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Review Paper on Performance Analysis of LPG Refrigerator

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Abstract – *Ozone depletion due to Chlorofluorocarbon (CFC) and Hydrofluorocarbon (HFC) refrigerants is one the major problem to our natural habitat. Also, availability of electricity is still not available in several areas of the world where one needed electricity and refrigeration of water, food, and medicine. The use of LPG for refrigeration purpose can be eco-friendly since it has no ozone depletion potential (ODP). LPG as a refrigerant for refrigeration can be a better alternative. (28) LPG is offered in high-pressure cylinders. When this high-pressure LPG gas passes through a capillary tube with a tiny internal diameter, the pressure drops due to expansion, and the LPG phase shifts in an isoenthalpic process. The liquid refrigerant gains latent heat when its phase changes from liquid to gas, and the temperature drops. LPG can generate a cooling effect in this manner. (21))*

Key Words: **LPG Refrigeration system, COP, VCR, Evaporator temp, refrigerating effect.**

1. INTRODUCTION

According to the Indian Government, the refrigerator is the 3rd heaviest consumer of power among household appliances. It is one of the few appliances that is running 365 days a year. According to the second law of thermodynamics, this process can only be performed with the supply of some external work. It is thus obvious, that supply of power (say electrical motor) is regularly required to drive a refrigerator. The substance which works in a heat pump to extract heat from a cold body to deliver it to a hot body is called refrigerant. When we think about refrigerators only remember refrigeration in the kitchen, but divided into three types in which each type has its own type of functioning. One which is used for Industrial purposes is called as Industrial refrigerator, which is used for food processing, chemical processing & cold storage. Industrial refrigeration, which frequently uses ammonia refrigeration to maintain temperature, is necessary for computers, foodstuffs, blood, vaccines, and quite a few other goods that must maintain a constant and steady temperature at all times. (28)

The climatic change and global warming demand accessible and affordable cooling systems in the form of refrigerators and air conditioners.

LPG is stored in liquefied state in a cylinder before its utilization as fuel. (1) LPG is more affordable and environmentally beneficial, as it has no Ozone Depletion Potential (ODP) and no Global Warming Potential (GWP) (GDP). It is used for cooking in various places of the world. This practice makes use of a refrigerator that runs on LPG refrigerant. When LPG refrigerant was used instead of R134a refrigerant, the refrigerator performed well. We can forecast the maximum value of cooling impact with the appropriate operating conditions of regulating the capillary tube of the setup based on the demonstration that is done in atmospheric conditions.

2. OBJECTIVES

1) Compare the important characteristics between the LPG refrigeration system and the traditional refrigeration system.
2) To distinguish between the current existing refrigerator. Cost and estimated cost of LPG refrigerator.
3) The performance of existing refrigerator and LPG refrigerator is to be compared.

3. SCOPE OF WORK

To study and analyze the vapour Compression Refrigeration system is our basic objective. We are substituting the compressor and condenser by a LPG cylinder. The pressure energy of LPG is very high as it can be compressed up to 12.5 bars and hence this pressure energy of LPG can be used for refrigeration by usage of this LPG system is also very low. (16)

It can be useful in remote parts where electricity is not available. It can play an important role in restaurants where continuously cooling and heating is required. It can be used in automobiles running on LPG or other Gaseous fuels for air conditioning. (1)

4. EXPERIMENTAL FEATURE

4.1 Vapour Compression Refrigeration System

The LPG Refrigerator is work on the simple Vapour Compression Refrigeration system. The construction and working of simple VCRS is as shown in fig. 1.

Process 2-3: When the compressor is started, it draws the low-pressure vapour from the evaporator at state 2 and compresses it is entropically to a sufficiently to a high pressure up to state 3. Since the compression work is done on the vapour, its temp also increases.

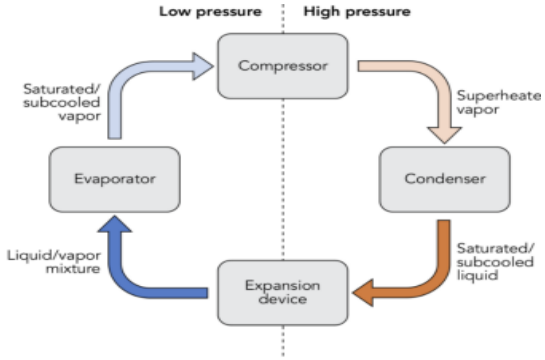

Fig -1 Schematic diagram of simple VCRS, (Henry Joseph A. et all, 2020)

Process 3-4: Hot vapour from compressor under pressure is discharged into the condenser where condenser cooling medium usually water or surrounding air is absorbing the heat from hot vapour. This converts the hot vapour into liquid and the liquid is collected in liquid receiver at state 4.

Process 4-1: The liquid from the liquid receiver at high pressure is then piped to a refrigerant control valve which regulates the flow of liquid into the evaporator. This control valve, while restricting the flow, also reduces the pressure of the liquid with the result the liquid change into vapour of low dryness fraction represented by state 1. During this process the temperature of the refrigerant reduces corresponding to its pressure.

Process 1-2: Finally, the low pressure, low temperature refrigerant passes through the evaporator coil where it absorbs its latent heat from the cold chamber or from brine solution at constant pressure and converts into vapour at state 2. It is again supplied to compressor. Thus, the cycle is completed. (6)

4.2 LPG Refrigeration Cycle Explanation

The LPG Refrigerator uses evaporation of LPG to absorb heat. LPG is stored in cylinders at pressure at about 80 psi. We lowering this pressure to pressure of 1 psi 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 cools down. Thus we can achieve cooling effect in refrigerator. LPG from evaporator is then passed through pipe to the burner. (1)

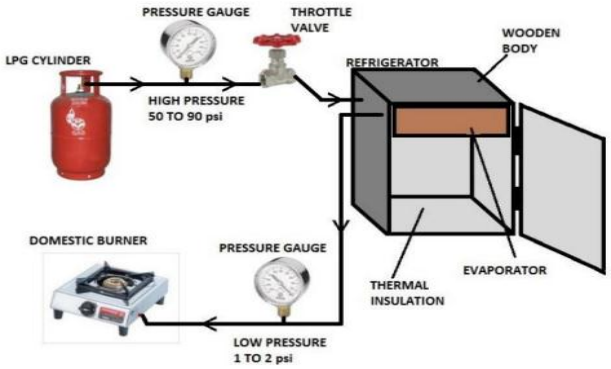

Fig -2 Schematic setup of LPG refrigeration system, (M. Manohar et all, 2020)

5. COMPONENT FEATURES

5.1 Gas Cylinder

From gas cylinder LPG in the start at a pressure of approximately 5.156 flows through the pipe to reach the capillary tube.

Fig -3 LPG Gas Cylinder, (Henry Joseph A. et all, 2020)

5.2 Capillary Tube

A capillary tube is of copper having a small-bore diameter. It reduces the pressure of liquid Refrigerant from condenser pressure to evaporator pressure when connected to a liquid line. The length of capillary tube is greater when the evaporator pressure is lower. The capillary tube is a simple device with no moving part. However, its small bore makes it

necessary that a filter and drier is fitted before the capillary tube to prevent choking. While passing through capillary tube the LPG expands and its pressure drops less than 1.2 bar.

Fig -4 Capillary Tube, (Henry Joseph A. et all, 2020)

5.3 Evaporator

In evaporator LPG is converted into the vapor form with low pressure. The evaporator is also an important component of the refrigeration system. The cooling effect is produced by passing the refrigerant through Evaporator coil.

Fig -5 Evaporator, (M. Manohar ET all, 2020)

5.4 Pressure Gauge

The most 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. These Gauges are available in the different ranges of pressure.

Fig -6 Pressure gauge, (Henry Joseph A. et all, 2020)

5.5 Gas Burner

After performing the cooling effect, low pressure LPG gas goes into the burner where it burns and through generator to generate electricity.

Fig -7 Gas Burner, (Henry Joseph A. et all, 2020)

6. OPERATIONAL PARAMETERS

TABLE -1: Experimental Readings,(M. Manohar et all, 2020)

Sr. No.	Inlet Pressure (bar)	Outlet Pressure (bar)	Time (min)	Evaporator Temp. (0C)
1	5	0.8	10	34.5
2	5	0.8	20	31.6
3	5	0.6	30	28.1
4	5	0.5	40	25.7
5	5	0.5	50	21.9
6	5	0.4	60	18.8
7	5	0.3	70	16.4
8	5	0.2	80	14.8
9	5	0.2	90	12.2

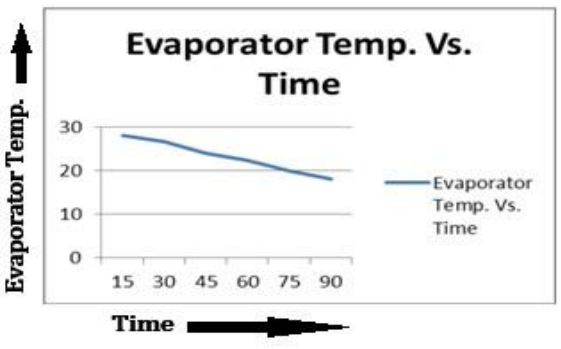

Chart -1: Evaporator temperature vs. time, (M. Manohar et all, 2020)

The properties of LPG at 5.525 bars are Enthalpy h1= 430.3 kJ/kg

The properties of LPG at 1.22 bars are Enthalpy hf = 107.3 kJ/Kg

h2 = 294.8 kJ/kg

hg = 482.3 kJ/kg.

h3 = 562.46kJ/kg

So the refrigerating effect is,

RE = h3-h2 = 562.46-294.8 = 267.66 kJ/kg

For calculating the COP of the system, we required the work input. For work input we have a 14.5 Kg. LPG cylinder. Hence, input work is the amount of power required for filling 1 cylinder. From the PCRA energy audit report power required to refill 1 cylinder is 3.1354kWh.

Therefore, for filling 1 kg of LPG power required is, = 3.1354/14.5 = 0.2162 kWh

For 1.5 hr. for that power is = 0.2162*1000/ (9.45/10000)*5400 = 42.39W

COP of the LPG Refrigeration System:

COP = RE/W = 267.66/42.39 = 6.3 (1)

7. ADVANTAGES

1) There is no any noise or vibration as the system does not contain any moving part.

2) One energy source is utilized for refrigeration and burning processes, Hence energy saving system.

3) No electricity is required, so power saving system.

4) In comparison to other refrigerants, LPG has no ozone depletion potential and no global warming potential.

5) LPG is a low-cost, environmentally beneficial alternative to other household refrigerants.

6) This refrigeration device operates even when the power is turned off.

8. COMPARE WITH DOMESTIC REFRIGERATOR

Cop of a domestic refrigerator is normally up to 2.95 which is lesser than the LPG refrigerator. Domestic refrigerator required high input power than LPG refrigerator. Also there are more moving parts in domestic refrigerator and not eco-friendly. Domestic refrigerator requires more maintenance and operation is noisy. (1) (16)

9. CONCLUSIONS

From this above papers we concluded that LPG is better alternative refrigerant and eco-friendly than other refrigerant. (28)

In a LPG refrigeration system capillary tube is more adjustable and better device. The initial and running cost of this LPG refrigeration system is really less. No outside energy source is required to run the system. As well as no moving components are present in the system which further reduces the maintenance cost as well. This LPG refrigeration system has wide scale application in hotel industries, chemical industries where the LPG consumption is at a higher level. (1) (16)

In this paper the refrigeration is amplified remarkably, and a cheaper and eco-friendly method is developed. This system is most suitable for hotel, industries, refinery, chemical industries where consumption of LPG is very high. (6)

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