.

Fig.4 shows the observed values for mixed refrigerants at different load condition. i.e., 0.5kg, 1 kg Chicken and 0.5kg, 1 kg vegetables. For this observation, 0.5kg vegetable and 1kg chicken reach -18ºC in a short duration of 17 minute. Based on the above graph, a smart observation was found in the loading of vegetables and chicken at the up and down the cooling effect.

Fig.5 shows the observed values for R134a and mixed refrigerants at different load condition. i.e., 0.5kg, 1 kg Chicken and 0.5kg, 1 kg vegetables. For this observation, 0.5kg vegetable reach -18ºC in a short duration of 12 minute for R134a.Using R134a, 1 kg chicken will take maximum time of 23 minutes to reach -18ºC. At the same time the involvement of mixed refrigerant 1kg of chicken reaches -18ºC in duration of 18minutes. Based on the above graph, we observe a drastic change of while using a mixed refrigerant compared with R134a.

4. CONCLUSION

This project endowed associate ozone friendly, energy economical, user friendly, safe and cost-efficient different refrigerant for HFC134a in domestic refrigeration systems. Once the triple-crown investigation on the performance of mixed refrigerants the subsequent conclusions are often drawn supported the results obtained. This experimental investigation allotted to work out the performance of domestic white goods once a propane/butane mixture is employed as a potential replacement to the normal refrigerant R134a. The domestic white goods were charged with 140g of HFC-134a and 80g of mixed refrigerant. Supported the higher than graphs, amendment observes a forceful modification whereas employing a mixed refrigerant compared with R134a. This can be a sign of higher performance of mixed refrigerant as refrigerants. The subsequent conclusions may be may be from our investigation.

1. Every mode of mixed refrigerant yields higher performance of cooling effect whereas compared with R134a.
2. Using the mixed refrigerant in domestic refrigerator, we have a tendency to be we the deep freezer temperature less than that of the R134a.
3. A sensible observation was found within the loading of vegetables and chicken at the up and down the cooling result, because chicken was taken to succeed in time to achieve all-time low temperature.

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