

EXPERIMENTAL INVESTIGATION ON THE PERFORMANCE OF V.C.R. SYSTEM USING REFRIGERANT

Miss. Rohini Zade¹, Prof. Prashant Walke², Prof. Avinash Khanderao³

¹Student, IV Semester M. Tech (Heat Power Engineering), Ballarpur Institute of Technology, Ballarpur – 442701 (Maharashtra) (India)

²Assistant Professor (Guide), Mechanical Engineering Department, Ballarpur Institute of Technology, Ballarpur – 442701 (Maharashtra) (India)

³Assistant Professor (Co-Guide), Mechanical Engineering Department, Ballarpur Institute of Technology, Ballarpur – 442701 (Maharashtra) (India)

ABSTRACT:-The “EXPERIMENTAL INVESTIGATION ON THE PERFORMANCE OF V.C.R. SYSTEM USING REFERIGTS”

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.

Key Words: vapor compression cycle, capillary tube, coefficient of performance, capillary tube geometry

1. INTRODUCTION

It is very much essential to put more efforts for improving the efficiency of thermal systems because of increasing energy prices and increasing concern of global warming. One of the methods of increasing efficiency is to recover and utilize waste heat from thermal systems for various applications like water heating. Hot water is required for various applications like bathing, processing, cooking, dish washing, sterilization, and utensils cleaning in dairy. In such applications, water is heated by electrical heating or burning the fossil fuels which is costly and also increases global warming.

Use of waste heat recovery is an important technique of reducing total energy costs in energy system design. Attachments need to be developed to recover waste heat energy from refrigeration systems by sub cooling technique in domestic refrigerator with varying expansion valve (throttling process).

Refrigeration systems play an important role for the human comfort in industry and households. These

systems mainly work on vapor compression cycle using certain eco-friendly refrigerant as a working fluid. A capillary tube is a small diameter tube which is used for the expansion of the flowing fluid. The pressure difference between the entry and exit ends of the capillary tube is always equal to the pressure difference between the condenser and the evaporator.

The inside diameter of the capillary tube used for the purpose of refrigeration ranges from about 0.5 mm to 2.30 mm. longer the capillary tube and/or smaller the inside diameter of the capillary tube, greater is the pressure drop it can create in the refrigerant flow. In other words, greater will be the pressure difference needed between the high pressure side and the low pressure side to establish a given flow rate of the refrigerant. It is possible to obtain the effective size (diameter, length & coil pitch) of capillary tube by using of experimental techniques and by maintaining proper pressure equalization between condenser and evaporator. It is possible to predict about mass flow rate of refrigerant in spiral capillary tube.

The influence of degree of sub cooling, pressure and geometric parameters such as diameter, length, and coil pitch on the performance i.e. COPS of the system and mass flow rate of refrigerant through capillary tube was reviewed in this paper. The vapor compression refrigeration cycle involves four components:- compressor, condenser expansion valve or throttle valve and evaporator. It is a compression process, whose aim is to raise the refrigerant pressure, as it follows from an evaporator.

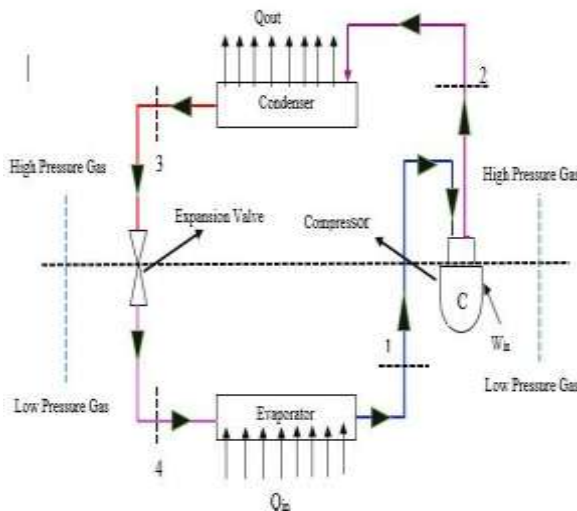


Fig. no. 1 Vapor Compression Refrigeration Systems

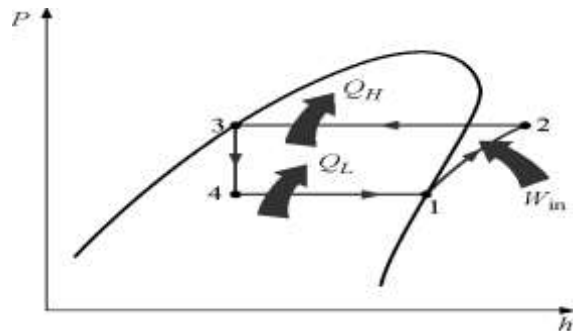
In a vapor-compression refrigeration cycle, the refrigerant enters the compressor as a saturated vapor and is cooled to the saturated liquid state in the condenser. It is then throttled to the evaporator pressure and vaporizes as it absorbs heat from the refrigerated space. The vapor-compression cycle consists of four processes

Process	Description
1-2	isentropic compression
2-3	Constant pressure heat rejection in the condenser
3-4	Throttling in an expansion valve
4-1	Constant pressure heat addition in the evaporator

Process 4-1: Two-phase liquid-vapor mixture of refrigerant is evaporated through heat transfer from the refrigerated space.

Process 1-2: Vapor refrigerant is compressed to a relatively high temperature and pressure requiring work input.

Process 2-3: Vapor refrigerant condenses to liquid through heat transfer to the cooler surroundings.



Process 3-4: Liquid refrigerant expands to the evaporator pressure.

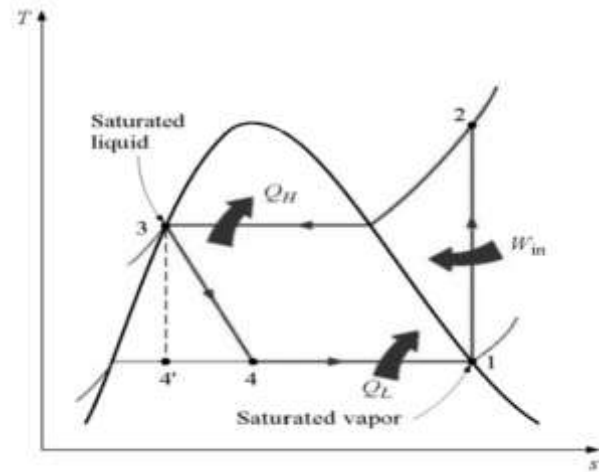


Fig. no. 1.2 T-s & ph diagram

Condenser is an important component of any refrigeration system. In a typical refrigerant condenser, the refrigerant enters the condenser in a superheated state. It is first de-superheated and then condensed by rejecting heat to an external medium.

The refrigerant may leave the condenser as a saturated or a sub-cooled liquid, depending upon the temperature of the external medium and design of the condenser. Figure shows the variation of refrigeration cycle on T-s diagram. In the figure, the heat rejection process is represented by 2-3'-3-4. Process 3-4 is a sensible, sub cooling process, during which the refrigerant temperature drops from T3 to T4.

2. LITERATURE REVIEW

The present work is focused on investigation on effect of variation in capillary tube diameter of spiral coiled on the coefficient of performance of vapor compression cycle and the mass flow rate of refrigerant.

The accurate size of the capillary tube and its configuration can be predicted with the help of the calculations for the refrigeration effect, coefficient of performance (cop) of the system and mass flow rate of the system. The effects of different geometries of capillary tubes have been studied by many researchers. Since the capillary tube can be straight, helical coiled and also serpentine coiled and all three configurations have their own distinct effect on the system performance, thus the literature review here is focused to give a brief introduction of the effects of the various configurations of the capillary tube on the system performance and thus pave the path for further studies.

The effects of different geometries of capillary tubes have been studied by many researchers Mr. Mutalubi Aremu Akintunde 1 (17,18) in vestigated the performance of capillary tube geometries having R-134a as the working fluid.

3. EXPERIMENTAL METHODOLOGY

The objective of the study was to compare the refrigeration performance of different capillary tube diameters with different load conditions. Instead of an orifice, a small diameter tube can be used for the expansion of the flowing fluid. This small diameter tube is known as the capillary tube expansion device and it produces the same effect as produced by the orifice. The term capillary tube" means „hair-like“. It is so called because of its very small bore diameter. The inside diameter of the capillary tube used for the purpose of refrigeration ranges from about 0.5 mm to 2.30 mm. longer the capillary tube and/or smaller the inside diameter of the capillary tube, greater is the pressure drop it can create in the refrigerant flow. In other words, greater will be the pressure difference needed between the high pressure side and the low pressure side to establish a given flow rate of the refrigerant.

4. EXPERIMENTAL SETUP DETAILS

The apparatus consist of a domestic refrigerator of desired capacity, as shown in figure (3), the connections between compressor suction ports, evaporator exit; capillary tube and evaporator inlet are modified to give an easy way to connect the tested capillary tube under study to the vapor compression cycle.

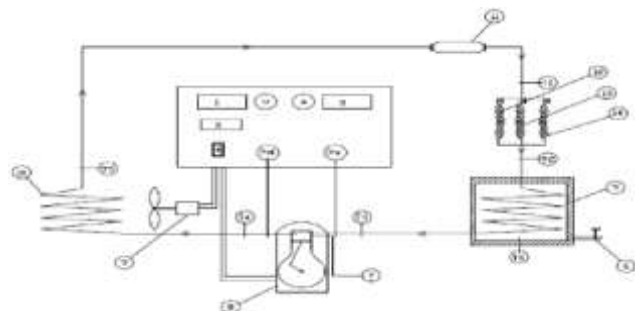


Fig. no. 4.1 Schematic diagram of experimental setup



Fig. no. 4.2 Experimental setup

The experimental setup consists of Hermetic sealed compressor unit and tubular condenser unit were used. Hermetic compressors are almost universally used in small systems such as domestic refrigerators, water coolers, air conditioners and deep freezer, where efficiency is not as important as customer convenience. In addition to this, the use of hermetic compressors is ideal in systems, which use capillary tubes as expansion devices to reduce the pressure in evaporator section. In capillary tube the refrigerant has to overcome the frictional resistance offered by tube walls which leads to some pressure drop, and also the liquid refrigerant flashes into wet vapour, as its pressure reduces through the capillary tube.

The evaporator unit was properly insulated to the best of the effort so as to minimize the heat leakage into the system from the surrounding. Copper tubes of diameter ¼ inches were used for providing the supply and return lines to the flowing fluid in the system. Refrigerant R134a was used as the cooling fluid. A filter/drier, specific for R134a, was installed just after the condenser unit in order to avoid any situation of choking of the flow lines. The filter/drier does not allow the ice to be formed in the flow lines by absorbing all the moisture particles present in the flowing fluid. The pressure gauge in the high pressure line was installed just after the filter/drier and just before the capillary tube. Another pressure gauge was installed in the low pressure return line to measure the pressure of the fluid returning back to the compressor. A digital temperature meter was used to determine the temperatures that were to be used in the analysis of the system. The readings of the temperature and pressure were plotted on the PH chart and the corresponding enthalpies were noted down and from the obtained values of the enthalpies.

Sr. No.	Equipment/ Instrument	Dimension/ Range/ Capacity	Accuracy
01	Compressor-Hermetically Sealed, Reciprocating type, Godrej company	410BTU/ hr, 120 watt 230V AC, 50Hz	-
02	Air cooled condenser Tubes- Copper Fins- Aluminium Fan Motor	09*09*02 row, Diameter of tubes- 9mm, Length of tubes- 40 ft., Fan diameter - 10 ft, 1/10 HP	-
03	Capillary tube of Test Section , Material -copper	Diameter:0.036", 0.040" & 0.050"Length- 1meter	-

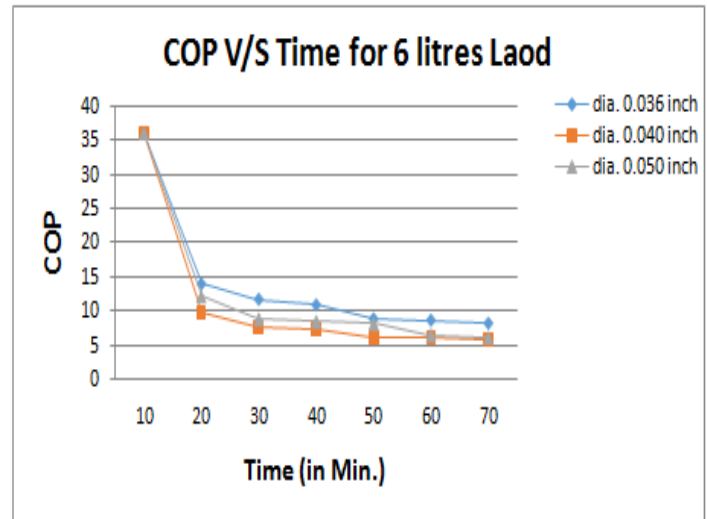
04	Evaporator coil & shell Capacity- 10 lit	Coil dia- 10", Tube dia. -12mm, Tube length- 40ft, Shell dia- 250 mm	-
05	Digital Temperature Indicator	0 to 99990C,	10C
06	Thermocouple (Cr-Al) K type	0 to 9000C, 06 Nos.	10C
07	Pressure Gauge, Connection 1/806 NPT	0 - 500 psi, 0 - 35kg/cm ²	0.1
08	Flow-meter	15 Lph	

Table 1 Experimental Setup Details

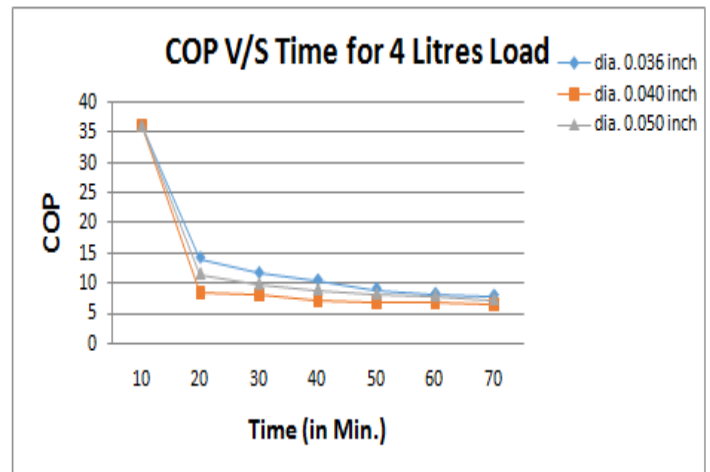
5. RESULTS & DISCUSSIONS

In present work, capillary tubes of diameter 0.036", 0.040" & 0.050" were used in the test sections. The length of each test section was kept constant to 1m. Every set of readings consists of at least five readings measuring the key variables like pressure & temperature at different load conditions. The aim of this part is to make the performance analysis the vapor compression refrigeration system & is based on the steady flow energy equation and pressure-enthalpy Diagram of R-143a (to evaluate the values of enthalpy of each points require), to study the key variables, namely, COP, power of compressor, enthalpy of each points and mass flow rate of refrigerant. therefore, many measured variables, namely, the refrigerant temperatures of each of inlet & outlet compressor (*TT1* & *TT2*), outlet condenser *TT3*, inlet & outlet evaporator *TT1* & *TT4* and evaporator cabinet, as shown in figures. Also it measured high & low pressure of vapor compression cycle and electrical voltage & current consumed by compressor that was used in this unit. From the above graphs, it is observed that at variable loads of 6litres, 4litres and 2litres, the coefficient of performance of vapor compression system is high, with respect to time, when the smallest diameter capillary tube is used i.e. 0.036". As we know that for a given state of refrigerant, the pressure drop is directly proportional to length & inversely proportional to the bore diameter of tube. The required pressure drop (pressure difference between condenser & evaporator pressure) is caused due to heavy frictional resistance offered by small diameter tube.

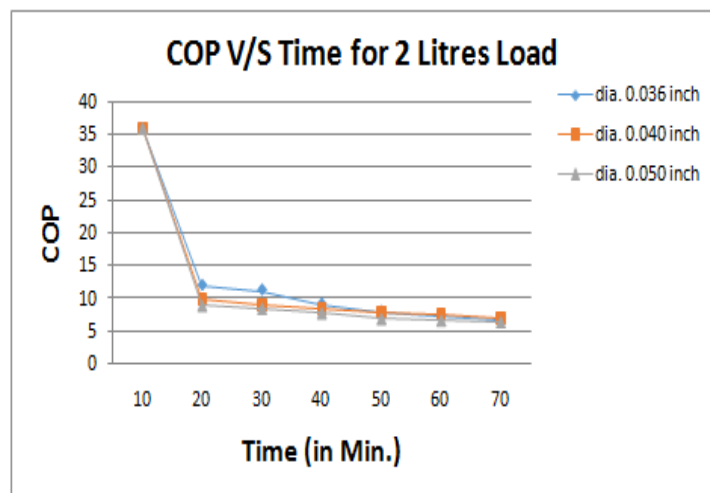
Graph 5.1,2,3 COP Vs TIME for different tube diameters & Loads



Graph no. 5.1



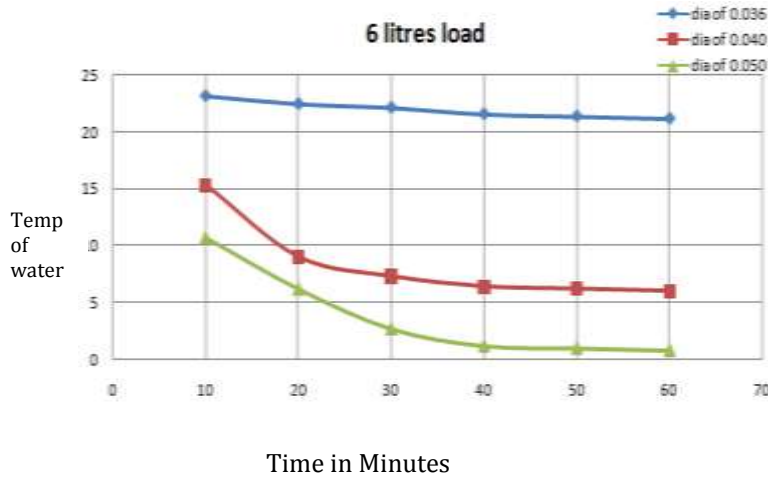
Graph no. 5.2



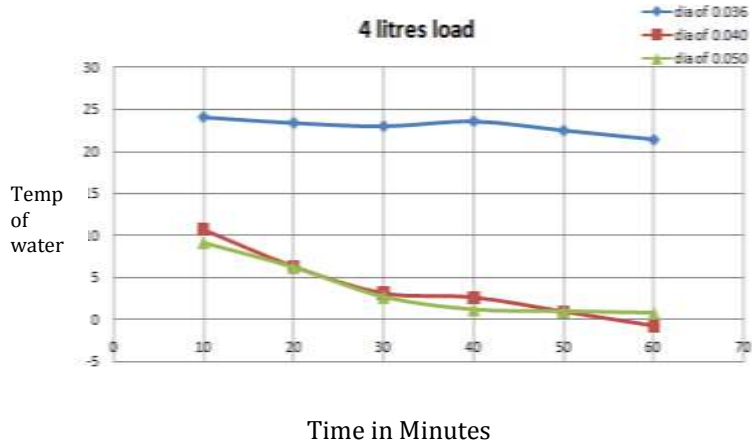
Graph no. 5.3

From the above graphs, it is observed that at variable loads of 6litres, 4litres and 2litres, the coefficient of performance of vapor compression system is high, with respect to time, when the smallest diameter capillary tube is used i.e. 0.036".

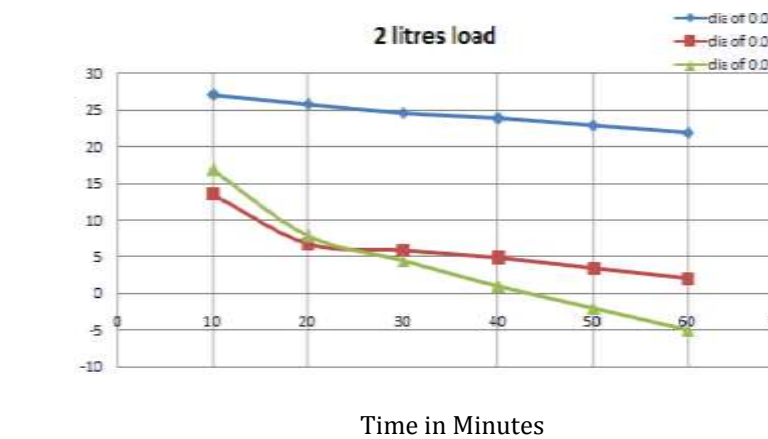
Graph 5.4,5,6 COP Vs TIME for different tube diameters & Loads



Graph no. 5.4



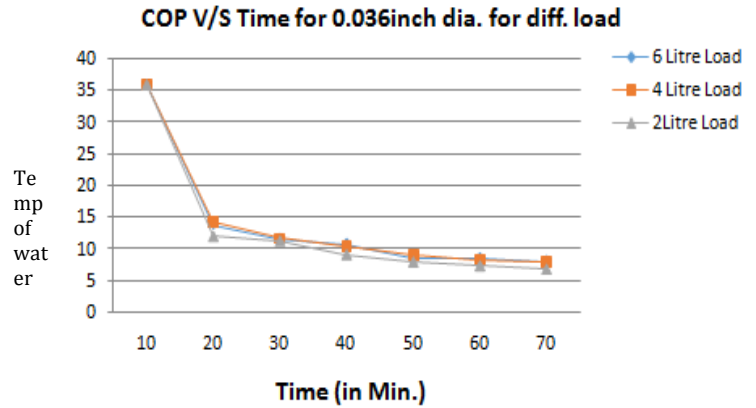
Graph no. 5.5



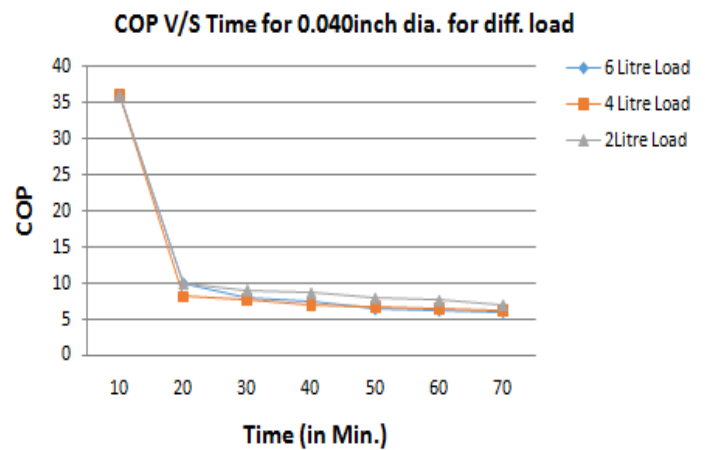
Graph no. 5.6

From the above graphs, it is observed that for different load, of 06Litre, 04Litre & 02Litrs, the temperature of water is more in case of smaller diameter capillary tube as mass flow rate of refrigerant is less in evaporator where it can absorb less amount of heat from the water/substance to be cooled.

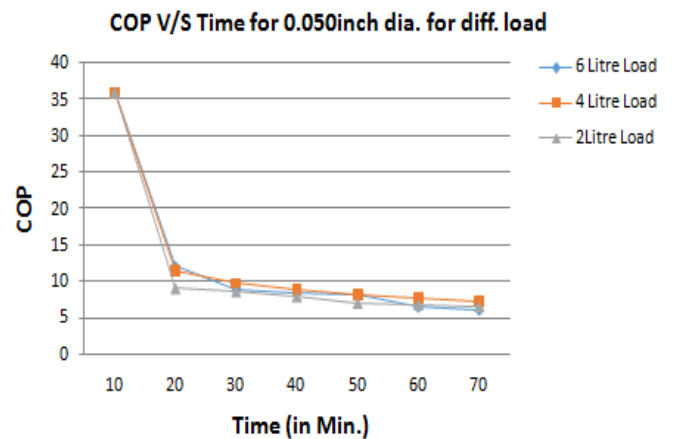
Graph COP Vs TIME for Tube at Different Loads



Graph no. 5.7



Graph no. 5.8



Graph no. 5.9

The rate of flow for selected capillary tube is the function of pressure difference between condenser & evaporator. From the above graphs it is observed that, as the load increase the tube supplies more quantity of refrigerant which lead to refrigeration effect. When the load on unit is decreased the flow through tube is decreased as an effect of decrease in condenser pressure.

6. CONCLUSION

From this study it is concluded that, single capillary tube having smaller inner diameter is suitable for freezing applications, whereas capillary tubes having more inner diameter are suitable for cold storage or air conditioning applications. With smaller diameter capillary tube the COP of the system is increased with different load conditions as the pressure drop is directly proportional to length & inversely proportional to the bore diameter of tube. The required pressure drop (pressure difference between condenser & evaporator pressure) is caused due to heavy frictional resistance offered by small diameter tube.

7. REFERENCES

- 1) A.S. Dalkilic, and S. Wongwises, "A performance comparison of vapour-compression refrigeration system using various alternative refrigerants,"
- 2) K. Mani, and V. Selladurai, "Experimental analysis of a new refrigerant mixture as drop-in replacement for CFC12 and HFC134a," *International Journal of Thermal Sciences* 47, pp. 1490–1495, 2008.
- 3) Ki-Jung Park, Taebeom Seo, and Dongsoo Jung, "Performance of alternative refrigerants for residential airconditioning applications," *Applied Energy* 84, pp. 985–991, 2007.
- 4) Ki-Jung Park, and Dongsoo Jung, "Thermodynamic performance of HCFC22 alternative refrigerants for residential air-conditioning applications," *Energy and Buildings* 39, pp. 675–680, 2007.
- 5) James M. Calm, "Emissions and environmental impacts from air-conditioning and refrigeration systems," *International Journal of Refrigeration* 25, pp. 293–305, 2002.
- 6) Samira Benhadid-Dib, and Ahmed Benzaoui, "Refrigerants and their environmental impact Substitution of hydro chlorofluorocarbon HCFC and HFC hydro fluorocarbon. Search for an adequate refrigerant," *Energy Procedia* 18, pp. 807 – 816, 2012.