Study on Performance Analysis of Refrigeration System using LPG as Refrigerant

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ABSTRACT

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 and comprises 24.4% propane, 56.4% butane and 17.2% isobutene which is very from company to company. 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 125 litre and is designed to work on LPG. The performance parameters investigated is the refrigeration effect in certain time. The refrigerator worked efficiently when LPG was used as refrigerant instead of CFC 12. The evaporator temperature reached -5 ºC with and an ambient temperature of 12 ºC. Also from the experiment which done in atmospheric condition, we can predict the optimum value of cooling effect with the suitable operating condition of regulating valve and capillary tube of the system. The results of the present work indicate the successful use of this propane-butane mixture as an alternative refrigerant to CFC 12 in domestic refrigerant.

INTRODUCTION

The term ‘refrigeration’ in a broad sense is used for the process of removing heat (i.e. cooling) from a substance. It also includes the process of reducing and maintaining the temperature of a body below the general temperature of its surroundings. In other words, the refrigeration means a continued extraction of heat from a body, whose temperature is already below the temperature of its surroundings.

For example, if some space (say in cold storage) is to be kept at -2 ºC, we must continuously extract heat which flows into it due to leakage through the walls and also the heat, which is brought into it with the articles stored after the temperature is one reduced to -2 ºC. Thus in a refrigerator, heat is virtually being pumped from a lower temperature to a higher temperature. According to second law of thermodynamics, this process can only be performed with the aid of some external work. It is thus obvious, that supply of power (say electrical motor) is regularly required to drive a refrigerator.

Theoretically, the refrigerator is a reversed heat engine, or a heat pump which pumps heat from cold body and delivers to a hot body. The substance which works in a heat pump to extract heat from a cold body and to deliver it to a hot body is called refrigerant.

When people hear the word refrigeration they immediately think of the refrigerator in their kitchen. However there are actually quite a few different kinds of refrigeration out three and they each have their own methods of functioning. One particular type of refrigeration is industrial refrigeration.

This type of refrigeration is typically used for cold storage, food processing, and chemical processing. The equipment is very large and made of industrial stainless steel. Industrial refrigeration, which frequently uses ammonia refrigeration to maintain temperature, is necessary for computer, foodstuffs, blood, vaccines, and quite a few other goods that must maintain a constant and steady temperature at all times.

Temperatures that are too high or too low may spoil certain goods or ruin them. As a result industrial refrigeration is especially important maintaining temperature is as well. Since temperature is so important into industrial refrigeration companies offering this service must pay attention at all times to the temperature of the industrial refrigerators.

Lpg Refrigeration

In India, more than 80% of the domestic refrigerator utilizes HFC 134a as refrigerant, due to its excellent thermodynamic and thermo physical properties. But, HFC 134a has a high global warming potential (GWP) of 1300.

There is a need of assess various refrigerant option considering the existing refrigerators in the field and for the future market.

CFC's are principally destroyed by ultraviolet radiations in the stratosphere; the chlorine released in the high stratosphere catalyzes the decomposition of ozone to oxygen; and an ultraviolet radiation penetrates to lower altitudes. Credible calculations of the magnitude of the effect (Hoffman 1987) and his team predicted 3% global ozone emissions of 700 thousand tonnes/year after a hundred years. The ozone impact of car air conditioners also cannot be ignored.

Hydro fluorocarbons (HFC's) can be thought of as a replacement, but unfortunately the radiation properties of HFC's like R-134a make them powerful global warming agents. HFC 134a and the HC blend have been reported to be substitutes for CFC 12, but they have their own drawbacks in energy efficiency, flammability and serviceability aspects of the systems.

HFC 134a is not miscible with mineral oil, and hence, polyol ester oil is recommended, which is highly hygroscopic in nature. This hygroscopicity demands stringent service practices, which otherwise results in moisture entry into the system.

Thus, hydrocarbon refrigerants; particularly LPG serves as the best contender to replace CFC's from domestic refrigerator as well as car air conditioners.

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. LPG mixtures have composition of a commercial LPG mixture suitable as 'drop-in' replacement for R-12 was calculated crudely as 64% propane and 36% butane by mass.

Liquefied petroleum gas (LPG) of 60% propane and 40% commercial butane has been tested 31 as a drop-in suitable for R 134a in a single evaporator domestic refrigerator with a total volume of 10 ft3.

The revival of LPG refrigerants in domestic and small commercial application in a happy accident (Vidal 1992). Engineers had known since the 1920's that LPG refrigerants performed well and in the 1980s refrigerators manufacturers again tested them (Kuijpers et al. 1988). Fear of a flammability campaign from the chemical industry deterred any manufacture.

Literature Review

A.Baskaran1, P.Koshy Mathews imposed, the ozone depleting potential (ODP) and global warming potential (GWP) have become the most important criteria in the development of new refrigerants apart from the refrigerants CFCs due to their contribution to ozone layer depletion and global warming.

In spite of their high GWP, alternatives to refrigerants CFCs and HCFCs such as hydro fluoro carbon (HFC) refrigerants with the zero ODP and hydro carbon refrigerants (HC) have been preferred for use in many industrial and domestic applications. The HFC refrigerants are considered as one of the six target greenhouse gases under Kyoto protocol of United Nations frame work convention on climate change (UNFCCC) In 1997.

Kyoto protocol was approved by many nations called for the reduction in emission of green house gas including HFC refrigerants. The presence of fluorine atoms in HFC134a is responsible for the major environmental impact (GWP) with serious implications for the future development of the refrigeration based industries.

A number of investigators reported that GWP of HFC refrigerants is more significant even though it has less than CFC refrigerants. Fatosh and kafafy theoretically assessed the mixture composed of 60% propane and 40% commercial butane is the best drop in substitute for HFC134a based domestic refrigerators.

Vapour Compression Refrigeration System:
In this study, an ideal vapor-compression system is used for the performance analysis of alternative new refrigerants substitute for R134a. Considering the comparison of performance coefficients (COP) and pressure ratio of the tested refrigerants and also the main environmental impacts of ozone layer depletion and global warming, refrigerant RE170 was found to be the most suitable alternative among refrigerants tested for R134a. The performance coefficient (COP) of the system, increases with increase in evaporating temperature for a constant condensing temperature in the analysis. All systems including various refrigerants were improved by analyzing the effect of the super heating / sub cooling case. Better performance coefficient values (COP) than those of non-super heating /sub cooling case are obtained as a result of this optimization.

A performance analysis on a vapour compression refrigeration system with various eco-friendly refrigerants of HFC152a, HFC32, HC290, HC1270, HC600a and RE170 were done and their results were compared with R134a as possible alternative replacement. The results showed that the alternative refrigerants investigated in the analysis RE170, R152a and R600a have a slightly higher performance coefficient (COP) than R134a for the condensation temperature of 50ºC and evaporating temperatures ranging between -30ºC and 10ºC.

Refrigerant RE170 instead of R134a was found to be a replacement refrigerant among other alternatives. The effects of the main parameters of performance analysis such as refrigerant type, degree of sub cooling and super heating on the refrigerating effect, coefficient of performance and volumetric refrigeration capacity were also investigated for various evaporating temperatures.

Comparison with other Alternative New Refrigerants

A.S. Dalkilic, S. Wongwises, imposed an ideal vapour-compression refrigeration system is used for the performance analysis of alternative new refrigerant mixtures as substitutes for CFC12, HFC134a, and CFC22. Considering the comparison of performance coefficients (COP) and pressure ratios of the tested refrigerants and also the main environmental impacts of ozone layer depletion and global warming, refrigerant blends of HC290/HC600a (40/60 by wt.%) and HC290/HC1270 (20/80 by wt.%) are found to be the most suitable alternatives among refrigerants tested for R12 and R22 respectively.

The refrigeration efficiency, the performance coefficient (COP) of the system, increases with increasing evaporating temperature for a constant condensing temperature in the analysis. All systems including various refrigerant blends were improved by analysing the effect of the superheating/subcooling case. Better performance coefficient values (COP) than those of the non-superheating/subcooling case are obtained as a result of this optimization.

In march 1989, the Institute of Hygiene in Dortmund Germany needed a new cold storage room. The young idealistic director, Dr Harry Rosin, could not consider using a CFC refrigerant and so tried propane and iso butane.

Greenpeace Australia imported a Foron refrigerator in February 1993 and in December 1993 Email Ltd, Australia's largest appliance manufacturer, displayed prototype LPG refrigerators. In 1994, German manufacturer announced one by one their intention of switch to LPG refrigerants.

OZ Technology Inc, a startup company in Idaho, introduced OZ-12 a mixture of commercial propane and butane in 1992. they sold over 50,000 170 g cans the first summer. The Mobile Air-Conditioning Society made flammability hazard claims including 'a bomb in the passenger compartment' (Keebler 1993, MACS 1993).

The US EPA refused to approve OZ-12 on flammability grounds. OZ then introduced another LPG refrigerant HC-12a, which has already sold over 100,000 cans. The US EPA may not approve this either but OZ's petition (OZ 1994) is convincing, comprehensive and technically sound especially on safety. Calor released Care 30 in June 1994. Care 30 is a high purity mixture of R-290 and R-600a and is a drop- in replacement for R-12 and R 134a. it has been very successful in vehicle refrigeration and air-conditioning.

METHODOLOGY

Construction of the Lpg Refrigerator

- The LPG refrigerator shown in figure. We make the one box of the plywood. The plywood sheet size is 12mm for used the LPG refrigerator. The size of the refrigerator is 724*457*381 mm3. The evaporator is fitted on the upper portion of box inside.
- Inside the refrigerator, we also put the thermo-coal sheet; because of the cold air can not the transfer from inside to outside of refrigerator.

Working Lpg Refrigerator

The basic idea behind LPG refrigeration is to use the evaporation of a LPG to absorb heat. The simple mechanism of the LPG refrigeration working is shown in figure.

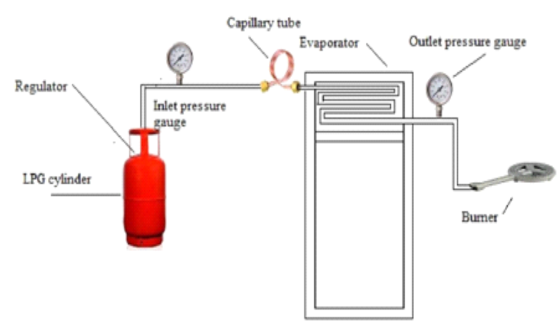

Fig 3.2.1 Working of LPG Refrigerator

- LPG is stored in the LPG cylinder under high pressure. When the gas tank of regulators is opened then high pressure LPG passes in gas pipe. This LPG is going by high pressure gas pipe in capillary tube.
- High pressure LPG is converted in low pressure at capillary tube with enthalpy remains constant.
- After capillary tube, low pressure LPG is passed through evaporator. LPG is converted into low pressure and temperature vapour from and passing through the evaporator which absorbs heat from the chamber. Thus the camber becomes cools down. Thus we can achieve cooling effect in refrigerator.
- After passing through the evaporator low pressure LPG is passed through pipe by burner. And we can uses the low pressure of LPG is burning processes.

Properties

- Colorless.
- Odorless. (It's normal to odorise LPG by adding an odorant prior to supply to the user, to aid the detection of any leaks).
- Flammable.
- Heavier than air.
- Approximately half the weight of water.
- Non toxic but can cause asphyxiation.
- LPG expands upon release and 1 litre of liquid will form approximately 250 litres of vapour**.**

A Good Mixture: LPG is mainly Propane (C3H8), Butane (C4H10) or a mix of Propane/Butane. Since LPG has such a simple chemical structure, it is among the cleanest of any alternative fuel.

Boiling Point: LPG's boiling point ranges from -42 ºC to 0 ºC depending on its mixture percentage of Butane and Propane.

Combustion: The combustion of LPG produces carbon dioxide (CO2) and water vapor but sufficient air must be available. Inadequate appliances flueing or ventilation can result in the production of carbon monoxide which can be toxic.

Vapour Pressure: LPG is a stored as a liquid under pressure. It is almost colorless and its weight is approximately half that of an equivalent volume of water. The pressure inside a closed container in which LPG is stored is equal to the vapour pressure of the liquid and corresponds to its temperature.

Ignition Temperature: The temperature required to ignite LPG in air is around 500ºC. 33

Calorific Value: The calorific value of LPG is about 2.5 times higher than that of main gas so more heat is produced from the same volume of gas.

Toxicity: LPG is a colorless, odorless and non-toxic gas. It is supplied commercially with an added odorant to assist detection by smell.

LPG is an excellent solvent of petroleum and rubber product and is generally non-corrosive to steel and copper alloys.
Safety: LPG is just as safe as any other fuel. In fact, it is safer than most fuels because neither LPG itself nor the end products that are produced by burning LPG in a suitable appliance are poisonous to inhale. Since LPG cannot burn without air, there can never be a 'Flash-back' into the cylinder.

You can feel safe with LPG as the most through precaution are taken to ensure your safety. All you have to do is to handle it correctly whilst adhering to the simple instructions provided.

Application
Application of LPG as refrigerant that divides in two categories:

- Processes that uses LPG
- Industries that uses LPG
- Processes that use LPG

LPG's high calorific value makes it a key gas for:

The Lpg Refrigeration Cycle:

1) **LPG Gas Cylinder:** From the LPG gas cylinder, LPG flows through the pipe and reaches to the capillary tube. LPG gas pressure is approximate 80-100 psi.
2) **Capillary Tube:** As the capillary tube, capillary tube downs the pressure up to less then 1 psi.
3) **Evaporator:** In the evaporator LPG is converted into the vapour from with low pressure. After passing through the evaporator low pressure and temperature LPG vapour absorbs heat from the chamber system.
4) **Gas Burner:** After performing the cooling effect, low pressure LPG gas goes into the burner where the burns.

Causes and Precaution

- Explosion in space any refrigerant with vapour pressure above ambient can flash to a larger volume. The potential increase in volume is greater if combustion of lubricant or refrigerant occurs. Explosion venting may be necessary to limit pressure rise to what the space can safely withstand. 2 kPa can blow window glass off a building.
- Fire Combustible lubricant and refrigerant must be discharged safely outside a building when a fire occurs especially it the heat of combustion exceeds 200 MJ.
- Asphyxiation or poisoning All refrigerants except air and oxygen are asphyxiations. Ventilation must prevent serious injury or death on a sudden total release of refrigerants. The quantity of ventilation necessary varies greatly between refrigerants.
- Flying metal System must comply with piping and pressure vessels codes.
- Corrosion or chemical reaction LPG refrigerants are non-reactive and chemically stable at refrigeration temperature.
- Chemical or cold burns Accidental contact between skin and cold metal must be prevented by insulation.

Accidental releases of liquid refrigerant must drain safely.

CONCLUSIONS

In this study, an ideal vapor-compression system is used for the performance analysis of alternative new refrigerants substitute for R134a. Considering the comparison of performance coefficients (COP) and pressure ratio of the tested refrigerants and also the main environmental impacts of ozone layer depletion and global warming, refrigerant RE170 was
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