ISSN 2393-8471

International Journal of Recent Research in Civil and Mechanical Engineering (IJRRCME)
Vol. 2, Issue 1, pp: (59-65), Month: April 2015 – September 2015, Available at: www.paperpublications.org

Experimental Optimization of Capillary Tube in Domestic Refrigerator

[1]Said Suraj R, [2] Raskar Tushar B, [3]Shaikh Sohel H, [4]Lande Dattatray R, [5]S.P. Chavan

[1,2,3,4] Students, [5]Assistant Professor Mechanical Engg. Department, Rajarshi Shahu School of Engineering & Research, Narhe, Pune University, Pune

Abstract: **This paper describes the experimental optimization of capillary tube for choosing best suitable capillary in domestic refrigerator and comparison in performance of two different refrigerants (R134a and R600a). This experiment deals with optimization performance testing for a domestic refrigerator using experimental method.**

Keywords: **Domestic refrigerator, Optimization, Capillary tube, COP, R134a, R600a.**

I. INTRODUCTION

Prior to the invention of the household refrigerator snow and ice were used to refrigerate and preserve food. Historically, ancient cultures (Chinese, Hebrews, Greeks, Romans, and Persians) stored snow and ice throughout the year in different types of ice houses or covered wells. The ice was harvested from winter lakes or was brought down from the mountains. Later, ice boxes were used in homes in which the ice were stored to keep the internal box cold. This highly work intensive transport of thermal energy existed at least into the 1950s when it was outclassed by the household refrigerator. In 1958, 94 % of the U.S households owned refrigerators. Today almost all modern homes have household refrigerators, typically powered by electricity and operating by the vapour compression cycle

1.1 Refrigeration System: Working Principle and Construction:

A domestic refrigerator is in complete compliance with the Clausius statement of the second law of thermodynamics. The Clausius statement simply states that a refrigerator cannot operate unless its compressor is driven by an external power source, such as an electric motor. In this case, the compressor leaves a trace in the surroundings by consuming some energy in the form of work by the electric motor so that to transfer heat from the colder body to a warmer one.

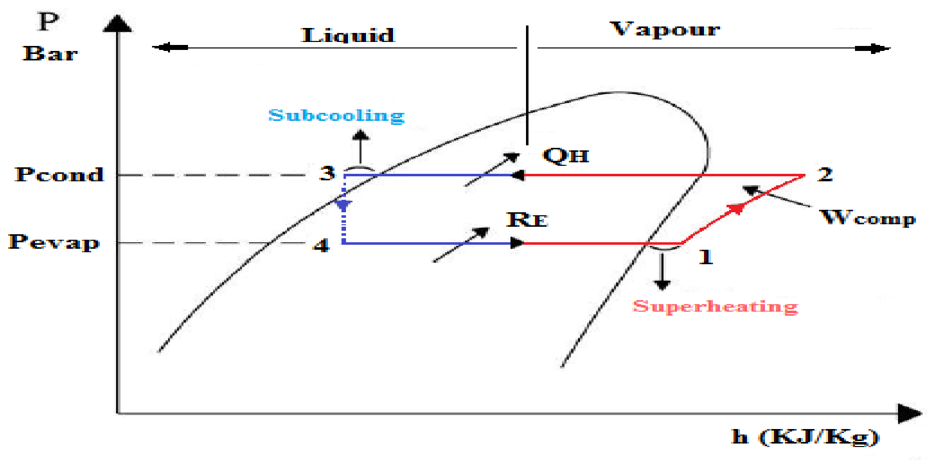


Figure1. P-h diagram of Vapour Compression Refrigeration System [15]

ISSN 2393-8471

International Journal of Recent Research in Civil and Mechanical Engineering (IJRRCME)
Vol. 2, Issue 1, pp: (59-65), Month: April 2015 – September 2015, Available at: www.paperpublications.org

- Process 1 – 2: Isentropic compression in compressor.
- Process 2 –3: Constant pressure heat rejection in condenser.
- Process 3 – 4: Isenthalpic expansion in expansion device.
- Process 4 – 1: Constant pressure heat absorption in evaporator

Household refrigerators and freezers are found in almost every home in the industrialized parts of the world and in increasingly larger number elsewhere. It is estimated that the global annual production is more than 90 million units. Therefore energy consumption is an important factor for the consumer, the first cost, as seen on the price tag is often the most important. Therefore it is interesting to explore other low cost solutions to lower the energy consumption. Of course, if such solutions can increase the operational efficiency without increasing the unit price it is even better.

II. EXPERIMENTAL SET UP

Introduction of test rig:

The schematic Diagram of experimental set-up of domestic refrigerator has been shown in fig. The test section was a copper capillary tube in which the refrigerant expands from high pressure side to low pressure side. Three helical coiled capillary tubes were put in parallel position having 0.71120 mm, 0.78740 mm and 0.9144 mm internal diameters and 2.4384m Length of capillary tubes used in the experiment. Hand shutoff valve were provided at the ends of the capillary tube. So that while changing the capillary, no loss of refrigerant takes place. The refrigerant entered into evaporator from capillary tube which consists of copper coil wound on aluminum box called de-freezer; where heat was absorbed from cabinet. Vapour refrigerant from evaporator entered into single phase hermetically sealed 1/8 HP compressor. The energy consumption of system was measured with the help of energy meter which was connected across the compressor.

High pressure superheated vapour emerging from compressor entered into condenser. The superheated vapour was condensed in coiled condenser. Heat is rejected by natural convection condenser coil having wire fins. Drier-cum-filter was also installed after condenser to remove unwanted solid particles and moisture. Five calibrated digital temperature sensors were attached to the external surface of copper tube at different locations of the setup. The working range of temperature sensors is between -30^{0}C to 80^{0}C. Experimental setup was instrumented with bourdon tube pressure gauges at inlet and outlet of test section for measuring suction and discharge pressure.

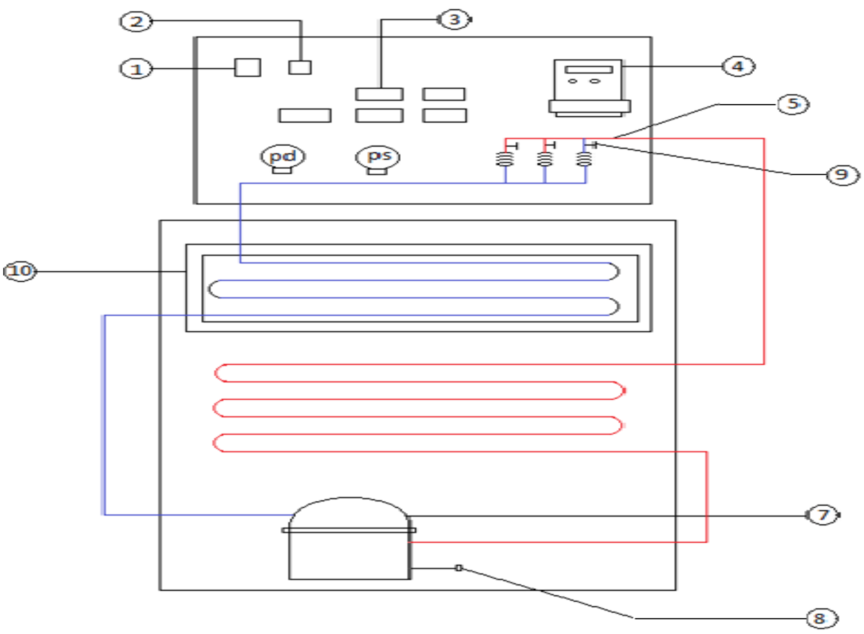


Figure 5 Schematic Diagram of Experimental Setup

ISSN 2393-8471

International Journal of Recent Research in Civil and Mechanical Engineering (IJRRCME)
Vol. 2, Issue 1, pp: (59-65), Month: April 2015 – September 2015, Available at: www.paperpublications.org

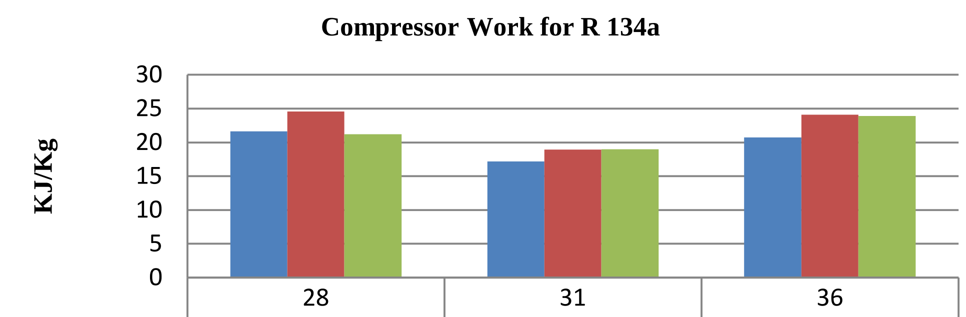
1. Main Switch
2. ON/OFF Switch
3. Digital Temperature Indicator
4. Energy meter
5. Capillary Tubes
6. Condenser
7. Compressor
8. Service Line
9. Hand Setup Valve
10. Evaporator
11. Ps-Suction Pressure
12. P_d-Discharge Pressure

The refrigeration cycle is charged by refrigerant with charging system and evacuated with vacuum pump to remove the moisture and to create vacuum in system. After charging refrigerants, data were collected at interest point with same operating condition. The system attains steady state condition after a run of one hour, after which experimental observations were made. The following parameters were obtained to compare refrigerant like refrigerating effect, compressor work, mass flow rate and coefficient of performance.

III. RESULTS AND DISCUSSION

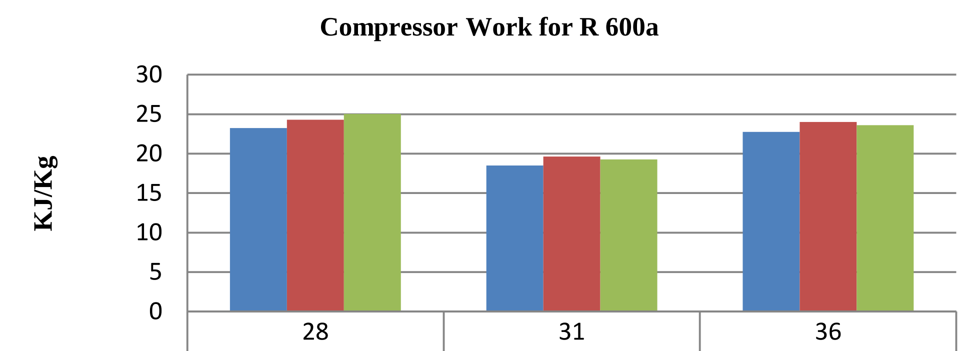
Following graph are deduced and can be taken for design purpose:

a) Compressor work:



	28	31	36
Morning	21.6277	17.1734	20.7409
Afternoon	24.5739	18.9178	24.1129
Evening	21.2135	18.9748	23.92

Graph 1: Compressor work for different capillary diameter at different time R 134a



	28	31	36
Morning	23.2521	18.4997	22.7442
Afternoon	24.3132	19.6157	24.0145
Evening	25.0206	19.2833	23.6259

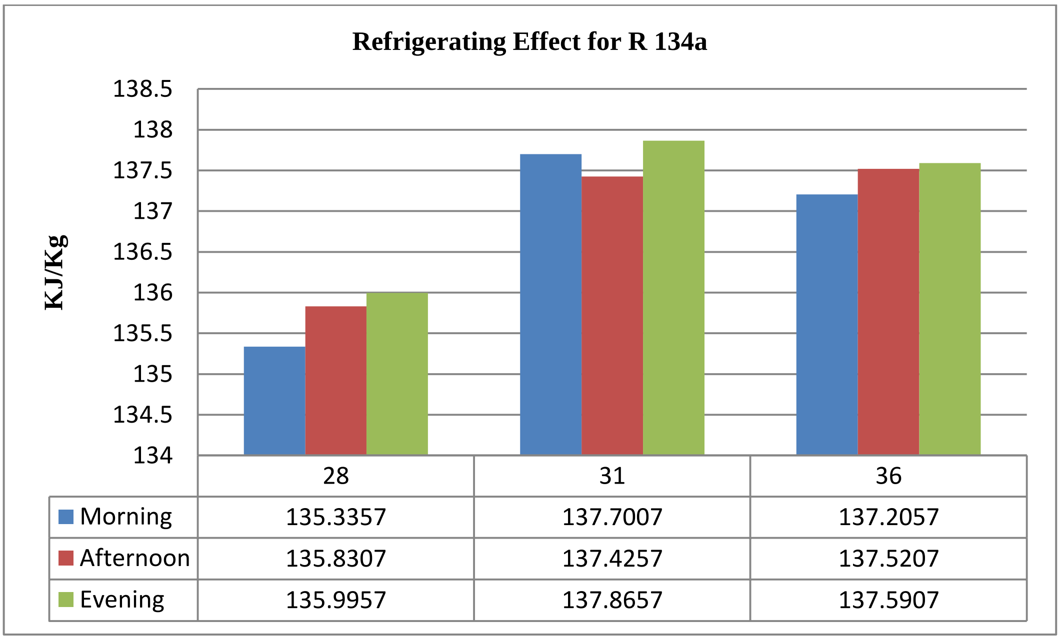
Graph 2: Compressor work for different capillary diameter at different time R 600a

ISSN 2393-8471

International Journal of Recent Research in Civil and Mechanical Engineering (IJRRCME)
Vol. 2, Issue 1, pp: (59-65), Month: April 2015 – September 2015, Available at: www.paperpublications.org

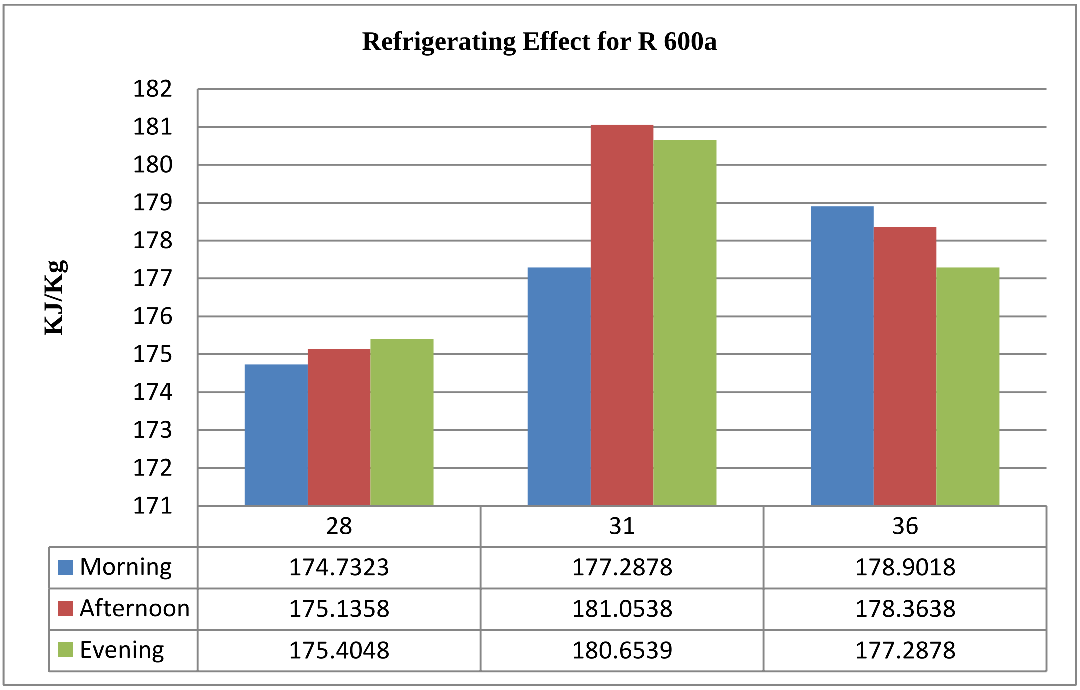
The above graph shows the variation of compressor work for R134a and R600a for different capillary tubes inner diameter. Figure shows that compressor work is high for the capillary 28 and low for capillary 31. In afternoon, Compressor work required is more than whole day. In morning, compressor work required is less. Compressor work decreases with increase in diameter of capillary tube.

b) Refrigerating effect:



	28	31	36
Morning	135.3357	137.7007	137.2057
Afternoon	135.8307	137.4257	137.5207
Evening	135.9957	137.8657	137.5907

Graph 3: Refrigerating Effect for different capillary diameter at different time R 134a



	28	31	36
Morning	174.7323	177.2878	178.9018
Afternoon	175.1358	181.0538	178.3638
Evening	175.4048	180.6539	177.2878

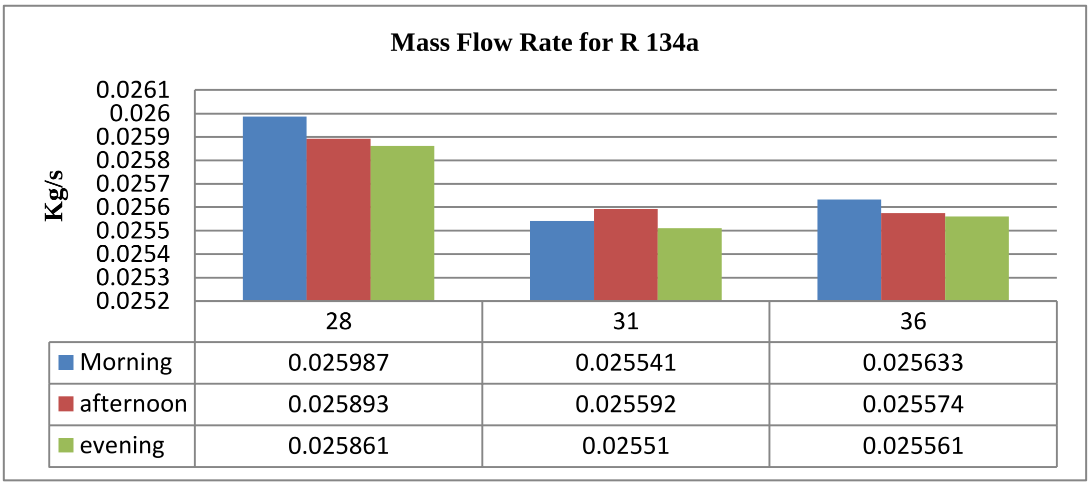
Graph 4: Refrigerating Effect for different capillary diameter at different time R 600a

In case of refrigerating effect for both refrigerant R134a and R600a, We get better results for capillary tube diameter of 31 as shown in graph 3 and 4. Refrigerating effect is less for capillary 28. Refrigerating effect increases with increase in capillary tube inner diameter.

ISSN 2393-8471

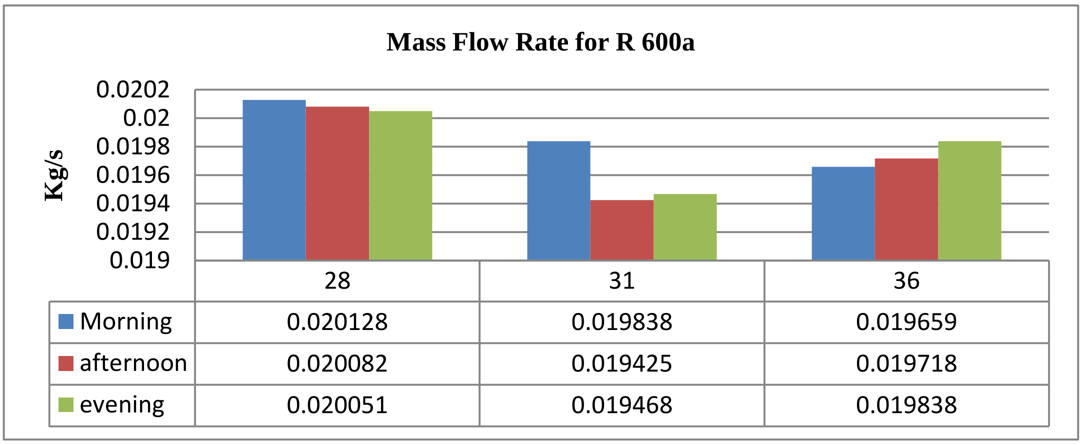
International Journal of Recent Research in Civil and Mechanical Engineering (IJRRCME)
Vol. 2, Issue 1, pp: (59-65), Month: April 2015 – September 2015, Available at: www.paperpublications.org

c) Mass Flow Rate:



	28	31	36
Morning	0.025987	0.025541	0.025633
afternoon	0.025893	0.025592	0.025574
evening	0.025861	0.02551	0.025561

Graph 5: Mass flow rate for different capillary diameter at different time R 134a

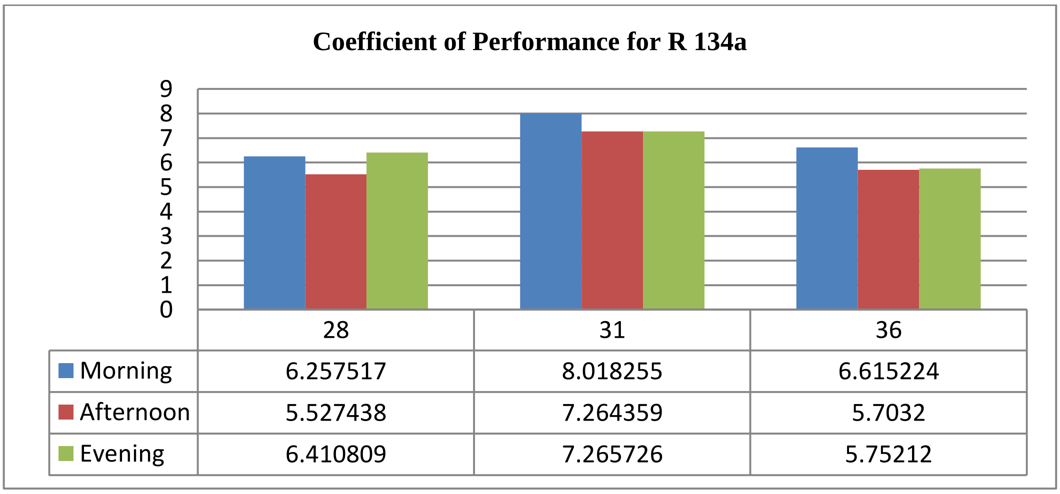


	28	31	36
Morning	0.020128	0.019838	0.019659
afternoon	0.020082	0.019425	0.019718
evening	0.020051	0.019468	0.019838

Graph 6: Mass flow rate for different capillary diameter at different time (R 600a)

The above graph shows the variation of mass flow rate for R134a and R600a for different capillary tubes inner diameter. Figure shows Mass flow rate required for one ton of refrigeration is less for 31 capillary and high for 28. Mass flow rate is inversely proportional to refrigerating effect. Mass flow rate required for one ton refrigeration decreases with increase in capillary tube inner diameter. Mass flow rate increases with increase in capillary inner tube diameter.

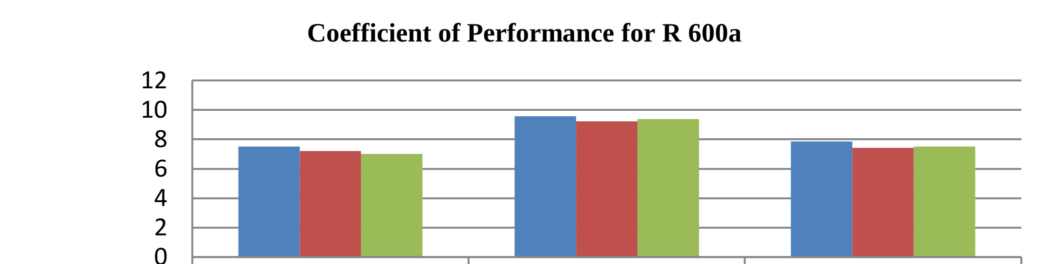
d) Coefficient of performance:



	28	31	36
Morning	6.257517	8.018255	6.615224
Afternoon	5.527438	7.264359	5.7032
Evening	6.410809	7.265726	5.75212

Graph 7: Coefficient of Performance for different capillary diameter at different time (R 134a)

International Journal of Recent Research in Civil and Mechanical Engineering (IJRRCME)
Vol. 2, Issue 1, pp: (59-65), Month: April 2015 – September 2015, Available at: www.paperpublications.org

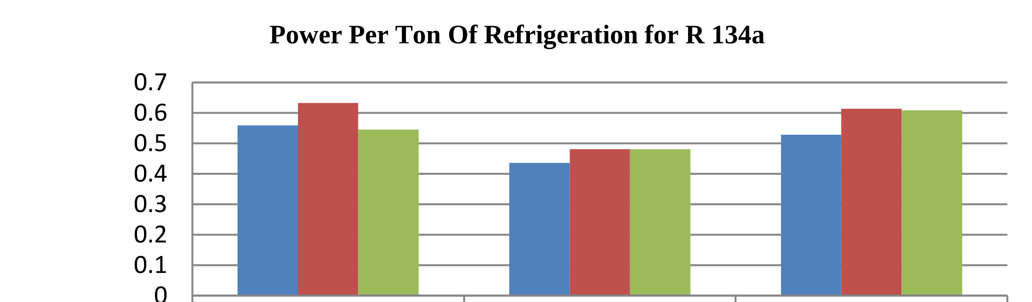


	28	31	36
Morning	7.514689	9.58328	7.865821
Afternoon	7.203322	9.230045	7.427338
Evening	7.010415	9.368412	7.50396

Graph 8: Coefficient of Performance for different capillary diameter at different time (R 600a)

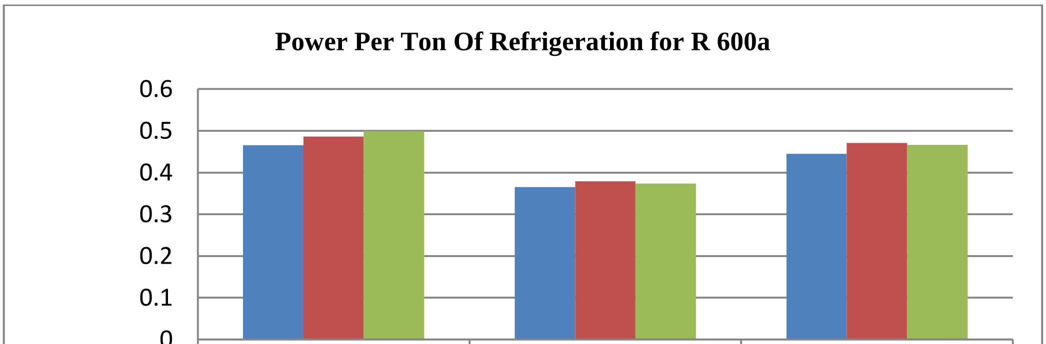
Graph 7 and 8 shows that for R134a and R600a, we get better COP for capillary tube diameter of 31. The COP is higher at morning for both refrigerant and different capillary tubes. The COP is less for capillary 28. For capillary 31 refrigerating effect is more and compressor work is less as compared to other capillary hence COP is high.

e) Power per Ton of Refrigeration:



	28	31	36
Morning	0.559327	0.436504	0.529083
Afternoon	0.633205	0.481804	0.613691
Evening	0.545953	0.481714	0.608471

Graph 9: Power per ton of refrigeration for different capillary diameter at different time (R 134a)



	28	31	36
Morning	0.465754	0.36519	0.444963
Afternoon	0.485887	0.379196	0.471232
Evening	0.499257	0.373596	0.46642

Graph 10: Power per ton of refrigeration for different capillary diameter at different time (R 600a)

As shown in above graph, power per ton of refrigeration is less for 31 capillary and maximum for 28 capillary. In case of power per ton of refrigeration (PPTR) is more at afternoon for all capillary tube diameter. Power per ton of refrigeration decreases with increase in capillary inner tube diameter.

IV. CONCLUSION

In this study, a domestic refrigerator working on vapour compression refrigeration is used for optimization capillary tube inner diameter and performance analysis with refrigerant R 134a and R 600a. The effect of capillary inner tube diameter on the coefficient of performance (COP), mass flow rate, and power per ton of refrigeration is reviewed. The following conclusion can be drawn from the analysis and discussion of the results:

i. R 134a exhibited lower compressor work than R 600a, but R600a exhibited significantly high refrigerating effect, which is compensation for its high compressor work.

ii. R 600a has the higher COP. The average COP's obtained for R 600a were 23% higher than that of R 134a.

iii. Out of three capillary tubes investigated, capillary with 0.031 inch inner tube diameter offers best desirable requirements; it has high refrigerating effect with low compressor work. It results in higher COP compare to other.

iv. In morning, refrigerating effect were more and compressor work were less as compared to whole day time. Compressor work and power consumption were more for same refrigerating effect in afternoon.

REFERENCES

[1] "Performance Analysis of Vapour Compression Refrigeration System Utilizing Different Refrigerant", Ashish Patidar, and Amitesh Paul International Journal of Sciences & Research Technology, pp. 3449-1852, 2014.

[2] "Effect of capillary diameter on the power consumption of VCRS using different refrigerants", Dr. A.G. Matani, and Mukesh K. Agrawal, International Journal of Application or Innovation in engineering & management, pp. 2319-4847, 2013.

[3] "Optimization of capillary tube in Air conditioning system", Akkarat Poolkrajang, and Nopporn Preamjai, Asian Journal on Energy and Environment, 1513-4121, 2009.

[4] "Hydrocarbons as refrigerants - an overview", Eric Granryd, International Journal of Refrigeration 24, pp. 15-24, 2001.

[5] "A homogeneous flow model for adiabatic helical capillary tube", Khan. M.K, R. Kumar, and P.K. Sahoo, ASHRAE Transactions 114(1), pp.239-49, 2008.

[6] "Influence of Geometrical Parameters on Capillary Behavior with New Alternative Refrigerants", S. M. Sami, P.E., H. Maltais and D. E. Desjardins, M.Tech Thesis, School of Engineering University of Moncton, Moncton, NB, E1A 3E9.

[7] "Performance analysis of a domestic refrigerator", M.Y.Taib, A.A.Aziz and A.B.S.Alias, National Conference in Mechanical Engineering Research and Postgraduate Students, 2010.

[8] "Selection of spiral capillary tube for refrigeration appliances", Nishant P. Tekade and Dr. U.S.Wankhede, International Journal of Modern Engineering Research, 2012.

[9] "Experimental study of azeotropic blend (30% propane, 55% n-butane, 15% iso-butane) refrigerant flow through the serpentine capillary tube in vapour compression refrigeration system", Sudharash Bhargava and Jagdev Singh, International Journal of Mechanical and Production Engineering Research and Development, 2013.

[10] "A review of an alternative to R 134a Refrigerant in Domestic Refrigerator", S.P. Chavhan, and S.D. Mahajan, International Journal of Emerging Technology and Advanced Engineering, 2250-2459, 2013

[11] "Refrigeration and Air Conditioning", Domkundwar and Arora, Dhanapat Rai & Co. Eighth edition.