ISSN: 2348 9510

International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 7, October 2015

PERFORMANCE ANALYSIS OF THE BLENDS OF HYDROCARBONS MIXED WITH LPG AS MODERN ECO FRIENDLY REFRIGERANT

Durgesh Choudhary
Lakshmi Narain Institute of Technology & Science (RIT), India
Durgesh.ch26@gmail.com

Kailash Kumar Lahadotiya
Lakshmi Narain Institute of Technology & Science (RIT), India

Ashok Kumar Gupta
Lakshmi Narain Institute of Technology & Science (RIT), India

Arjun Panthi
Mahakal Institute of Technology, Ujjain, India

Abstract

This work represents the experimental study and analysis of the mixture of modern eco-friendly hydrocarbons such as isobutene, propane and LPG as refrigerant in domestic refrigerator without any change in its design specification. There is a need to find out the alternative to R134a, R22 and R12 in domestic refrigerator and air conditioners refrigerant due to increasing the global warming potential (GWP) and ozone depletion potential (ODP) with rapid rate. R134a is quite good refrigerant but it consist 1300 global warming potential which is seriously very high so there is a need to find out modern eco friendly hydrocarbon

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 7, October 2015

refrigerant. The modern eco-friendly refrigerant is the mixture of hydrocarbons such as Isobutene and Propane with suitable amount of liquefied petroleum gas (LPG). The LPG is also a mixture of isobutene and propane and some other gases used also for leak detection and for greater refrigeration performance. The modern eco-friendly hydrocarbon refrigerant also gives the greater COP, lower power consumption and comparably lower refrigerant cost per 100 grams as compare to R134a.

Key words: - Global warming potential, ozone depletion, eco-friendly, hydrocarbon.

1. Introduction

Interest in and application of hydrocarbon (HC) refrigerants is growing, especially now that the global warming impact of refrigerants is becoming an increasingly important aspect for the refrigeration and air conditioning industry and also for improving the coefficient of performance of vapor compression refrigeration system there is need to develop modern and eco friendly refrigerant.

The first generation (1830-1930) of refrigerants was based on the availability. These natural refrigerants such as ammonia, carbon dioxide and methyl chloride has consist very good refrigerant properties but this were often highly toxic, flammable and some very highly reactive.
The second generation (1930-1990) of refrigerants focused on reducing toxicity and flammability. Example: CFCs, HCFCs, HFCs, NH_3, H_2O etc

The third generation (1990-2010) of refrigerants focused on protecting the ozone layer. Example: HCFCs, HFCs, HCs, NH_3, H_2O, CO_2 etc.

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 7, October 2015

The fourth generation (from 2010 onwards) focused on refrigerants that do not contribute to global warming, ozone layer depletion, efficient, non flammable and non toxic with good stability. But the outlook for discovery or synthesis of these ideal refrigerants is extremely unlikely. Therefore, trade–off among desired objectives is necessary to achieve the balanced solution.

2. Major Issues With Conventional Refrigerant

The major concern with conventional refrigerant R134a is their higher ozone depletion potential. The ozone layer is protects us for the harmful ultraviolet radiations emitted from sun. The ozone depletion rate is continuously increasing so there is a need to find out the alternate of conventional refrigerant Ozone depletion potential is evaluated on a scale that uses CFC-11 as a benchmark. All the other components are based on how damaging to the ozone they are in relation to CFC-11 HCFC.

The one another major concern is global warming. The conventional refrigerant consist higher global warming potential it is also a major concern. The Global warming is the increase in global earth surface temperature due to the absorption of infrared emission from earth surface. Global warming potential is evaluated on a scale that uses CO_2 as the bench mark i.e. CO_2 is assigned a value and other components are compared to CO_2.There is also a strong reason to use of hydrocarbon refrigerants due to its higher coefficient of performance (COP), lower power consumption and also it is cheaper than R134a.

3. Experimental Setup Of Vapor Compression Refrigeration Cycle

Refrigeration may be defined as the process of achieving and maintaining a temperature below that of the surroundings, the aim being to cool some product or space to the required

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 7, October 2015

temperature. One of the most important applications of refrigeration has been the preservation of perishable food products by storing them at low temperatures A domestic vapor compression refrigerator of capacity 165 liter is used for analysis of the experimental sat up. There are five basic components of a refrigeration system, these are:

A. Evaporator
B. Compressor
C. Condenser
D. Expansion Valve
E. Refrigerant- to conduct the heat from the product.

The schematic Diagram of the refrigeration cycle which is given bellow:-

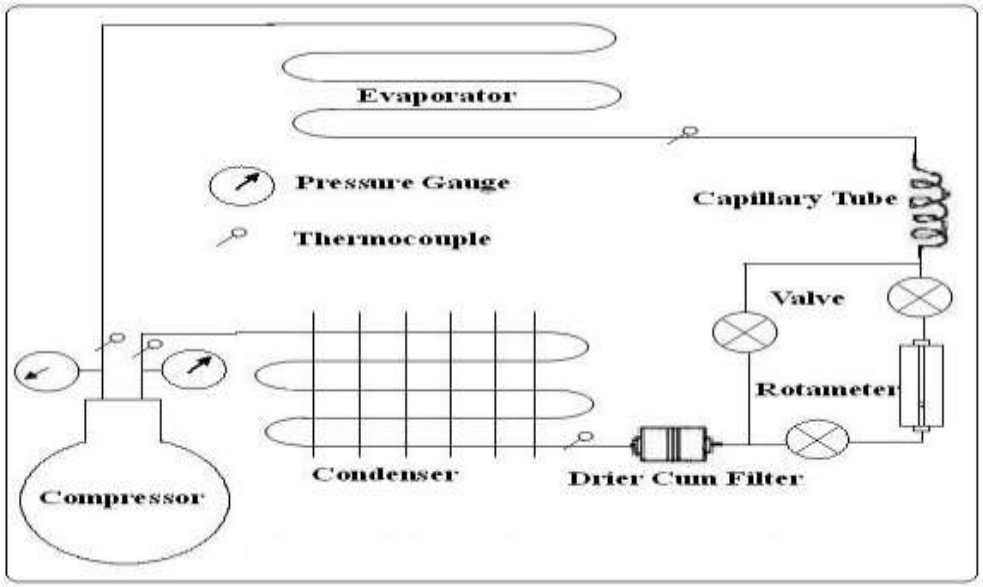

Figure: 1 Schematic Diagram of Refrigeration cycle

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 7, October 2015

A. Evaporator

The purpose of the evaporator is to remove unwanted heat from the product, via the liquid refrigerant. The liquid refrigerant contained within the evaporator is boiling at a low-pressure.

B. Compressor

The purpose of the compressor is to draw the low-temperature, low-pressure vapor from the evaporator via the suction line. Once drawn, the vapor is compressed. When vapor is compressed it rises in temperature. Therefore, the compressor transforms the vapor from a low-temperature vapor to a high-temperature vapor, in turn increasing the pressure. The vapor is then released from the compressor in to the discharge line. The hermetically sealed and the capacity of 1 ton LG compressor are used in the experimental system.

C. Condenser

The purpose of the condenser is to extract heat from the refrigerant to the outside air. The condenser is usually installed on the reinforced roof of the building, which enables the transfer of heat the condenser unit is used to draw air through the condenser coils According to the capacity of 165 liters refrigeration test setup the Godrej condenser is used.

D. Expansion Valve

Within the refrigeration system, the expansion valve is located at the end of the liquid line, before the evaporator. The high-pressure liquid reaches the expansion valve, having come from the condenser. The valve then reduces the pressure of the refrigerant as it passes through the orifice, which is located inside the valve. On reducing the pressure, the temperature of the refrigerant also decreases to a level below the surrounding air. This low-pressure, low-temperature liquid is then pumped in to the evaporator. This low-pressure, low-temperature liquid is then pumped in to the evaporator.

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 7, October 2015

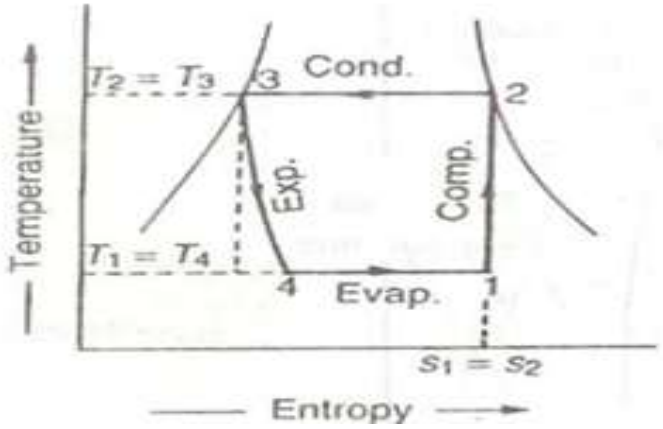

Figure: 2 T-S Diagram of Vapour Compression Refrigeration System

E. Refrigerant to Conduct the Heat from the Product

The refrigerant is a substance it consist the lower boiling point and higher freezing point. The refrigerant is a substance which is used to maintain the lower temperature in evaporator. In the experimental setup both refrigerants such as R134a and blend of hydrocarbon as refrigerant are used and by apply test on it and complete the analysis work on the domestic refrigerator.

The measuring instrument which is attached to the experimental test rig which are:

- Suction pressure meter
- Discharge pressure meter
- Condenser temperature measuring digital temperature meter
- Evaporator temperature measuring digital temperature meter
- Electronic power consumption meter.

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 7, October 2015

4. Refrigerant Requirement

When CFCs and HFCs are vented into the atmosphere they linger for over 100 years. During this time they rise to the stratosphere where they are broken down by the stronger sunlight. This decomposition releases the chlorine which depletes ozone. The ozone is the form of oxygen with three atoms instead of the two that are in the air we breathe. One chlorine atom has the potential to destroy thousands of ozone molecules.

The ozone layer protects us from ultra violet radiation. As this layer gets thinner the incidence of skin cancer and eye cataracts increases and crop yield reduce. Very serious ozone depletion occurs over the Antarctic but significant ozone layer depletion is also occurring further north. The CFCs and HCFCs are the widely used refrigerants, foam blowing agents, aerosol propellants and cleaning agents. Different refrigerants have a varying effect on ozone depletion.

Carbon dioxide concentration in the atmosphere has been steadily rising for over one hundred years and perhaps longer. Early this century the radiation properties of carbon dioxide were known to increase the earth's temperature. The radiation properties of CFS and their long atmospheric lifetime make them thousands of time worse than carbon dioxide (Table 1). The consequence of rising global temperatures includes inundation of entire cities and countries. Reducing global warming was an overwhelming argument of CFC's.

The magnitudes of ozone depletion and global warming effect are known only within a factor of ten but the relative effect of different chemicals emitted to the atmosphere are known more accurately. The ozone depletion potential(ODP) for a specified time is the ratio of ozone destroyed by 1kg of substance emitted instantaneously to the atmosphere to that destroyed by 1 kg dichlorodifluoromethane (R12). The global warming potential (GWP) for specified time is the ratio of the radiant heat at the earth's surface due to 1kg of substance emitted instantaneously to

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 7, October 2015

the atmosphere to that from 1kg of carbon dioxide. ODPs and GWPs may be used in future taxes.

Table: 1 Environmental Impacts of Refrigerants (100 year basis).

Refrigerant	R12	R22	R134a	R600a	R290
Class	CFC	HCFC	HFC	LPG	HC
Atmospheric lifetime (years)	130	15	16	<1	<1
Ozone depletion potential(ODP)	1.0	0.07	0	0	0
Global warming potential(GDP)	7300	1500	1300	8	8
Atmosphuric life	130	15	16	< 1	< 1

5. Hydrocarbon Refrigerants for the Domestic Refrigeration Cycle

For Domestic Refrigerator's refrigeration cycle the three different hydrocarbons refrigerants are interest:

- Pure isobutene (R600a).
- Pure propane (R290).
- Liquefied petroleum gas (LPG).

For domestic refrigerators the appropriate blend of propane, isobutene and LPG R600a is the perfect choice. It consist a very good refrigerant properties so it can easily be used in two temperature models. It operates with low noise good efficiency and low pressure without any

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 7, October 2015

type modification into the design of refrigeration cycle component. The blend of r600a and R290 is consist very good refrigerant properties and the LPG is also a mixture of isobutene, butane and propane and it can be also a very good leak deduction properties by its sensitive smell.

In various papers present in which pure LPG has been used on domestic refrigeration cycle and it has worked with increased COP in the cycle, less Power consumption KW/h in a day and with very good flow rate into the cycle.

6. Properties of Hydrocarbons and its Blends as Refrigerants

The important properties of hydrocarbons (HCs) as refrigerants compared with hydrofluoro (HCFs) and hydro chlorofluorocarbons (HCFCs) are discussed in table 2.

The customers are demanding LPG refrigerant because they occur naturally, cause no ozone depletion and negligible global warming. Initially R290 can replace R22 and LPG mixtures replace R12 and R134a. The market for R600a will grow as new equipment exploits the advantages of its lower vapor pressure.

The total climate chenge and ozone depliaion depends on both the global warming potential and ozone depleation potential of the substances. The alternative to HFC refrigerants can be HC (hydrocarbon) as there is no chlorine content.

Hydro carbon s (HCs) are the class of natural occuring substances that include propane, pentane and butane. HCs are excellent refrigerants in many ways energy effeciency, critical point, solubility, transport, heat transfer properties and environmentally sound but their major concern is their flammability. The properties of alternative refrigerants of R134a are give In bellow table:-

Table: 2 Properties of Alternative Refrigerants of R134a

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 7, October 2015

Refrigeration Name	Chemical Formula	Normal Boiling point Tempreature (°C)	Critical Tempreature (°C)	Tripal point Tempreature (°C)
R134a (HFC)	CF3CH2F	-26.07	101.06	-103.3
R152a (HFC)	CH3CHF2	-24.02	113.3	-118.44
R290	HC	-42.1	-42.08	-189
R600a	HC	-11.7	-11.76	-145
R600	HC	-0.5	-0.54	-138

7. Analysis of the Blends of HCs and LPG in V.C.R. Cycle

Thermodynamic analysis is the analysis based on energy raising and the efficiency of an energy system within the domain of thermodynamics.

The economic analysis is the analysis based on economic principles to provide system designer or operator with information available of conventional refrigerant and the blends of HCs and LPG economic analysis.

The previous literature review and study and analysis that the hydrocarbon refrigerant give the lower power consumption and comparatively lower compressor work as compare to conventional R134a.

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 7, October 2015

8. Result

- **Coefficient of Performance of Refrigerant R134a**

This Calculation is based on reverse Carnot cycle. On different thermostat set points of the Refrigerator are:-

Table: 3 Coefficient of Performance of Refrigerant R134a

S.No.	Thermostat Position	Condenser temp. (ºC) T_1	Evaporator temp. (ºC) T_2	COP
1	3	40.2	-14.2	4.74
2	6	42.9	-17.8	4.18
3	9	45.8	-21.7	3.72
Average COP				**4.213**

Table: 4 Coefficient of Performance of Refrigerant Blends

S.No.	Thermostat position	Condenser temp. (ºC) T_1	Evaporator temp. (ºC) T_2	COP
1	3	39.4	-14	5.84
2	6	42.8	-18.2	5.11
3	9	44.8	-21	3.82

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 7, October 2015

Average COP	**4.923**

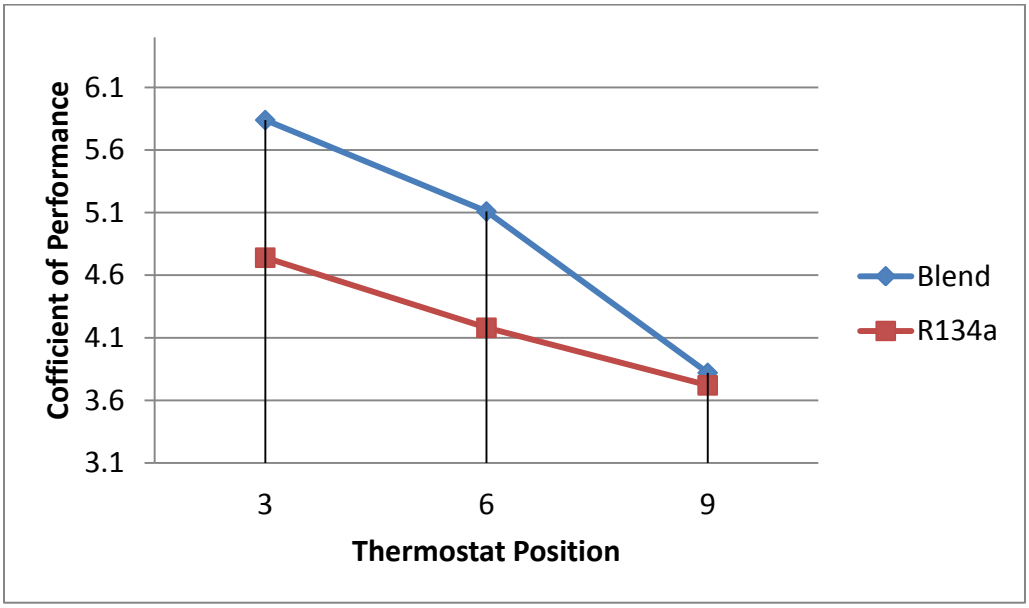

Figure: 3 Graphical Presentation of COP of R134a and Blend at Each Thermostat Position

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 7, October 2015

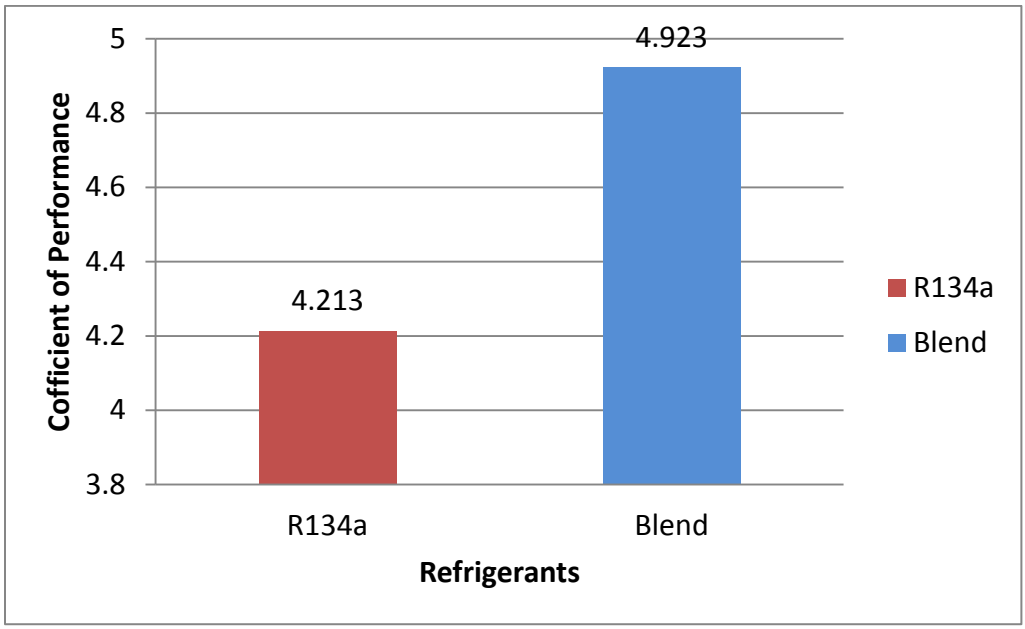

Figure: 4 Comparison of COP of R134a and hydrocarbon Blend

Table: 5 Power Consumption

Refrigerant	Energy (Power) Consumption (kWh/day)
R-134a	1.237
Refrigerant Blend	1.166

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 7, October 2015

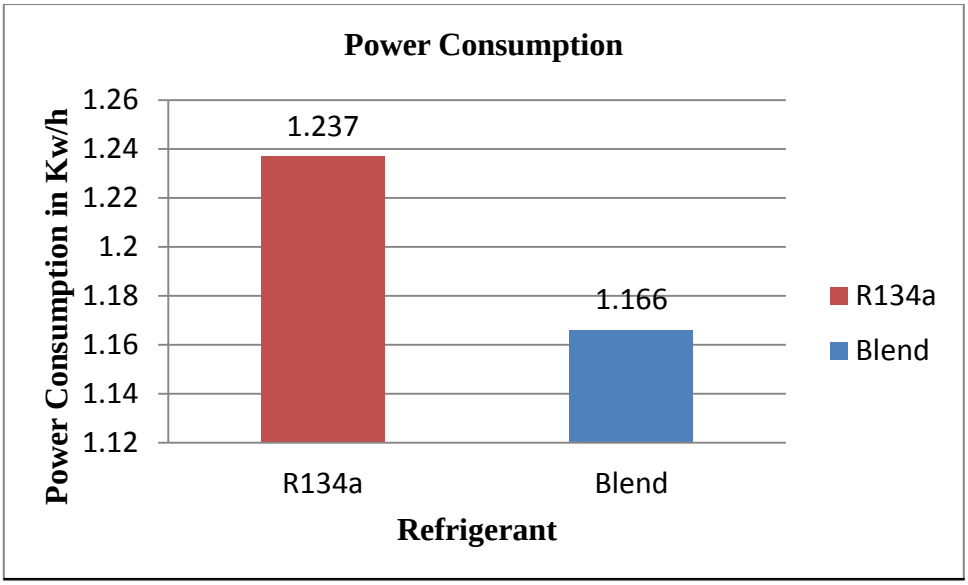

Figure: 5 Power Consumption of both refrigerants

9. Conclusion

- No operation problems encountered with the refrigerator compressor where no degradation of lubricating oil has been detected for a better COP and refrigerator efficiency.
- Isobutene (R 600a) is a well suited refrigerant for household application, with good energy efficiency and isobutene is modern and widely used refrigerant.
- Availability of isobutene and propane and LPG all over the world they have been discussed widely for CFC, H-CFC and HFC replacement.
- In previous papers present the LPG which has worked with very satisfactory as refrigerant in domestic refrigerator with increased coefficient of performance. The LPG which is also easily available and it is also very cheapest refrigerant.

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 7, October 2015

- The property of LPG is its extreme smell which is also helpful for leak detection of refrigerant.
- LPG is safe to act as a refrigerant comply with the safety parameter that was highlighted.
- The LPG operated domestic refrigerator has given lower power consumption as compare to R134a which has been analysed in previous paper present.
- No operation problems have been encountered with the refrigerator compressor where no degradation of lubricating oil has been detected.
- LPG refrigerants have superior properties often giving 10 to 20% energy savings.
- The blend of Hydrocarbons is loking like modern ecofriendly and effective refrigerant.

References

[1]B.O Bolaji and Z. Huan. Energy Performance of Eco-friendly RE170 and R510a Refrigerants as Alternatives to R134a in Vapour Compression, Refrigeration System.

[2]Somchai Wongwises, Nares Chimers, Experimental Study of Hydrocarbon Mixture to replace HFC-134a in a domestic refrigerator. Energy conservation and management 46 (2005) 85-100.

[3]Amjad khan, Dr. Kuldeep Ojha and Prakash Gowali, Analysis of Modern Eco-Friendly Refrigerant, International Journal on Emerging Technologies 4(1):177-181(2013).

[4]Gaurav,Dr. rajkumar, Alternative to R134a (CF3CH2F) Refrigerant – A Review, YMCA University of Science & Technology, Faridabad, Haryana, Oct 19-20, 2012.

[5]Mohd. Aasim Nazeer Ahamad, Chidanand Mangrulkar, Ehsanullah Khan, Syed Mohiuddin, Experimental analysis of refrigerator by replacing conventional HFC refrigerants with hydrocarbons, IOSR-JMCE, *e*-ISSN: 2278-1684, p-ISSN: 2320-334X PP 01-05.

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 7, October 2015

[6]Jetendra kumar verma, Ankit satsangi, vishal chaturani, A Review of Alternative to R134a (CH_3CH_2F) Refrigerant, International Journal of Emerging Technology and Advanced Engineering, Volume 3, Issue 1, January 2013.

[7]L. Maclaine-cross, E. Leonardi, Performance and safety of LPG refrigeration's, School of mechanical and manufacturing engineering the university of new south wells, Sydney NSW, Australia 2025.

[8]Mohd.Aasim Nazeer Ahmad, Chaidnand Mangrulkar, Ehsanullah Khan, Syed Mohiuddin, Experimental analysis of refrigerator by replacing conventional HFC refrigerants with hydrocarbons, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, P-ISSN: 2320-334X PP 01-05.

[9]N. Austin, Dr. P. Senthil kumar, N. kanthavelkumaran, thermodynamic optimization of household refrigerator using propane–butane as mixed refrigerant, international journal of engineering research and applications (IJERA) issn: 2248-9622, vol. 2, issue 6, November-December-2012, PP.268-271.

[10]The Air Conditioning and Refrigeration Industry Board, Guidelines for the use of hydrocarbon refrigerants in static refrigeration and air conditioning system.

[11]Vishwadipsinh J. Ghariya, Swastik R. Gajjar, Thermodynamically Evolution of LPG Refrigerator for Restaurant, IJSRD - International Journal for Scientific Research & Development, Vol. 2, Issue 03, 2014 ISSN (online) 2321-0613.

[12]Vishwadipsinh J. Ghariya, Dipak C. Gosai, Swastik R.Gajjar, Thermodynamically Evolution of LPG Refrigerator : A Literature Review, International Journal of Engineering Research & Technology (IJERT)Vol. 2 Issue 12, December-2013,ISSN: 2278-0181.

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 7, October 2015

[13]P. Thangavel, Dr. P. Somasundaram, T. Sivakumar, C. Selva Kumar, G. Vetriselvan, Simulation Analysis of Compression Refrigeration Cycle with Different Refrigerants, International Journal of Engineering and Innovative Technology (IJEIT) Volume 2, Issue 10, April 2013.

[14]Moises A. MARCELINO NETO, Jader R.BARBOSA Jr, Absorption of Isobutane (R-600a) in Lubricant Oil, International Compressor Engineering Conference, Federal University of Santa Catarina 2010.

[15]The use of hydrocarbons propane and isobutane in Refrigeration systems, 18th International Congress of Mechanical Engineering Copyright © 2005 by ABCM November 6-11, 2005, Ouro Preto, MG.

[16]Guidelines for the safe use of hydrocarbon refrigerants, A handbook for engineers, technicians, trainers and policy-makers - For a climate-friendly cooling, Eschborn, September 2010.

[17]Zainal zakaria & zulaikha shahrum, the possibility of using liquefied petroleum gas in domestic refrigeration systems, IJRRAS 9 (3), December 2011.

[18]Anil S.Katarkar & Lenin Dhale, Coefficient of Performance increment in Domestic Refrigerator: A Literature Review, International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181, Vol. 3 Issue 4, April – 2014.