Brief On Using Isobutane Mixture For Cooling System And Comparative Energy Analysis With Conventional System

Sayli G. Gokhale[1] , Dr. Nilesh C. Ghuge[2]
Department of Mechanical Engineering
[1] Matoshri College of Engineering and Research, Nashik
[2] Assistant Professor, Matoshri College of Engineering and Research, Nashik

Abstract- *At present energy conservation is a vastly researched and renowned topic. It is also of need. In India as a domestic fuel iso-butane gas is stored in liquefied state before its utilization. The energy spent for pressurizing is almost wasted. If this can be expanded in controlled manner it can produce cooling effect. This property has been used for refrigeration and air conditioning. So that the liquefied form of iso-butane can be used for cooling by expansion and the expanded gas can be further used for combustion. Hence actual setup for checking cooling effect of LPG is considered and modelled by many researchers. In this article theoretical comparison of this system with conventional on basis of COP is calculated; to check its liability safety and other factors are also considered. Storage after expansion is majorly faced conflict is discussed. Conclusions are drawn based on the cooling effect produce. This system can limit use of conventional refrigerants.*

Keywords- Petroleum, refrigerant, evaporator, LPG

I. INTRODUCTION

We live in world on brink of crisis. Due to development electricity dependency id highly increased in past few years. The only ways to face this is limiting consumption of available depleting resources and creating highly efficient systems. Also one way to approach this is utilizing already spent energy in most of the commonly used system. Regenerative brakes can be considered as one such example. The global warming issue also demands unconventional and affordable cooling systems. Hence many researchers are concentrating on this area. One form of solution for this is using LPG cooling system. LPG is liquefied combination of iso-butane and butane stored liquid state in before its utilization as fuel.

This article proposes using LPG in liquefied state as coolant while expanding it absorbs the latent heat and produces cooling effect. Liquefied Petroleum gas is stored under high pressure to and extracted in same state. Its flow rate and pressure is controlled. It is then expanded in capillary and passed through evaporator at required pressure in suitable quantity. In evaporator it absorbs latent heat and gets converted in gaseous state. This alternatively provides cooling effect to the area adjacent to evaporator. Evaporator is covered with fins for fast and effective heat transfer. Also the proper insulation helps to maximize the cooling effect. After phase change this gas can be utilized for burning purpose as required. Hence it is not consumed in cooling process. As commonly used refrigerants have either high Ozone depleting potential or global warming potential LPG domestic refrigeration is attractive alternate available. Most of the argument against use of LPG is on the basis of flammability but as long as necessary safety measures are considered it is safe to use. It can be easily seen from [Table 1] comparison between other refrigerants and LPG (R600 and R600a), that in terms of Ozone Depletion (OD) potential Global Warming (GW) potential using proposed mixture is highly potent.

It can be easily seen that R600a exhibits not only zero ozone depletion potential but also has much lower of global warming potential. Although it is highly flammable it already contained enough domestically to avoid any harm same can be done during experimentation. Taking care of leakage can be assured using appropriate quality valves and sealing. Also moat workplaces using lpg as fuel are always in dire need of air conditioning cooling load of such places can be diverted to this system which will not only result in energy saving but also comfort environment

Table 1

S/N	Class	Refrigerant	Critical pressure (MPa)	Critical temperature (K)	OD potential (Yes/No)	GW potential	ASHRAE flammability classification
1	CFCs	R32	5.78	351.26	Yes	675	A2
		R22	4.99	369.3	Yes	1810	A1
2	HCFCs	R11	4.41	470.96	Yes	4750	A1
		R12	4.14	384.97	Yes	10900	A1
3	HFCs	R134a	4.06	374.21	No	1430	A1
		R152a	4.52	386.41	No	124	A2
4	HCs	R290	4.25	369.89	No	3	A3
		R600a	3.63	407.81	No	4	A3
5	HC Blend	R436a	4.27	389.04	No	3	A3

Problem Statement

Energy conservation is need of time. Utilizing the energy already spent can give hand to this instead of wasting it by following conventional uses. Also modern day refrigerant having high global warming potential add to this crisis. This waste energy stored in liquefaction of fuel petroleum gas be utilized for significant cooling effect and reduce the use of high GWP refrigerant also provide compressor free refrigeration in the sector where large and continues use of LPG is already existing. This paper follows the effort made in possible development whether LPG can be used as effective refrigerant and provides necessary cooling effect. Also refers to practical application of such cooling system made.

II. LITERATURE REVIEW

N. Austin, dr. P. Senthil kumar, n, (2012) have performed experiment domestic refrigeration system. They worked with R134a. And also on mixed refrigerants. These matures were compared with standard R134a and comparative results were drawn. Energy consumption in both the cases were compared and calculated. Running cycle showed R134a with 100g charges or 80 g charge the minimum temperature achieved was -150c mixture achieved high cooling capacity and it can be concluded that some refrigerant mixture will have high cooling capacity than R134a. They yield lower evaporator temperatures and high cooling effect also lower condensation temperatures.

Nikam S .D. , Dargude S. B., (2015) have developed electricity free refrigeration system which is what aim of this research is. This can be used in remote electricity deficient areas, which our country has no shortage of. It can be used to preserve food, small scale food processing industries, medicine and meat storage, domestic LPG is readily available and used for this purposes. Hence it can be used for simultaneous cooling. also has no global warming potential making it environment friendly. already pressurized LPG was expanded to absorb latent heat and provide cooling effect “analysis and performance of domestic refrigerator using LPG as refrigerant” is based on the principle of adiabatic expansion of a refrigerant (in this case LPG) from 80 psi to 10 psi.

Damola S. Adelekan et al., performed experimental analysis of LPG refrigerant charges with varied concentration of TiO2 nano-lubricants in a domestic refrigerator, Hence they both analyzed whether LPG is suitable for refrigerant and can be used with combination of nanofluids for better performance they used charges of Liquefied Petroleum Gas 40 g, to 70 g (with 10g variation) enhanced with varied TiO2 nanoparticle concentrations with 0.2 g/L, 0.4 g/L and 0.6 g/L nano-lubricants in a domestic refrigerator’s compressor designed for R134a. It was investigated at steady state. Their research yield highest COP of 2.8 when LPG was 40 g charge of LPG using 0.4 g/L concentration of nano-lubricant. Also results were compared with conventional refrigerant and found promising.

Zainal Zakaria & Zulaikha Shahrum, (2016) 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 Ozone Depletion Potential (ODP) and Global Warming Potential (GWP). Good progress is being made with the phase out of CFC 22 from new equipment manufacture by replacing LPG since it possesses an environmentally friendly nature with no ODP. Therefore, this two types of refrigerants (LPG and CFC 22) to be examined using a modified domestic refrigerator in term of their performance characteristics parameters such as pressure and temperature at specified location at the refrigerator and the safety requirements while conducting the experiment. Based on the present work, it is indicated that the successful of using LPG as an alternative refrigerant to replace CFC 22 in domestic refrigerators is possible by getting LPG COP as 13 compared to 10 for CFC22.The performance of LPG as an alternative refrigerant to CFC 22 in domestic refrigerators will be studied. The following are the conclusion.

Mhaske M. S., Deshmukh T. S., (2016) have performed experiments on designed and analyzed on refrigerator using LPG as refrigerant. As the pressure of LPG is high this stored in cylinder.

Ibrahim Hussain Shah, Kundan Gupta, (2014) has studied Supply of continuous electricity is still not available in several areas of the country and the world. At such places, this work will be helpful for refrigeration of food, medicines, etc.

III. METHODOLOGY

Process Parameters (Process variables):

1) Capillary inlet pressure (in bar)
2) Evaporator outlet pressure (in bar)
3) Evaporator temp (in $^{\circ}$C)

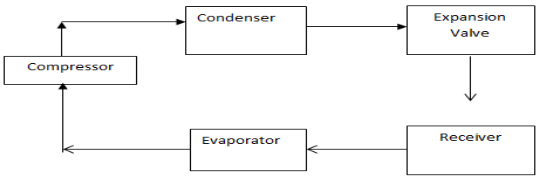

Figure 1:- Conventional System

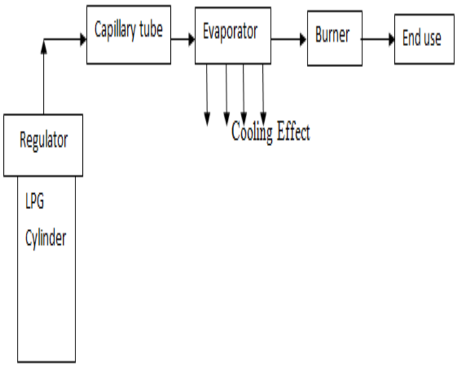

Figure 2:- Refrigeration System with LPG

Conventional system can be shown as figure 1. Most researchers have used the proposed system as shown in figure 2. Such system can be built and proper theoretical calculation for designing of capillary tube and evaporator should be carried using following relations there are main four parts in this system

LPG REFRIGERATION CYCLE EXPLANATION

[a] 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.

[b] CAPILLARY TUBE

While passing through capillary tube the LPG expands and its pressure downs upto or less than 1.2 bar.

[c] EVAPORATOR

In evaporator LPG is converted into the vapor form with low pressure. After passing through the evaporator low pressure and temperature LPG vapor absorbs heat from the casing.

[d] GAS BURNER/GENERATOR

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

Capillary tube

An analytical computation of length of capillary tube The fundamental equations applicable to the control volume bounded by points

1. Conservation of mass
2. Conservation of energy
3. Conservation of momentum

The equation relating state and conditions in a very short length of capillary tube is written using following notions

A: Cross sectional area of inside of tube, m^2
D: ID of tube, m.
f: friction factor, dimensionless
h: enthalpy, kJ/kg.
hf : enthalpy of saturated liquid , kJ/kg
hg : enthalpy of saturated vapour, kJ/kg
ΔL: length of increment, m.
P: pressure, Pa
Re: Reynolds No., VD/Ʋ
v: specific volume of m^3/kg
vf : specific volume of saturated liquid, m^3/kg
vg: specific volume of saturated vapour, m^3/kg
V: velocity of refrigerant, m/s
w: mass flow rate, kg/s
x: dryness friction
μ: Viscosity, pa×s
μf: viscosity of liquid, pa×S
μ g: viscosity of Vapour, pa×s

For calculation of length of capillary tube we have used the following relations and find out the length.

The equation of conservation of mass is as follows

$w = V1A/v1 = V2A/v2$... (1)

or

$w = V1/v1 = V2/v2$ ... (2)

The conservation of energy gives

$1000\,h1 + V^2 1/2 = 1000\,h2 + V^2 2/2$... (3)

This assumes negligible heat transfer in and out of system. The momentum equation in words states that the difference in forces applied to the element because of drag and pressure difference on opposite ends of the element equals that is needed to accelerate the fluid

$[(p1-p2) - f\Delta L/D\ V2/2v]\ A = w\ (V1-V2)$ ..... (4)

As the refrigerant flows through the tube, its pressure and saturation temperature progressively drop and the fraction of vapors .x. continuously increases. At any point

$h = hf\,(1-x) + x\,hg$.... (5)

And

$v = vf\,(1-x) + x\,vg$..... (6)

The quantities of equation (4) V, v and f all change as refrigerant flows. Simplifying using equation (2)

$f \Delta L/D. V2/ 2v = f \Delta L/D\ V/ 2\ w/A$...... (7)

In the calculation to follow, V used in equation (7) will be mean velocity

$Vm = V1+ V2 / 2$..... (8)

The friction factor with turbulence is

$F= 0.33/Re\ 0.25 = 0.33/ (VD/ \mu\ v)\ 0.25$... (9)

The viscosity in two phase flow is given by

$\mu = \mu f (1-x) + x\ \mu g$.... (10)

The mean friction factor fm applicable to incremental length

$fm = f1+f2/2 = [0.33/Re10.25 + 0.33/Re20.25]/ 2$.. (11)

The result of the analytical calculation is to determine the length ΔL between points for a given reduction in saturation temperature of the refrigerant. The flow rate and other conditions at start point are known and for a required selected temperature at end point, The Remaining conditions are computed in the following steps:

1. Temperature t2 selected
2. p2, hf2, hg2, vf2, and vg2 are computed, all being function of temperature (or pressure).
3. Combination of equation (2) and (3) gives

$1000\ h\ 2+ v^2 2/ 2\ (w/A)2 =1000\ h1+ v^2/ 2$... (12)

Substituting equations (5) and (6) into (12)

$1000\ hf2 +1000(hg2- hf2)\ x + [\{vf2+ (vg2 - vf2)\ x\}^2 (w/A)^2] = 1000\ h1 + V12/ 2$...... (13)

In equation, all quantities being knows except x, which could be solved by quadratic equation,

$X= [-b+\sqrt{b2-4ac}]/2a$.... (14)

Hence accurate system could made with appropriate capillary length

IV. CONCLUSION

From this above papers we concluded that LPG can be used for designing cooling system which is both cost efficient and eco-friendly than other refrigerant. The aim of this paper is to follow the work related to use LPG as a refrigerant and utilizing the energy of the high pressure in the cylinder for producing the refrigerating effect and then for running the generator or burner. The COP of LPG refrigerator (5.08) is greater than COP of domestic refrigerator (2.53) using conventional refrigerants. This system will have low initial as well as running cost. It does not require any external energy sources to run the system and no moving part so maintenance is also very low. Although the cooling effect produced in normal consumption is low and gas can't be stored efficiently after expansion. This system find uses at numerous place where continues use of LPG as fuel is currently done. At such places, the refrigeration may be amplified remarkably and a cheaper and eco-friendly method will be developed. This system is most suitable for hotel, industries, refinery, chemical industries where rate consumption of LPG is very high.

REFERENCES

[1] N. Austin "Thermodynamic Optimization of Household Refrigerator Using Propane –Butane as Mixed Refrigerant", International Journal of Engineering Research and Applications, 2 (6), 268-271, 2012

[2] Nikam S.D. "Electricity Free Refrigeration System using Domestic LPG Design of Energy Saving Refrigerator", International Journal of Emerging Technology and Advanced Engineering. 5 (3), 456-460, 2015

[3] Zainal Zakaria1, Zulaikha shahrum. "The possibility of using liquefied petroleum gas in domestic refrigeration systems", 9(3), 347-354. 2011.

[4] Mhaske.M.S., "Performance Evolution of Domestic Refrigerator Using LPG Cylinder", International Research Journal of Engineering and Technolog, 3(4),2586-2592, 2016

[5] Ibrahim Hussain Shah., "Design of LPG Refrigeration System and Comparative Energy Analysis with Domestic Refrigerator", International journal of engineering sciences & research technology,3(7), 206-213, 2014

[6] Dr. Amir S. Dawood and Salim Ibrahim Hasan, "Numerical study of Refrigerant flow in capillary tube using Refrigerant (R134a), Journal (2011) 1- 19

[7] Zainal zakaria and Zuliaikha shahrum, "The possibility of using LPG in Domestic Refrigeration System"(2011) 347-354.

[8] Wong, T.N. Ooi, K.T. "Adiabatic capillary tube expansion devices: a comparison of the homogenous flow and the separated flow models" Applied Thermal Eng. 16 (7) (1996) 625-634.

[9] Bilal A. A. and Salem A. A. (2002). Assessment of LPG as a possible Alternative to R12 in Domestic Refrigerators. Ener. Conv. And Man. 44: 381-388.

[10] Fatouh, M. and Kafafy, M.E (2005). Experimental Evaluation of a Domestic Refrigerator Working with LPG. 26: 1593-1603.

[11] Vishwadipsingh J. Ghariya and Swastik R. Gajjar "International Journal for Scientific Research and Development" ISSN (online): 2321-0613, March 2014, Vol.2

[12] Ibrahim Hussain Shah and Kundan Gupta "International Journal of Engineering Sciences and Research

Technology" ISSN: 2277-9655, July 2014, Vol. 3(206-213).

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