PERFORMANCE ASSESSMENT OF LPG COOLING SYSTEM-A REVIEW

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Abstract: The aim of this study is to assess the application of LPG which is widely used as domestic fuel for cooking applications as a refrigerant to achieve cooling effect. LPG refrigeration model will be useful for storing food, medicines etc. in several parts of the nation where electricity is not continuously available. LPG also benefits in protecting the environment as they do not contribute for increasing the temperature of the atmosphere compared to other available refrigerants. LPG refrigeration system works on the principal that during the conversion of LPG from liquid into gaseous form, expansion takes place and there is a pressure drop and increase in the volume of LPG. This results in drop of temperature which produces a refrigerating effect. This refrigerator effect is used for cooling purpose.

***Index Terms* – Cooling, Coefficient of Performance, Evaporator, LPG, Pressure gauges.**

I. INTRODUCTION

As there is a huge demand of electricity all over the world, we think of utilizing the energy which is already spent but not being recovered and solve this crisis with less investment. The climatic change and global warming demand cooling systems in the form of refrigerators and air conditioners. Annually Billions of dollars are spent in for this purpose. Hence forth, we suggest COST FREE Cooling Systems. Many area are deprived of continuous electricity supply, this project has the novelty of using LPG instead of electricity for refrigeration. Refrigeration the process of removing heat (i.e. Cooling) from a substance. Flammability is the main disadvantage of using hydrocarbons as refrigerant. By taking proper safety measures we can prevent refrigerant leakage from the system, then this flammable refrigerant could be used and will be as safe as other refrigerants.

LPG based refrigeration works on the principle that during the conversion of LPG into gaseous form, expansion of LPG takes place. Due to expansion the pressure drops and increases in volume of LPG, this results in the drop of temperature and a refrigerating effect is obtained. This refrigerating effect is used for cooling purposes in LPG refrigeration. So this work provides refrigeration for various household and commercial 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, high pressure LPG is passing through a capillary tube and expands. Phase of LPG is changed and converted from liquid to gas after expansion process 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 can be used for cooking purpose.

II. LITERATURE REVIEW

Nikam S.D., Dargude S. B et.al [1] had performed experiments on Electricity free refrigerator system throughout which we can make refrigeration system in electricity less areas. In India there are so many areas where electricity not available. So in those areas to preserve food, medicine, meat and other essential commodities the electric refrigeration must be required. LPG (Liquefied Petroleum Gas) is the mixture of propane, isobutene, butane and highest amount among these consists of butane with 56.4%. The use of LPG can be environment friendly since it has no ozone depletion potential (ODP) if we use it for refrigeration.

Zainal Zakaria& Zulaikha Shahrum et.al [2] had performed experiments on Domestic refrigerators which annually consume approximately 17,500 metric tons of traditional refrigerants such as Chlorofluorocarbon (CFC) and Hydrofluorocarbon (HFC) which contribute to very high Global Warming Potential (GWP) and Ozone Depletion Potential (ODP). Progress is being made to slowly phase out of CFC 22 from modern equipment manufacture by replacing LPG since it has an environmentally friendly nature with no ozone depletion potential.

Mhaske M. S., Deshmukh T. S. et.al [3] have performed experiments on designed and analyzed on refrigerator using LPG as refrigerant. The pressure of LPG is high and this is stored in cylinder. Based on the principle of adiabatic expansion of a refrigerant (in this case LPG) from 80 psi to 10 psi, as this pressurized LPG is passed through the capillary tube of small internal diameter, the pressure of LPG decreases due to expansion and phase change from liquid to gas of LPG occurs in an isenthalpic process. Due to phase change, latent heat of evaporation is gained by the liquid refrigerant and the temperature decreases. In this way refrigerating effect is produced by LPG in the surrounding. From experimental investigations, we have found that the COP of a LPG Refrigerator is higher than a domestic refrigerator.

A. Baskaran &P.Koshy Mathews et.al [4] studied the performance comparison of Vapour Compression Refrigeration System Using eco-friendly refrigerant of low Global Warming Potential VCR system with the new R290/R600a refrigerant mixture as a substitute refrigerant for CFC12 and HFC 134a. The refrigerant R290/R600a had a refrigerating capacity 28.6% to87.2% higher than that ofR134a.

A.Baskaran&P.Koshy Mathews et.al [5] studied the performance comparison of Vapour Compression Refrigeration System Using Eco Friendly Refrigerants of Low Global Warming Potential. R600a performance have a slightly higher than coefficient(COP) R134a for the condensation temperature of 50^0C and evaporating temperatures ranging between -30^0Cand10^0C.Hence,the coefficient performance (COP) of this mixture was up to 5.7% higher.

M. Mohan raj et. al [6] have studied experimentally the drop in substitute for R134a with the environment friendly, energy efficient hydrocarbon (HC) mixture which consists of 45% HC290 and 55% R600a at various mass charges of 50g, 70g and 90g in domestic refrigerator. The experiments were carried out in 165 liters domestic refrigerator using R134a with POE oil as lubricant. The discharge temperatures of this mixtures were found lower than R134a by 13.76%, 6.42% and 3.66% for 50g, 70g and 90g respectively. The power consumption of this mixture at 50g and 70g were lower by 10.2% and 5.1% respectively and 90g showed higher power consumption by 1.01%. The percentage reduction in pull down time is 18.36%, 21.76% and 28.57% for 50, 70 and 90g mass charges respectively when compared to R134a. The HC mixture has high energy efficiency which will reduce the indirect global warming. In conclusion HC mixture of 70g is found to be an effective alternative to R134a in165 liters domestic refrigerator.

B.O.Bolaji [7] have experimentally studied of R152a/R32 to replace R134a in a domestic refrigerator and find out that COP obtained by R152a is 4.7% higher than that of R134a. COP of R32 is 8.5% lower than R134a and propane is an better and environmentally friendly alternative to currently used CFCs.

W.James&J.F.Missenden et.al [8] have studied the use of propane in domestic refrigerators and keeping consumption, compressor costs, availability, to energy lubrication, environmental factors and safety as parameters and conclude that the implications of using propane in domestic refrigerators is an better and environmentally friendly alternative to CFCs used currently.

Bilal A. Akash et. al [9] has conducted performance tests of liquefied petroleum gas (LPG) as a possible substitute for R12 in domestic refrigerators. The refrigerator is used to conduct the experiment for LPG (30% propane, 55% n-butane and 15% isobutane) was initially designed for R12 refrigerant. Various mass charges of 50, 80 and 100g of LPG were used during this experiment. LPG was a very well alterantive to R12. It was found that the COP was higher for all mass charges at evaporator temperatures lower than −15˚C. Overall, it was found that LPG had the best results when 80g charge was used in this refrigerator. A constant temperature of 47˚C was maintained at the condenser. Cooling capacities were obtained and they were in the order of about three to fourfold higher for LPG than that of R12.

M. Fatouh et. al [10] investigated substitute for R134a in a single evaporator domestic refrigerator with a total volume of 0.283 m3 with Liquefied petroleum gas (LPG) of 60% propane and 40% commercial butane. Different capillary lengths and different charges of R134a and LPG were taken and tests were conducted. Experimental results of the refrigerator using LPG of 60g and capillary tube length of 5 m were compared with those using R134a of 100g and capillary tube length of 4 m. Pull-down time, pressure ratio and power consumption of LPG refrigerator were lower than those of R134a by about 7.6%, 5.5% and 4.3%, respectively. COP of LPG refrigerator was observed to be 7.6% higher than that of R134a. Lower on-time ratio and energy consumption of LPG refrigerator was lower than 14.3% and 10.8%, respectively, compared to R134a. In conclusion, optimization of capillary length and refrigerant quantity was needed in the proposed LPG so that it be a appropriate replacement for R134a and to have the better performance.

III. PURPOSE OF PRESENT STUDY

The objectives of our project work are as follows:

- To benefit the Cooling effect at minimum cost by eliminating the compressor.
- To eliminate the use of ozone depleting refrigerants and to produce by green technology an refrigeration system which is eco-friendly.
- To design and fabricate a low cost refrigeration system which uses Liquefied petroleum gas as a refrigerant.

IV. METHODOLOGY

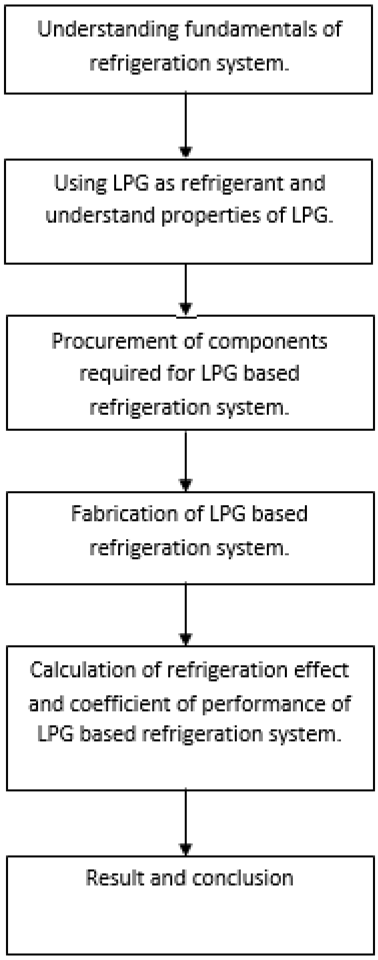

Figure.1 Methodology of Project work

The sequence of the work carried out is represented by a flow chart in Figure1.The project work commenced from identifying the problem followed by collecting the available relevant work through literature survey and with understanding the basics properties of refrigerant and refrigerating systems.

V.EXPERIMENTAL WORK

The refrigerator unit is fabricated by a wooden box inside which is 15mm thick thermocol shield is given for insulation purpose i.e. to prevent the heat transfer from inside the refrigerator to the surroundings [11]. The refrigerator unit is divided into 2 parts i.e. the upper part, which consists of an evaporator unit and lower part consisting of a Temperature measuring device. The gas cylinder is fitted with a high pressure regulator, which is connected by high pressure pipe provided with high pressure gauge to measure the gas pressure at the inlet of the capillary tube. The evaporator is made of up aluminum metal of size (355*254*152 mm^3) and it is completely wounded by Copper tubes through which the expanded LPG gas flows. Hence, the low pressure LPG gas coming out of the evaporator is passed to the burner by low pressure pipes and can be used for cooking or other applications. A low pressure gauge to measure the output pressure which is connected in between the outlet of evaporator and the burner.

Figure.2 Photograph of fabricated Refrigeration unit

5.1 BASIC COMPONENTS OF LPG REFRIGERATION UNIT

The basic and essential components of a refrigeration system using LPG as a refrigerant are LPG cylinder, Capillary tubes (an expansion device), the pressure gauges to measure the inlet (high pressure) and exit pressures (low pressures) and also monitor the pressure of the gas flowing through tubes, pressure regulators to control the pressure or flow of the refrigerant. An Evaporator which is the heart of the refrigeration system where the cooling effect is achieved by removing the heat from the objects kept inside it. The images of these components is shown below in above mentioned sequence.

Figure.3 Image of LPG storage unit

Figure.4 Image of Capillary tubes

Figure.4 Image of Pressure gauges

Figure.5: Image of Pressure regulators

Figure.6: Image of cooling chamber

5.2 CALCULATIONS

The Literature survey reveals the following procedure in determining the Cooling effect and C.O.P of a LPG refrigeration system [11, 12] for the following listed specifications and operating conditions:

Size of refrigerator: - 335×265×135 mm^3

Initial temperature of water: 30ºC

Initial temperature of evaporator: 33ºC

Specific heat of LPG vapor is 1.495kJ/Kg K

5.2.1 Estimation of Refrigerating Effect:

From propane table,

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.

hfg = 375kJ/kg

X_{LPG} = Dryness fraction of LPG from graph =0.5

h_2 = hf+ X.hfg……………….. (1)

= 107.3 + 0.5 x 375

= 294.8 KJ/Kg

hg = hf+ hfg…………………(2)

= 107.3 + 375

= 482.3 KJ/Kg.

h_3 = hg + Cp. ΔT…………… (3)

= 482.3 + 1.67 x 48 = 562.46 KJ/Kg

So the refrigerating effect is,

R.E = $h_3 - h_2$………………. (4)

= 562.46 – 294.8

= 267.66 KJ/Kg

5.2.2 Estimation of Work Input:

For work input we have a LPG cylinder of 14.5 Kg. so the work input is amount of energy required for filling of 1 Cylinder. Some of the LPG bottling plants use a comprehensive monitoring technique for. Keeping track of energy / fuel Consumption on per ton basis. From the PCRA Energy Audit,

1. Consumption = 40×4200=168000kWh
2. For lighting energy consumption= 227340kWh
3. LPG compressor consumption= 153360 kWh

Total consumption for LPG pumps

One pump having 40 kW motor and 96 m head or 150cubic meter /hour discharge

Annual operating = 4200 hrs

Annual energy 6 hrs /day in 350 days

= 168000+227340+153360

= 548700kWh

Per day consumption

= 548700/350

=1567.71 kWh

500 cylinders are refilled every day, so per cylinder electricity consumption.

=1567.71/500

=3.1354kWh

For filling of 1 LPG cylinder of 14.5 kg the power input is

= 3.1354kWh

So 1 kg of LPG is

= 3.1354/14.5

=0.2162 kWh

We run the set up for 1 hr

= 0.2162×1000/ (9.45/10000) ×3600

= 63.55W

5.2.3 Estimation of Coefficient of Performance (COP):

COP = $(h_3-h_2)/W$…………… (5)

= (267.66)/63.55

= 4.2

We run the set up for 1.5 hr

= 0.2162×1000/ (9.45/10000) ×5400

= 42.39W

5.2.4 Estimation of Coefficient of Performance (COP):

COP = $(h_3-h_2)/W$…………… (6)

= (267.66)/42.39

= 6.3

VI. CONCLUSION

The conclusions of the project review work are as follows:

- LPG refrigeration system is cheaper, with low running and maintenance cost due to elimination of compressor.
- Propane is an attractive and environmentally friendly alternative to CFCs used currently thereby reducing the ozone layer depletion and global warming.
- High cooling capacities and better COP were obtained. COP of LPG refrigerator was higher than that of R134a by about 7.6%.
- A recommended system for hotels, refineries and chemical industries where LPG consumption is high.

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