Experimental Study of Performance Evaluation of Domestic Refrigerator Working With Mixture of Various Refrigerants

L.Vijyabaskar
Department of Mechanical Engineering
CK College of Engineering & Technology, India

Abstract— In many developing countries Like India, most of the vapor compression based refrigeration, air conditioning and heat pump systems continue to run on halogenated refrigerants due to its excellent thermodynamic and thermo-physical properties apart from the low cost. However, the halogenated refrigerants have adverse environmental impacts such as ozone depletion potential (ODP) and global warming potential (GWP). This project is devoted to feasibility study of substitution of LPG which is locally available and comprises 24.4% propane, 56.4% butane and 17.2% isobutene. The LPG is cheap and possesses an environmentally friendly nature with no ozone depletion potential (ODP). It is used in Libya for cooking purposes. Experimental result showed that the LPG refrigerant with charge of 25g worked well under unloaded condition. It took 15 minutes to bring down evaporator temperature from 31 degree Celsiuse to 0 degree Celsius, in comparison to 90g R-134a which took 14 minutes for the same, under designed project set up. While LPG charge of 35g worked well under unload condition. It took 12 minutes to bring down the evaporator temperature from 31 degree Celsius to 0 degree Celsius in comparison to 90g R-134a which took 15 minutes for the same, under designed project. Ammeter continuously gave reading in the range of 0.6 A to 0.9 A and voltmeter as 210V while working with LPG as refrigerant in comparison to R134a in which ammeter gave reading of 1A and voltmeter as 220V. From here we can easily conclude that power consumed by compressor while working with LPG as refrigerant decreased considerably.

Key words: Domestic Refrigerator System, R–134a, Mixture of Propane, Butane and Isobutene (LPG)

I. INTRODUCTION

Refrigeration may be defined as lowering the temperature of an enclosed space by removing heat from the space transferring it elsewhere. Advice the performs this function may alsabe called an air conditioner, refrigerator, air source heat pump, geothermal, heat pump or chiller (heat pump).

The vapor compression uses a circulating liquid refrigerant as the medium which absorbs and removes heat from the space to be cooled and subsequently rejects that heat elsewhere. A vapor compression refrigeration system is an improved type of air refrigeration system in which a suitable working substance termed as refrigerant is used. It condenses and evaporates at temperatures and pressures closed to atmospheric conditions. The refrigerants used generally does not leave the system, but is circulated throughout the system alternately condensing and evaporating. In evaporating, the refrigerants absorbs its latent heat from the heat load and while condensing it gives out latent heat to condensing medium air or water. The vapor compression refrigeration system is now-a-days used for all purpose refrigeration. It is generally used for all industrial purposes, from a small domestic refrigerator to big air conditioning plant.

II. MATERIALS AND METHODS

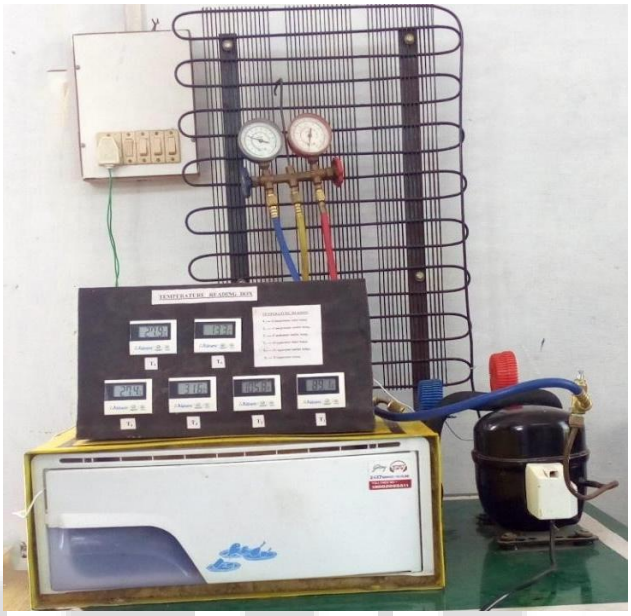

Fig. 1: Photograph of VCR system

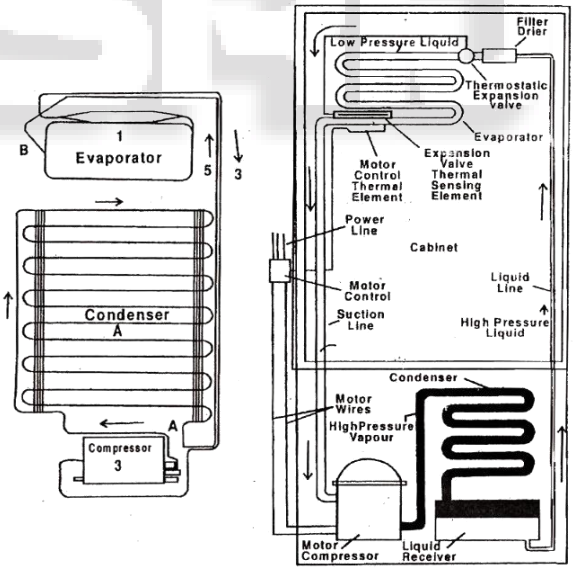

Fig. 2: Block diagram of experimental Setup

A. Components added to the mean components of domestic refrigerator

1) Pressure Gauges

Instruments used to measure pressure are called pressure gauges or vacuum gauges

2) Gauge pressure

is zero-referenced against ambient air pressure

– High pressure gauge:

Diameter	70mm
THR	1/8"
Reading	(0-500) psi / (0-35) kg/cm

– Low pressure gauge

Diameter 70mm
THR 1/8"
Reading (0-250) psi / (0-17.5) kg/cm

3) Temperature sensor

These instruments are used by us to measure temperature at various points during experiment.

Temperature Measuring Range 0 ^{o}C to 80 ^{o}C

Accuracy ±1 ^{o}C
Size (55.5*42.5*16) mm

4) Voltmeter

A voltmeter is an instrument used for measuring electric potential difference between two points in an electric circuit. Analog voltmeters move a pointer across a scale in proportion to the voltage of the circuit; digital voltmeters give a numerical display of voltage by use of an analog to digital converter Voltmeters operating on the electrostatic principle use the mutual repulsion between two charged plates to deflect a pointer attached to a spring. Meters of this type draw negligible current but are sensitive to voltages over about 100 volts and work with either alternating or direct current.

Range 300V
Diameter 72 mm
Type C / DC

5) Ammeter

An ammeter is a measuring instrument used to measure the electric current in a circuit. Moving iron ammeters use a piece of iron which moves when acted upon by the electromagnetic force of a fixed coil of wire. This type of meter responds to both direct and alternating current.

Range 5A
Diameter 72 mm
Type AC/ DC

III. OBSERVATION TABLE

Refrigerant–R134a Amount of gas–90g
With load (A) 500 g of water at 29 o C

Time (min)	Evaporator Temp. T6 ( )	Compressor inlet temp. T1 ( )	Compressor outlet temp. T2 ( )	Condenser outlet temp. T3 ( )	Evaporator inlet temp. T4 ( )	Evaporator outlet temp. T5 ( )	LPS (Psi)	HPS (psi)
At start	31	30.7	30.5	30.9	30.2	31	65	80
2	30	29.4	33	32.5	28.5	28.3	10	190
4	28	29	35	34	26.5	28	10	190
6	25	27.5	37	36	23.4	26.2	10	180
8	23	20.4	39	37.5	20.4	22	9	180
10	20.5	16.3	40.7	38	21.5	19.3	9	180
12	18.2	13	40.7	38	17	15	7	170
14	15.3	11	41	38	12.5	12.6	6	170
16	13.5	9.2	41.5	38.2	10.5	12.5	6	170
18	11	7.5	42.3	38.7	10	12.3	6	170
20	10	6	42.9	39	9.8	11.9	6	170
22	8	5.5	43	39.3	9.5	10.2	6	170
24	6	5.5	43.2	39.3	9.2	10	6	170
26	5	5.2	43.4	39.6	9.1	10	6	170
28	4	5	44	39.8	8.5	9.8	6	180
30	2.9	5	44.5	39.8	8.2	9.8	6	180

Table 1: Study of performance of 90g R134a as refrigerant

Charge–LPG Amount of charge 25gm with load
(A) 500g water at 29

Time (min)	Evaporator Temp. T6 ( )	Compressor inlet temp. T1 ( )	Compressor outlet temp. T2 ( )	Condenser outlet temp. T3 ( )	Evaporator inlet temp. T4 ( )	Evaporator outlet temp. T5 ( )	LPS (Psi)	HPS (Psi)
Start	31	30.5	30.6	30.2	30	30.7	40	45
2	29	29.5	34.7	32.6	29.1	30.1	7	130
4	27.5	28.5	35.9	33.5	26.5	29	7	130
6	23.9	27	38	33.7	24.2	28.2	6	120
8	20	25.1	39	33.7	22.3	27	6	120
10	16.5	23.2	40.5	33.9	20.1	26	5	110
12	12.4	22	41	34.1	19	24.9	5	110
14	9.2	20.5	42.2	34.3	18.2	23.5	5	120
16	6.3	19.2	42.7	34.5	17	23	6	120
18	4.1	18.7	43	34.7	16.6	22.7	6	120
20	1.2	18.2	43.5	34.9	16.1	22	6	120
22	-1.4	18	43.7	35	15.2	21	6	120
24	-3.2	17.2	44.5	35.2	14.7	20	6	120

Table 2 Study performance of 25g LPG as refrigerant

IV. RESULTS

In this study I used liquefied petroleum gas (LPG) as refrigerant in domestic refrigerator of 165 liter, basically designed for R-134a as refrigerant .No modification has been made by me in the basic design of any component or capillary length of refrigerator . I first of all tested the coefficient of performance, by charging 90g R-134a with no load, then with load 500g of water at different temperature 29 and 45 degree Celsius, after that I charged it with 35g, 30g, 25g, and 20g of LPG, at no load, then with load 500g of water at different temperature 29 and 45 degree Celsius for each of charging respectively, consequently and checked its performance.

A. My findings are as follows:

1) Charge: LPG, Amount: 25g

Investigation has been performed first without load, after that under load of 500g water at temperature 29 kept in steel vessel, then the same amount of water at 45.reading from various temperature sensors (fixed at various points), Pressure gauges(fixed at compressor inlet and compressor outlet), ammeter and voltmeter were taken at an interval of two minutes each.

Calculation of COP for LPG, 25g

PARAMETER	NO LOAD	Load A (with 500g of water at	LOAD B (with 500g of water at
Mix Temp T_6	-15	-3.2	-7.8
Mix Temp T_2	44	44.5	46.9
Spend time (min)	26	24	40
LPS (bar)	0.345	0.414	0.414
HPS (bar)	7.59	8.28	8.97
V (volt)	210	210	210
(ampere)	0.7	0.7	0.7
COP	2.189	2.017	1.909

Table 3: Parameter charging of 25g of LPG

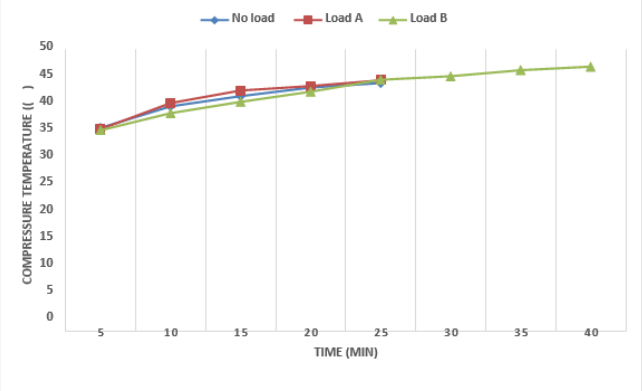

Fig. 3: Compressure temp. vs time graph of 25g LPG as refrigerant

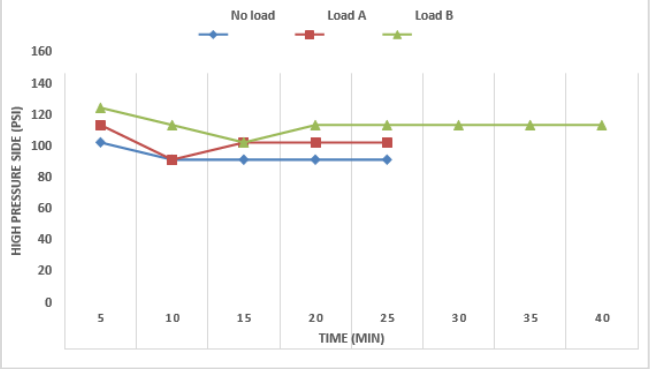

Fig. 4: HPS vs time graph of 25g LPG as refrigerant

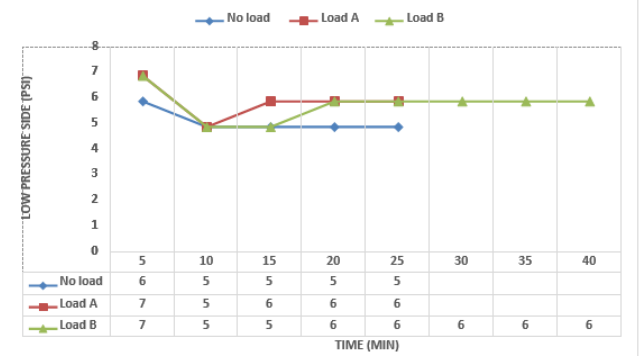

Fig. 5: LPS vs time graph of 25g LPG as refrigerant

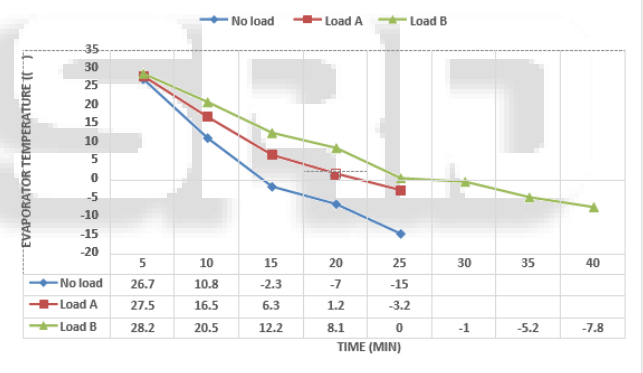

Fig. 6: Evaporator temp. vs time graph of 25g LPG as refrigerant

V. CONCLUSION

The performance of a domestic refrigerator was investigated using LPG as refrigerant. This simulation aimed at comparing the performance characteristics of the domestic refrigerator working with R134a, mixtures with 24.4% propane, 56. % butane and 17.2% isobutene. Based on the simulation results, the following conclusions are drawn:

1) Hydrocarbon refrigerants offer desirable environmental requirements, i.e. zero ozone depletion potential and approximately zero global warming potential.
2) The mixture of propane, butane and isobutene (LPG) offers many desirable characteristics, such as low operating pressure, discharge temperature and mass flow rates and high COP and specific volume, but requires a compressor design change.
3) The Evaporator temperature of R134a and the ternary hydrocarbon mixture with amount of 20g are nearly the

same. However, the hydrocarbon mixtures with amount of 25g yield lower, than that of R134a.

4) The optimum charge amounts for LPG were found to be in between 25g to 35g. Moreover, results showed that energy consumption was reduced.
5) Safety analysis showed that in case of a sudden leakage of total amount of hydrocarbon refrigerants, it would not result in explosive conditions.

REFERENCES

[1] Alsaad, M. A. & Hammad, M. A. (1998). The application of Propane/ Butane mixture for domestic refrigerator. Applied Thermal Engineering, 18: 911–918.
[2] Ashish Patider, Amitesh Paul. (2014). Performance Analysis of vapour compression Refrigeration System Utilizing Different Refrigerant. International Journal of Engineering Sciences and Research Technology. 627–631.
[3] Austin, N., Senthilkumar, P. & Kanthavel kumaran, N. (2012). Thermodynamic optimization of household refrigerator using Propane-Butane as a mixed refrigerant, International Journal of Engineering Research and Application, 2: 268-271.
[4] P. Thangavel, P. Somasundaram, T. Sivakumar, (2013).Simulation Analysis of Compression Refrigeration Cycle with Different Refrigerants. International Journal of Engineering and Innovative Technology.23:517-527.
[5] Rasti, Mehdi, Aghamiri, Sayedfoad &Hatamipoar, Mohammad-Sadegh (2013). Energy efficiency enhancement of a domestic refrigerator using R436A and R600a as alternative refrigerants to R134a. International Journal of Thermal Sciences, 74: 86-94.
[6] Russo, Giovanni, Anifantis, Alexandros S., Verdiani, Giuseppe & Mugnozza, Giacomo Scarascia (2014). Environmental analysis of geothermal heat pump and LPG green house heating systems. International Journal of Green house gas control, 127: 11-23.
[7] Sattar, M.A., Saidur, R. & Masjuki, H. H. (2007). Performance Investigation of Domestic Refrigerator Using Pure Hydrocarbons and Blends of Hydrocarbons as Refrigerants. International Journal of Mechanical Systems Science and Engineering, 1: 50-55.
[8] Shah, Ibrahim Hussain & Gupta, Kundan (2014). Design of LPG refrigeration system and comparative energy analysis with domestic refrigerator. IJESRT, 7: 206-213.
[9] Somchai Wongwises, Nares Chimres. (2005). Experimental study of hydrocarbon mixtures to replace HFC-134a in a domestic refrigerator. Energy Conversion and Management.46:85-100.
[10] Suresh Boorneni, A. V. Satyanarayana, (2014). Improving and Comparing the Coefficient of Performance of Domestic Refrigerator by using Refrigerants R-134a and R600a.International Journal of Computational Engineering Research.
[11] Yu, Chao-Chieh & Teng, Tun-Ping (2014). Retrofit assessment of refrigerator using hydrocarbon refrigerant. Applied themal engineering, 66: 507-518.Study of Performance Evaluation of Domestic Refrigerator working with Mixture of Propane, butane and isobutene Refrigerant (LPG)
[12] Zakaria, Zainal & Shahrum, Zulaikha (2011). The possibility of using LPG in domestic refrigeration system. IJRRAS, 9: 347-354.
[13] Santosh Chandra Anand, Dr. Ajeet Kumar Rai and Vivek Sachan, Comparative Study of Parabolic Trough Concentrators, International Journal of Mechanical Engineering and Technology, 5(7), 2014, pp. 65-73
[14] Ajeet Kumar Rai, Ashish Kumar, Vinod Kumar Verma, Effect of Water Depth and Still Orientation on Productivity of Passive Solar Still, International Journal of Mechanical Engineering and Technology, 3(2), 2012, pp. 740-753
[15] Singh Ankur Kumar, Rai Ajeet Kumar and Sachan Vivek (2014) Energy and Exergy Analysis of a Double Slope Solar Still International Journal of Mechanical Engineering and Technology :5(6) 47-54
[16] Singh Parmendra, Rai Ajeet Kumar and Sachan Vivek (2014) Study of Effect of Condensing Cover Materials on the Performance of a Solar, Still International Journal of Mechanical Engineering and Technology :5(5) 98-107

