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Reconditioning of Domestic Refrigerator Test Rig & Experiment Investigation with Ecofriendly Refrigerant

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1. ABSTRACT:

The VCR test rig was repaired by replacing Hermatically Sealed compressor of same capacity. R134a refrigerant used has highest GWP so eco-friendly refrigerant R600a is selected for experimentation. Experiments were performed by without doing any modifications in set up.Existing VCR Set up had compressor under maintenance showing very low COP so same capacity of compressor was replaced in set upAs per environment concern ecofriendly refrigerant R600a which has lowest GWP is selected for experimentationAfter experimentation it concluded that without any modifications R600a gas can be replaced in set up working of R34a but maximum mass charge of R600a should be less than 150 gram as R600a is flammable gas

Keywords: R600a,

2. INTRODUCTION:

Refrigerants are chemical substances used in cooling systems such as air conditioners, refrigerators, and heat pumps to transfer heat and enable temperature regulation. These substances undergo phase transitions between liquid and gas states to absorb and release heat efficiently. The selection of refrigerants is crucial for the performance, energy efficiency, and environmental impact of cooling systems. Over time, different types of refrigerants have been developed, each with specific thermodynamic properties and environmental considerations. Historically, chlorofluorocarbons (CFCs) were widely used as refrigerants due to their stability and effectiveness. However, they were found to cause severe damage to the ozone layer, leading to the development of hydrochlorofluorocarbons (HCFCs) as transitional alternatives. While HCFCs had a lower ozone depletion potential (ODP), they still contributed to environmental harm, prompting the phase-out of both CFCs and HCFCs under international agreements such as the Montreal Protocol. Hydrofluorocarbons (HFCs) emerged as the next-generation refrigerants, designed to eliminate ozone depletion concerns, but they were later identified as potent greenhouse gases with high global warming potential (GWP). This led to further research and the introduction ofmore environmentally friendly alternatives such as hydrofluoroolefins (HFOs) and natural refrigerants like ammonia (NH3), carbon dioxide (CO2), and hydrocarbons (such as propane and isobutane). These newer refrigerants offer significant reductions in GWP and energy consumption while maintaining efficient cooling performance. The global refrigeration and air conditioning industry is actively transitioning toward sustainable cooling solutions, driven by environmental regulations, energy efficiency goals, and consumer demand for eco-friendly products. The Kigali Amendment to the Montreal Protocol has played a crucial role in phasing down HFCs and promoting the adoption of greener refrigerants.

3. Related Work:

Using mixtures of R134a and R134a/R32, the current study assesses the performance of the domestic refrigerator. Tests were conducted on with R134a and different mass fractions of R134a/R32 mixture, such as 95%/5%, 90%/10%, and 85%/15%. The refrigerant R134 R134a and R32 were supplied by Om Shriram Engineeirng Services, Secunderabad, India. The properties of R134a and R32 are given in table 1.

Table 1. Shows the physical properties of R134a and R32

Sr NO	Physical parameter	R134a
1	Boiling Point	-26
2	Freezing Point	-103.3
3	Critical Temprature	122
4	Critical Pressure (bar)	4.06
5	P_V(Kg/m^3)	14.35
6	P_1Kg/m^3)	1295
7	Latent heat of vaorization (kJ/kg)	198.72
8	ODP	0
9	GWP	1300
10	Saftey	A1

4. LITERATURE REVIEW:

1) Hmood KS et. Al. studied that According to the EU F-gas Regulation, the phase-out of the high global warming potential (GWP) refrigerants (with higher than 150 GWP value) had been established. The most cur rently existing household and commercial refrigerators and automobile air conditioners appli cations based on single-stage vapour compression systems operate with R134a as working f luid. The present paper aims, to review and evaluate the performance of a set of eco-friendly alternatives refrigerants to replace R134a, without change or with minor modifications in refrigeration equipment. The theoretical and experimental studies performed in this field of research were reviewed for this objective. These alternative refrigerants are some of HFCs, HFOs and HCs and their mixtures, which are expected to be an excellent candidates in many refrigeration applications. There are Many replacement possibilities had been proposed viz. drop-in replacement, retrofit refrigerant, and new systems. The results exhibited that the most suitable refrigerants as R134a drop-in substitutes are R1234yf, R152a, R450A, and R513A. T he pure R1234ze and its mixtures are not suitable drop-in replacements of R134a but can be a good alternative to R134a only in new refrigeration systems. In terms of hydrocarbon refrigerants R290, R600, and R600a could replace R134a with some modifications to existing refrigeration systems to overcome the flammability issue. We should be using certain HFC and HC mixtures with the lowest TEWI index.

2) J.T. McMullan et Al. studied that This paper presents an experimental study of R152a and R32, environment-friendly refrigerants with zero ozone depletion potential (ODP) and low global warming potential (GWP), to replace R134a in domestic refrigerator. A refrigerator designed and developed to work with R134a was tested, and its performance using R152a and R32 was evaluated and compared with its performance when R134a was used. The results

obtained showed that the design temperature and pull-down time set by
International Standard Organisation (ISO) for small refrigerator were achieved earlier using refrigerant R152a and R134a than using R32. The average coefficient of performance (COP) obtained using R152a is 4.7% higher than that of R134a while average COP of R32 is 8.5% lower than that of R134a. The system consumed less energy when R152a was used. The performance of R152a in the domestic refrigerator was constantly better than those of R134a and R32 throughout all the operating conditions, which shows that R152a can be used as replacement for R134a in domestic refrigerator.

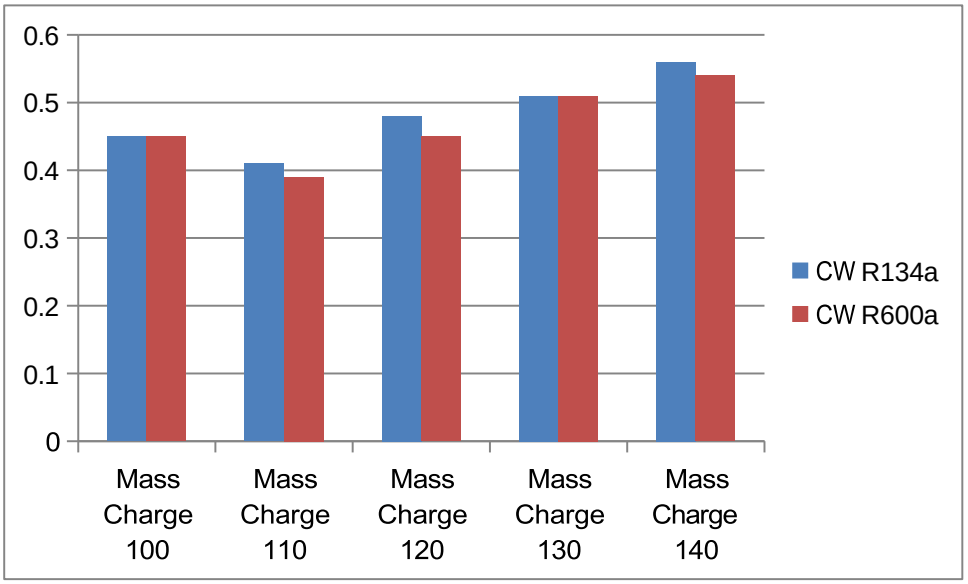
3) T.O Babarinde et. al. have done Experimentation on refrigerator with various mass charges of R600a and variable concentrations of the multi-walled CNTs nanolubricant. The findings demonstrated a reduction in pull down time and evaporator temperature when employing R600a with a multi-walled CNTs nanolubricant concentration of 0.4 g/L to 0.6 g/L and a charge of 50 g to 60 g extra. The least amount of electric energy is used when 50 g of R600a and 0.4 g/L multi-walled CNTs nanolubricant are used. This combination achieves higher refrigeration. In conclusion, it seems that the suggested multi-walled carbon nanotube nanolubricant is a suitable substitute for pure lubricant in the refrigerator.

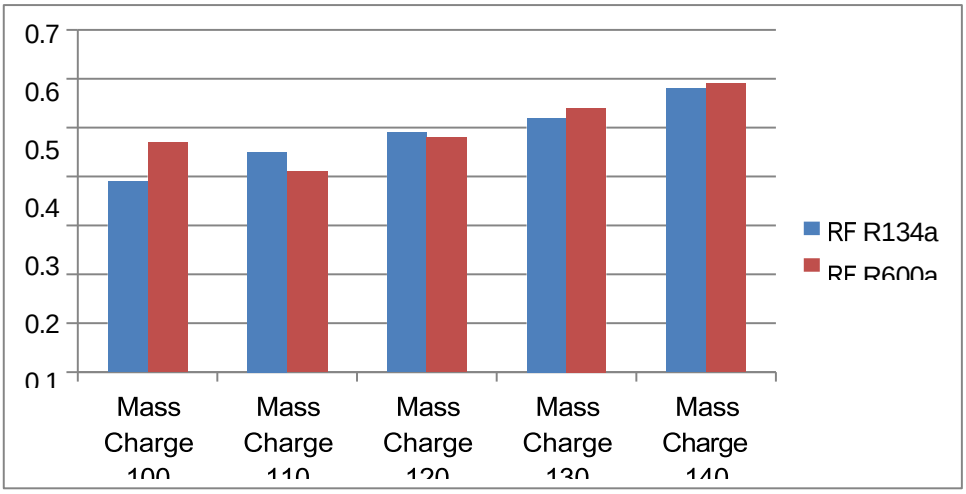
5. METHODOLOGY:

- To reconditioning exist VCR test rig.
- To select low GWP refrigerants for experimentation.
- To measure performance of low GWP refrigerant.

6. Observation And Result

COP VS Mass charge





R600a refrigerants showed better performance for all mass charge of gas tested in this experiment except 110 gram as compared to R134a refrigerant. In the reading 140 gram of gas has highest COP & 100 gram of gas highest lowest COP.CW VS MASS CHARGE

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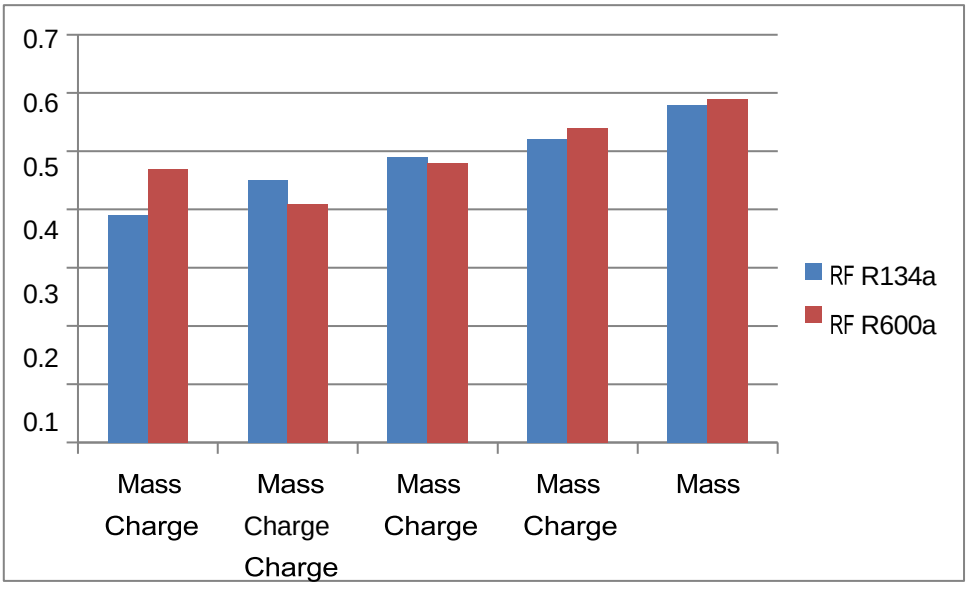
RF VS MASS CHARGE



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- **Advantages**

1. Low Global Warming Potential (GWP): R-600 has a GWP of 3, which is significantly lower than many other refrigerants.
2. Natural Refrigerant: R-600 is a natural refrigerant, which means it is not synthesized and does not contribute to ozone depletion.
3. High Coefficient of Performance (COP): R-600 has a high COP, which means it can provide efficient cooling and heating.
4. Low Operating Pressures: R-600 operates at lower pressures than some other refrigerants, which can reduce the risk of leaks and equipment damage.
5. Compatibility with Existing Systems: R-600 can be used in existing systems with minimal modifications.

- **Limitations**

1. Flammability: R-600 is a flammable refrigerant, which can pose a safety risk if not handled properly.
2. Limited Availability: R-600 may not be as widely available as some other refrigerants, which can make it more difficult to source.
3. Higher Cost: R-600 can be more expensive than some other refrigerants, which can make it less attractive to some users.
4. Limited Temperature Range: R-600 has a limited temperature range, which can make it less suitable for certain applications.
5. Requires Specialized Equipment: R-600 requires specialized equipment and training to handle safely and efficiently.

· **Applications**

R-600 is commonly used in:

1. Commercial Refrigeration: R-600 is used in commercial refrigeration systems, such as those found in supermarkets and convenience stores.
2. Industrial Refrigeration: R-600 is used in industrial refrigeration systems, such as those found in food processing and storage facilities.
3. Air Conditioning: R-600 can be used in air conditioning systems, particularly those that require a low-GWP refrigerant.

7. CONCLUSION:

· Existing VCR Set up had compressor under maintenance showing very low COP so same capacity of compressor was replaced in set up

· As per environment concern ecofriendly refrigerant R600a which has lowest GWP is selected for

experimentation

- After experimentation it concluded that without any modifications R600a gas can be replaced in set up working of R34a but maximum mass charge of R600a

should be less than 150 gram as R600a is flammable gas

- 140 gram of R600a has highest COP for selected set of experimentation where as 100 gram of R600a has lowest COP for selected set of readings
- R600a gas has showed better performance for as compered to all mass charge of R134a

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