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Design of LPG used refrigeration system using Nozzle expansion

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Abstract

The major reason for the depletion of the ozone layer is refrigerants from to refrigeration system, instead of that to hydrocarbons(HC) like liquefied petroleum gas(LPG) is proposed as working fluid in refrigeration system .The hydrocarbons while used as a refrigerant posses many good characteristics such as:-very low cost, nontoxic, zero ozone layer depletion potential, strong compact ability. To safeguard the depleting ozone layer LPG is the perfect option. This system works by the expansion of LPG from its form to gaseous form resulting in decrease of pressure and increase in volume of the LPG. By this the temperature drop occurs and makes a refrigerant effect. This cooling effect can be utilized for refrigeration work. For heating purposes the same gas is again utilized after the cooling cycle.

Keywords: Hydrocarbon, Refrigeration system, cooling cycle, ozone layer

1.Introduction

The word 'refrigeration' is used for the heat removal cycle Because of the immense worldwide demand for electricity, we are thinking about recovering the energy that is already being invested but not used more, in order to solve this crisis with less investment. LPG is kept in liquefied form in bottle for its usage as gasoline. The refrigerator is one of the largest producers of electricity amongst household appliances. The energy usage of the refrigerators increased slowly year after year[1]. This works on the assumption that expansion of LPG will take place during the conversion of liquid LPG into gaseous form. As a consequence, the density of LPG gas reduces and the amount of gas rises, contributing to a drop in the temperature of the gas and serving as a coolant. By the second law of thermodynamics the required process of cooling can be done only with the help of any external source[2]. Therefore a refrigerator is needed to drive the power supply on a regular basis. The material in cooler which does the work of extraction of heat cold body and exchange the heat to the hot body is called refrigerant. Refrigeration such as CFC, HFC which causes high depletion if there is an ozone layer (ODP) and a global warming risk. Good drug efficiency results from the usage of LPG, owing to its characteristics. There is a transformation of liquefied petroleum gas(LPG) into gaseous form, tis process is called expansion of LPG, by this principle only the system works. Because of this development, the demand decreases and the amount of LPG rises, resulting in a drop in temperature and causing a refrigerating effect. This refrigerant impact may be used to cool down[3]. This work thus provides cooling for socially important needs and replaces refrigerants produced by manufacturers of global warming products. While the LPG refrigeration device literature review is underway, conventional VCR (Vapour Compression Refrigeration Method) uses LPG as a refrigerant and provides a cooling impact. Yet the high-pressure LPG passes through a nozzle and a capillary tube in our proposed very basic type of cooling device and expands[4]. After LPG has been expanded it has been transformed from its liquid phase to gaseous phase the heat absorption takes place in the evaporator thus the cooling effect is achieved. After the evaporation the gas directly goes to the gas burners for burning[5].

2. Literature Survey

A.Baskaran&P.Koshy Mathews Performance study of the vapor compression cooling method utilizing theoretically low global warming eco-friendly coolants. R600a performance is marginally better than coefficient (COP) R134a With a condensation temperature of 50 C0 and an evaporation temperature of -30 0C to 100C. Thus, this mixture's coefficient of success (COP) was up to 5.7% greater.3 M. B.O.Bolaji, have R152a / R32 experimental analysis replacing R134a in a domestic cooler and notice that R152a COP is 4.7% higher than R134a COP. R32 COP is 8.5% lower than R134a COP and propane is an appealing and environmentally friendly substitute to widely used CFCs R.W.James&J.F.Missenden's use of propane in domestic refrigerators suggests that the implications of using propane in domestic refrigerators are discussed in relation to use, compressor costs, supply, energy lubrication, environmental considerations and propane protection as an appealing and environmentally sustainable option to CFCs currently in use. Akash and. Bilal A. Al, performed performance studies on liquefied petroleum gas (LPG) in domestic refrigerators as a possible substitute for R12. The refrigerator was originally designed to operate with R12 and is used to perform the LPG experiment (30 per cent propane, 55 per cent n-butane, and 15 per cent isobutane). Various mass charges of 50, 80 and 100 g LPG were used throughout the experiment. LPG blends in well with R12. The COP was higher for all mass charges at evaporator temperatures below −15 C. In general, it was observed that when used in this refrigerator, LPG produced the strongest results at a charge of 80 g. The condenser was held at a steady temperature of 47 ° C. Cooling capacity was obtained and was around three to four times higher for LPG than for R12 [1−4]

3.Types of Refrigeration

The refrigeration systems are classified into the following types

3.1 Cyclic Refrigeration:

The heat is removed from the low temperature tank and poured through the cyclic refrigeration process to a high point. Within the second rule of thermodynamics the natural heat transfer is from high temperature to low temperature reservoir. During the cyclic refrigeration process the exterior work on the device will be done as the heat flow is retained [6]. The cyclic refrigeration system often reverses the thermodynamic power loop or the Carnot process in which the heat moves from a high temperature reservoir to a low temperature tank. So the Inverted Carnot Process is often called the refrigeration process. There are two forms of cyclic refrigeration process: cycle of vapors and cycle of gases [7].

3.2 Vapor Cycle:

There are two types of vapor cycle, they are: Vapor compression cycle and Vapor absorption cycle.

Vapor Compression Cycle:

In vapor compression system commonly an evaporator and liquid-gas separator is available, such things are placed together. Therefore, when the refrigerant is discharged, the heat absorption of the liquid phase refrigerant from the atmosphere may be limited to the heat loss from the gas-liquid separator[8]. In fact, the pressure drop between the gas liquid separator and the evaporator in the refrigerant direction may be minimised.

Vapor Absorption Cycle:

The vapor absorption method was used very widely until development of the refrigeration vapor compression system. The vapor compression method substituted the absorption of vapor since it has high performance (COP) factor. Only significant amount of heat and very less amount of energy is needed for this system, thus it is commonly used in industries where excess stem stocks are available. Thus it saves high amount of carbon by optimal usage of excess stem stocks.[5−8]

3.3 Gas Cycle:

Much as in the method of vapor combustion and the phase of vapor absorption, vapor is used for cooling, hydrogen is used in the period of air refrigeration. When gas is placed through the throttling valve from very high pressure to lower pressure, its temperature decreases abruptly, while its enthalpy stays unchanged. Inspite of using common refrigerants like Freon and ammonia, here gas is used as coolant in this system. There are no phase changes in the gas present in the liquid refrigerant during the cycle. Water is the most widely used product in these air refrigeration processes, often known as refrigerant.

3.4 Non Cyclic Refrigeration:

Either by dry ice or by melting ice only the common refrigeration has been done. Since we are not using refrigerant benefit, in any case, as in cyclic refrigeration, no compressor is required to compress the refrigerant. Such techniques are used in small-scale refrigeration, in labs and factories for example, or in compact coolers.This method of refrigeration sees application in aircraft cooling as air enters and exits the system rapidly as aircraft move forward. But we can use it in non-cyclic refrigeration where there is enough refrigerant at no expense necessary.[9−11]

3.5 Vapor Compression Cycle:

The method of vapor compression is the refrigeration device commonly used in industrial use. Your kitchen fridge, water cooler, deep freezer, air conditioner, and so on, all work on vapor compression processes. The method is called the vapor compression cycle, because the refrigerant vapors are compressed to create the cooling impact in the device compressor.

4. Working process

4.1 Compression:

The coolant vapors join the compressor and are trapped at extreme pressure and elevated temperatures. Ideally, during this process the refrigerant entropy stays steady and leaves in a superheated environment.

4.2 Condensation:

The overheated refrigerant then enters the heat exchanger where it is whether cooled by air or water as a consequence of which the temperature decreases but the pressure remains constant and is liquid.

4.3 Expansion:

If the refrigerant spreads quickly, the liquid refrigerant then arrives at the expansion valve or capillary drain, which allows its temperature and pressure to decrease. The refrigerant exits the expansion valve or capillary channel partially liquid and partially gasic.

4.4 Evaporation or Cooling:

The partially air, partially gaseous refrigerant enters the evaporator at very low temperature, where the cooled content is processed. It is here where the refrigeration effect is produced. The refrigerant removes heat from the cooled substance and is turned into a vapour state.

5. Parts of LPG Refrigerator

5.1 LPG Gas Cylinder

LPG is liquefied petroleum gas. This contains traces of propane(C3H8) and butane (C4H10), either contained separately or together as a combination. This happens when those gasses may be liquefied at natural temperatures by introducing low pressure rises or by adding cooled LPG at high pressure.

Fig 1 LPG Gas Cylinder

LPG is used as fuel in household, industrial, cooking, heating, drying, and farming operations. LPG is created by extracting petroleum or "wet" natural gas and is derived almost entirely from fossil fuel sources, developed during petroleum processing, or extracted from petroleum or natural gas flows when they derive from the soil.LPG is generated by extracting gasoline or wet natural gas which is obtained almost exclusively from fossil fuels generated through gasoline extraction (crude oil) or collected from natural gas or petroleum sources when they come from the earth. Dr. Walter Snelling first discovered this in 1910, and the first consumer goods emerged in 1912. In addition, this provides around 3 per cent of all electricity consumed and burns relatively cleanly without any soot and very little sulfur emissions.

Since its boiling point is below room temperature, LPG evaporates rapidly at regular temperatures and pressures and is usually distributed in pressurized steel containers. They are normally loaded up to 80–85 per cent of their ability to enable the stored liquid to expand thermally.The ratio between the volumes of the vaporized gas and the liquefied gas differs based on structure, pressure, and temperature but is typically about 250:1. The vapor pressure sometimes changes according to composition and temperature which is the pressure at which the LPG transforms into liquid.

LPG can be used as an industrial diesel, or as a propellant for aerosols. At LPG the gas pressure is about 12-18 bar. It is normally placed at 12.7bar for household use cylinder and other specialist applications LPG may also be used to illuminate using pressure.There are two major threats by the system. The first threat is a possible explosion if the combination of LPG and air is in the explosive maximum, while there is an external ignition source. The second threat is suffocation by the reduction of oxygen concentration by the movement of air and LPG.

5.2 Capillary tube

The capillary tube is the widely used throttling tool in home cooling. The capillary tube is a very thin, very long, copper tube with an internal diameter.it, which is coiled to many turns so that it can take up less room. The internal diameter of the capillary tube used in refrigeration applications varies from 0.5 to 2.28 mm (0.020 to 0.09 inches) As the refrigerant exits the capillary tube the pressure unexpectedly reduces due to its rather limited diameter.The capillary tube is a non-adjustable system which means that the refrigerant flow through it can not be regulated much as one would do in the automated throttling valve itself. As a consequence, the movement of the refrigerant through the capillary varies with increasing ambient circumstances.The capillary diameter and capillary volume depend on the reduction of the refrigerant pressure through the capillary. The width becomes less, so the capillary duration also is the reduction of the strain of the refrigerant as it passes into it.

Fig 2 Capillary tube

5.3 Evaporator

The evaporators are also a vital part in refrigeration systems. The cooling effect is generated in the refrigeration device through the evaporators.

Fig 3 Evaporator

If the real result of cooling is in the refrigeration devices it is in the evaporators. For several, the evaporator is the cooling system's key element, which renders the other portion less useful. The evaporators are heat exchanger surfaces that transfer the heat from the cooling fluid to the refrigerant, thus extracting the heat from the object.The evaporators are used for a broad variety of specific purposes of refrigeration, and are also available in a large range of types, sizes and styles. These are often classified according to the process of feeding the refrigerant, the configuration of the evaporator, the air movement route through the evaporator, the operation and also the refrigerant regulation.The evaporators in the domestic refrigerators are generally known as freezers

5.4 Pressure gauge

Techniques for calculating the pressure and the vacuum are growing. Pressure measurement instruments are pressure gages and vacuum gages.

Fig 4 Pressure gauge

The most commonly used automatic gauge is the Bourdon style pressure scale. This is a solid, smooth metal wire, shaped to a triangular shape. With the strain only the fluid inside the tube isto be weighed. There are two ends for this tube. One of that end of the tube is fixed, and another is free to turn either inside or out. The most commonly known mechanical gage is the Bourdon style pressure gage. This is a solid, smooth metal wire, shaped to a triangular shape. The fluid inside the tube is the one that must be weighed with the strain. The inward and outward movement of free end pushes a button, a dial graduated in pressure device i.e. knob, via a contact and gear arrangement. Pressure monitor controls the monitor monitoring the instrument level which is the difference between the outside surface pressure and the outside atmospheric value. Those gages are available in multiple ranges of strain.

5.5 High pressure pipe

Fig 5 High pressure pipe

The range of high pressure pipes covers most applications where high pressure gas transmission is needed. They consist of a steel pipe with a steel ring, installed at both ends. Such balls are squeezed against the connecting hole seating by two swiveling touch nipples and thereby seal off the gas leakage. Wide variety of tubing. All pipes are tested at an appropriate working pressure of 100 M Pa (14,500 psi)

5.6 Nozzle

Nozzle is a device designed to regulate a fluid flow's path or characteristics as it exits (or enters) an enclosed chamber or pipe (especially for the speed).

Fig 6 Nozzle

A nozzle is also a variable sectional length pipe or tube that can be used to direct or adjust a flow of fluid (gas or liquid). Also, nozzles are used to control the flow rate, velocity, distance, density, form and/or the pressure of the stream that comes out of them. Fluid velocity increases in a nozzle, at the cost of its motion power.

6. Working of LPG Refrigerator

The underlying principle behind the LPG cooler is the use of LGP for heat absorption. The LPG is stored in a jar of high pressure LPG. When the regulator gas tank is removed then the high pressure tubing moves into the LPG. This LPG moves to the capillary tube from a very high pressure pipe. There the pressure is reduced from high to lop with no change in enthalpy.During capillary drain the low pressure LPG is sent to the evaporator. The heat is removed from the liquid by this transformation of pressure in LPG. This ensures the room is cooled down.While we will obtain cooling impact in the refrigerator. The LPG is directly sent to the burner for firing process after it crossed the evaporator.

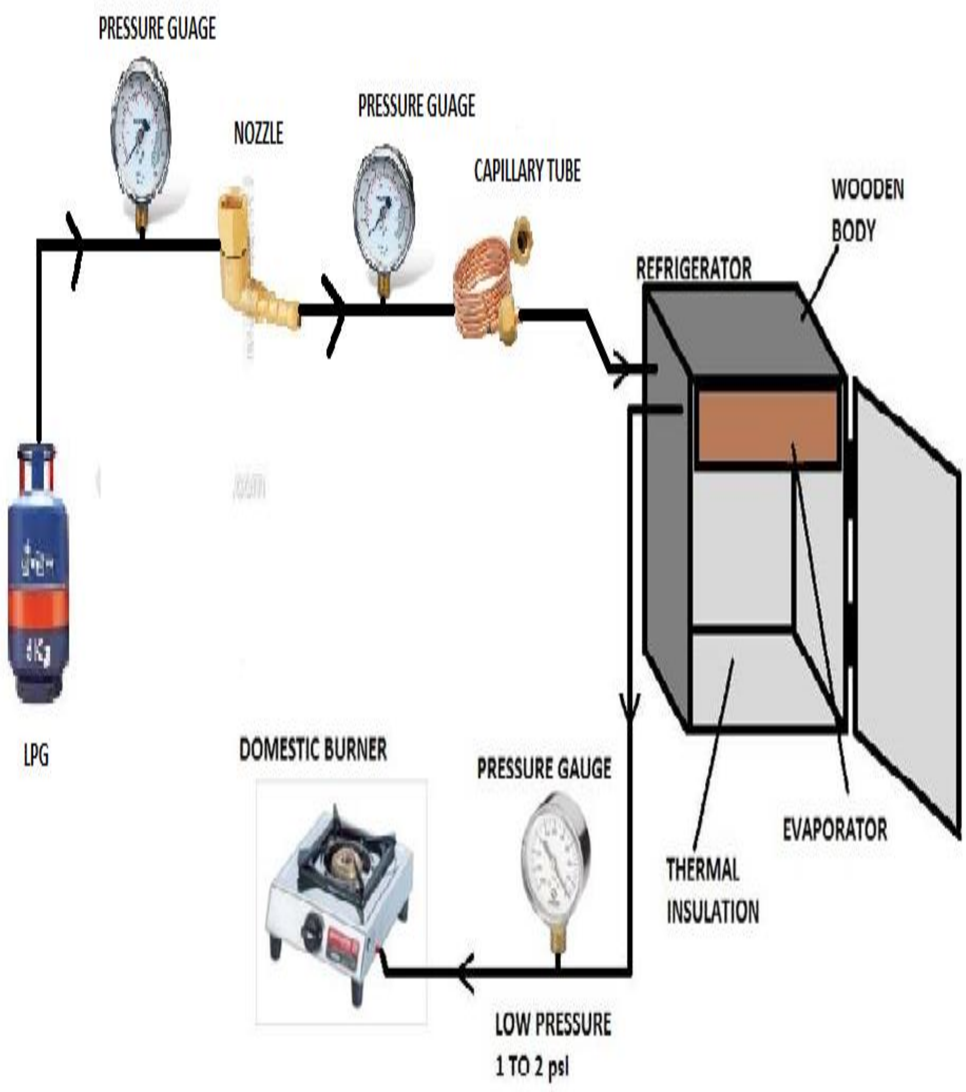

Fig 7 Block dig of refrigeration system

Table1: Experimental Observations

SL NO :	Inlet pressure nozzle (in bar)	Outlet pressure nozzle (in bar)	Time (in min)	Inlet pressure capillary tube (in bar)	Outlet pressure capillary tube (in bar)	Evaporator Temp (in c)
1	10	6.8	10	6.8	2.18	29
2	10	6.8	20	6.8	2.18	26.3
3	10	6.8	30	6.8	2.19	23
4	10	6.8	40	6.8	2.18	19.4
5	10	6.8	50	6.8	2.18	14
6	10	6.8	60	6.8	2.18	10

7. Conclusion

From the above papers we inferred that the LPG is better alternative refrigerant and environmentally efficient by using the high-pressure energy in the cylinder to produce the refrigerant impact. The following table 1 indicates that the usage of a nozzle allows to reduce the LPG pressure until the capillary tube hits.The pressure control tends to reduce the temperatures with less time. The nozzle used in the system has greater cooling power.

This system is cheap at both original and running cost. It will not require any supply of energy and no moving component in the machine to operate the device. And the expense of reparations is still very small. This LPG cooling system is widely used in the hotel and chemical sectors where there is larger usage of LPG.

8. Advantages

- Use of LPG as a refrigerant also improves the overall efficiency of by 10 to 20%.
- The ozone depletion potential (ODP) of LPG is zero
- Environment friendly,
- There is 60% reduction in weight of the system due to higher density of LPG.
- This fridge works when electricity is off.
- The parts are effectively silent in operation.
- Running cost is zero
- Eliminates the compressor and condenser.
- Pollution free
- Fuel saving

9. Applications

- Critical feature in restaurants where heating and refrigeration is needed continuously.
- Petroleum Refrigeration Sectors
- It can be useful for remote areas where there is no electricity available.
- It can be used in refineries where LPG is high intake.
- Medical field
- It can be used in automobiles running on LPG or other Gaseous fuels for air conditioning.
- It can be useful in remotes parts where Electricity is not available.
- Cooling and storage of essentials in remote areas and in emergency vehicles, such as storage in an ambulance, is easily possible.
- It can be used for zero cost air-conditioning of spaces like airports, shopping malls, etc.

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References

[1]. ZainalZakaria and ZulaikhaShahrun " The possibility of using liquefied petroleum gas in domestic refrigeration system" International Journal of Research and Reviews in Applied Science(IJRRAS), December 2011, Volume9

[2]. S. J. Cleg, "Thermodynamic analysis of LPG as refrigerant for industrial refrigeration andtransportation", Institute of Transport Studies, University of Leeds, Working paper of 471, 1996.

[3]. Ibrahim Hussain Shah and Kundan Gupta "International Journal of Engineering Sciences andResearch Technology" ISSN: 2277-9655, July 2014, Vol. 3(206- 213).

[4]. Text book of refrigeration and air conditioning by Arora and Domkundwar.

[5]. A Textbook of Refrigeration And Air Conditioning By R.S. Khurmi, S. Chand Publication.

[6]. "PCRA energy audit report", HPCL LPG bottling plant AsaudaBahadurgarh (Haryana) Dec. 2006.

[7]. "Basic statics on Indian petroleum and natural gas" 2006-07.

[8]. Shank K. Wang, "Handbook of air conditioning and refrigeration" page no. 11.14 chapter 11.

[9]. Catalogue of Gas Authority of India on "Properties of combustible gases for industrial purpose

[10]. Dr. Iqbal Husain, "Analysis of VCR and VAR systems using organic refrigerants", CRC press,Taylor and Francis Group, USA, 2012

[11]. Khandare R. S. and Bhane A. B "International Journal of[4] Emerging Technology and AdvancedEngineering" ISSN: 2250-2459, March 2015, Volume 5.