Design and Manufacturing of LPG Refrigerator

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***Abstract*: Currently we are facing environmental issues which are mostly due to harmful by-product of Chemical used in the cooling sector. Traditional coolant used i.e. CFC are the main reason for ozone depletion causing high CO_2 level in the atmosphere trapping heat and raising global temperature level at an alarming rate, though the use of this material is reduced drastically in industrial applications the damage it caused cannot be undone. So to make cooling eco-friendly and reduce the damage on the environment we can replace the traditional coolant with LPG which is readily available in household and can be used without much capital requirements. So it can be used in village where are people do not enough vages to afford a traditional fridge. The LPG is cheaper and possesses an environmental friendly nature with no Ozone Depletion Potential (ODP) and no Global Warming Potential (GDP). 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. It is used for cooking purposes. From the experiment, which we 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 refrigerator used in the present study is designed to work on LPG. The performance parameters investigated are the refrigeration effect in certain time. The refrigerator worked efficiently when LPG was used as a refrigerant instead of domestic refrigerant. The evaporator temperature reached 7 °C with an ambient temperature of 33 °C. And also we can re-utilize the refrigerant as a fuel for burner.**

***Keywords*: Liquefied Petroleum Gas (LPG), CFC, Ozone Depletion Potential (ODP), Global Warming, Refrigeration, Refrigerant**

1. 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 °C, 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. The refrigeration system is known to the man, since the middle nineteenth century. The scientist, of the time, developed a few stray machines to achieve some pleasure. But it paved the way by inviting the attention of scientist for proper studied and research.

Refrigeration has a large impact on industry, lifestyle, agriculture, and settlement patterns. The idea of preserving food dates back to at least the ancient Roman and Chinese empires. However, mechanical refrigeration technology has rapidly evolved in the last century, from ice harvesting to temperature-controlled rail cars. The introduction of refrigerated rail cars contributed to the westward expansion of the United States, allowing settlement in areas that were not on main transport channels such as rivers, harbors, or valley trails. Settlements were also developing in infertile parts of the country, filled with newly discovered natural resources.

These new settlement patterns sparked the building of large cities which are able to thrive in areas that were otherwise thought to be inhospitable, such as Houston, Texas, and Las Vegas, Nevada. In most developed countries, cities are heavily dependent upon refrigeration in supermarkets in order to obtain their food for daily consumption. The increase in food sources has led to a larger concentration of agricultural sales coming from a smaller percentage of farms. Farms today have a much larger output per person in comparison to the late 1800s. This has resulted in new food sources available to entire populations, which has had a large impact on the nutrition of society.

1.1 Types of Refrigeration System

There are different types of refrigeration system.

1. Non-Cyclic Refrigeration

This refrigeration method cools a contained area by melting ice, or by sublimating dry ice. Perhaps the simplest example of this is a portable cooler, where items are put in it, then ice is poured over the top. Regular ice can maintain temperatures near, but not below the freezing point, unless salt is used to cool the ice down further (as in a traditional ice-cream maker). Dry ice can reliably bring the temperature well below water freezing point.

2. Cyclic Refrigeration

Cyclic Refrigeration: In the cyclic process of refrigeration the heat is removed from the low temperature reservoir and is thrown to high temperature. As per the second law of thermodynamics the natural flow of heat is from high temperature to low temperature reservoir. In the cyclic refrigeration process since the flow of heat is reserved, the external work has to be done on the system. The cyclic process of refrigeration is also reverse of the thermodynamic power cycle or Carnot cycle in which the heat flows from high temperature reservoir to low temperature reservoir. Hence the cycle of refrigeration is also called as Reversed Carnot Cycle.

Cyclic refrigeration can be classified as:
1. Vapour Cycle
2. Gas Cycle

Vapor cycle refrigeration can further be classified as:
1. Vapor-compression Refrigeration
2. Absorption Refrigeration
   2.1. Vapor-absorption Refrigeration
   2.2. Adsorption Refrigeration

Vapor Compression Cycle: In vapor compression system, an evaporator and a gas-liquid separator are received in a common casing, so that the gas-liquid separator and the evaporator are placed close to each other. Thus, it is possible to limit heat absorption of the liquid phase refrigerant from the atmosphere to reduce the heat loss upon discharge of the refrigerant from the gas-liquid separator. Also, it is possible to reduce pressure loss in refrigerant passage between the gas liquid separator and the evaporator.

Vapor Absorption Cycle: Before the development of the vapor compression system of refrigeration, vapor absorption system was very widely used. The vapor compression system replaced vapor absorption system because it has high coefficient of performance (COP). The vapor absorption system requires very less amount of electricity but large amount of heat; hence it can be used very effectively in industries where very large stocks of excessive stem are available. In such cases there is not only effective utilization of steam, but also lots of savings in electricity costs.

Adsorption Refrigeration: The main difference with absorption cycle, is that in adsorption cycle, the refrigerant (adsorbate) could be ammonia, water, methanol, etc., while the adsorbent is a solid, such as silicone gel, activated carbon, or zeolite, unlike in the absorption cycle where absorbent is liquid. The reason adsorption refrigeration technology has been extensively researched in recent 30 years lies in that the operation of an adsorption refrigeration system is often noiseless, non-corrosive and environment friendly.

1.2 Objectives

1. To obtain the characteristic benefits of LPG refrigerant.
2. To determine the COP of refrigerator using LPG as refrigerant.
3. To benefit the Cooling effect at free of cost by eliminating the compressor.
4. To produce an eco-friendly refrigeration system, by green technology that eliminates the use of ozone depleting refrigerants.

1.3 Properties of LPG

1. Colourless.
2. Odourless (It's normal to odorize LPG by adding an odorant prior to supply to the user, to the aid detection of any leaks).
3. Heavier than air.
4. Liquid LPG is half the weight of water.
5. Non-toxic.
6. LPG expands upon release and 1 liter of liquid will form approximately 250 liters of Vapour.

2. Methodology

2.1 Working Principle

The vapour absorption refrigeration system comprises of all the processes in the vapour compression refrigeration system like compression, condensation, expansion and evaporation. In the vapor absorption system the refrigerant used is ammonia, water or lithium bromide. The refrigerant gets condensed in the condenser and it gets evaporated in the evaporator. The refrigerant produces cooling effect in the evaporator and releases the heat to. the atmosphere via the condenser. The refrigerant enters the condenser at high pressure and temperature and gets condensed. The condenser is of water cooled type. When the refrigerant passes through the expansion valve, its pressure and temperature reduces suddenly. This refrigerant (ammonia in this case) then enters the evaporator. The refrigerant at very low pressure and temperature enters the evaporator and produces the Cooling effect. In the vapor compression cycle this refrigerant is sucked by the compressor, but in the vapor absorption cycle, this refrigerant flows to the absorber that acts as the suction part of the refrigeration cycle.

3. Modeling And Analysis

3.1 Components Used

a. LPG Cylinder

LPG is a mixture of butane and isobutene. It is generally stored at 12.7 bar for house hold purpose cylinder. By using a suitable regulator LPG is sent into capillary tube. 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 a propellant for aerosol, in addition to other specialist applications LPG can also be used to provide lighting through the use of pressure lantern.

Fig. A - LPG Cylinder

b. 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 0.09 inch). The capillary tube is shown in picture.

Capillary tube

Fig. B - Capillary Tube

c. 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.

evaporator

Fig. C - Evaporator

d. Pressure Guages

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. D - Pressure Gauge

e. High Pressure Pipes

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. Wide range of pipes All pipes are pressure tested to 100 M Pa(14,500 psi) over recommended working pressure.

Fig. E - High Pressure Pipes

f. High Pressure Regulator

This type of regulator is used to send high pressure gas from the cylinders. These are mainly used in functions to Bhatti stoves. The LPG refrigerator is shown in the figure. We make the one box of the Thermo-coal sheet. The thermo-coal sheet size is 15mm used for the LPG refrigerator. The size of the evaporator is 355*254*152 mm^3. We kept the thermo-coal sheet because the cold air cannot transfer from inside to outside of refrigerator. And the evaporator is wrapped totally with aluminum tape.

Fig. F - High Pressure Regulator

g. Gas Burner

After performing the cooling effect low pressure LPG goes into the burner where burning takes place.

Fig. G - Gas Burner

The schematically diagram of the LPG refrigeration system is shown in below diagram.

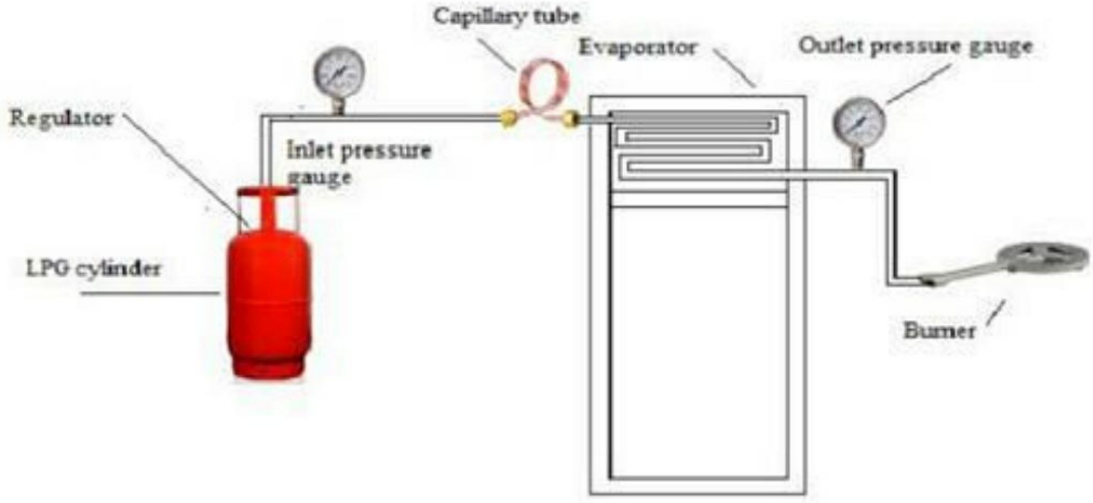

Fig. - Schematic Diagram of the LPG Refrigeration System

4. Conclusion

In this experimental study "LPG Refrigerator", it is concluded that refrigerating effect is produced with the use of LPG. From observation table, It is concluded that, when the regulating valve is fully open then the evaporator temperature downs from 30 °C to 7 °C in minutes. It is also concluded that, in the capillary tube pressure of gas 9 bar from the cylinder is reduced to 2.5 bar. The capillary tube is more suitable throttling device in LPG refrigeration system. This system is cheaper at initial as well as running cost. It does not require an external energy sources to run the system and no moving part in the system. So maintenance cost is also very low. This type of LPG refrigerant system is used in home needs, restaurants, industries and chemical processing units are mostly used LPG refrigerants Etc.

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