IJMTST is UGC Approved Journal with Journal Id: 43137

International Journal for Modern Trends in Science and Technology, 8(S06): 76-80, 2022

ISSN: 2455-3778 online
DOI: https://doi.org/10.46501/IJMTST08S0712
Available online at: https://www.ijmtst.com/vol8si07.html

Performance Analysis of Domestic Refrigerator Using R600a by Varying L/D Ratio of Capillary Tube

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To Cite this Article
M.Balakrishna, N.P.Manichandra, G.S.N.D.Vamsi, I.S.S.Sabarish and D.H.V.S.S.Venkat. Performance Analysis of Domestic Refrigerator Using R600a by Varying L/D Ratio of Capillary Tube. International Journal for Modern Trends in Science and Technology 2022, 8(S06), pp. 76-80. https://doi.org/10.46501/IJMTST08S0712

Article Info
Received: 26 April 2022; Accepted: 24 May 2022; Published: 30 May 2022.

ABSTRACT

A Domestic Refrigerator is an electrical appliance which is used to store the items for longer period of time to avoid spoiling items.In this research the evaluation of performance of R600a is refrigerant grade Iso-Butane used as a replacement for R12 and R134a in a variety of high temperature refrigeration applications and low global warming potential. Vapour compression system was investigated and the experiment have been conducted by varying L/D ratio of capillary tube in order to achieve best coefficient of performance. The research also have been analyzed how the various important parameters varies with respect to L/D ratio such as, refrigeration effect, power required to run the compressor, mass flow, specific volume, variation of suction and discharge pressures. In order to find optimal value COP, C-Programming has been used to find optimal value of COP for various L/D ratios.

KEYWORDS:R600a, coefficient of performance, capillary tubes, suction pressure gauge, discharge pressure gauge.

1. INTRODUCTION

Refrigeration is one of the methods to lowering the temperature in order to produce cooling effect to an object by removing unwanted heat in it[1]. They are different types of refrigeration systems are used some of them are Mechanical Compression Refrigeration System , Evaporative Cooling system , Thermoelectric Refrigeration and Absorption Refrigeration systems . In this project we are focusing on vapour-compression refrigeration system. The vapour compression refrigeration cycle involves four processes namely compression, condensation, expansion and evaporation[5]. In compression process the vapour refrigerant is compressed in a compressor to a high pressure due to the compression temperature of the vapour refrigerant is also increased after that this high temperature and high pressure vapour refrigerant is entered into the condenser in condensation process in which high temperature vapoursloses its heat to the circulating cooling water of condenser and phase change takes place from vapour to liquid .And then low temperature and high pressure liquid refrigerant enters into the expansion valve and further gets cooled and finally this chilled low pressure liquid refrigerant enters into evaporator where the cooling effect takes place due the absorption of heat from the object or conditioned space and due to this heat exchange the refrigerant gets heated and phase change also takes place . In this project we are using R600a refrigerant. Generally,R12 refrigerant is used but due to R12 refrigerant releases Cfc's which causes the depletion of ozone layer to overcame these disadvantages we are using R600a[3]. The main reason of selecting the R600a is, it is eco-friendly and it is more effective and it consumes less power as compared with

other refrigerants and it consists of better coefficient of performance. In this project we are varying capillary L/D Ratios and experimentally find out the best suitable refrigerant for domestic refrigerators.

2. REALATED WORK

The refrigerants R401C and R134a are compared in reference to the parameters COP and refrigerant effect with and without receiver.The parameters COP and refrigerant effect can also be improved by the incorporation of low-pressure receiver R401C[2].And on the other hand the length of the coil in the system is optimized and various capillary diameters gives better cop of refrigerant[6].

3. PROPOSED WORK

Generally, in this we change the size of the capillary tube and perform the experimental study on coefficient of performance of domestic refrigerator working on vapour compression refrigeration cycle in order to improve the coefficient of performance of refrigerator to get most suitable size of capillary tube[4]. For this experimentation , domestic refrigerator is connected to an experimental setup which consists suction pressure gauge and discharge pressure gauge , eliminator , capillary tubes with nut that can be fixed to test rig , digital temperature indicator , high pressure and low-pressure cutoff , ball valves ,thermocouple etc.

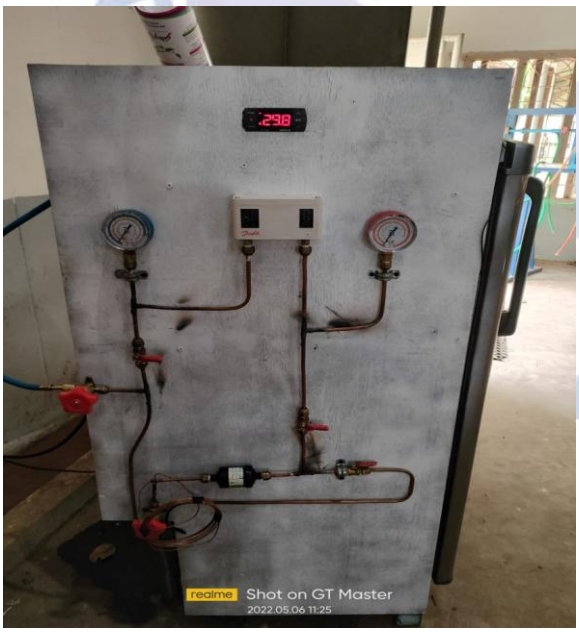

Figure 1:Experimental Test Rig

To perform the experiment suction pressure gauge is connected to the suction side i.e., pipe from compressor inlet and discharge gauge is connected to discharge side i.e., pipe from compressor outlet and other end of this suction and discharge pressure gauges are connected to high pressure and low-pressure cutoff device. In order to control the flow of refrigerant ball valves are connected to the pipes. At discharge side of compressor an eliminator is connected to the pipe that filters the unwanted gas impurities from high pressure hot refrigerant. This provides the refrigerant is flow into the capillary tube and turning into low pressure and low temperature liquid refrigerant and further it is flows into evaporator inlet and outlet pipe of the evaporator is connected inlet side of the compressor there a closed system is formed. A digital temperature indicator is placed on the top of the high pressure -low pressure cutoff. A thermocouple is connected to the temperature indicator which is free move to a required position to determine the temperature of a required spot. After setup the experimental system the refrigerant R600a is charged into the refrigerator and the pressure is noted during the system is at steady state operating condition.

SPECIFICATIONS OF REGRIGERATOR:

Table 1: Specification of the Setup

specifications	
Compressor type	Reciprocating
Refrigerant type	R600a
Refrigerant capacity	185 liters
Capillary diameters	3.1mm ,3.6 mm
Test rig type	Copper

Experimental procedure

- Initially switch on the power unit and wait some time to reach its steady state.
- After reaching the steady state to release the valves and take the suction and discharge readings
- Then place the sub-zero bulb at the inlet and outlet of each and every component and note down the respective readings.

Experimental observation(R600a)

Table 2: Observation for the 3.1mm of dia capillary size length of 2130mm and L/D Ratio is 687mm

Device	Inlet	Outlet
Compressor pressure	3.01 bar	15.5 bar
Compressor	35°C	45°C
Condenser	48°C	36°C
Expansion valve	37°C	29°C
Evaporator	-1°C	31.7°C

Table 3: Observation for the 3.6mm of dia capillary size length of 3650mm and L/D Ratio is 1013mm

Device	Inlet	Outlet
Compressor pressure	2.86 bar	14.3 bar
Compressor	33°C	48°C
Condenser	46°C	37°C
Expansion valve	37°C	21°C
Evaporator	0°C	32.4°C

Table 4: Observation for the 3.1mm of dia capillary size length of 1500mm and L/D Ratio is 484mm

Device	Inlet	Outlet
Compressor pressure	1.9bar	18.61bar
Compressor	28°C	46°C
Condenser	45°C	43°C
Expansion valve	43°C	15°C
Evaporator	-1°C	20°C

Table 5: Observation for the 3.6mm of dia capillary size length of 1800mm and L/D Ratio is 500mm:

Device	Inlet	Outlet
Compressor pressure	1.4 Bar	17.23 bar
Compressor	35°C	55°C
Condenser	49°C	44°C
Expansion valve	43°C	19°C
Evaporator	0°C	32°C

4. RESULTS:

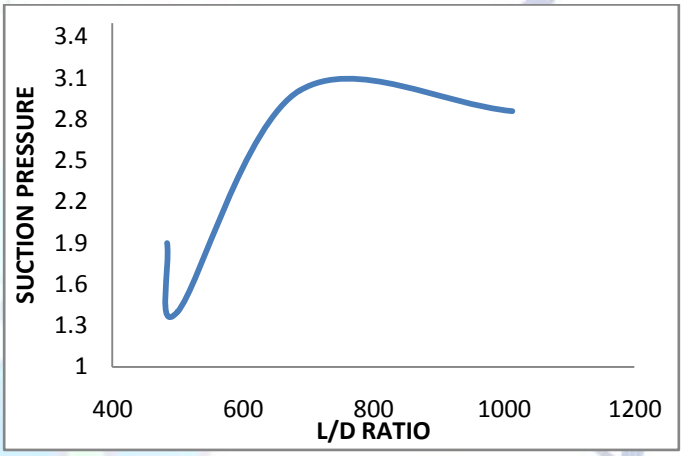

Figure 2: varying suction pressure with l/d Ratio

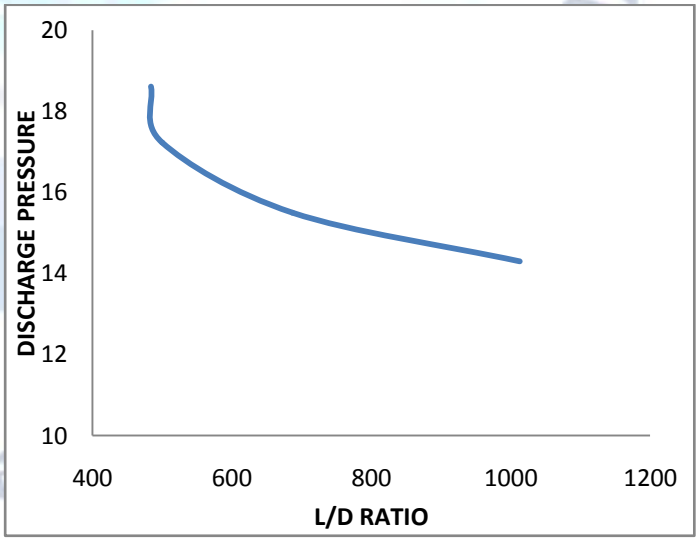

Figure 3: variation of discharge pressure with l/d ratio

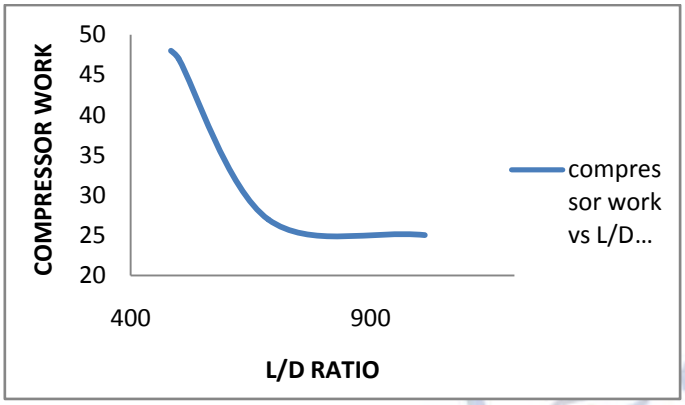

Figure 4: varying compressor work with l/d ratio

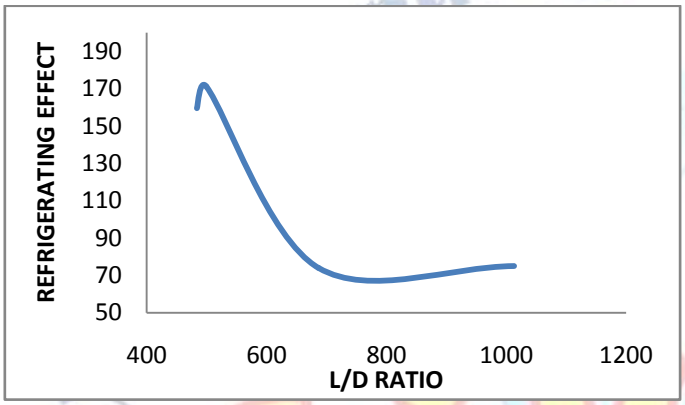

Figure 5: varying refrigerating effect with l/d ratio

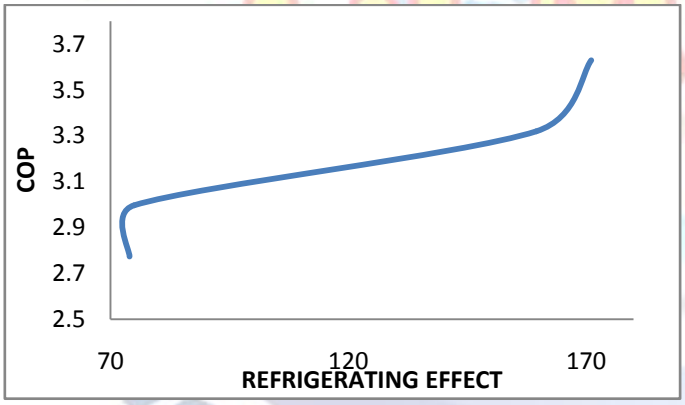

Figure 6: varying cop with refrigerating effect

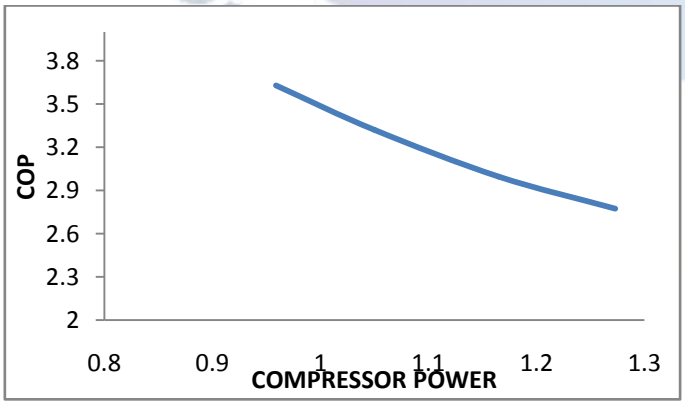

Figure 7: varying cop with compressor power

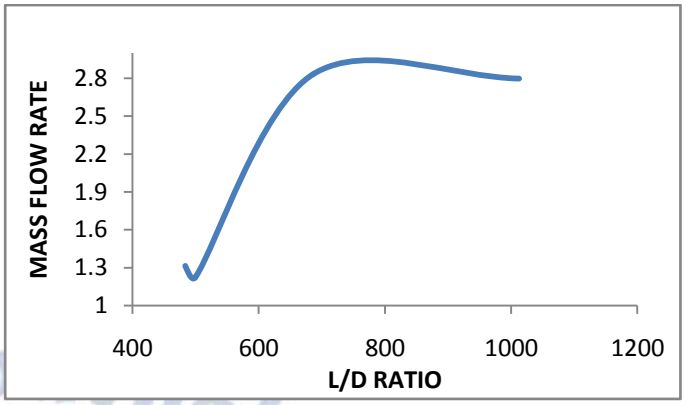

Figure 8: varying mass flow rate with l/d ratio

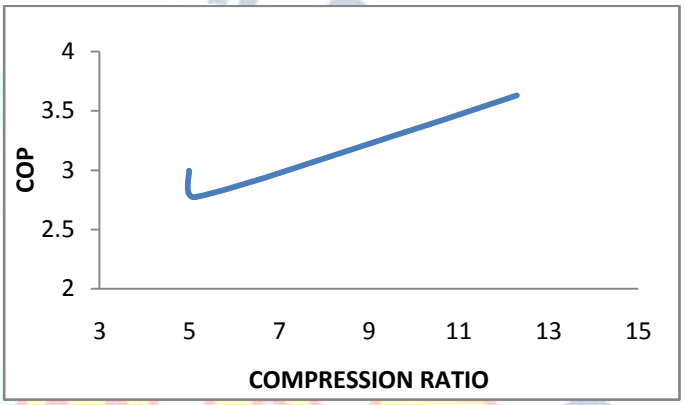

Figure 9: varying cop with compression ratio

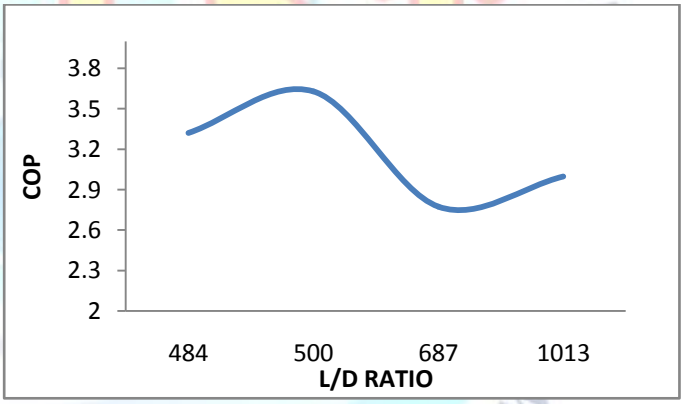

Figure 10: varying cop with l/d ratio

Here plottedbetweenvarious parameters (i.e. suction pressure , discharge pressure , compressor work , refrigerating effect , cop vs. L/D ratio andcop vs. refrigerating effect, compression ratio, compressor power ,L/D ratio and mass flow rate vs. L/D ratio.) and graphically represent the performance curves, which is obtained from the output of the experimentation.

5. CONCLUSION:

Finally, concluded that for the considered domestic refrigerator, R600a-refrigerant with capillary L/D ratio of 500mm gives higher coefficient of performance as compared with other capillary L/D ratios and the optimizing cop is 3.63, when the cop increases the compressor power is decreases and also observed that

the inner diameter of the capillary is directly proportional to the Coefficient of performance of refrigerator. So that, if capillary inner diameter increases there is a significant increase in cooling effect produced in the evaporator of the refrigerator. And there is also decrease in power consumption of a refrigerator while using R600a as a refrigerant. The optimal cop is obtained through optimization technique in C-language.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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