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LPG REFRIGERATION SYSTEM

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Abstract – *This paper researches the world today is concerned about saving the environment, everywhere measures have been taken up to reduce pollution. Investigates the result of an experimental study carried out to determine the LPG is locally available which comprises of 24.4% propane, 56.4% butane, and 17.2% isobutane which is varied from company. The LPG is cheaper and possesses an environment friendly nature with no Ozone Depletion Potential (ODP) and no Global Warming Potential (GDP). We have design and analyzed a refrigerator using LPG as refrigerant. As the high-pressure LPG stored in cylinder. Pressurized LPG is passed through the small internal diameter of capillary tube. The result is decreasing the pressure of LPG due to expansion and phase of LPG occurs in an isenthalpic process. The latent heat of evaporation gained by the liquid refrigerant in evaporator and temperature decrease of surrounding. That is the way the LPG can produce refrigerating effect. Performance parameters investigated is the refrigeration effect in certain time. The refrigerator worked efficiently when LPG was used as a refrigerant instead of any other refrigerant. 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 and the evaporator temperature goes down to the 0.5 ˚C. In the final result we have found that the COP of a LPG Refrigerator is higher than a domestic refrigerator.*

Key Words: LPG Refrigerant, Domestic Refrigerator, Expansion, Refrigerating Effect, Cooling Effect, COP, Capillary tube, Environment friendly.

1.INTRODUCTION

Domestic refrigerators consume approximately 17,500 metric tons of traditional refrigerants such as chlorofluorocarbon (CFC) and hydrofluorocarbon (HFC) every year which contribute to very high ozone depletion potential (ODP)and global warming potential (GWP). There are very remote areas in India where electricity is not available, hence LPG as a refrigerant for refrigeration can be a better alternative.

Although government agencies are not able to continuously supply a major portion of electricity in both the urban as well as in rural areas. Still the people in these regions require refrigeration for a variety of socially relevant purposes such as cold storage or storing medical supplies and domestic kitchens this project has the novelty of using LPG instead of electricity for refrigeration. This solution is convenient for refrigeration in regions having scares in electricity. It works on the principle that during the conversion of LPG into gaseous form, expansion of LPG takes place. Due to this expansion there is a pressure drop and increase in volume of LPG that results in the drop of temperature and a refrigerating effect is produced. This refrigerating effect can be used for cooling purposes. So, this work provides refrigeration for socially relevant needs as well as replaces global warming creator refrigerants. While going through the literature review in LPG refrigeration system, Conventional VCR (Vapor Compression Refrigeration System) uses LPG as refrigerant and produced the refrigerating effect. But in our proposed very simple type of refrigeration system in which the high-pressure LPG is passing through a capillary tube and expands. After expansion the phase of LPG is changed and converted from liquid to gas and then it passes through the evaporator where it absorbs the heat and produces the refrigerating effect. After evaporator it passes through the gas burner where it burns.

1.1 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.
- Approximately half the weight of water.
- Nontoxic but can cause asphyxiation.
- A good mixture: LPG is mainly Propane (C3H8), Butane (C 4H10) or a mixture of Propane/Butane.
- Boiling Point: LPG's boiling point ranges from -42 ˚C to 0 ˚C depending on its mixture percentage of Butane and Propane.

1.2 Objectives

- Use liquid LPG as a refrigerant.
- Run LPG refrigerator without electricity by eliminate the compressor and condenser.
- To produce the ecofriendly refrigerator.
- To determine the COP of the refrigerator using LPG as a refrigerant.

2. LPG REFRIGERATION

2.1 WORKING PRINCIPLE

This work replaces the conventional refrigerant by LPG as a cooling medium in a refrigerator. It works on the principle that during the change of LPG from liquid into gaseous form, expansion of LPG takes place. Due to this expansion pressure drop occurs and increase in volume of LPG. It results in the drop of temperature and a refrigerating effect is produced and it is used for cooling purposes. In this refrigeration system the high-pressure LPG is passed through capillary tube and it expands, after expansion the phase change occurs and it convert from liquid to gas. Then it passes through the evaporator where it absorbs the latent heat of the stored product and produces the refrigerating effect.

2.2 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.

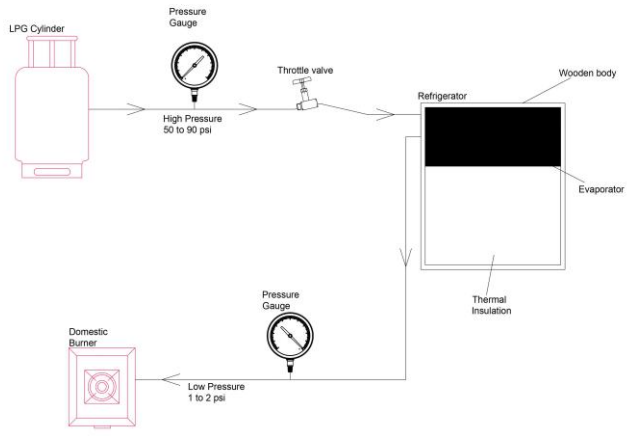

FIG. 2.2 BLOCK DIAGRAM OF LPG REFRIGERATION

3. CONSTRUCTION OF LPG REFRIGERATION

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. The schematically diagram of the LPG refrigeration system is shown in below diagram. The gas cylinder is connected to high pressure regulator, which is connected to high pressure pipes. To the other end of the high-pressure pipes pressure gauge is connected. To another end a copper tube is connected which is connected to the capillary tube. The capillary tube is fitted with evaporator. The evaporator coil end is connected to the stove by another high-pressure pipe. One pressure gauge is put between capillary tube and cylinder and another is put at the end of the evaporator.

3.1 PARTS OF LPG REFRIGERATOR

- **LPG CYLINDER**

LPG is Liquefied Petroleum Gas. This is general description of Propane (C3H8) and Butane (C4H10), either stored separately or together as a mix. This is because these gases can be application of a liquefied at a normal temperature by moderate pressure increases or at normal pressure by application of LPG using refrigeration. LPG is used as a fuel for domestic, drying can industrial, LPG be horticultural, to agricultural, another cooking, heating fuel or as LPG processes. Also, can be used as automotive specialist propellant foraerosal.

FIG.3.1 LPG CYLINDER

- **CAPILLARY TUBE**

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. 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 the capillary tube.

FIG.3.2 CAPILLARY TUBE

- **EVAPORATOR**

The evaporators are another important part of the refrigeration systems. It through the evaporators that 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, evaporators' refrigeration thus removing the heat from the are used for wide variety in and hence the available from of the substance. The diverse application in wide variety of shape, sizes and they are also classified in different manner depending on the method of feeding the refrigerant, construction of the evaporator, direction of air circulation around the evaporator, application and also the refrigerant control. In the domestic refrigerators the evaporators are commonly known as freezers since the ice is made in these compartments. In the evaporators the refrigerant enters at very low pressure and temperature after passing through the capillary tube. This refrigerant absorbs the heat from the substance that is to be cooled so the refrigerant gets heated while the substance gets cooled. Even after cooling the substance the temperature of the refrigerant leaving the evaporator is less than the substance. In the large refrigeration plants the evaporator is used for chilling water. In such cases shell and tube type of heat exchanger are used as the evaporators.

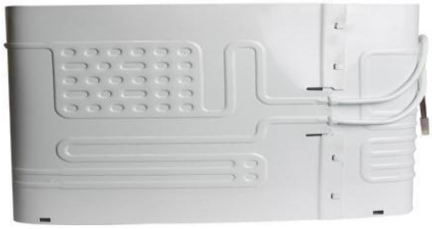

FIG.3.3 EVAPORATOR

- **PRESSURE GAUGE**

The most commonly used mechanical gauge is Bourdon type pressure gauge. It is a stiff, flattened metal tube bent into a circular shape. The fluid whose pressure is to be measured is inside the tube. One end of the tube is fixed and another end is free to move inward or outward. The inward and outward movement of free end moves a pointer, through a linkage and gear arrangement, a dial graduated in pressure unit i.e. bar. Pressure gauge records the gauge records the gauge pressure which is the difference between fluid pressure and outside atmospheric pressure.

FIG.3.4 PRESSURE GAUGE

- **HIGH PRESSURE PIPES**

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

FIG.3.5 COPPER PIPE

FIG.3.6 HOSE PIPE

- **HIGH PRESSURE REGULATOR**

This type of regulator is used to send high pressure gas from the cylinders. These are mainly used in functions to industrial purpose.

FIG.3.7 HIGH PRESSURE REGULATOR

- **ACCUMULATOR**

copper accumulator is used for liquid storage, liquid / gas separation, impurity filtering, and refrigerant cushion.

FIG.3.8 ACCUMULATOR

4. ACTUAL EXPERIMENTAL SETUP

FIG.4.1 ACTUAL EXPERIMENT SETUP

5. EXPERIMENTAL READINGS

5.1 TABLE READINGS

The setup experiment of this project was done on 10 March, 2020 at 3:00 p.m. and readings were taken at 10 minute's intervals, for 1 hour which is as shown in table 1 below:

LOADING CONDITION (1.25 L WATER BOTTLE)				
INLET PRESSURE (bar)	OUTLET PRESSURE (bar)	TIME (min)	EVAPORATOR TEMP. (°C)	WATER TEMP. (°C)
4.82	1	0	29.1	29.6
4.82	1	10	13.4	24.9
4.82	1	20	8.6	21.3
4.82	1	30	5.6	18.1
4.82	1	40	3.5	14.2
4.82	1	50	2.1	10.0
4.82	1	60	0.5	8.4

TABLE: -1 EXPERIMENTAL READINGS OF LOADING CONDITION

Graphical representation of water and evaporator temperature as per the experimental readings of the table: -1 is shown in chart.1 as follow below:

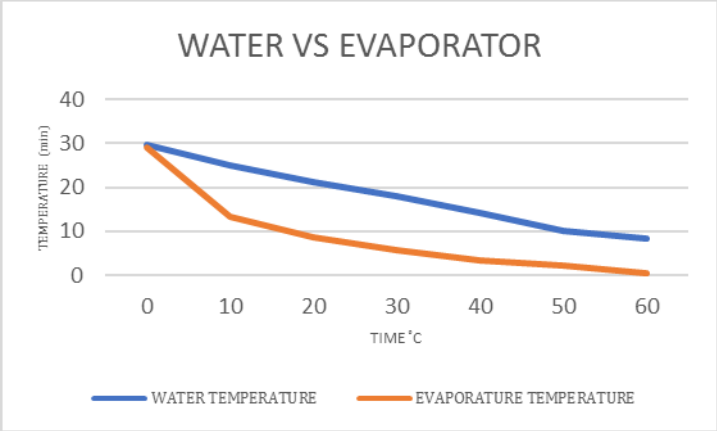

CHART.1 WATER VS EVAPORATOR

The setup experiment of this project was done on 8 March, 2020 at 4:00 p.m. and readings were taken at 10 minute's intervals, for 1 hour which is as shown in table 2 below:

UNLOAD CONDITION			
INLET PRESSURE (bar)	OUTLET PRESSURE (bar)	TIME (min)	EVAPORATOR TEMP. (°C)
4.82	1	0	27.8
4.82	1	10	7.3
4.82	1	20	3.1
4.82	1	30	1.6
4.82	1	40	-0.1
4.82	1	50	-1.3
4.82	1	60	-2.0

TABLE: -2 EXPERIMENTAL REDINGS OF UNLOADING CONDITION

Graphical representation of evaporator temperature as per the experimental readings of the table: -2 is shown in chart.2 as follow below:

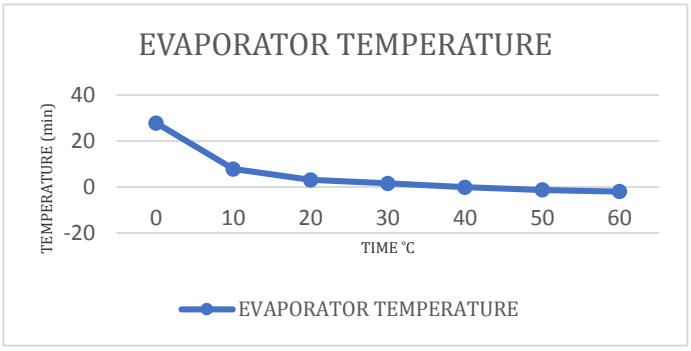

CHART.2 EVAPORATOR TEMPERATURE

6. ADVANTAGES OF LPG REFRIGERATION

- Use of LPG as a refrigerant also improves the overall efficiency of by 10 to 20 %.
- The ozone depletion potential (ODP) of LPG is 0 and global warming potential (GWP) is 8 which is significantly negligible as compare to another refrigerant.
- A part from environment friendly, use of LPG also gives us lot of cost advantages.
- 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.

7. DISADVANTAGES OF LPG REFRIGERATION

- Efficiency is poor.
- LPG is explosive in nature.
- Put the LPG cylinder in inverted position.
- After the refrigeration process the exhaust of LPG is burn into burner. Because of the exhausted vapor LPG cannot converted again liquid phase.
- The prevention of leakage of the LPG is the major problem in LPG refrigeration system, because the LPG is highly flammable.

8. APPLICATIONS OF LPG REFRIGERATION

- 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.
- It can be used in refineries where consumption of LPG is high.
- The system can universally be used in industrial central cooling and domestic refrigeration and air conditioning as well.
- It can be used in automobiles running on LPG or other Gaseous fuels for air conditioning

- It can be used for zero cost air-conditioning of spaces like airports, shopping malls, etc. which have their own gas turbine power-plants.

3. CONCLUSIONS

From the experiment we have conclude that the high-pressure LPG gas stored in a cylinder at 12.41 bar with the weight of 14.5 kg equipped with a high-pressure regulator. when LPG gas released the pressure drop occurs and the weight decrease. With the help of capillary tube, the pressure will drop down to the 1 bar from the operational pressure 4.82 bar. Due to the pressure drop the refrigerating effect occurs in an evaporator. The refrigerating effect changes the properties of LPG before and after evaporator. Therefor a conclusion we can use LPG as a refrigerant in a refrigeration. LPG will not harm the environment and the eco system. The potential of ozone layer depletion and global warming will be reduced due to usage of current refrigerant in a domestic refrigerator.

As per the experimental readings (table: -1) we conclude that the evaporator temperature reduces 29.1 ˚c to 13.4 ˚c at loading condition in just 10 mins. And as per the experimental readings (table: -2) the Evaporator temperature reduces 27.8 ˚C to 7.3 ˚C at unloading condition in just 10 min.

As per the above paragraph the cooling effect of LPG refrigeration varies with the load and pressure. So that the design of the refrigerator is different cooling load under the different pressure.

From this temperature drop we can say that the refrigerating effect is higher than the other domestic refrigerator. Eliminates the Compressor and condenser we can conclude that the COP is higher than the other domestic refrigerator.

FUTURE SCOPE OF LPG REFRIGERATION

An introduction of new product in the field of refrigeration is expected and to give out positive result with this normal product. The main aim is to focus on restaurant and community program hall, mid-day meal of school so to preserve food products like vegetables, milk etc. Also, at small snack stores by increasing the probability of refrigerator by reducing its weight, removing compressor totally as well as maximum cost reduction due to no cost of refrigeration.

The system can further be improved and implementing in air conditioning of vehicles where LPG is used a fuel.

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