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Refrigeration System using LPG as a Refrigerant

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Abstract: *This paper investigates the result of an experimental study carried out to determine the performance of domestic refrigerator when a liquefied petroleum gas (LPG) which is locally available which comprises of 24.4% propane, 56.4% butane and 17.2% isobutene which is varied from company to company is used as a Refrigerant.[1] The LPG is cheaper and possesses an environmental friendly nature with no Ozone Depletion Potential (ODP) and no Global Warming Potential (GDP).[2] It is used in world for cooking purposes. The refrigerator used in the present study 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 a refrigerant instead of R134a. The use of LPG for refrigeration purpose can be environment friendly since it has no ozone depletion potential (ODP). Usually LPG is used as a fuel for cooking food in houses, restaurants, hotels, etc.[3] and the combustion products of LPG are CO2 and H2O.[4] In this project we have designed and analyzed a refrigerator using LPG as refrigerant.[5] LPG is available in cylinders at high pressure. When this high pressure LPG is passed through the capillary tube of small internal diameter, the pressure of LPG is dropped due to expansion and phase change of LPG occurs in an isoenthalpic process.[7] Due to phase change from liquid to gas latent heat is gained by the liquid refrigerant and the temperature drops. In this way LPG can produce refrigerating effect for a confined space. [8]*

Keywords: LPG Refrigerant, Domestic Refrigerator, Expansion, Refrigerating Effect, Cooling Effect, COP

I. INTRODUCTION

The most important details are that cost-free cooling systems can be used to reduce and maintain the temperature of a body below the general temperature of its surroundings.[2,10] This solution is convenient for regions with scares in electricity, as it uses LPG instead of electricity for refrigeration.[11] The refrigeration system has been known since the mid-19th century, [13]and this study investigated the performance parameters of a refrigerator using LPG as a refrigerant. The results showed that the refrigerator worked efficiently and was environment friendly due to its lack of ozone.[14] LPG is used as a fuel for cooking food, and its combustion products are CO2 and H2O. Refrigeration is divided into types, with industrial refrigeration being used for food processing, chemical processing, and cold storage.[1,6] It works on the principle that during the conversion of LPG into gaseous form, expansion of LPG takes place, resulting in a pressure drop and increase in volume of LPG that results in a drop of temperature and a refrigerating effect is produced. This work provides refrigeration for socially relevant needs as well as replaces global warming creator refrigerants.[5]

II. PROPERTIES OF LPG

- Colorless
- Odorless - (It's normal to odorize LPG by adding an odorant prior to supply to the user, to aid the detection of any leaks).
- Flammable.
- Heavier than air.
- Nontoxic but can cause asphyxiation.
- A good mixture: LPG is mainly Propane (C3H8), Butane (C 4H10) or a mixture of Propane/Butane.

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III. OBJECTIVES

- Compare the important characteristics between LPG refrigeration system and traditional refrigeration system.
- To replace compressor by pressurized LPG
- The main objective behind this project is to increase COP and the refrigerating effect of the system.
- Use of LPG not for only heating as well as cooling.
- Reducing need of electricity for cooling purpose.

IV. WORKING PRINCIPLE

- Compression: The vapour of refrigerants enters the compressor and get compressed to high pressure and high temperature. During this process the entropy of the refrigerant ideally remains constant and it leaves in superheated state.
- Condensation: The superheated refrigerant then enters the condenser where it is cooled either by air or water due to which its temperature reduces, but pressure remains constant and it gets converted into liquid state.
- Expansion: The liquid refrigerant then enters the expansion valve or throttling valve or capillary tube when sudden expansion of the refrigerant occurs, due to which its temperature and pressure falls down. The refrigerant leaves expansion valve or capillary tube in partially liquid state and partially in gaseous state.

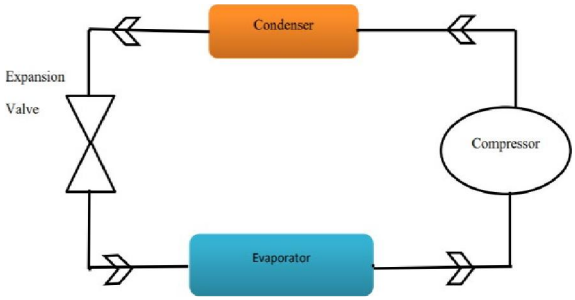

Fig.4.1 Block diagram of VCR Cycle

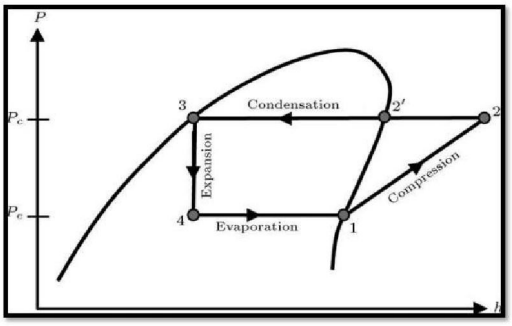

Fig.4.2 P-H Diagram of VCR

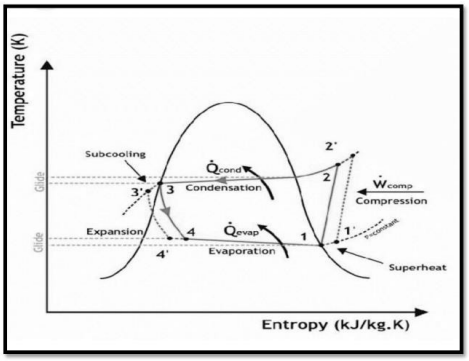

Fig.4.3 T-S Diagram of VCR

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- Evaporation or cooling: The partially liquid and partially gaseous refrigerant at very low temperature enters the evaporator where the substance to be cooled is kept. It is here where the refrigeration effect is produced. The refrigerant absorbs the heat from the substance to be cooled and gets converted into vapour state.

V. ACTUAL SYSTEM

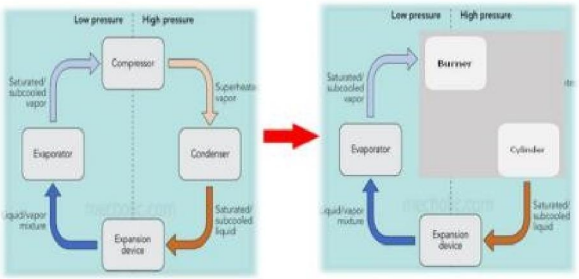

Fig.5.1 Modification of VAC

The straightforward instrument of the LPG refrigeration working is appeared in figure2. The thought behind LPG refrigeration is to assimilate heat from encompassing by utilizing the vanishing of a LPG. The weight of LPG which is put away in barrel is at around 120 psi. We bringing down this weight of LPG up to weight 30 psi by utilizing fine thus that cooling is done on encompassing by engrossing warmth isentropically. Weight of LPG in barrel is high, when the controller of gas tank is opened then high weight LPG goes through gas pipe. After that this high weight LPG is goes in the fine cylinder from high weight pipe. In the fine cylinder this high weight LPG is changed over in to low weight adiabatically for example enthalpy stays consistent. After fine cylinder, this low weight LPG is gone through evaporator. In the evaporator LPG is changed over into low weight and temperature vapor structure which ingests the warmth from the cooling chamber. Therefore the chilling chamber moves toward becoming chills.

VI. WORKING OF LPG REFRIGERATION

The LPG Refrigerator uses evaporation of LPG to absorb heat. LPG is stored high pressure in cylinders and working pressure at about 70 psi. We lowering this pressure to atmospheric pressure so that the heat absorbed adiabatically from refrigeration box and cooling is obtained on surrounding. 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 passed to capillary tube at high pressure. High pressure LPG is converted in low pressure at capillary tube with enthalpy remains constant. Low pressure LPG is passed through evaporator. LPG is converted into low pressure and temperature. Vapour from passing through the evaporator which absorbs heat from the refrigeration box. Thus, the refrigeration box becomes cool down. Thus, we can achieve cooling effect in refrigerator. LPG from evaporator is then passed through pipe to the burner.

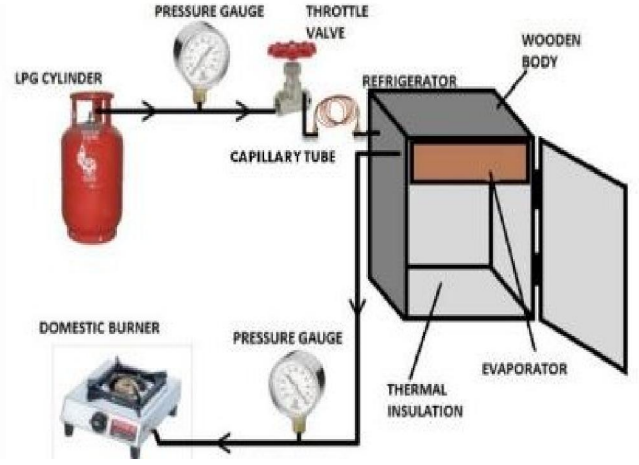

Fig.6.1 Block Diagram LPG Refrigeration system

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COMPONENTS

LPG Gas Cylinder

Fig.6.1.1 LPG Cylinder

This is because these gases can be liquefied at a normal temperature by application of a moderate pressure increases, or at normal pressure by application of LPG using refrigeration. LPG is used as a fuel for domestic, industrial, horticultural, agricultural, cooking, heating and drying processes. LPG can be used as an automotive fuel or as propellant for aerosol, in addition to other specialist applications. LPG can also be used to provide lighting through the use of pressure lanterns.

Capillary Tube

Fig.6.2.1 Capillary Tube

The capillary tube is the commonly used throttling device in the domestic refrigeration. The capillary tube is a copper tube of very small internal diameter. It is of very long length and it is coiled to several turns so that it would occupy less space. The internal diameter of the capillary tube used for the refrigeration applications varies from 0.5 to 2.28 mm (0.020 to .09 inch).

The capillary tube is shown in picture.When the refrigerant enters in the capillary tube, its pressure drops down suddenly due to very small diameter. The decrease in pressure of the refrigerant through the capillary depends on the diameter of capillary and the length of capillary. Smaller is the diameter and more is the length of capillary more is the drop in pressure of the refrigerant as it passes through it.

Evaporator

The evaporator is the component of a refrigeration system in which heat is removed from air, water or any other body required to be cooled by the evaporating refrigerant.

Fig.6.3.1 Evaporator

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In experimental setup plate and tube type evaporator has been used because it provides a gentle type of evaporation with low residence time. It also preserves the food and other products from bacterial attack and requires low installation cost. Fig shows evaporator, The evaporators are another important parts of the refrigeration systems. Through the evaporators the cooling effect is produced in the refrigeration system. It is in the evaporators when the actual cooling effect takes place in the refrigeration systems. For many people the evaporator is the main part of the refrigeration system, consider other part as less useful. The evaporators are heat exchanger surface that transfer the heat from the substance to be cooled to the refrigerant, thus removing the heat from the substance.

Pressure Gauges

Many techniques have been developed for the measurement of pressure and vacuums. Instruments used to measure pressure are called pressure gauges or vacuum gauges.

Fig. 6.4.1 Pressure Gauge

High pressure pipe

Fig. 6.5.1 High Pressure Pipe

The range of high-pressure pipes covers most application where there is a requirement to transfer gas at high pressure. They consist of a steel pipe with steel ball fitted to both ends. Two swiveling connection nipples press these balls against the seating of the connecting hole and thus sealing against gas leakage. All pipes are pressure tested to 100 M Pa (14,500 psi) over recommended working pressure.

High pressure regulator

Fig. 6.6.1 Regulator

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This type of regulator is used to send high pressure gas from the cylinders. These are used in regular gas cylinder.

Gas Burner

Fig. 6.7.1 Burner

After Gas comes out from the evaporator by giving refrigeration effect to the refrigerator and ahead is connected to the burner and it is utilized for the cooking purpose

VII. SPECIFICATION

LPG Cylinder	14.2kg
Capilary Tube	D=0.031mm L=300mm
Pressure Guage	500psi and 250psi
Regulator	D=4mm upto 250psi
Pressure Pipes	1500mm
Evaporater	Plate and tube type

Table 7.1 specification

VIII. EXPERIMENTAL READINGS

INLET PRESSURE (bar)	TIME (min)	EVAPORATOR TEMP. (˚C)	WATER TEMP. (˚C)
5.5	0	37.1	38
5.5	15	31.3	32.3
5.5	30	27.1	28.4
5.5	45	23.6	24.4
5.5	60	20.3	21.6
5.5	75	17.5	18.5
5.5	90	16.4	17.2

TABLE 8.1 EXPERIMENTAL READINGS

IX. ADVANTAGE OF LPG REFRIGERATION SYSTEM

- The cooling capacity of LPG is 10% higher than R-12 and the vapour pressure is appropriate.
- LPG is naturally occurring and non- toxic.
- Use of LPG as a refrigerant also improves the overall efficiency by 10 to 20%.
- The ozone depletion potential (ODP) of LPG is 0 and Global warming potential (GWP) is 8 which Significantly negligible as compared to another refrigerant.

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- Apart from environment friendly, use of also LPG gives us lot of cost advantages.

X. DISADVANTAGE OF LPG REFRIGERATION SYSTEM

- LPG is explosive in nature.
- Do not maintain constant pressure in LPG cylinder.
- Put the LPG cylinder is inverted position.
- After the refrigeration processes, the exhaust of LPG is burn into burner, Because of the exhausted vapour LPG cannot converted again liquid phase, because this process is very costly.

XI. APLICATION

- Hospitality and Leisure: - as a heating and cooking gas in restaurant, cafes and mobile catering vans.
- Agriculture:- for crop drying, heating greenhouses and animal sheds and for flame weeding and pest control.
- Construction:- LPG's portability allow its use for general space heating to enable work on projects during winter months, and for road heating in bitumen replacement work.
- It can play an important role in restaurants where continuously cooling and heating is required
- It can be useful in remote parts where electricity is not available.

XII. CONCLUSION

The experiment concluded that high-pressure LPG gas stored in a cylinder at 12.41 bar with a weight of 14.5 kg has a refrigerating effect that changes the properties of LPG before and after evaporation. The cooling effect of LPG refrigeration varies with the load and pressure, so the design of the refrigerator is different cooling load under different pressure. Eliminating the compressor and condenser, the COP is higher than other domestic refrigerators.The LPG refrigerator uses high pressure in the cylinder to produce the refrigerating effect, making it cheaper and easier to maintain. It is suitable for high consumption industries and has a higher coefficient of performance than R134a.The LPG based refrigerator has a cooling effect comparable to a domestic refrigerator, allowing it to reach 10°C within 45 minutes.

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