EXPERIMENTAL ANALYSIS ON THE PERFORMANCE OF VAPOUR COMPRESSION REFREGERATION SYSTEM USING DIFFERENT REFRIGERENTS

Mr. Amit Pandey[1], Dr.Ajay Singh[2], Prof. Nitin Barodia[3],

1 Research Scholar, Department of Mechanical Engineering, Radharaman Institute of Technology & Science Bhopal, MP, India.

2 Professor & Head, Department of Mechanical Engineering, Radharaman Institute of Technology & Science Bhopal, MP, India.

3 Asst. Professor, Department of Mechanical Engineering, Radharaman Institute of Technology & Science Bhopal, MP, India

Abstract: In Vapour compression refrigeration system used are a different diameter and shape of capillary tube and refrigerant. The design of capillary is helical capillary tubes and refrigerant of R134a and R134a mix in Hydrocarbon (HC). The capillary tube used mostly in the refrigerant flow control devices. Hence performance of the capillary tube should be good for smooth refrigerant flow. In domestic refrigerators widely used refrigerant R134a. R134a refrigerant is a Hydro fluorocarbon (HFC) with high global warming potential of 1200 and hence it A numerical study has been carried out for with CO2 refrigerant. The numerical models are developed based on the fundamental conservation principles of mass, momentum, and energy. Within this, outer loop, the ordinary differential equations are solved from the inlet to the exit of the capillary tube. Helical coiled capillary tube of 1.5mm, 1.7mm, 1.9mm diameter carried out from of refrigerant R134a and mix in Hydrocarbon (HC). The findings of the experimental study revealed that the mass flow rate is maximum for the 1.9 mm diameter of the capillary tube and is found to be 4.2g/s and 1.7mm diameter of the capillary tube and is found to be 4.5g/s at same operating conditions for R134a&HC. Moreover, for the mixture of R134a&HC maximum pressure ratio at 1.5mm dia. of capillary is 11.81 and minimum pressure ratio at 1.9mm dia. of capillary is 8.40 C.O.P assessed for R134a at 1.7mm dia. capillary gave better result over the 1.9mm dia. and 1.7mm dia. capillary. Maximum COP is found to be 4.50 at 1.9 mm diameter. Carnot C.O.P for R134a refrigerant at 1.7mm diameter capillary is found to be 4.28 and for mixture of R134a&HC at 1.9mm diameter capillary is 4.5 which is better than another diameter. In this study it has been concluded that the performance mixture of refrigerant R134a&HC is found to be better than R134a. The present work is focused on the influence of tube diameter, tube length, coil pitch, and inlet condition on mass flow rate of refrigerant through helical coil capillary tube and also on investigation about the Coefficient of Performance (COP) of the system due to coiling effect of capillary tube. The use of helical capillary tube reduces the space for the refrigeration system which is the need for more compact refrigeration system in the current trend.

Keywords: - Vapor compression Refrigeration System, capillary tube, refrigerants, coefficient of performance.

I. Introduction

Refrigeration is the 'artificial' extraction of heat from a substance in order to lower its temperature to below that of its surroundings. Primarily, heat is extracted from fluids such as air and many liquids, but ultimately from any substance. In order to extract heat a region of 'cold' has to be created. In thermodynamic terms a refrigerator is a reversed heat engine. I.e. heat may transfer from a cold reservoir to a hot reservoir by expending work. Modern refrigerators operate by the same reverse-heat-engine principle. Whereas a heat engine converts heat (from a high-temperature area) to work, a refrigerator converts work to heat. Modern refrigerators use substances other than air as the coolant; the coolant substance changes from gas to liquid as it goes from higher to lower temperature. This change from gas to liquid is a phase transition, and the energy released upon this transition is mainly dependent on the intermolecular interactions of the substance. Refrigeration maintains the temperature of the heat source below that of its surroundings while transferring the extracted heat and any required energy input, to a heat sink, atmospheric air, or surface water.[12] A refrigeration system is a combination of components and equipment connected in a sequential order to produce the refrigeration effect.

The vapor compression system uses a circulating liquid refrigerant as a working medium which absorbs and removes heat from the space to be cooled and subsequently rejects that heat to some other space. There are several mechanical components required for the refrigeration system. Among that several components there are four major components of a system and some auxiliary equipment associated with these four major components. These components include condenser, evaporators, compressor, and refrigerant lines and piping, refrigerant capacity controls, receivers, and accumulators.

2.0 Literature Review

S.K.gugulothu et.al [1] The performance parameters such as pull-down time, desired effect, power consumption, and running cost of the system are to be analyzed at different eve- orator temperatures, the mass of refrigerant and varying length of capillary tubes. To evaluate the refrigeration effect, Power consumption and COP of the domestic refrigerator at various freezer temperatures (–9°C, –12°C & –15°C) were selected. Results report that out of all the alternative mixtures the amount of energy input was less consumed in the case of HCM1 at a minimal expansion length of 6.3 mm. In the case of HCM5, the least energy was consumed at a capillary length of 5.24 mm whereas in the case of R134a it was at 3.3 mm.

y. chandrasekhar yadav et.al [2] the design of capillary tube plays a very important role in the performance of a vapour compression refrigeration system. Optimized design is possible through theoretical calculations, however may fail due to the reason that the uncertainties in the formulation of pressure drop inside the capillary tubes. Hence experimental investigations are the best in terms of optimization of certain design parameters. Components of the vapour compression refrigeration system never work in isolation; change in performance of one component affect the performance of the other components and in turn overall performance of the system. Performance of the system also depends on the type, quantity of the refrigerant charged.

Miss. Rohini Zade et.al [3] capillary tube of different diameter used to control the temperature and pressure in the refrigeration unit .results are plotted on the graph by using the capillary tube of different diameter with different load condition and conclusion are drawn showing the effect of coefficient of performance (cop). The objective of the study was to compare the refrigeration performance of different capillary tube diameters with different load conditions. The present work is focused on the influence of tube diameter on mass flow rate of refrigerant through helical coil capillary tube and also on investigation about the Coefficient of Performance (COP) of the system due to coiling effect of capillary tube.

Zhaohua Li et.al [4] In this research paper a comparative study on energy efficiency of R600a, R717, R 1234 and R134a in domestic refrigerator using in oil-free linear compressor. In this experiment the test rig consist with two similar linear compressors, an evaporator with electric heater and an off-the-shelf water-cooled coaxial condenser. Various operation are performed in the test rig and the result show that the R717 (ammonia) has the highest cooling capacity, power input, resonant frequency while R600a (iso butane) has the lowest, and R1234yf has identical mass flow rate, saturation pressure, power input and resonant frequency of R134a which could be regarded as an ideal drop-in alternative to R134a with minor changes for an existing refrigerator and a slight efficiency drop.

Muhammad Tauseef Nasir et.al [5] The objective was to locate the most reasonable blend of working liquids considering R245fa, R600, R600a and R134a as refrigerants for ORCVCC framework trading heat with water as heat source. Subsequently, multi-target advancement was led to decide ideal working conditions by amplifying the second law productivity and limiting the estimation of the UAtot. At the outdoor temperature of 30 °C, R245fa ORC-R600a VCC was the best mix while at 35 °C and 40 °C, R600a ORC-R245fa VCC rules. Technique for order of preference by similarity to ideal solution (TOPSIS) was utilized to pick the ideal structure arrangement from Pareto front. In general, the ideal answer for heat source at 95 °C showed most elevated decrease in UAtot up to 37% in a roundabout way lessening the framework by and large expense while forcing the sentence of under 10% in second law efficiency compared to the maximum value.

Mert Tosuna Bahadır Doğanb M. et.al [6] This trial study is completed on a commercial household refrigerator in a climatic chamber regarding IEC standards. During the trials, two sorts of smaller than usual channel condensers have been dissected with five diverse capillary lengths and five varying coolant sums so as to locate the best blend for better execution. The results of the investigation discharge the limits for either capillary length or refrigerant amount, which are 3.25 m and 50 g, As an outcome of the analyses, the common association of the refrigerant charge amount and the capillary cylinder length on the vitality utilization of the ordinary fridges are introduced for the two kinds of smaller than usual channel heat exchangers.

Pravin Jadhav & Neeraj [7] In this manuscript author focus on the flow characterization of the simple straight and spiral capillary tube of a carbon dioxide (CO2) and R22 refrigerants are statistically investigated. Here a homogenous one dimensional steady state adiabatic flow model is created using basic principles of thermodynamics and fluid dynamics. Churchill and Ju et al. employed friction factor correlations as well. The models are created using the energy, mass and momentum law of conservation equations. The impact of pitch of the spiral capillary cylinder on refrigerant mass flow rate is examined. A decrease in a mass flow rate by 22% and 15% of the spiral cylinder is seen with CO2 and R22 refrigerant, individually.

Liu Zhang et.al [8] In this study analysis the mixture of refrigerant combing HFCs/HCs are better substitute to decrease the flammability of HCs while lowering the GWP of HFC. In this paper four types of HCFs/HCs mixture of refrigerants which is (R290/R134a, --R600a/R134a, and R1270/134a) with different compositions are investigated in vapor compression heat pump cycle. The effect of HCs refrigerant fraction on the mixture properties, including saturated liquid line, critical temperature, latent heat, critical pressure, and isotropic behavior are comparatively a analyzed. thermodynamic model is installed of heat pump simulation. For each R134a/HCs mixtures both the heating and cooling coefficient of performance normally first decrease and increase with the HCs mass friction.

Mohd Hazwan Yusof and Sulaiman Mohd Muslim [9] : The present work emphasizes on determining the performance of the air conditioner over a variation of outdoor temperatures. As recently featured, since the examination work was not led as per the ARI 210/240 norm, the outcomes couldn't be contrasted straightforwardly with the maker's information and past works by experts. However, it provides information on how the system performs and react with outdoor temperature variations. The conclusions are as follows: The condenser performance of the air conditioner maxed at lowest outdoor temperature, To = 30°C. The total cooling capacity (CT) and COP dropped with the increase in the outdoor temperature. As the outdoor temperature increased from 30°C to 36°C, the CT and COP dropped by 3.7% and 10.9% respectively.

Azridjal Aziz1 et.al [10]: The effect of cooling load on the performance of R22 RSAC when retrofitting with HCR22 as the working fluid in the standard condition has been conducted. The outcomes illustration evidence that the COP of RSAC surge with the growing cooling load, on the other hand the COP with HCR22 rise 16.10%, 12.66%, 16.56% and 19.99% greater than R22 for the cooling load of 0 W, 1000 W, 2000 W and 3000 W, respectively. The power consumption of compressor were censored with HCR22 which is lower than that of R22 by around 18.27%, 20.1%, 16.26% and 22.56% for different cooling load of 0 W, 1000 W, 2000 W and 3000W while the cooling of HCR-22 R-22 was Increasing the COP (%) Cooling Load capacity as well as the heat rejection capacity is maintained almost equal to that of the R22just slightly lower in value.

Adrián Mota-Babilonia et.al [11] In this research paper reduction in GHG emissions is a priority for stopping climate change. Such a decrease can be accomplished through an expansion in the energy efficiency and lessening the measure of refrigerant utilized in cooling frameworks, along these lines legitimately affecting the GWP. R32, with a GWP of 677, is being considered as an option to R410A (GWP of 1924) in cooling apparatuses in Europe and the USA. The present status of refrigerant R32 has been introduced in this work, and the principle ends are as per the following. The thermodynamic properties of R32 are very much characterized, and current examinations have concentrated on characterizing the most exact blend properties reachable. R32 is less combustible than hydrocarbons, and the measure of refrigerant permitted is adequate to be utilized in RACs.

Sharmas ValiShaika and T.P. Ashok Babub [12] The paper present theoretical examination of several alternative refrigerants of R22. In this paper alternative refrigerant blend of R1270,R290,R134a,R32,R170 at various composition are considered. All the refrigerants possess low GWP and zero ODP compared to R22. The main objective of these work is to calculate thermodynamic performance of standard vapour compression refrigeration cycle (SVRC) with R22 and its alternative refrigerants. A MATLAB programming language code is evolved to itemize the thermodynamic performance of all the considered refrigerant. Thermodynamic analysis of the refrigerants are rated at the condensing temperature 54.4°C and evaporating temperature 7.2°C. the result show that coefficient of performance for the refrigerant mixture Re170/R1270/R134a(7.5/37.5/55 by % of mass) is 5.35% higher between the R22,R470C and four refrigerant. In this paper is about the different evaporating temperature by keeping condenser temperature as constant.

K.Harby et.al [13] The utilization of hydrocarbons offers a great drop-in substitute for the current halogenated refrigerants regarding natural effects and vitality utilization. In this examination, an audit of the past investigations did with hydrocarbons as elective refrigerants in refrigeration, cooling and heat pump, here vehicle cooling frameworks is also introduced and the results demonstrated that regardless of profoundly combustible qualities, hydrocarbons can offer legitimate options to the halogenated refrigerants from the point of view of condition sway, energy effectiveness, COP, refrigerant mass, and compressor discharge temperatures Guide on the future work needs in this field is introduced. At long last, a synopsis of past examinations and techniques on unadulterated HC, HC blends, and HC/HFC mixes utilized for various applications has been introduced and talked about in detail.

Santosh kumar dubba et.al [14] In this paper discuss the flow characteristic of refrigerant over the diabetic and adiabatic capillary tubes to other geometries like coiled and straight. The summary of this paper the efficient techniques revealed in literature to increase the overall performance of a capillary tube based refrigeration system. The examine the flow characteristic of HCFC/HFRC/CFC refrigerants, their blends inside the capillary tubes. The transcritical R-744 is efficient with capillary tube for heat pump or refrigeration system. This paper the flow characteristic of refrigerants over adiabatic and diabetic capillary of different geometries and predict the number of model and its flow behaviors in a different capillary tubes have been prepared based on homogenous flow assumption.

Buddha Chouhan et.al [15] capillary tubes are used as expansion device in low capacity refrigeration machines like domestic refrigerators and window type air conditioners. The advantages of the capillary tube over other expansion devices are simple, inexpensive and cause compressor to start at low torque as the pressure across the capillary tube equalize during the off-cycle. The flow characteristics of refrigerants through capillary tubes have been studied extensively in past six decades, both experimentally and analytically, most of these studies mainly focused on straight capillary tubes.

3.0. Experimental Procedure

We start compressor and one finger is attached at the mouth of the capillary because our stopper valve is being open, the compressor starts sucking all the air present in supply pipe of the system and throwing it out to the surrounding through the condenser and the moisture content inside the system is eliminated by supplying 10 grams of refrigerant. The system is completely vacuumed now so we start filling refrigerant gas. For comparing the performance of the R134a&H.C and R134a systems, tests were carried out initially with R134a. Firstly, the system was charged with 120 g of R134a by the manufacturing specifications, and the energy performance tests were conducted to evaluate the C.O.P, pressure ratio, mass flow rate, the Energy efficiency and the total energy destruction in the refrigeration system with a capillary tube length of 4.4m.

In the first time, we run the set-up using R134a as a refrigerant. Fill the refrigerant with a mass of 120 g. Mass of charged is measured by the digital weighing balance. One end of the compressor is remaining closed that provided for charging refrigerant we welded a gas charging valve to charge refrigerant when required. One end of charging valve is connected with a compressor charging line and other end connected with refrigerant cans. In charging valve hand regulated valve is fitted. Valve is open and therefore the refrigerant has started the charging after 120 g stops the valve and removes the charging pipe and prepared for testing. Now turn on and provides power supply through energy meter. Here we use a soap bubble test to perform a leak detection test.

Within the soap bubble test, a solution is made by detergent powder with water and using sponge and cover within the joint part like pressure gauge, capillary joint, evaporator joint etc. If any leakage occurs then repair After the testing system is prepared to figure with R134a refrigerant. In starting we are given the load 1 Kg water at the normal temperature at 15- minute interval reading start and each 15 minutes take the reading. First set the 1.5 mm diameter capillary and take the entire the reading. And after taking reading change the capillary 1.7mm diameter and similarly take the reading again change 1.9mm diameter reading and take all reading. Now change the refrigerant of the system which is another important part of in this experiment. New refrigerant is the mixing of hydrocarbon and R134a in the ratio of 72:28 by mass. Mass of mixture is 100 g in this experiment. The mass of mixture is 72 g hydrocarbon and 28 g R134a. This charge is filling in the previous method. In this process, we are increasing the load.

In the first time, we run the set-up using R134a as a refrigerant. Fill the refrigerant with a mass of 120 g. Mass of charged is measured by the digital weighing balance. Valve is open and therefore the refrigerant has started the charging after 120 g stops the valve and removes the charging pipe and prepared for testing. Now turn on and provides power supply through energy meter. Here we use a soap bubble test to perform a leak detection test.

Within the soap bubble test, a solution is made by detergent powder with water and using sponge and cover within the joint part like pressure gauge, capillary joint, evaporator joint etc. If any leakage occurs then repair after the testing system is prepared to figure with R134a refrigerant. In starting we are given the load 1 Kg water at the normal temperature at 15- minute interval reading start and each 15 minutes take the reading. First set the 1.5 mm diameter capillary and take the entire the reading. And after taking reading change the capillary 1.7mm diameter and similarly take the reading again change 1.9mm diameter reading and take all reading. Now change the refrigerant of the system which is another important part of in this experiment. New refrigerant is the mixing of hydrocarbon and R134a in the ratio of 72:28 by mass. Mass of mixture is 100 g in this experiment. The mass of mixture is 72 g hydrocarbon and 28 g R134a. This charge is filling in the previous method. In this process, we are increasing the load.

Fig.3.1 Experimental test setup.

4. Result and Discussion

In this literature comparison of variation of pressure ratio, $(C.O.P)_{max}$ or Carnot C.O.P, respect to time. Show the graph of these variations and result discuss below. In this literature, the graph is plotted in three diameters 1.5mm, 1.7mm, and 1.9mm for R134a and mixture of R134a& H.C.

4.1 Performance analysis for R134a refrigerant of Refrigeration system

4.1.1 Effect of time duration on pressure ratio at different diameter of capillary tube for R134a Refrigerant

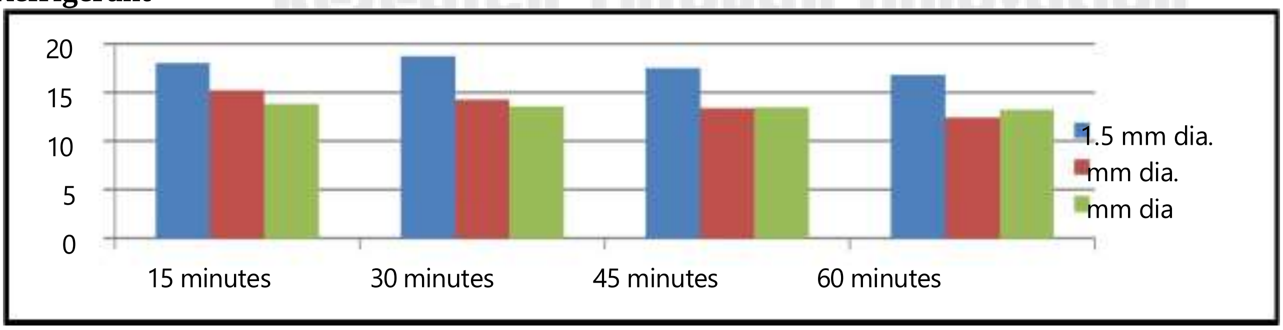

Fig 4.1.1 Effect of time duration on pressure ratio at different diameter of capillary tube

Figure 4.1.1 shows that the effect of time duration on pressure ratio at capillary tube diameters in 1.5mm maximum pressure ratio is 18.70 and minimum pressure ratio is 16.84. whereas in 1.7mm diameter, maximum pressure ratio is 15.21 and minimum pressure ratio is 12.40. In 1.9mm diameter maximum pressure ratio is 13.78 and minimum pressure ratio is 13.19. We know that C.O.P of the system is increase with decreasing the pressure ratio because increase the pressure ratio increase the compressor work and decrease the refrigeration effect. In the whole study of pressure ratio, minimum pressure ratio get for 1.7 mm diameter is 12.40 and maximum pressure ratio is got for 1.5mm diameter capillary 18.70.

4.1.2 Effect of time duration on $(C.O.P)_{max}$ at different diameter of capillary tube for R134a Refrigerant

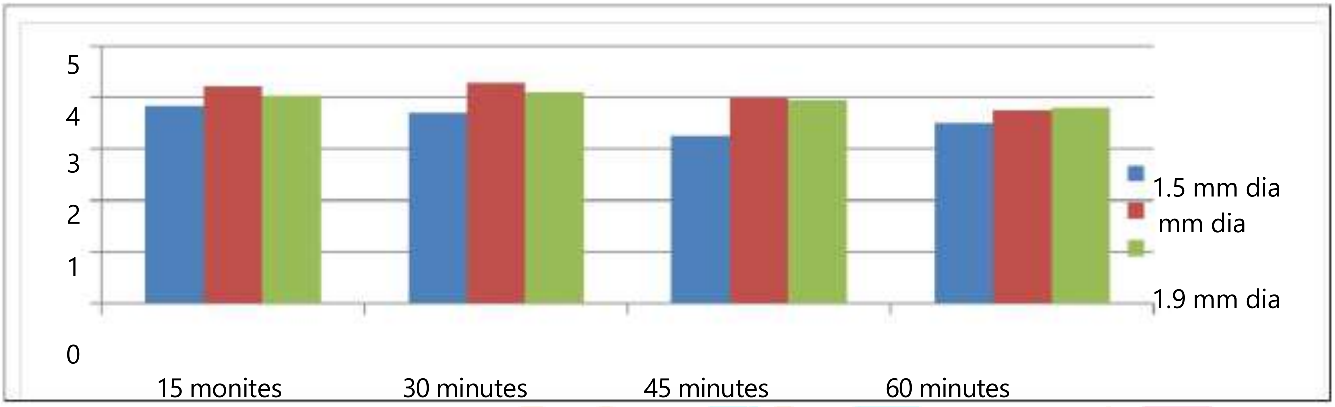

Fig 4.1.2 Effect of time duration on $(C.O.P)_{max}$ at different diameter of capillary tube

Figure 4.1.2 shows that the effect of time duration on (C.O.P)max at different diameter of capillary tube is the important factor in the refrigeration system, The variation of $(C.O.P)_{max}$ with respect to time. In 1.5mm dia. the maximum $(C.O.P)_{max}$ is 3.84 and minimum $(C.O.P)_{max}$ is 3.51, for 1.7mm diameter we have find maximum $(C.O.P)_{max}$ is 4.28 and minimum $(C.O.P)_{max}$ is 3.75 and in 1.9mm diameter maximum $(C.O.P)_{max}$ is 4.03 and minimum $(C.O.P)_{max}$ is 3.8. The maximum $(C.O.P)_{max}$ is 4.28 for 1.7 mm diameter and minimum $(C.O.P)_{max}$ is 3.51 for 1.5mm diameter.

4.1.3 Effect of time duration on $(C.O.P)_{actual}$ at different diameter of capillary tube for R134a Refrigerant

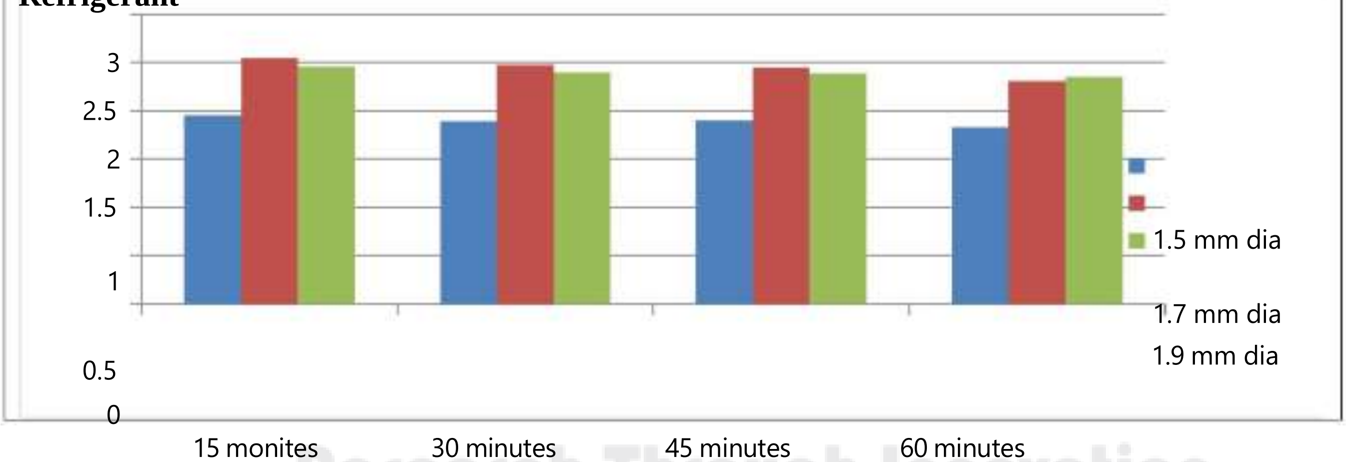

Fig. 4.1.3 Effect of time duration on $(C.O.P)_{actual}$ at different diameter of capillary tube

Figure 4.1.3 shows that the effect of time duration on $(C.O.P)_{actual}$ is the important factor in the refrigeration system. The figure shows the bar is variation of $(C.O.P)_{actual}$ with respect to time. In 1.5mm dia. the maximum $(C.O.P)_{actual}$ is 1.95 and minimum $(C.O.P)_{actual}$ is 1.83, for 1.7mm diameter we have find maximum $(C.O.P)_{actual}$ is 2.55 and minimum $(C.O.P)_{actual}$ is 2.31 and in 1.9mm diameter maximum $(C.O.P)_{actual}$ is 2.46 and minimum C.O.P is 2.35. The maximum $(C.O.P)_{actual}$ is 2.55 for 1.7mm diameter and minimum $(C.O.P)_{actual}$l is 1.83 for 1.5mmb diameter.

4.1.4 Effect of time duration on mass flow rate at different diameter of capillary tube for R134a Refrigerant

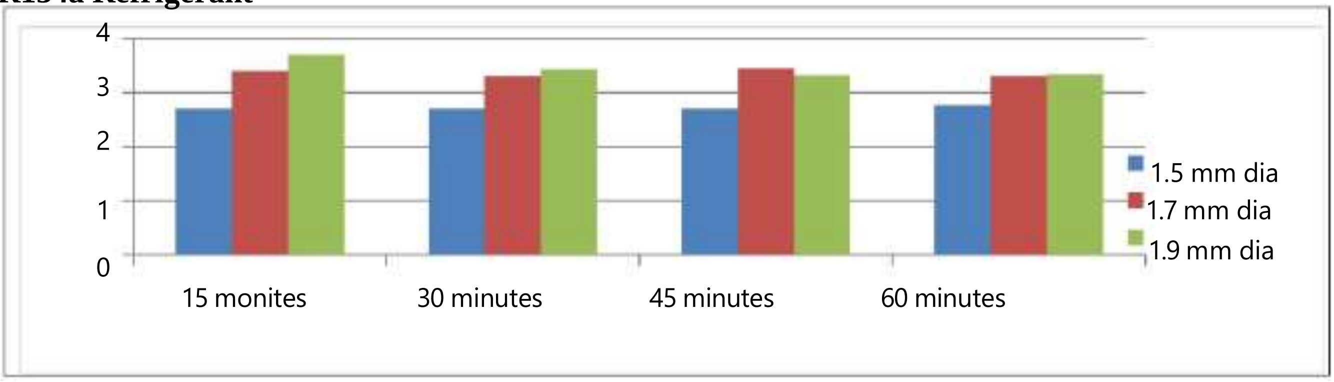

Fig. 4.1.4 Effect of time duration on mass flow rate at different diameter of capillary tube

Figure 4.1.4 shows that the effect of time duration on mass flow rate at different diameter of capillary tube with different diameter of Mass flow rate is directly related with the refrigeration capacity. But C.O.P of the system does not depend on mass flow rate. Below show in the bar, maximum mass flow rate. For 1.5mm diameter maximum mass flow rate is 2.77g/s and minimum mass flow rate is 2.72g/s, for 1.7mm diameter maximum mass flow rate is 3.45g/s and minimum mass flow rate is 3.33g/s and in 1.9mm diameter mass flow rate is 3.70g/s and minimum mass flow rate 3.33 g/s. The maximum mass flow rate is 3.70g/s for 1.9mm diameter and minimum mass flow is 2.72g/s.

4.2 Performance analysis for R134a refrigerant of Refrigeration system

4.2.1 Effect of time duration on pressure ratio at different diameter of capillary tube for mixtures of R134a&H.C refrigerant

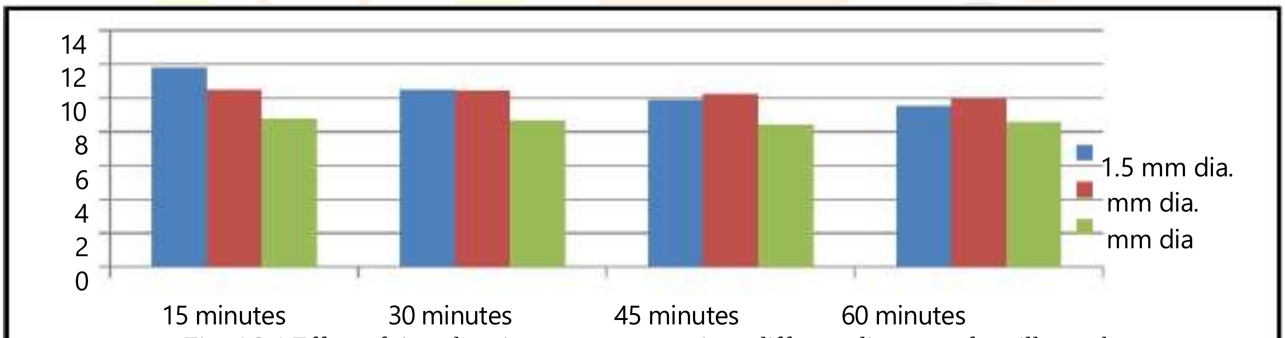

Fig. 4.2.1 Effect of time duration on pressure ratio at different diameter of capillary tube

The figure 4.2.1 shows the variation of pressure ratio with three different diameters. In 1.5mm diameter maximum pressure ratio is 11.81 and minimum pressure ratio is 9.54. Whereas in 1.7mm diameter, maximum pressure ratio is 10.6 and minimum pressure ratio is 10 and in 1.9mm diameter, maximum pressure ratio is 8.79.and minimum pressure ratio is 8.40 We know that C.O.P of the system is increase with decreasing the pressure ratio because increase the pressure ratio increase the compressor work and decrease the refrigeration effect. The pressure ratio graph minimum pressure ratio get in the 1.9 mm diameter is 8.4, and maximum pressure ratio is get in 1.5 mm diameter capillary is 11.81.

4.2.2 Effect of time duration on $(C.O.P)_{max}$ at different diameter of capillary tube for mixtures of R134a&H.C refrigerant

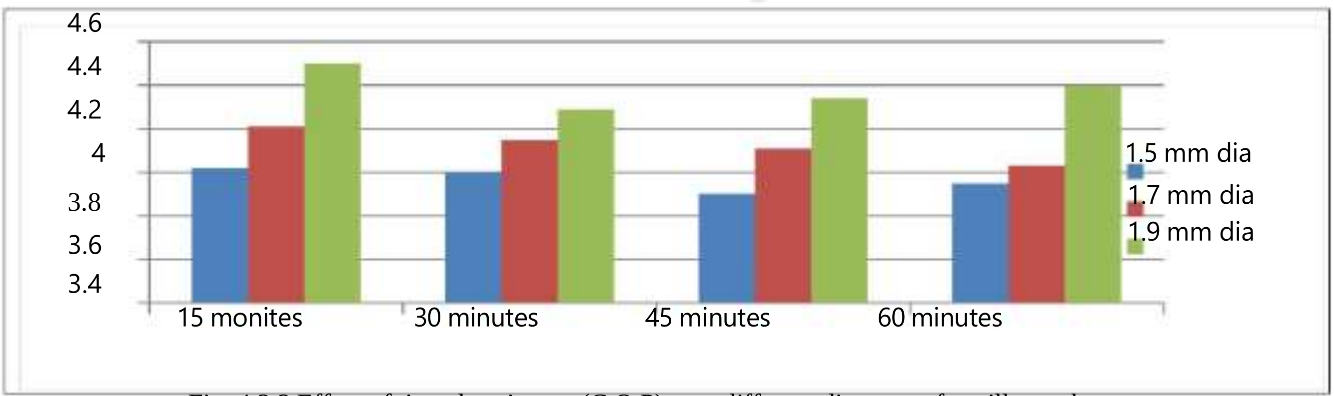

Fig. 4.2.2 Effect of time duration on $(C.O.P)_{max}$ at different diameter of capillary tube

Figure 4.1.2 shows that the effect of time duration on C.O.P$)_{max}$ at different diameter of capillary tube with (C.O.P$)_{max}$ is the very important factor in the refrigeration system, Table shows the bar is variation of (C.O.P$)_{max}$ with respect to time. In 1.5mm dia. maximum (C.O.P$)_{max}$ is 4.02and minimum (C.O.P$)_{min}$ is 3.90, for 1.7 diameter we have find maximum (C.O.P$)_{max}$ is 4.21 and minimum (C.O.P$)_{min}$ is 4.03 and in 1.9mm diameter maximum (C.O.P$)_{max}$ is 4.50 and minimum (C.O.P$)_{min}$ is 4.29. The maximum (C.O.P$)_{max}$ is 4.50 for 1.9mm diameter and minimum (C.O.P$)_{min}$ is 3.90 for 1.5mm diameter.

4.2.3 Effect of time duration on (C.O.P$)_{actual}$ at different diameter of capillary tube for mixtures of R134a&H.C refrigerant

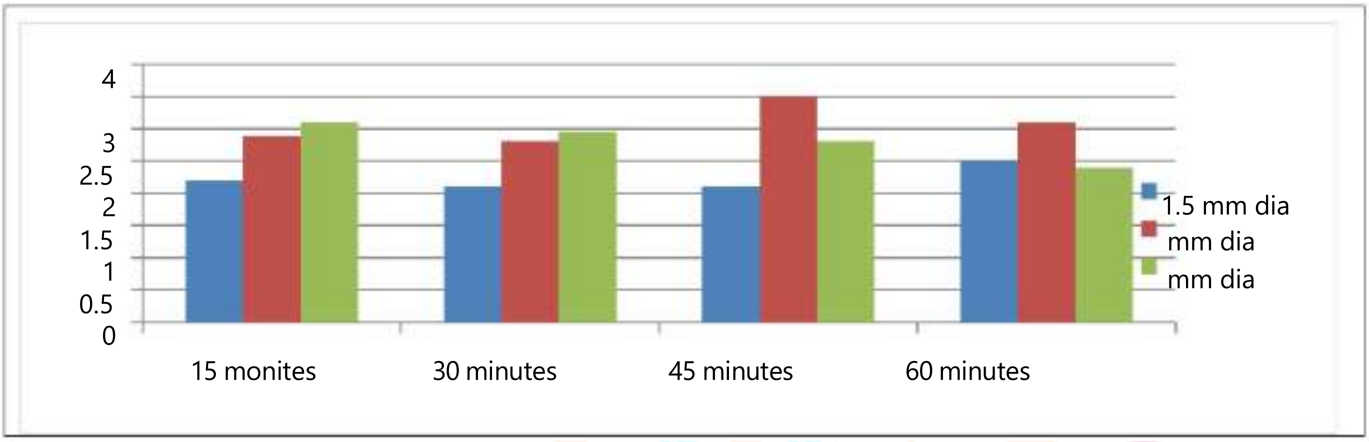

Fig. 4.2.3 Effect of time duration on (C.O.P$)_{actual}$ at different diameter of capillary tube

Figure 4.1.3 shows that the effect of time duration on (C.O.P$)_{actual}$ at different diameter of capillary tube with (C.O.P$)_{actual}$ is the important factor in the refrigeration system. The figure shows the bar is variation of (C.O.P$)_{actual}$ with respect to time. In 1.5mm dia. the maximum (C.O.P$)_{actual}$ is 2.5 and minimum (C.O.P$)_{actual}$ is 2.1, for 1.7mm diameter we have find maximum (C.O.P$)_{actual}$ is 3.5 and minimum (C.O.P$)_{actual}$ is 2.81 and in 1.9mm diameter maximum (C.O.P$)_{actual}$ is 3.1 and minimum C.O.P is 2.52. The maximum (C.O.P$)_{actual}$ is 3.5 for 1.7mm diameter and minimum (C.O.P$)_{actua}$ is 2.1 for 1.5mm diameter.

4.2.4 Effect of time duration on mass flow rate at different diameter of capillary tube for mixtures of R134a&H.C refrigerant

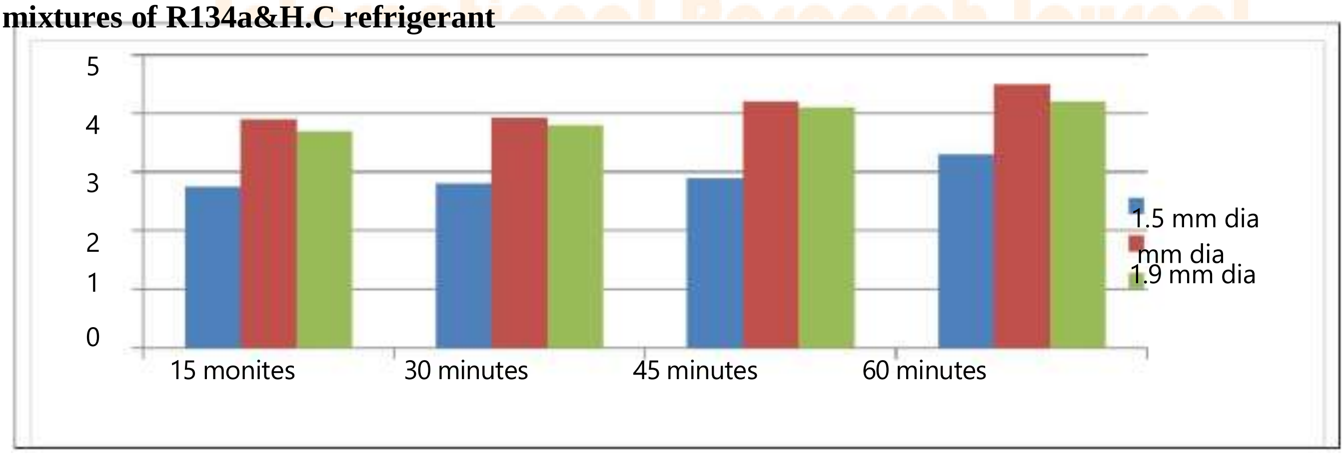

Fig. 4.2.4 Effect of time duration on mass flow rate at different diameter of capillary tube

The figure 4.2.4 shows the variation of mass flow rate with respect to time with different diameter. Mass flow rate is directly related with the refrigeration capacity. But C.O.P of the system does not depend on mass flow rate. Below show in the bar, maximum mass flow rate. For 1.5mm diameter maximum mass flow rate is 3.3g/s and minimum mass flow rate is 2.75g/s, for 1.7mm diameter maximum mass flow rate is 4.5g/s and minimum mass flow rate is 3.9g/s and in 1.9mm diameter mass flow rate is 4.2g/s and minimum mass flow rate 2.7g/s. The maximum mass flow rate is 4.50g/s for 1.7mm diameter and minimum mass flow is 2.75g/s.

4.3 Comparative analysis for R134a and mixture of R134a&H.C refrigerant in Refrigeration system

Above we are draw various type figures of R134a and mixture and discusses individually. Now we are going to discusses comparatively analysis of R134a and mixture.

4.3.1 Comparative analysis pressure ratio at 1.5 mm capillary tube diameter for R134a and mixture of R134a&H.C

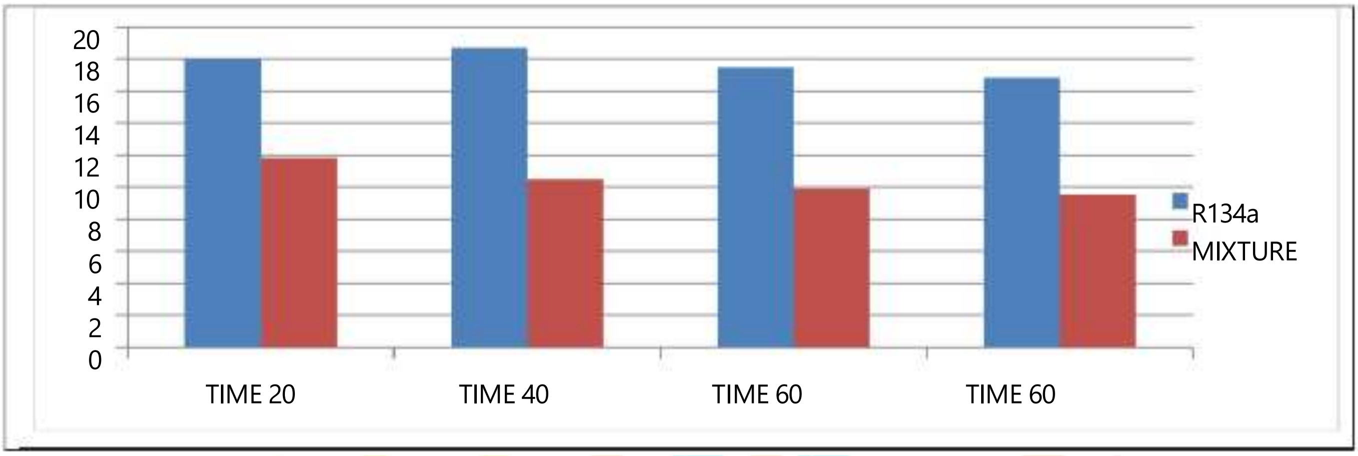

Fig. 4.3.1 Effect of time duration with pressure ratio for R134a and mixture of R134a&H.C

The figure 4.3.1 shows the variation of pressure ratio of the R134a and mixture refrigerant for 1.50mm diameter. In the figure we have seen that pressure ratio of R134a is always greater than mixture. At first reading pressure ratio of R134a is 52.41% greater than mixture. After 15-minute gap of pressure ratio increase and pressure ratio of R134a is 78.0% greater than of mixture. After 30- minute gap of pressure ratio is decrease and 76.9% greater than mixture and at the last reading we have calculated pressure ratio of R134a is 76.51% greater than mixture. The pressure ratio of R134a is average 70.95% greater than mixture.

4.3.2. Comparative analysis of pressure ratio at 1.7 mm capillary tube diameter for R134a and mixture of R134a&H.C

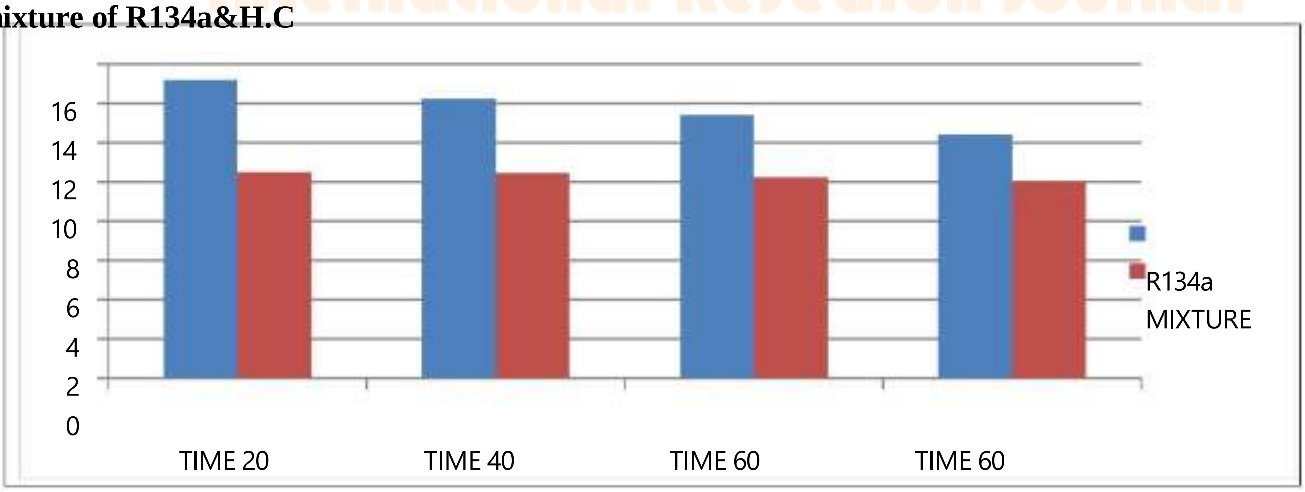

Fig. 4.3.2 Effect of time duration with pressure ratio for R134a and mixture of R134a&H.C

The figure 4.3.2 shows the variation of pressure ratio of the R134a and mixture refrigerant for 1.70mm dia. In the figure we have seen that pressure ratio of R134a is always greater than mixture. At first reading pressure ratio of R134a is 44.85% greater than mixture. After 15 minute gap of pressure ratio increase and pressure ratio of R134a is 36.49% greater than of mixture. After 30 minute gap of pressure ratio is increase and 30.73% greater than mixture and at the last reading we have calculated pressure ratio of R134a is 24% greater than mixture. The pressure ratio of R134a is average 34% greater than mixture

4.3.3 Comparative analysis of pressure ratio at 1.9 mm capillary tube diameter for R134a and mixture of R134a&H.C

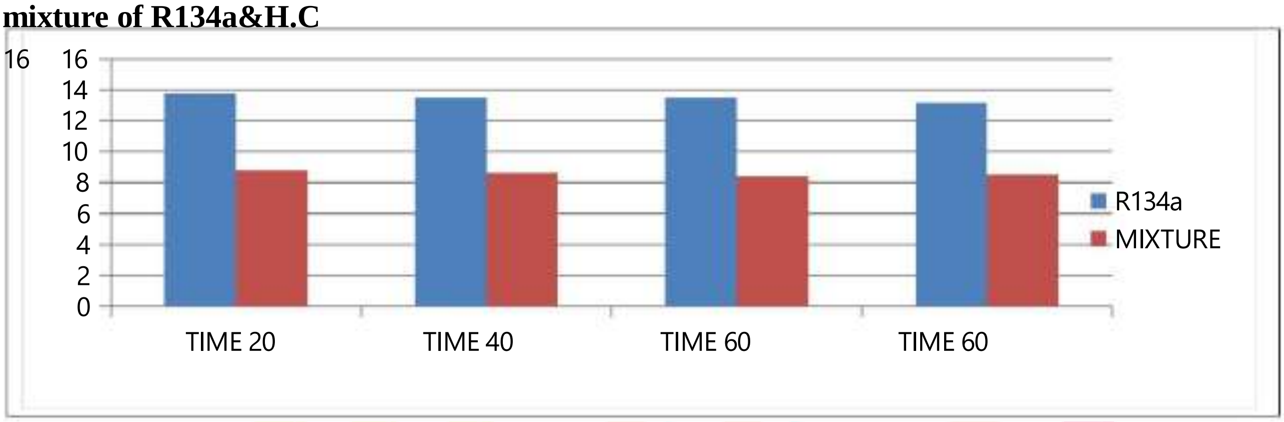

Fig. 4.3.3 Effect of time duration with pressure ratio for R134a and mixture of R134a&H.C

The figure 4.3.3 shows the variation of pressure ratio of the R134a and mixture refrigerant for 1.90mm dia. In the figure we have seen that pressure ratio of R134a is always greater than mixture. At first reading pressure ratio of R134a is 56.83% greater than mixture. After 15 minute gap of pressure ratio decrease and pressure ratio of R134a is 56.06% greater than of mixture. After 30 minute gap of pressure ratio is decrease and 60.59% greater than mixture and at the last reading we have calculated pressure ratio of R134a is 54.26% greater than mixture. The pressure ratio of R134a is average 56.93% greater than mixture.

4.3.4 Comparative analysis of $(C.O.P)_{max}$ at 1.5 mm capillary tube diameter for R134a and mixture of R134a&H.C

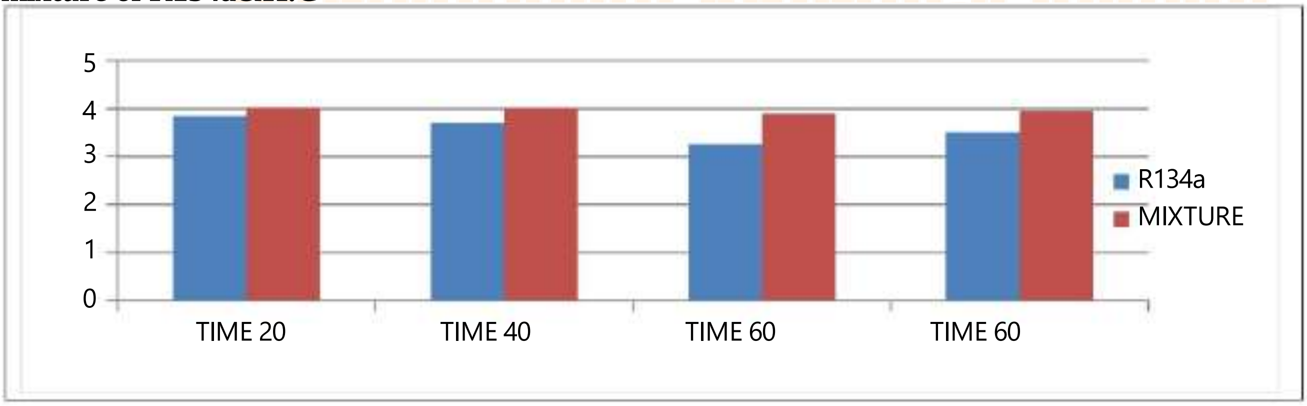

Fig. 4.3.4 Effect of time duration with $(C.O.P)_{max}$ for R134a and mixture of R134a&H.C

The figure 4.3.4 shows the concluded that variation of $(C.O.P)_{max}$ of R134a and mixture for 1.5mm diameter .The figure shows the $(C.O.P)_{max}$ of mixture is greater than R134a. In first reading at 15 minute $(C.O.P)_{max}$ is 4.68% greater than R134a, at 30 minute $(C.O.P)_{max}$ of mixture increase and R134a are decrease and $(C.O.P)_{max}$ of mixture is 8.1% greater than R134a, at 45 minute mixture $(C.O.P)_{max}$ is 20% greater than R134a and at 60 minute mixture $(C.O.P)_{max}$ is 12% greater than R134a. We conclude that mixture $(C.O.P)_{max}$ is average 11.19% is greater than R134a.

4.3.5 Comparative analysis of $(C.O.P)_{max}$ at 1.7 mm capillary tube diameter for R134a and mixture of R134a&H.C

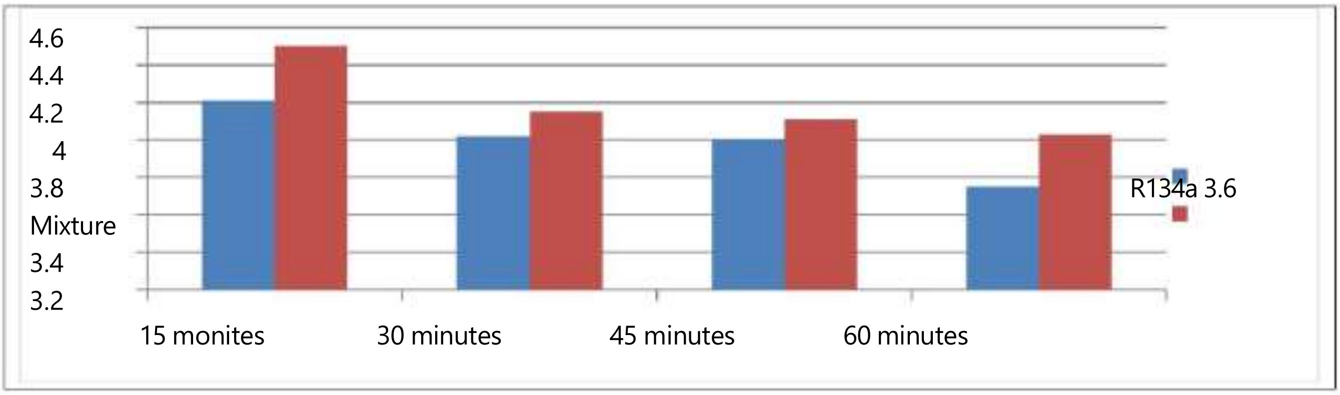

Fig 4.3.5 Effect of time duration with $(C.O.P)_{max}$ for R134a and mixture of R134a&H.C

The figure 4.3.5 shows the concluded that variation of $(C.O.P)_{max}$ of R134a and mixture for 1.70mm diameter . The figure shows the $(C.O.P)_{max}$ of mixture is greater than R134a. In first reading at 15 minute $(C.O.P)_{max}$ is 6.8% lower than R134a, at 30 minute $(C.O.P)_{max}$ of mixture is 6.4% lower than R134a, at 45 minute mixture $(C.O.P)_{max}$ is 2.7% greater than R134a and at 60 minute mixture $(C.O.P)_{max}$ is 7.4% greater than R134a. We conclude that mixture $(C.O.P)_{max}$ is average 6.8% is greater than R134a.

4.3.6 Comparative analysis of $(C.O.P)_{max}$ at 1.9 mm capillary tube diameter for R134a and mixture of R134a&H.C

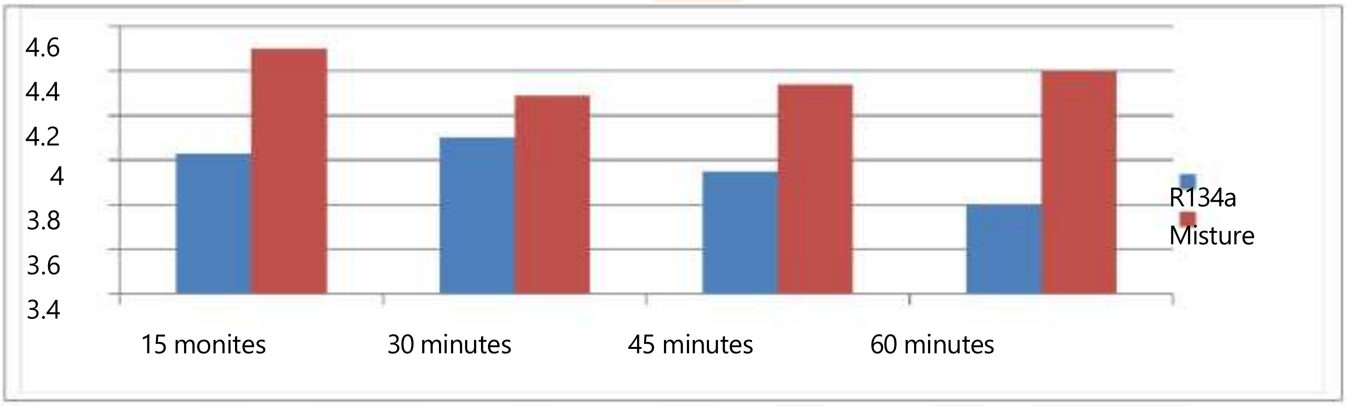

Fig 4.3.6 Effect of time duration with $(C.O.P)_{max}$ for R134a and mixture of R134a&H.C

The figure 4.3.6 shows the concluded that variation of $(C.O.P)_{max}$ of R134a and mixture for 1.90mm diameter . The figure shows the $(C.O.P)_{max}$ of mixture is greater than R134a. In first reading at 15 minute $(C.O.P)_{max}$ is 11.6% greater than R134a, at 30 minute $(C.O.P)_{max}$ of mixture decrease and R134a are increase but $(C.O.P)_{max}$ of mixture is 4.6% greater than R134a, at 45 minute mixture $(C.O.P)_{max}$ is 9.8% greater than R134a and at 60 minute mixture (C.O.P)max is 15.7% greater than R134a. We conclude that mixture $(C.O.P)_{max}$ is average 10.42% is greater than R134a.

V. Conclusions

In these experiments we are study in helical capillary tube with three different diameters 1.5mm, 1.7mm and 1.9.and two type of refrigerant one is a R134a and second is a mixture of R134a and hydrocarbon. All result concludes and given above in tabular form and graphical form And conclusion of experiment is discussing below.

1. Maximum pressure ratio for R134a is 18.70 for 1.5mm diameter capillary tube, and for mixture are 11.81 for 1.5 mm diameter capillary tube. Maximum pressure ratio of R134a is 58.34% greater than mixture.
2. Minimum pressure ratio for R134a is 12.4 for 1.7mm diameter capillary tube, and for mixture is 8.4 for 1.7 mm diameter capillary tube. Minimum pressure ratio of R134a is 47.62% greater than mixture.
3 Vapour pressure characteristics of mixture closely match with R134a refrigerant thus same R134a compressor can be used. Actual C.O.P is maximum for R134a is 4.28 for 1.7mm diameter capillary tube and minimum C.O.P is 3.51 for 1.5 mm diameter capillary tube.
4. Mass flow rate occur maximum at 1.9mm diameter of capillary tube is 4.2g/sec, and average mass flow rate for 1.9 mm diameter of capillary tube is 3.70 g/sec which is 6.49% lower than maximum mass flow rate.
5. At 1.5mm, 1.7mm and 1.9 mm diameter of capillary tube with R134a and mixture of R134a&H.C refrigerant is maximum $(C.O.P)_{max}$ is 4.50 for mixture at 1.52mm diameter of capillary tube. In case R134a refrigerant use then 1.4mm diameter of capillary is best which give avg. $(C.O.P)_{max}$ is 3.98.
6. In case mixture refrigerant use then 1.9mm diameter of capillary is best which give avg. $(C.O.P)_{max}$ is 4.50.

From the finding it can be concluded that pressure ratio 18.7 is maximum for the helical capillary tube at diameter 1.5mm in flow R134a refrigerant which is smaller diameter in my project. It concludes that pressure ratio is increase with decrease the diameter of capillary. And for $(COP)_{max}$ R134a &HC refrigerant mixture is better than R134a refrigerant. At diameter 1.9mm $(COP)_{max}$ is maximum 4.50, this diameter is large size this work.

Reference

1. S.K.gugulothu, “Enhancement of household refrigerator energy efficiency by studying the effect of refrigerant charge and capillary tube length” and “Refrigeration books” vol. 7, No. 5, pp, 1121-1129, July 2021.
2. y. chandrasekhar yadav, “the effect of capillary tube length on the performance of vapour compression refrigeration system” vol. 13, issue 1, issn no: 0898-3577, July 2022.
3. miss. rohini zade et. al [3] the “experimental investigation on the performance of v.c.r. system using refrigerants ” volume: 06 issue: 07/ July 2019.
4. ZhaohuaLi, “Comparative study on energy efficiency of low GWP refrigerants in domestic refrigerators with capacity modulation”, Energy and Buildings, vol. 192, pp: 93-100, 1 June 2019,
5. Muhammad Tauseef Nasir, “Performance assessment and multi objective optimization of an Organic Rankin Cycle driven cooling air conditioning system”, Energy and Buildings, vol. 191, pp: 13-30 15 May 2019.
6. Mert Tosun BahadırDoğan M. MeteÖztürk L. BerrinErbay, “Integration of a mini-channel condenser into a household refrigerator with regard to accurate capillary tube length and refrigerant amount”, international Journal of Refrigeration, vol. 98, pp 428-435 February 2019.
7. Pravin Jadhav & Neeraj Agrawal, “A comparative study in the straight and a spiral adiabatic capillary tube”, International Journal of ambient Energy, issue 7, vol. 40, pp 693-698, 2019.
8. Liu Zhang “Cycle performance evaluation of various R134a/hydrocarbon blend refrigerants applied in vaporcompression heat pumps”, Advance in Mechanical Engineering, vol. 11(1) pp 1–14, 2019
9. Mohd Hazwan Yusof , Sulaiman Mohd Muslim “The Effect of Outdoor Temperature on the Performance of a Split-Unit Type Air Conditioner Using R22 Refrigerant”, MATEC Web of Conferences, Volume 225, November 2018.
10. Azridjal Aziz1, “Effect of Cooling Load on the Performance of R22 Residential Split Air Conditioner when Retrofitted with Hydrocarbon Refrigerant (HCR22)”, Journal of Advanced Research in Fluid Mechanics and Thermal Sciences, issue 1 vol.48,pp 100-108, 2018.
11. AdriánMota-Babiloni, “Refrigerant R32 as lower GWP working fluid in residential air conditioning systems in Europe and the USA”, Renewable and Sustainable Energy Reviews vol. 80, pp 1031-1042, December 2017.
12. Sharmas ValiShaika, T.P. AshokBabub, “Theoretical Computation of Performance of Sustainable Energy Efficient R22 Alternatives for Residential Air Conditioners”, International Conference on Alternative Energy in Developing Countries and Emerging Economies, vol. 138, pages 710-716, October 2017.
13. K.Harby, “Hydrocarbons and their mixtures as alternatives to environmental unfriendly halogenated refrigerants: An updated overview”, Renewable and Sustainable Energy Reviews vol. 73, Pages 1247-1264, June 2017.
14 Santosh kumar dubba, “Flow of refrigerants through capillary tubes: A state-of-the-art”, Experimental Thermal and Fluid Science, vol. 81, pp 370-381, February 2017.
15. Buddha Chouhan, Poshal, Suresh Kumar, "Analytical Investigation of R134a Flowing Through Adiabatic Helically Coiled Capillary Tubes" SO 3297:2007 Certified Vol. 4, Issue 2, February 2017.