

# Experimental Analysis on Vapour Compression Refrigeration System with TEV and Microchannel Condenser

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**ABSTRACT:** This Paper is concerned with the overview of the project based on the Experimental analysis on Vapour compression refrigeration system with Thermostatic expansion valve and Micro channel condenser with the refrigerant R134a. For the purpose of analysis, the experimental set up with two condenser and two expansion devices is manufactured. The Thermostatic expansion valve and the Micro channel condenser was selected as per the load required and type of refrigerant. The Capillary tube is selected as per the compressor specification. As per the Analysis, the combination of thermostatic expansion valve and micro channel condenser were found to give the higher Co-efficient of performance and less power consumption across the entire range of operating conditions.

## I. INTRODUCTION

Out of all refrigeration systems, the vapour compression refrigeration system is the most important system from the view point of commercial and domestic utility. It is most practical form of refrigeration. In this system the working medium is a vapour which evaporates and condenses alternately between vapour and liquid phases without leaving the refrigerating plant. During evaporation working medium absorbs heat from the cold body, this heat is used as its latent heat for converting it from the vapour to liquid. During condensation, working medium rejects heat to external body, so the cooling effect is produced. The basic function of the Condenser is Phase changing i.e., conversion of the high pressure vapour refrigerant into high pressure liquid refrigerant. The basic functions of an expansion device used in refrigeration systems are to:

1. Reduce pressure from condenser pressure to evaporator pressure, and
2. Regulate the refrigerant flow from the high-pressure liquid line into the evaporator at a rate equal to the evaporation rate in the evaporator.

### 1.1 Capillary Tube:

A capillary tube is a long, narrow tube of constant diameter. The word “capillary” is a misnomer since surface tension is not important in refrigeration application of capillary tubes. Typical tube diameters of refrigerant capillary tubes range from 0.5 mm to 3 mm and the length ranges from 1.0 m to 6 m. Several combinations of length and bore are available for the same mass flow rate and pressure drop.

### 1.2 Thermostatic Expansion Valve:

Thermostatic expansion valve is the most versatile expansion valve and is most commonly used in refrigeration systems. A thermostatic expansion valve maintains a constant degree of superheat at the exit of evaporator; hence it is most effective for dry evaporators in preventing the slugging of the compressors since it does not allow the liquid refrigerant to enter the compressor. This consists of a feeler bulb that is attached to the evaporator exit tube so that it senses the temperature at the exit of evaporator. The feeler bulb is connected to the top of the bellows by a capillary tube. The feeler bulb and the narrow tube contain some fluid that is called power fluid. The power fluid may be the same as the refrigerant in the refrigeration system, or it may be different. In case it is different from the refrigerant, then the TEV is called TEV with cross charge.

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**1.3 Micro channel Condenser:**Micro channel condenser is an effective enhancement technique for its relatively high heat transfer coefficient and low pressure drop penalty. Micro channels bring to the overall performance of the heat exchanger include the increase in compactness, possible reduction of their-side pressure drop, improvement of the heat transfer, and the Reduction of the refrigerant charge. It is also frequently used in automotive refrigerant condensers, which use aluminum tubes. It can reduce equipment weight, improve the device compactness, also reduced the manufacturing cost & competitiveness can be improved by using aluminums. Air conditioning and refrigeration system plays an important role in industry, infrastructure and household. The industry sectors include the food industries, textiles chemicals, printings, transports and others. Infrastructure includes banks, restaurants, schools, hotels and recreational facilities. The micro channel condenser is made to have nearly an identical face area, depth and fin density as the round tube condenser which is the baseline. Micro channel condenser should provide higher capacity and system COP

### 1.4 Experimental setup

Set up is manufactured for the analysis purpose. Two expansion devices namely thermostatic expansion valve and capillary tube are placed in the vapour compressor refrigeration system in parallel with hand shut off valves for the purpose of analysis individually. As same as the expansion devices the two condenser are placed in parallel connection with hand shut off valves in same system.

Compressor specifications are:

Compressor specification are: <b>Model Number</b>	<b>THK9414YGS</b>
Displacement (CC)	6.90
<b>Power (Watts)</b>	<b>230</b>
Current (Amp)	1.60
LRA (Amp)	15.0
Circuit	CSIR

.Table no. 1 Compressor Specification

Sr. No.	Parameter	Description
1	Type	Test Rig
2	Refrigerant	R134a
3	Capacity	
4	Compressor	Hermetically Sealed, Single cylinder, reciprocating.
5	Condenser	Normal round tube condenser, Micro channel condenser
6	Expansion Device	TEV, Capillary Tube.
7	Evaporator	Coil Type

## 2. Proposed refrigeration system

Considering an existing vapour compression refrigeration system explained above has consisting and working under round tube condenser. In this section, experimental setup we used was explained this experimental kit is a proposed kit and it is shown in figure. 4.9

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Fig 4.9 Photo copy of refrigeration system with micro channel condenser, but this proposed vapour compressor refrigeration system working under the round tube and also micro channel condenser in swapping with capillary and Thermostatic expansion devices.

### III. EXPERIMENT PROCEDURE

- First of all, the refrigerant R134a was filled in the refrigeration system when flow is available to both the condenser. After filling, flow of refrigerant to the micro channel was closed.
- Now fill the water inside the evaporator cabin and note down its weight and temperature.
- Switch on the compressor, it compresses the refrigerant R134a and it starts to flow through the refrigeration system. Now the temperature of the water, which is available inside the evaporator cabin, is starts to decrease. When its temperature reaches to 25°C, the following readings were note down.
- Temperature at compressor inlet, outlet temperature, Expansion valve inlet and outlet.
- Final Energy meter reading

Again the same procedure was repeated and note down the required valves when evaporator water temperature is 20°C, 15°C.

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### IV. RESULTS AND DISCUSSION

Values obtained from the experimentations were tabulated and which is known in tables. Table no 3 Experimental values on working with Normal condenser and capillary tube refrigeration system.

Sl. No	Load at °C	Temperature at different inlet and outlet of Refrigerant in (°C)				Pressure at different inlet and outlet of refrigerant in (bar)				Energy meter reading in kWhr	
		T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	P <sub>1</sub>	P <sub>2</sub>	P <sub>3</sub>	P <sub>4</sub>	Initial	Final
1	20	30.6	51.2	39.2	7.9	0.39	9.80	9.90	0.39	1.38	1.47
2	15	26.1	60.1	44.6	15.7	2.74	12.35	12.55	2.35	1.38	1.49

Sl. No	Load at °C	Temperature at different inlet and outlet of Refrigerant in (°C)				Pressure at different inlet and outlet of refrigerant in (bar)				Energy meter reading in kWhr	
		T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	P <sub>1</sub>	P <sub>2</sub>	P <sub>3</sub>	P <sub>4</sub>	Initial	Final
1	20	31.5	59.3	39.5	0.3	0.49	9.51	9.51	0.49	1.52	1.62
2	15	28.5	57.3	38.8	-4.8	0.39	9.21	9.12	0.39	1.52	1.68

Table no 4 Experimental values on working with Normal condenser and Thermostatic expansion valve refrigeration system.

Sl. No	Load at °C	Temperature at different inlet and outlet of Refrigerant in (°C)				Pressure at different inlet and outlet of refrigerant in (bar)				Energy meter reading in kWhr	
		T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	P <sub>1</sub>	P <sub>2</sub>	P <sub>3</sub>	P <sub>4</sub>	Initial	Final
1	20	30.3	55.4	37.5	-3.9	0.98	9.02	8.92	0.49	1.68	1.75
2	15	29.3	55.1	37.9	-4.1	0.68	9.02	9.02	0.39	1.68	1.79

Table no 5 Experimental values on working with Micro channel and capillary tube refrigeration system.

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Sl. No	Load at °C	Temperature at different inlet and outlet of Refrigerant in (°C)				Pressure at different inlet and outlet of refrigerant in (bar)				Energy meter reading in kWhr	
		T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	P <sub>1</sub>	P <sub>2</sub>	P <sub>3</sub>	P <sub>4</sub>	Initial	Final
1	20	32.2	50.1	36.4	-1.7	0.49	8.13	8.13	0.098	1.79	1.88
2	15	30.8	55.0	37.0	-2.8	0.68	8.23	8.23	0.19	1.79	1.95

Table no 6 Experimental values on working with Micro channel condenser andThermostatic expansion valve refrigeration system.

### 4.1 Experimental Calculation:

Here, abbreviations for the symbols were listed.

E<sub>i</sub>=Initial energy meter readings

E<sub>0</sub>=Final energy meter readings

W=Work done of compressor

T<sub>R</sub>=Room temperature

T<sub>F</sub>=Final temperature

h<sub>1</sub>=Enthalpy of refrigerant at compressor inlet which is taken from p-h chat of R134a for its corresponding pressure and temperature.

h<sub>2</sub> = Enthalpy of refrigerant at compressor outlet which is taken from p-h chat of R134a for its corresponding pressure and temperature.

h<sub>4</sub> = Enthalpy of refrigerant at Evaporator inlet which is taken from p-h chat of R134a for its corresponding pressure and temperature.

h<sub>3</sub> = Enthalpy of refrigerant at Evaporator outlet / compressor inlet which is taken from p-h chat of R134a for its corresponding pressure and temperature.

#### i. Actual COP

$$\begin{aligned} \text{Input power} &= (E_0 - E_i) * 860.4 \\ &= (0.09 * 860.4) \\ &= 77.436 \text{kcal} \end{aligned}$$

$$\begin{aligned} \text{Output power} &= W (T_R - T_F) \\ &= 10(30 - 22) \\ &= 80 \text{kcal} \end{aligned}$$

$$\begin{aligned} \text{Actual COP} &= \text{output power} / \text{input power} \\ &= 80 / 34.416 \\ &= 2.32 \end{aligned}$$

#### ii. Theoretical COP

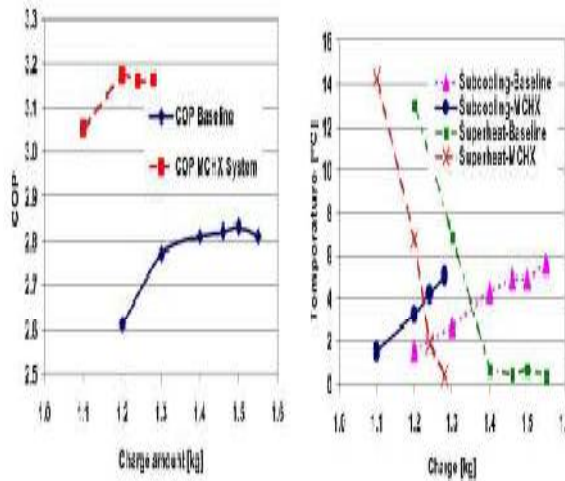
$$\begin{aligned} \text{Theoretical COP} &= (h_4 - h_1) / (h_3 - h_2) \\ &= (240 - 220) / (260 - 245) \\ &= 20 / 15 \\ &= 1.03 \end{aligned}$$

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COP vs. Refrigerant amount sub-cooling

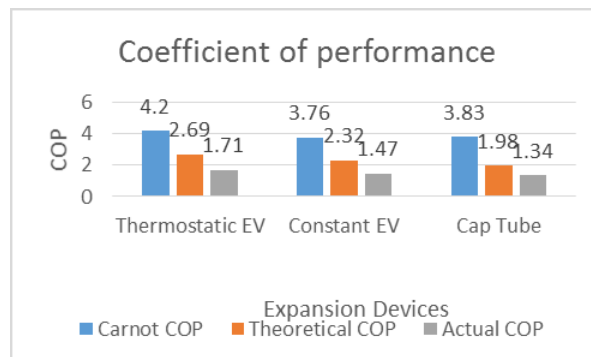


Fig 2 Comparison of COP

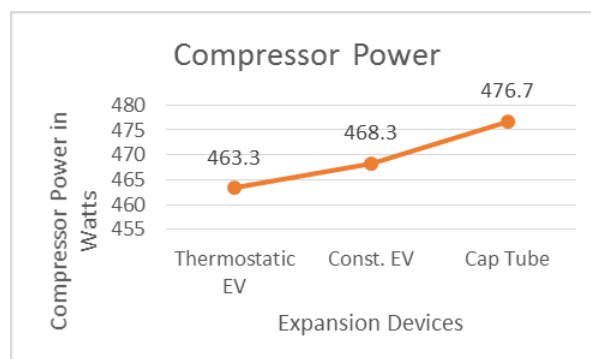


Fig 3 Compressor power consumption

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## V. CONCLUSION

In this study, Refrigeration systems with micro channel condenser, round tube condenser, capillary tube and thermostatic expansion valve were experimentally examined. These two condensers had almost identical frontal area and depth because the purpose of this study was to measure performance improvement using the micro channel condenser and thermostatic expansion valve.

- In the condenser comparison the micro channel condenser performance is better than the Normal round tube condenser.
- Coefficient of performance of vapour compression refrigeration system is calculated for Thermostatic expansion valve, and capillary. Carnot, theoretical and actual COP of thermostatic expansion valve is more than the capillary tube.
- Thermostatic expansion valve provides maximum efficiency over a wide temperature and load range, it gives improved refrigerant return to the compressor assures better cooling at high temperatures and reduces the possibility of liquid slugging which can destroy the compressor.
- At same operating conditions, the refrigerating effect produced by using thermostatic expansion valve is 20% more than capillary tube.
- The overall performance of the Thermostatic expansion valve is reasonably good as compared to capillary tube.

The combination of the Micro channel condenser and Thermostatic expansion valve is better than others.

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