IIETA International Information and Engineering Technology Association
Advancing the World of Information and Engineering

International Journal of Heat and Technology
Vol. 42, No. 6, December, 2024, pp. 1879-1886
Journal homepage: http://iieta.org/journals/ijht

Performance of a VCR System with Variable Capillary Tube Geometry and R134a Refrigerant Charge Through Forced Convection at Various Air Velocities

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https://doi.org/10.18280/ijht.420605

Received: 16 October 2024
Revised: 5 December 2024
Accepted: 19 December 2024
Available online: 31 December 2024

Keywords:
vapour compression refrigeration system, refrigerants, cooling, capillary tubes, P-h diagram, low temperature

ABSTRACT

Refrigerators are now considered to be the most vital component of modern life. The primary criterion is energy usage because the compressor in refrigerators (vapour compression refrigeration systems) needs fuel to work. The main problems brought in by the over use of fossil fuels are the quick depletion of fossil fuel resources and the environmental contamination. Therefore, a methodical approach is required to achieve the refrigeration system's optimized design parameters, which improve the refrigerator's overall functionality and reduce compressor work. Theoretical calculations can be used to create an optimized design, but they are subject to error because of the ambiguity and complexity when heat transmission from the refrigerant through the condenser tube towards the environment is formulated. To overcome this drawback, the problem is dealt practically. The project entails a trial run of an experimental vapour compression refrigeration system using various capillary tube sizes such as 0.031 in, 0.036 in and 0.042 in and refrigerator charges 100 g, 200 g and 300 g. Modification of Condenser & Evaporator coil subjected to forced convection is also incorporated. Investigation will be carried out for optimum geometry of capillary tube subjected to forced convection by regulating the condenser fan speed from 2 m/s to 3 m/s. Finally, the performance of the refrigeration system will be evaluated on different air velocities. And thus, it was found out that the unit working on the capillary tube of size 0.031in and refrigerant R134a had the maximum COP of 2.85, with refrigerant charge of 300 g at condenser fan speed of 3 m/s.

1. INTRODUCTION

The technique of obtaining and maintaining a temperature that is lower than the immediate environment with the intention of cooling a product or area to the necessary temperature is known as refrigeration. Perishable food products are preserved by being kept at low temperatures, which is the most significant use of refrigeration. Air conditioning is the process of altering air while maintaining its temperature, humidity, purity, outdoor, and circulation to meet the needs of the space's inhabitants, a process, or products. The procedure can be carried out in two different ways: naturally by using a medium with a temperature lower than that of the substance to be cooled, and artificially by using a thermodynamic process that results in a working medium with a low temperature.

In order to cool or remove heat from places or entities, a refrigerant is pumped through a combination of mechanical components known as refrigeration. The refrigeration system that is used the most in fridges is fume pressure refrigeration framework. The functioning liquid referenced in the framework is in the condition of fluid and fume. The capacity of specific fluids to retain huge amounts of hotness as they disintegrate is the premise of this framework.

In a VCR system, flowing liquid simply absorbs and dissipates heat from the environment to cool it down, and then releases it outdoors.

Optimizing the refrigeration system's design parameters, which enhance overall refrigerator performance and minimize compressor workload, necessitates a systematic approach.

Blends in refrigerant charges, modification in the geometry of components of VCRS, analysis of various parameters have been studied by many researchers. This work primarily focuses on integrating a fan into the condenser while accounting for air velocities in the assessment of VCRS performance, given the alterations in the geometry of the system components.

2. LITERATURE REVIEW

The impact of a capillary tube's coiled diameter and pitch distance was studied by Abed et al. [1] using a household refrigerator with a 5 ft3 capacity. There are five capillary tubes used, each with dimensions of 1500 mm in length and 2 mm in diameter. The capillary tubes are built in five different ways, with coil diameters (D) that range from 25, 50, 75, 100, and 125 mm in each case. Three coil pitch (P) distances - 6, 8 and 10 mm - are also evaluated. The results shown, when the cabinet temperature is 8°C, as the diameter (D) of the capillary coil increases from 25 to 100 mm, the cycle COP rises from 2.8 to 3.7. COP is unaffected by an increase in coil diameter of greater than 100 mm. However, the cycle COP is only slightly affected by the pitch space of a coiled capillary tube.

Dabas et al. [2] A simple vapour compression refrigeration system's actual COP was investigated experimentally to determine the effects of capillary tube length and refrigerant charge on the overall heat transfer coefficient for the condenser and evaporator. It was determined that raising the refrigerant charge significantly improves the evaporator's total heat transfer coefficient by increasing the area filled by liquid refrigerant. The length of the capillary tube is crucial because it directly influences the evaporator's temperature and pressure. It also has an impact on the likelihood that the evaporator will need to be refilled with liquid refrigerant after initial starting, which changes the amount of optimal charge in the system.

In this inquiry, an R134a-based vapour compression refrigeration unit is thermodynamically analyzed. The experimental investigation of R134a and other refrigerant ratios have been studied [3]. The applied mixtures generally outperformed R134a in terms of overall performance.

Capillary tubes of various diameters used for controlling temperature and pressure in the refrigeration system were the subject of research by Zade et al. [4]. Results are graphed using capillary tubes of various diameters under varied load situations, and inferences are made that demonstrate the influence of coefficient of performance.

R134a, a replacement refrigerant used in refrigeration appliances like home refrigerators and air conditioners, enhanced COP through experimental testing by Coumaressin and Palaniradja [5]. In these studies, it was discovered that the use of CuO-R134a in the vapour compression unit impacted the evaporating heat transfer coefficient by the use of CFD heat transfer analysis using the FLUENT programme.

The examination of the system's COP caused by the capillary tube's coiling impact is the main emphasis of the work, along with the impacts of the tube's diameter, length, coil pitch, and entrance condition on the mass flow rate of refrigerant through helical coil capillary tubes [6]. The incorporation of helical capillary tubes reduces the space needed for the refrigeration system, which is in line with the current trend towards smaller refrigeration systems.

The study of Gil and Singh [7] examined the energy efficiency of R134a/LPG and R134a in a monitored vapour compression refrigeration unit working in various conditions of experimentation. In order to test the system with R134a/LPG (28:72), the capillary tube length, and the refrigerant charge were altered. The study's suggestion to combine R134a with LPG as a VCRS next generation refrigerant appears to be a viable long-term replacement for R134a.

Cabello et al. [8] have investigated the operation of a vapour compression refrigeration unit with three different working fluids: R134a, R407C, and R22. The operating variables are the evaporating pressure, condensing pressure, and degree of superheating at the compressor input. They found that utilizing R22 boosts compression ratio more efficiently than using the other operating fluids.

Rasti et al. [9] used a refrigerant consisting of a combination of hydrocarbons to do research on the energy efficiency index. It comes to the conclusion that there was a 13.3% and a 5.3% decrease in daily energy usage and on-time ratio, respectively. And although the ideal charge for R436a is 55g, the mass of charge for R134a is 105g, showing a 48% less to achieve the same refrigeration capacity.

Bolaji et al. [10] experimentally tested R12, R152a, and R134a to see how well they performed as ozone-friendly hydrofluorocarbon refrigerants. R134a refrigerant was discovered to be interchangeable with R152a in vapour compression systems.

Bolaji [11] mentioned that the new refrigerants R23 and R32 from derivatives of methane, as well as R152a, R143a, R134a, and R125 from derivatives of ethane, are non-toxic, have minimal flammability, and are environmentally benign. To examine the performance of these refrigerants in the system, theoretical and experimental study is required.

Benhadid-Dib and Benzaoui [12] have shown that halogen-containing refrigerants are environmentally harmful, employing "natural" refrigerants is a viable option. They likewise have concerns about replacing harmful cooling fluids like HCFC and reducing greenhouse gas emissions.

VCRS performance with isobutene has been investigated, and the findings with R12 and R22 have been compared [13]. Additionally, they discovered that a setup with just one tube is suitable for chilling applications whereas a setup featuring two capillary tubes functioning in tandem works well for tasks requiring frigid storage and air conditioning.

In a vapour compression refrigeration system, the novel R290 and R600a refrigerant mixture was looked into as an alternative drop-in for R12 and R134a [14]. The results showed that R134a has a slightly reduced COP than R12. The blend of R290 and R600a had discharge temperatures and pressures that were quite similar to those of R12.

Dalkilic and Wongwises [15] have investigated how various ratios of the refrigerant combinations R134a, R152a, R32, R290, R1270, R600, and R600a perform on a VCRS and compared their performance to that of R12, R22, and R134a as potential substitutions. Effective replacement refrigerant mixtures include R290 and R1270 (20/80 by weight%) in place of R22 as well as R290 and R600a (40/60 by weight%) in place of R12.

We looked at the structure and functioning of a condenser that uses R134a refrigerant for air conditioning and refrigeration in this study [16]. To demonstrate the effectiveness of the condensers and determine whether performance might improve with a more potent condenser, experiments were conducted. The Ansys simulation results showed that R134a is a viable refrigerant for refrigeration and air conditioning systems because it is environmentally beneficial.

The review study focuses on the impact of capillary tube design and geometry, including coil, diameter, length, and pitch, on the system's overall performance [17]. Experiments on the effectiveness of the capillary tube topology in the refrigeration unit are carried out while maintaining the correct pressure equalisation between the condenser and the evaporator.

Akintunde [18] analyzed the impact of various capillary tube shapes. This study looked into how a vapour compression refrigeration system will work with helical and serpentine-coiled capillary tubes.

The adiabatic transport of a coolant in a capillary tube is the subject of this investigation [19]. The capillary tube's working fluid in the current study has been changed from R-134a to R600a, along with change in the length and diameter of the capillary tube, which were derived from credible literature.

The usage of a diffuser at the condenser inlet of a vapour compression refrigeration unit has been studied by Saboor et al. [20]. While the system's cop increases by 6.2%, the compressor's labour is reduced by 6.15%.

Jasim and Alaiwi [21] built a novel setup that included a heat exchanger at the condenser outlet and a diffuser between the condenser inlet and compressor. Utilizing these to assess the various R134a refrigerant-related system metrics, including compressor performance, refrigerating effect, and coefficient of performance. When these characteristics were compared to those of the convectional mechanism, the improved system's cop went up by around 1.14.

Hmood et al. [22] created and verified a model to ascertain the steady-state functioning of the capillary tubes (activated with the refrigerants R134a, R1234yf, R1234ze(E), R600, R600a, R152a, and R513A). The capillary tube outlet characteristics of small-scale refrigeration systems primarily determine their operating performance. A capillary tube (CT) with a specific geometry that includes a straight, helical, and suction line heat exchanger (SLHX) section has been the subject of experiments.

3. METHODOLOGY

3.1 Schematic layout

According to Figure 1, the five primary components of the study's architecture were a compressor, an evaporator, a condenser with a fan attached, capillary tubes in three different widths (0.031, 0.036, and 0.042 inches), and a liquid line filter-drier. The condenser-attached fan is run at two and three meters per second. Additionally, the three capillary tubes of varying sizes have valves so that only one capillary tube size can be used during the experiment.

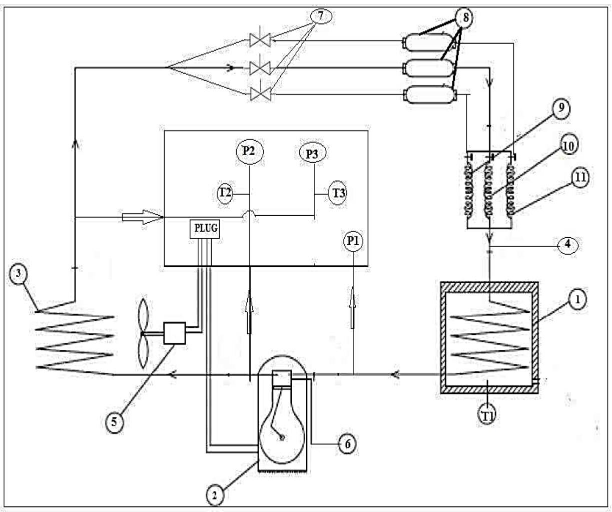

Figure 1. The laboratory setup's conceptual layout

A three-phase, 220V reciprocating compressor made for R134a refrigerant was utilized in the system. The system's input power for the compressor varied between 230 W and 300 W.

Mineral oils made up the majority of the compressor lubrication. The moisture was absorbed using a silica gel drier. Because of their effective heat transfer capabilities, compact forced air-cooled type condensers were utilized. We employed capillary tubes with various interior sizes to determine the system's ideal operating points. Copper tubing and a fibre tank were used to create the evaporator part.

R134a is the refrigerant in use. A gas flow control valve, an electrical switch, a digital thermometer, a bourdon tube type low pressure gauge, and high-pressure gauges are some of the system's additional measuring and regulating components as shown in Figure 2.

Figure 2. Experimentation environment

3.2 Experimental calculations

Plots were made to determine the COP of the trial VCRS across different capillary tube sizes.

The graph was plotted by taking the notations as: 1-Evaporator, 2-Compressor, 3-Condenser and 4-Capillary Tube.

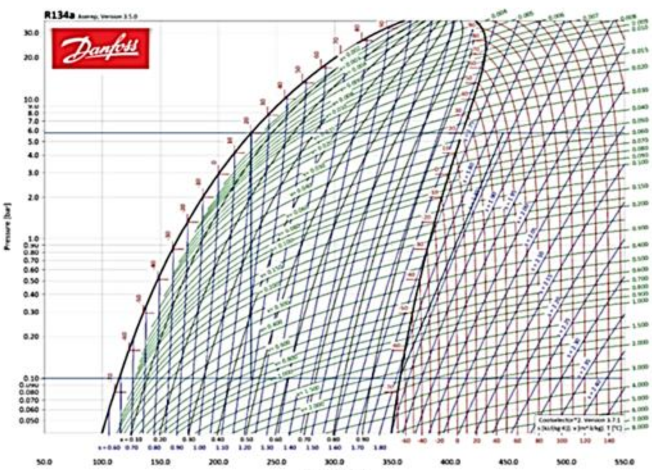

Figure 3. Data from tests using a capillary tube size 0.031 inches and a refrigerant charge of 100 g with condenser fan velocity=3 m/s

$h1$=365 kJ/kg, $h2$=450 kJ/kg, $h3$=$h4$=238 kJ/kg corresponding to the pressures are taken from the graph shown in Figure 3.

$$\text{Work input: } h2 - h1 = 450 - 365 = 85\ \frac{kj}{kg} \tag{1}$$

$$\text{Refrigeration Effect: } h1 - h4 = 365 - 238 = 127\ \frac{kj}{kg} \tag{2}$$

$$\text{COP: } \frac{Q}{W} = \frac{127}{85} = 1.49 \tag{3}$$

$$\text{Mass flow rate: } \dot{m} = \frac{3.150\times10^{-3}\times210}{127} = 5.21 \times 10^{-3}\ \frac{kg}{min} = 5.21\ \frac{g}{min} \tag{4}$$

$$\text{Pressure ratio: } \frac{Pcomp}{P_{eva}} = \frac{6.9}{0.1} = 69 \tag{5}$$

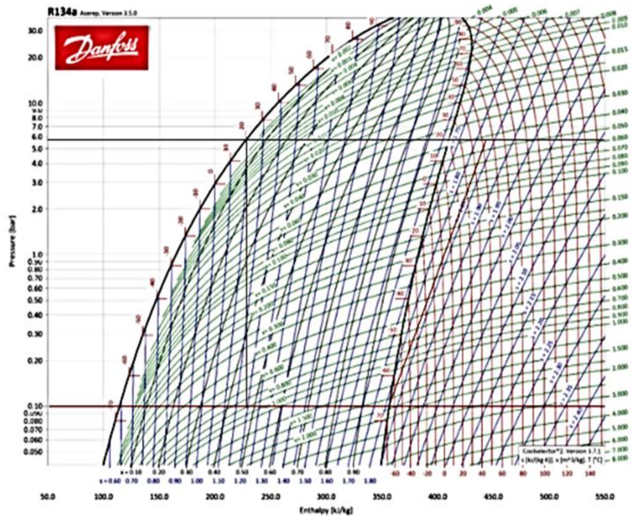

Figure 4. Data from tests using a capillary tube size 0.031 inches and a refrigerant charge of 100 g with condenser fan velocity=2 m/s

$h1$=353 kJ/kg, $h2$=445 kJ/kg, $h3$=$h4$=230 kJ/kg corresponding to the pressures are taken from the graph shown in Figure 4.

$$\text{Work input: } h2 - h1 = 445 - 353 = 92\ \frac{kj}{kg} \tag{6}$$

$$\text{Refrigeration Effect: } h1 - h4 = 353 - 230 = 123\ \frac{kj}{kg} \tag{7}$$

$$\text{COP: } \frac{Q}{W} = \frac{123}{92} = 1.34 \tag{8}$$

$$\text{Mass flow rate: } \dot{m} = \frac{3.150\times10^{-3}\times210}{123} = 5.37 \times 10^{-3}\ \frac{kg}{min} = 5.37\ \frac{g}{min} \tag{9}$$

$$\text{Pressure ratio: } \frac{Pcomp}{P_{eva}} = \frac{6.8}{0.1} = 68 \tag{10}$$

$h1$=365 kJ/kg, $h2$=443 kJ/kg, $h3$=$h4$=243 kJ/kg corresponding to the pressures are taken from the graph shown in Figure 5.

$$\text{Work input: } h2 - h1 = 443 - 365 = 78\ \frac{kj}{kg} \tag{11}$$

$$\text{Refrigeration Effect: } h1 - h4 = 365 - 243 = 122\ \frac{kj}{kg} \tag{12}$$

$$\text{COP: } \frac{Q}{W} = \frac{122}{78} = 1.56 \tag{13}$$

$$\text{Mass Flow rate: } \dot{m} = \frac{3.150\times10^{-3}\times210}{122} = 5.42 \times 10^{-3}\ \frac{kg}{min} = 5.42\ \frac{g}{min} \tag{14}$$

$$\text{Pressure ratio: } \frac{Pcomp}{P_{eva}} = \frac{7.7}{0.35} = 22 \tag{15}$$

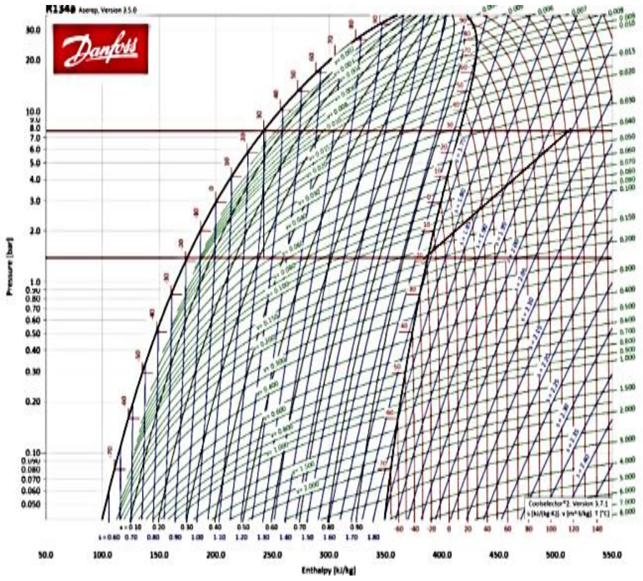

Figure 5. Data from tests using a capillary tube size 0.031 inches and a refrigerant charge of 200 g with condenser fan velocity=3 m/s

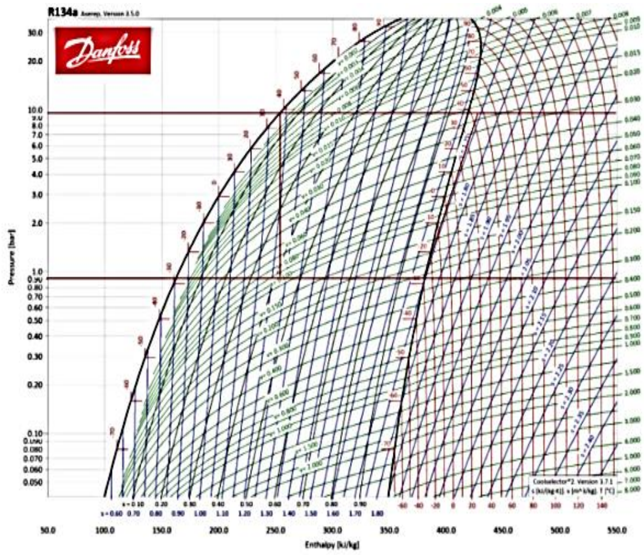

Figure 6. Data from tests using a capillary tube size 0.031 inches and a refrigerant charge of 200 g with condenser fan velocity=2 m/s

$h1$=393 kJ/kg, $h2$=491.66 kJ/kg, $h3$=$h4$=245 kJ/kg corresponding to the pressures are taken from the graph shown in Figure 6.

$$\text{Work input: } h2 - h1 = 491.66 - 393 = 98.66\ \frac{kj}{kg} \tag{16}$$

$$\text{Refrigeration Effect: } h1 - h4 = 393 - 245 = 148\ \frac{kj}{kg} \tag{17}$$

$$\text{COP: } \frac{Q}{W} = \frac{148}{98.66} = 1.5 \tag{18}$$

$$\text{Mass flow rate: } \dot{m} = \frac{3.150\times10^{-3}\times210}{148} = 4.47 \times 10^{-3}\ \frac{kg}{min} = 4.47\ \frac{g}{min} \tag{19}$$

$$\text{Pressure ratio: } \frac{Pcomp}{P_{eva}} = \frac{8}{0.15} = 53.3 \quad (20)$$

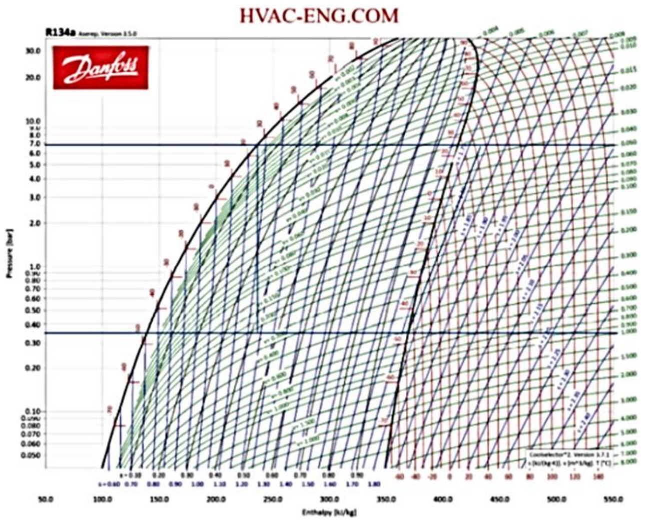

Figure 7. Data from tests using a capillary tube size 0.031 inches and a refrigerant charge of 300 g with condenser fan velocity=3 m/s

$h1$=390 kJ/kg, $h2$=438 kJ/kg, $h3$=$h4$=253 kJ/kg corresponding to the pressures are taken from the graph shown in Figure 7.

$$\text{Work input: } h2 - h1 = 438 - 390 = 48 \ \frac{kj}{kg} \quad (21)$$

$$\text{Refrigeration Effect: } h1 - h4 = 390 - 253 = 137 \ \frac{kj}{kg} \quad (22)$$

$$\text{COP: } \frac{Q}{W} = \frac{137}{48} = 2.85 \quad (23)$$

$$\text{Mass flow rate: } \dot{m} = \frac{3.150\times10^{-3}\times210}{137} = 4.82\times10^{-3} \ \frac{kg}{min} = 4.82 \ \frac{g}{min} \quad (24)$$

$$\text{Pressure ratio: } \frac{Pcomp}{P_{eva}} = \frac{10.6}{1} = 10.6 \quad (25)$$

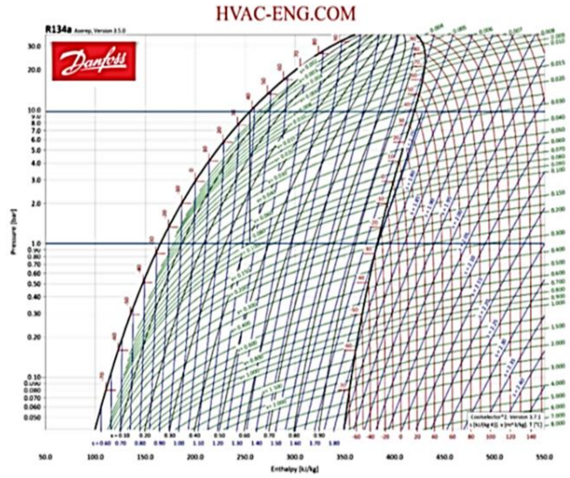

Figure 8. Data from tests using a capillary tube size 0.031 inches and a refrigerant charge of 300 g with condenser fan velocity=2 m/s

$h1$=385 kJ/kg, $h2$=435 kJ/kg, $h3$=$h4$=253 kJ/kg corresponding to the pressures are taken from the graph shown in Figure 8. The data from experiments using capillary tubes with 0.036 and 0.042-inch diameters are shown in Table 1.

$$\text{Work input: } h2 - h1 = 435 - 385 = 50 \ \frac{kj}{kg} \quad (26)$$

$$\text{Refrigeration Effect: } h1 - h4 = 385 - 253 = 132 \ \frac{kj}{kg} \quad (27)$$

Table 1. Similarly, data from experiments using capillary tubes with 0.036 and 0.042-inch diameters and refrigerant charges 100 g, 200 g, 300 g with fan speeds 3 m/s and 2 m/s were carried out and all the results are tabulated as follows

S.No.	Dia of Capillary Tube (inches)	Refrigerant Charge(g)	Fan Speed (m/s)	Work Input (kJ/kg)	Refrigeration Effect (kJ/kg)	COP	Mass Flow Rate (g/min)	Pressure Ratio
1.	0.031	100	3	85	127	1.49	5.21	69
		100	2	92	123	1.34	5.37	68
		200	3	78	122	1.56	5.42	22
		200	2	98.66	148	1.5	4.47	53.3
		300	3	48	137	2.85	4.82	10.6
		300	2	50	132	2.64	5.01	11.67
2.	0.036	100	3	85	133	1.56	4.97	68
		100	2	93	127	1.37	5.20	67
		200	3	93	113	1.21	5.8	70
		200	2	130.6	145	1.11	4.56	80
		300	3	72	120	1.67	5.51	16.43
		300	2	87.3	131	1.5	5.05	16
3.	0.042	100	3	75	125	1.67	5.29	28.75
		100	2	96	117	1.22	5.65	68
		200	3	70	130	1.85	5.08	12.57
		200	2	72.22	130	1.8	5.08	21.25
		300	3	60	125	2.08	5.29	7.14
		300	2	70.5	141	2	4.69	8

Note: Load on evaporator is calculated as follows 15 bottles of 200ml each = 3 liters OR Bottle and water weight (in grams) = 210 grams load on evaporator = 210 * 15 = 3150 grams.

$$\text{COP: } \frac{Q}{W} = \frac{132}{50} = 2.64 \quad (28)$$

$$\text{Mass flow rate: } \dot{m} = \frac{3.150\times10^{-3}\times210}{132} = 5.01 \times 10^{-3}\ \frac{kg}{min} = 5.01\ \frac{g}{min} \quad (29)$$

$$\text{Pressure ratio: } \frac{Pcomp}{P_{eva}} = \frac{10.5}{0.9} = 11.67 \quad (30)$$

4. RESULTS AND DISCUSSIONS

4.1 Experimental results and graphs

The Vapour Compression Refrigeration Cycle's performance varies greatly depending on the capillary tube's diameter and refrigerant charge based on experimentation conducted on domestic refrigeration system. Calculations are done with the load on evaporator as 3150 grams. Utilizing calculations and graphs, the system's COP is calculated in the manner listed below.

COP of the refrigeration unit using 100g of refrigerant charge and 0.031-inch capillary tubes at fan speed of 3 m/s= 1.49
COP of the refrigeration unit using 100g of refrigerant Charge and 0.031-inch capillary tubes at fan speed of 2 m/s= 1.34
COP of the refrigeration unit using 100g of refrigerant Charge and 0.036-inch capillary tubes at fan speed of 3 m/s= 1.56
COP of the refrigeration unit using 100g of refrigerant Charge and 0.036-inch capillary tubes at fan speed of 2 m/s= 1.37
COP of the refrigeration unit using 100g of refrigerant Charge and 0.042-inch capillary tubes at fan speed of 3 m/s= 1.67
COP of the refrigeration unit using 100g of refrigerant Charge and 0.042-inch capillary tubes at fan speed of 2 m/s= 1.22
Similarly, the COP of a refrigeration unit with capillary tubes of 0.031 in, 0.036 in, and 0.042 in diameters and refrigerant charges of 200 g and 300 g at fan speeds 3 m/s and 2m/s is examined. Graphs are used to plot the results. The following graphs analyse and display the relation between capillary tube size as well as performance metrics.

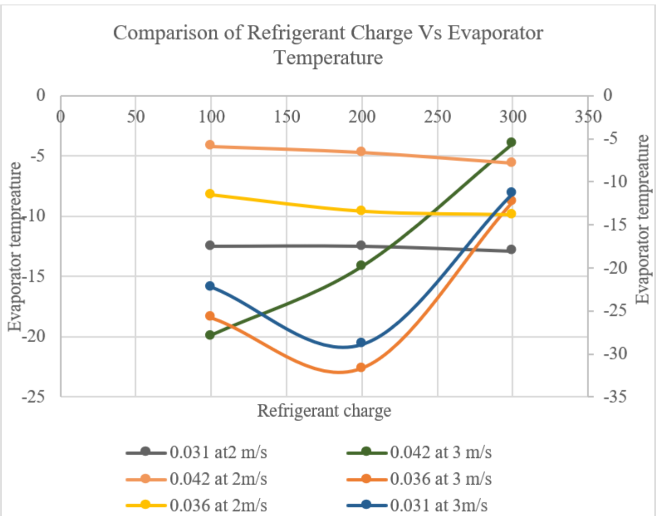

Figure 9. Comparison of the evaporator temperature and Refrigerant charge for VCRS for different capillary tube diameters with condenser Fan velocity = 3 and 2 m/s

- It is observed from Figure 9 that the capillary tube diameter 0.031 inches has the lowest evaporator temperature of -24°C at refrigerant charge of 200 g and fan speed of 3 m/s. The COP is observed to be 1.56.

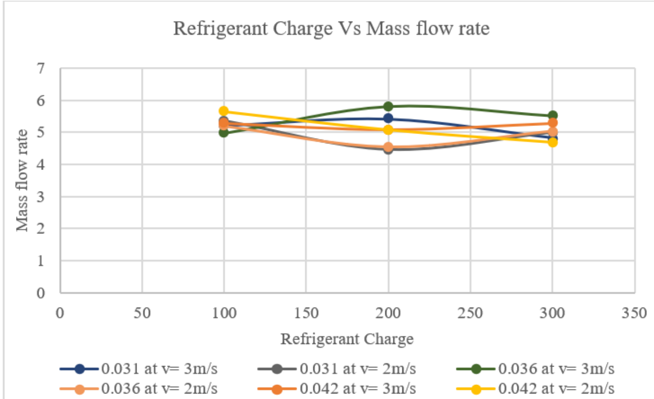

Figure 10. Comparison of refrigerant charge vs mass flow rate for VCRS for different capillary tube sizes at fan speeds 3 and 2 m/s

- It is observed from Figure 10 that, the capillary tube size 0.042in, operates at 100 g refrigerant and a 2 m/s fan speed. The highest mass flow rate recorded was 5.65 g/min. The COP under these conditions is 1.22.
- The minimum mass flow rate is 4.47 g/min for the capillary tube size 0.031in, a refrigerant charge of 200g, and a fan speed of 2 m/s. The COP under these conditions is 1.5.

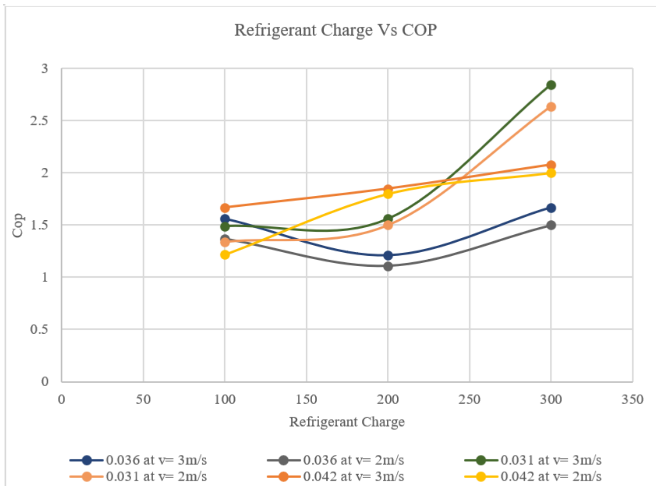

Figure 11. Refrigerant charge vs. COP for VCRS for various capillary tube sizes at 3 and 2 m/s

- From Figure 11, the capillary tube size 0.031in, at fan speed 3 m/s, COP of VCRS is observed to be 2.85 which is maximum for a refrigerant charge of 300 g.
- Also observed that the capillary tube size 0.036in, at fan speed 2 m/s, COP of VCRS is observed to be 1.11 which is minimum for a refrigerant charge of 200 g.
- From Figure 12, the capillary tube size 0.036in, at fan speed 2m/s, and a refrigerant charge of 200 g, pressure ratio is observed to be 80 which is maximum. The COP under these conditions is 1.11.
- Additionally, the capillary tube size of 0.042in, a fan speed 3 m/s, and a refrigerant charge of 300g is seen to have a pressure ratio of 7.14, which is the lowest value. The COP under these conditions is 2.08.

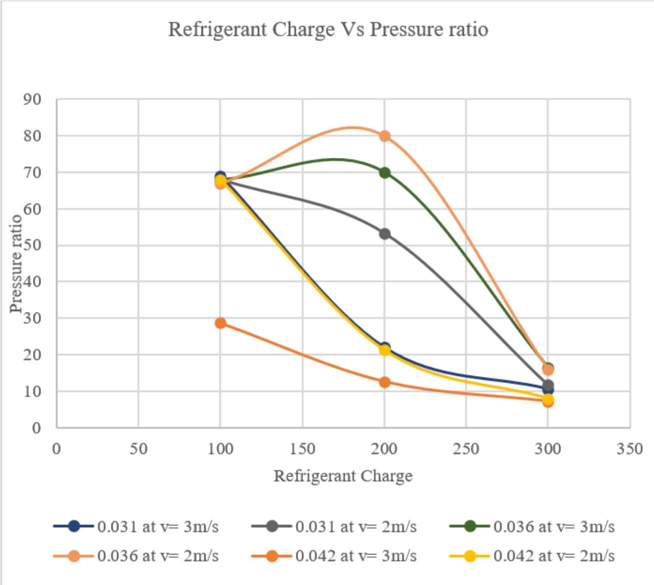

Figure 12. Comparison of refrigerant charge vs pressure ratio for VCRS for different capillary tube diameters at fan speeds 3 and 2 m/s

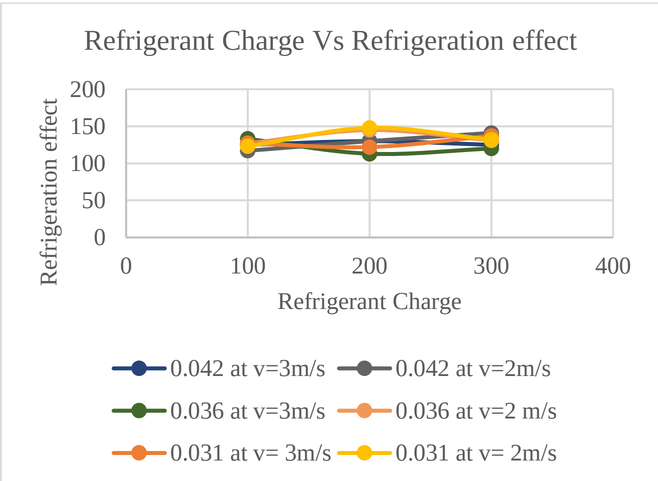

Figure 13. Comparison of refrigerant charge vs refrigeration effect for VCRS for different capillary tube diameters at fan speeds 3 and 2 m/s

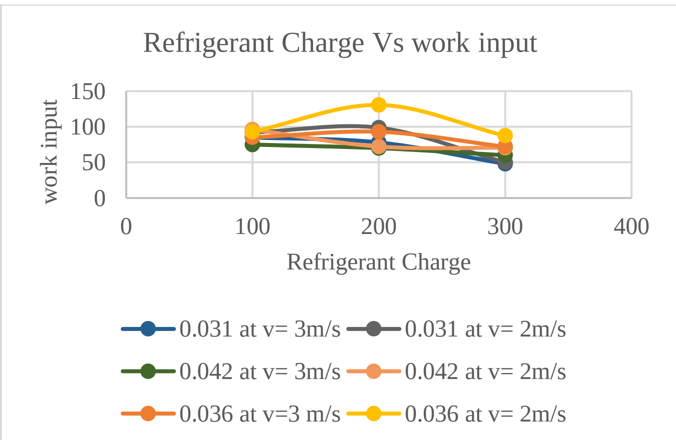

Figure 14. Comparison of refrigerant charge vs work input for VCRS for varoius capillary tube sizes at fan speeds 3 and 2 m/s

- From Figure 13, the Refrigeration effect is observed to be maximum (148 kJ/kg) for a capillary tube size 0.031in and refrigeration charge of 200g with fan speed of 2 m/s. The COP under these conditions is 1.5.
- Refrigeration effect is observed to be minimum (113 kJ/kg) for a capillary tube size 0.036in and refrigeration charge of 200 g with fan speed of 3 m/s. The COP under these conditions is 1.21.
- From Figure 14, for a capillary tube diameter of 0.031inches, work input is observed to be minimum (48 kJ/kg) at fan speed of 3 m/s and refrigerant charge being 300 g. The COP under these conditions is 2.85.
- For a capillary tube diameter of 0.036inches, work input is observed to be maximum (130.6 kJ/kg) at fan speed of 2 m/s and refrigerant charge being 200g. The COP under these conditions is 1.11.

5. CONCLUSIONS

Experimental research has been done to assess the system performance under numerous operating conditions. A separate Experimental Setup has been fabricated for determining pressure, temperature, and Coefficient of Performance along with the Constant length of three Capillary tubes of different diameters and condenser fan velocity.

The investigations lead to the following findings.

- The capillary tube's length is maintained constant in the current study for various capillary tube diameters, speeds, with R-134a as the refrigerant.
- From all the graphs the unit working on the capillary tube of size 0.031in and refrigerant R134a had the maximum COP of 2.85, with refrigerant charge of 300 g at condenser fan speed of 3m/s compared to 2 m/s.
- With a 300 g refrigerant charge and a 3 m/s fan speed as opposed to a 2 m/s speed, the ideal capillary tube for a household single door refrigerator is one with an inner diameter (ID) of 0.031 inches.
- The system's cooling effectiveness at 200 g of refrigerant charge and 0.031-inch capillary tube size and 2 m/s fan speed is more than the remaining ones.
- For capillary tubes with the largest diameter, it is observed the discharge of the refrigeration system is lowest.
- As the capillary tube's size rises, the compressor pressure ratio falls.
- According to test results, the refrigeration effect significantly improves as the capillary tube's size rises.

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