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Analysis of Modern Eco-Friendly Refrigerant

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ABSTRACT: Refrigerator is one of the home appliance utilizing mechanical vapour compression cycle in it process. Performance of the system becomes main issue and many researches are still ongoing to evaluate and improve efficiency of the system. Therefore, this paper presents the development process of refrigerator test rig and performance analysis of a domestic refrigerator using LPG as a refrigerant. The experiment platform which called test rig was developed from refrigerator model Videocon National brand. The main objective in this study was to obtain performance of the refrigeration system using LPG as a refrigerant in term of Refrigeration Capacity, Compressor work and Coefficient of Performance (COP) by determining three important parameters during in operating mode which are temperature, pressure and refrigerant flow rate. In the test rig, all temperature probes were connected to thermocouple scanner to measure temperature at particular points on the refrigeration system. Pressure gauges were used to measure pressure and a magnetic flow meter was used to measure refrigerant flow rate. In order to avoid effects of a changing the measured data, the environmental of testing was controlled according to Association of Home Appliance Manufacturers (AHAM) standard. There are three sets of experiment data were collected in order to evaluate the refrigerator performance. Each data was collected for a cycle of operation for 2 hours.

Key words: Eco-friendly, energy efficient, COP, ODP, GWP

I. INTRODUCTION

Refrigerator is a cooling appliance comprising a thermally insulated compartment and a refrigeration system is a system to produce cooling effect in the insulated compartment meanwhile, refrigeration is define as a process of removing heat from a space or substance and transfers that heat to another space or substance. Nowadays, refrigerators are extensively used to store foods which deteriorate at ambient temperatures; spoilage from bacterial growth and other processes is much slower in refrigerator that has low temperatures. In refrigeration process, the working fluid employed as the heat absorber or cooling agent is called refrigerant. The refrigerant absorbs heat by evaporating at low temperature and pressure and remove heat by condensing at a higher temperature and pressure. As the heat is removed from the refrigerated space, the area appears to become cooler. The process of refrigeration occurs in a system which comprises of a compressor, a condenser, a capillary and an evaporator arranged. The refrigeration plant used in the present work is called refrigerator currently, the refrigerator is used widely around the world and this appliance become necessity for household. Performance of a modern refrigerator is very efficient but the research still ongoing to optimize the system. This work investigates the result of an experimental study carried out to determine the performance of domestic refrigerator when a propane-butane mixture is liquefied petroleum gas (LPG) which is locally available .The LPG is cheaper and possesses an environmental friendly nature with no ozone depletion potential (ODP). It is used in world for cooking purposes. The various methods of refrigeration on the basis of standard refrigerant discussed. He refrigerator used in the present study is of medium size with a gross capacity of 150 liter and is designed to work on LPG as a refrigerant. LPG consists mainly of propane (R-290) and butane (R-600), and LPG is available as a side product in local refineries. In Cuba for already several decades LPG is used as a drop-in refrigerant.

II. LITERATURE REVIEW

Bolaji [4] provided comparative experimental steady is carried out of there refrigerator R-152a R-32 & R-134a to replace R-134a R-152a & R-32 are new refrigerant having zero ODP & GWP finally, he considered that Cop of R-152a 4.7% higher than R-134a & Cop of R-32 is 8.5% less than R-134a. Pull down time is achieved early than R-32. Power is considerably reduced with R-152a than the R-32 R-134a. Shegstan Bi et al R-600a is mixed with nano refrigerants ratio2, by mixing this nano refrigerants power consumption is reduced & cop & miscibility of oil with refrigerants is increased. Finally results indicated that tio2-R-600a nano refrigerants work normally and safely in the refrigerator. Songwo *et al*, [8]. taken mixture of R-290 & R-600a is mixed with each 50% ratio & compared with R-134a.440l refrigerator is taken and charged with 150g of R-134a,similarly mixture of R-290 & R-600a is taken and same parameters is calculated, refrigerating effect is improved by using HC refrigerants.4.4% energy is consumed and applied mass of refrigerants is reduced to 40%. Mohanraj *et al.* [13] experimental comparison is done between mixture of R-290,R-600a and R-134a.(45.2:54.8) ratio is taken for R-290 and R-600a.two tests is carried out one continuous running tests second cycling running tests. Continuous running tests is performed under different ambient temperature (24,28,32,38 and 43oc) while cycling running tests is performed only under 32oc ambient temperature. Finally researcher have concluded that power consumption is reduced while cop is increased.

Fatouh *et. al.*, proposed simulation analysis of propane and commercial butane to replace R-134a in domestic refrigerator. During this analysis evaporation temperature range is kept between(-35 to -10oc) while condenser temperature range is kept between (40 to 60oc).to predict the performance of refrigerator COP, volumetric cooling capacity, cooling capacity, condenser capacity, input power to compressor, discharge temperature, pressure ratio and refrigerant mass flow rate parameters is taken. The result showed that mixture of these refrigerants provides higher COP than R-134a. National Conference in Mechanical Engineering Research and Postgraduate Students (1st NCMER 2010) 26-27 MAY 2010, FKM Conference Hall, UMP, Kuantan, Pahang, Malaysia; pp. 582-591 ISBN: 978-967-5080-9501 (CD ROM); Editors: M.M. Rahman, M.M. Noor and K. Kadirgama ©Universiti Malaysia Pahang. Boot (1990), Radermacher *et al.* (1993), Jurgensen (1995), Tiedemann and Kruse (1995), Junge *et al.* (1996), *Dossat* and *Horan* (2002) and *Sattar et al.* (2007) have done work in the issue of alternative refrigerants (R134a, R152a, R409A, R409B, R290, R744, R600a) but none of these works, his to our knowledge, led to a general methodology for the optimum choice for selecting between these refrigerants.

III. METHODOLOGY

Refrigerator is one of the home appliance utilizing mechanical vapour compression cycle in it process. Performance of the system becomes main issue and many researches are still ongoing to evaluate and improve efficiency of the system. Therefore, this paper presents the development process of refrigerator test rig and performance analysis of a domestic refrigerator. The main objective in this study was to obtain performance of the refrigeration system in term of Refrigeration Capacity, Compressor work and Coefficient of Performance (COP) by determining three important parameters during in operating mode which are temperature, pressure and refrigerant flowrate. Naturally occurring substances, e.g., water, carbon dioxide, ammonia, and hydrocarbons are believed to be environmentally safe refrigerants. Now, with the CFC phase-out underway, interest in these environmentally safe refrigerants is growing. The thermodynamic properties of hydrocarbons, for example propane, are similar to that of R12 and R22. Hydrocarbons have lower viscosity and higher thermal conductivity compared to that of **CFCs** and HFCs. These superior transport properties are believed to contribute to the higher energy efficiency of hydrocarbons vise-a-vise CFCs and HCFs. Table 1 & 2 shows that the global warming potential **(GWP)** of hydrocarbons such as propane (R290), n-butane (R600a), and n-pentane (n-c5) is much lower than that of synthetic refrigerants. It also shows that the ozone depletion potential (ODP) of hydrocarbons is zero. Another advantage of hydrocarbons is their solubility in mineral oil, which is traditionally used as a lubricant in the compressors.

Methodology of this work is concentrated on two important things that need to be developed in order to investigate the performance of the domestic refrigerator which is location of measurement points and it devices, and experiment set-up.

Refrigerator test rig was developed in order to investigate the performance of the system. In developing the reliable refrigerator test rig, consideration should be highly addressed especially the development method and measurement locations of pressure and temperature. These are very important to ensure that the test rig can produce reliable data, the locations of temperature and pressure measurement points, measurement devices and measurement methods.

Table 1: Environmental effect of some Refrigerants (UNEP, 2002).

Refrigerants		ODP	GWP(Time horizons of 100 years)
HCFC'S	R-22	0.055	1700
HFC'S	R-134a	0	1300
	R-404A(R125/143a/134a)	0	3800
	R-410A (R32/125)	0	2000
Natural Refrigerant	Ammonia (R-717)	0	<1
	Propane (R-290)	0	20
	Isobutene (R-600a)	0	20
	Cyclopropane (RC-270)	0	N/A

Table 2.

Refrigerant	Group	Atmospheric life	ODP
R11	CFC	130	1
R12	CFC	130	1
R22	HCFC	15	0.055
R134a	HFC	16	0
R404a	HFC	16	0
R410a	HFC	16	0
R507	HFC	130	1
R717	NH3	-	0
R744	CO_2	-	0
R290	HC	< 1	0
R600a	HC	< 1	0

IV. DATA ANYLSIS

Coefficient of performance

1. Calculation based on reverse Carnot cycle.

Sr. No.	Atmospheric temp(^{O}C) T_2	Evaporator temp.(^{O}C) T_1	Set point	COP
1	25	-13	1	6.84
2	26	-18	2	5.79
3	27	-19.8	3	5.41
4	29	-20.5	4	5.10
5	29.5	-23.9	5	4.66
6	30	-23.9	6	4.62
7	30.5	-26.9	7	4.28
8	31	-28.9	8	4.07
9	33	-32.8	9	3.65

The energy consumption in refrigerator

Refrigerant	Energy Consumption (kW. h/day)	Energy Consumption % Increase
R-134a	1.127	+7.5
R-600	1.0013	-4.0

V. CONCLUSION

Performance of the domestic refrigerator was investigated with indicator of COP was about 5.6 and refrigeration capacity was ranging from 150 watt to 205 watt. Besides that, test rig development method that has been presented in this work was plays important role in order to investigate the performance of the refrigerator. The correct data from experiment can be produced from a reliable test rig as such presented and the method must be parallel with high skill of work and reliable measurement devices. Other refrigeration systems, such as heat pumps, operate at different conditions that could affect the refrigerant performance and thus alter the result. In addition, the conclusions are based on only one test series for determine energy consumption and are not sufficient to adequately predict the overall performance of the system under other conditions such as pull-down and elevated ambient temperatures. Therefore, further tests, such as system reliability and accelerated life, are required before a final decision can be made as to the adequacy of the alternative refrigerants.

- The use of R134a as an alternative refrigerant along with polyolester oil resulted in a 7.5% increase in energy consumption compared to R12.
- R134a/R22 is possible short-term alternative on the basis of reduced energy consumption. The reason it is only short-term alternative is that still contain R22, which is in the process of being phased out of production. However, the tests results reveal that a reduction of approximately 90% to 95% in the ozone depletion potential could be realized from it use.
- The hydrocarbon mixture of 61 wt.% R290/39 wt.% R600a has 4% lower energy consumption than R12 when run in a system with a mineral oil. The preceding results were for a modified refrigeration system by using a different compressor and optimizing the capillary tube size for each alternative refrigerant. The possibility exists that some of the results could be altered by changing the system design either by using a different condenser and evaporator size. Additionally, results could be affected by testing in another manufacturer's product.

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