# Effect of Single Expansion Valve Comparing With Multiple Expansion Valves on The Performance of Vapour Compression Refrigeration System

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***Abstract****- Now-a-days majority of the refrigerators works on the vapour compression refrigeration system. Vapour compression machine is a refrigerator in which the heat removed from the cold by evaporation of the refrigerant is given a thermal potential so that it can gravitate to a natural sink by compressing the vapour produced. The system mainly consists of components like compressor, condenser, expansion valve, capillary-tube and evaporator. The pressure gauges and temperature indicate joints are integrated with the system at appropriate positions. The performance of the system depends on all the components of the system.*

*The design of expansion valve plays a very important role in the performance of a vapour compression refrigeration system. Effective new design is possible through theoretical calculations, however may fail due to the reason that the uncertainties in the formulation of pressure difference from the refrigerant inside the expansion valves. Hence experimental investigations are the best in terms of optimization for certain design parameters.*

*This project deals with the effect of single expansion valve comparing with multiple expansion valves on the performance of a vapour compression refrigeration system.*

*The refrigerant used in the vapour compression refrigeration system is R-134a and experimentally investigated. The main objective of the present work for verifying the effect of multiple expansion valves on the performance of a domestic refrigerator.*

*Finally an attempt is made to verify the performance of the system. It is observed that operating with single expansion valve gave a better performance of vapour compression refrigeration system comparing with multiple expansion valves.*

***Keywords****-* Compressor, Condenser, Expansion Valve, Capillary tube, Evaporator.

## I. INTRODUCTION

The term 'refrigeration' may be defined as the process of removing heat from a substance under controlled conditions. It also includes the process of reducing and maintaining the temperature of a body below the general temperature of its surroundings. In other words, the refrigeration means a continued extraction of heat from a body whose temperature is already below temperature of its surroundings. In a refrigerator, heat is virtually pumped from a lower temperature to a higher temperature. According to second law of thermodynamics, this process can only be performed with the aid of some external work. It is thus obvious that supply of power is regularly required to drive a refrigerator. Theoretically, a refrigerator is a reversed heat engine or heat pump which pumps heat from a cold body and delivers it to a hot body. The substance which works in a pump to extract heat from a cold body and to deliver it to a hot body is known as refrigerant.

'Refrigeration cycle' is a thermodynamics cycles that explains the processes required for the production of refrigeration. There are various refrigeration cycles.

1. Air refrigeration cycle
   (a) Reversed Carnot cycle (most efficient cycle)
   (b) Bell –Coleman cycle (modified Carnot cycle for practical )
2. Vapour refrigeration cycle
3. Steam-jet refrigeration cycle

To provide the refrigeration there are various refrigeration systems are improved working with above refrigeration cycles. In different types of the refrigeration systems, some physical property of matter is used for producing cold.

In vapour refrigeration systems instead of air, vapour like ammonia, carbon dioxide, and sulphur-dioxide is used as working fluids. The pump in the steam power plant is replaced by throttle valve, boiler is replaced by refrigerator and the turbine is replaced by a compressor.

The heat carried away by the air from the refrigeration in the air refrigeration systems is in the form of sensible heat as there is no change of phase so that the effectiveness of the air refrigeration system is less. In vapour refrigeration system heat carried away by the vapour in the refrigerator is in the form latent heat of refrigerant so that the capacity of refrigerant of vapour refrigeration system per kg of refrigerant is far superior to the air refrigeration system.

## II. LITERATURE REVIEW

The basis of modern refrigeration is the ability of liquids to absorb enormous quantities of heat as they boil and evaporate. Professor William Cullen of the University of Edinburgh demonstrated this in 1755 by placing some water in thermal contact with either under a receiver of a vacuum pump. The evaporation rate of ether increased due to the vacuum pump and water could be frozen. This process involved to thermodynamic concepts, the vapour pressure and the latent heat. A liquid is in thermal equilibrium with its own vapour at a pressure is called the saturation pressure, which depends on the temperature alone. If the pressure is increased for example in a pressure cooker, the water boils at high temperature. The second concept is that the evaporation of the liquid requires latent heat during evaporation. If latent heat is extracted from the liquid, the liquid gets cooled. The temperature of ether will remain constant as long as the vacuum pump maintains a pressure equal to saturation pressure at the desired temperature. This requires the removal of all the vapour formed due to vaporization. If a lower temperature is desired, then a lower saturation pressure will have to be maintained by the vacuum pump. The component of the modern day refrigeration system where cooling is produced by this method is called evaporator.

1) If this process of cooling is to be made continuous vapors have to be recycled by condensation to the liquid state. The condensation process requires heat rejection to the surroundings. It can be condensed at atmospheric temperature by increasing its pressure. The process of condensation was learned in the second half of eighteen century. U.F.CLOUET and G. MONGE liquefied $SO_2$ In 1780 while van Marum and Van Troostwijk liquefied $NH_3$ in 1787.
2) Hence, a compressor is required to maintain a high pressure so that the evaporating vapour can condense at a temperature greater than that of the surroundings.
3) John Hague made Perkin's design into working model with some modifications. The earliest vapour compression system used either sulphuric (ethyl) or methyl ether. The American engineer Alexander Twining (1801 – 1884) received a British patent in 1850 for a vapour compression system by use of ether, $NH_3$ and $CO_2$.
4) The man responsible for making a practical vapour compression refrigeration system was James Harrison who took a patent in 1856 for a vapour compression system ether, alcohol or ammonia. Charles Tellier of France patented in 1864, refrigeration system using dim-ethyl ether which has a normal boiling point of -23.6 °C.

## III. REFRIGERATION EQUIPMENT

A refrigerant compressor is a machine used to compress the refrigerant from the evaporator and to raise its pressure so that the corresponding temperature is higher than that of cooling medium. The condenser is an important device used in the higher pressure side of a refrigeration system. Its function is to remove heat of the hot vapor refrigerant discharged from the compressor. The evaporator is used in the low pressure side of a refrigeration system. The liquid refrigerant from the expansion device enters into the evaporator where it boils and changes into vapor. The function of an evaporator is to be absorbing heat from the surrounding location or medium which is to be cooled, by means of a refrigerant. The temperature of boiling refrigerant in the evaporator must always be less than that of surrounding medium so that the heat flows to the refrigerant. The expansion device which is also known as throttling device, divides the high pressure side and the low pressure side of a refrigeration system. It is connected between the receiver and evaporator.

### 3.1 COMPRESSOR:

The hermetically sealed reciprocating compressor is widely used for refrigeration and air conditioning applications.

The hermetically sealed reciprocating compressor is very easy to handle, and requires low maintenance. They are used with motor power requirements from 1/20 to 71/2 hp.

**3.2 CONDENSER:**

We used here a wire and tube condenser which is a natural air cooled condenser and it is common application to domestic refrigerator, the following is a one kind of wire and tube condenser.

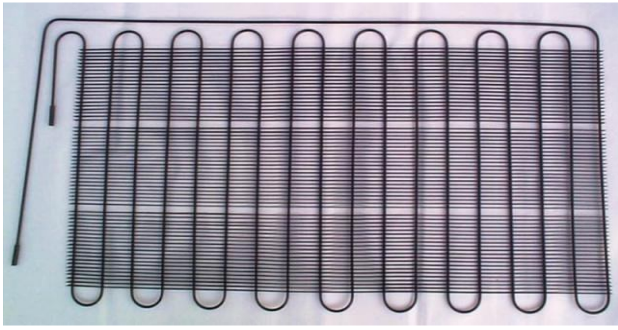


**Fig. Wire and tube type condenser**

**3.3 CAPILARY TUBE:**

**Fig. 4.4. Capillary tube**

Instead of an orifice, a length of a small diameter tube can offer the restrictive effect like expansion.Small diameter tubing is called capillary tube. Meaning hair like. The inside diameter of capillary used in refrigeration is generally about 0.5 to 2.28 mm (0.020 to 0.090). the longer the capillary tube and the smaller the inside diameter of the tube, greater is the pressure drop it can create in the refrigerant flow or in other words, greater will be the pressure difference needed between the high side and low side to establish a given flow rate of the refrigerant.

**3.4 EVAPORATOR:**

Evaporator is most required important part of the refrigeration system. The refrigerant from the capillary tubes comes into evaporator below the temperature required maintained in the evaporator and carries the heat from the evaporator. The evaporator is known as cooler or freezer. The evaporators are manufactured in the different sizes, shapes and types as per requirements.

**IV. EXPERIMENTAL INVESTIGATION**

**4.1 Pressures gauges:**


***Fig.a) High pressure gauge (b) Low pressure gauge***

We placed pressure gauges at suction and discharge of the compressor. In the above fig. the red one is the high pressure gauge placed at discharge and the other (blue) is the low pressure gauges placed at suction.

**4.2 Digital thermometer:**


Fig.5.10. Digital Thermometer

We used digital thermometer to find the temperatures. The specifications of the thermometer: The temperature range – (-50$^{\circ}C$ to 90$^{\circ}C$)

**4.3 EXPERIMENTAL SETUP**

**4.3.1 EXPERIMENTAL CONDITIONS:**

Experiments were carried out for various capillary tubes using refrigerant R134a. Extensive data were collected and tabulated for various operating conditions. Flow behavior of refrigerant flow in capillary tubes depends on expansion valves i.e. capillary tube length, capillary diameter, capillary coil diameter, capillary tube inlet pressure and refrigerant, Experiments were conducted at the following conditions

1) All the measurements were taken only after the system reached the steady state.

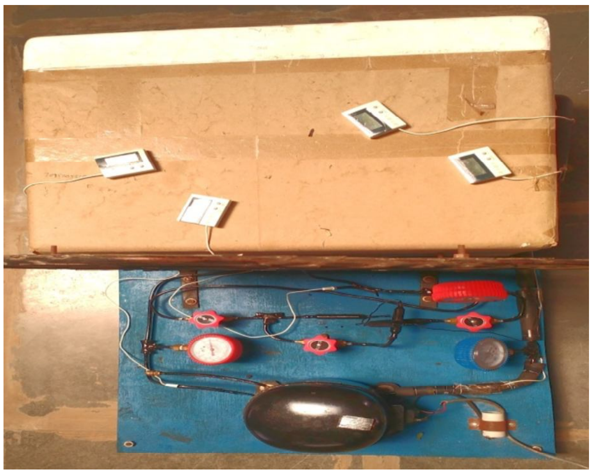
2) Set of experiments is done by keeping evaporator temperature at a specified level and varying the condensing temperature and vice versa.

3) Measures of all operating parameter were taken at every 20 min.

**4.3.2 EXPERIMENTAL PROCEDURE:**

Experimental procedure, which is carried out during the experiment, is given below: 1) The vapour compression refrigeration unit switched on. 2) The required evaporator temperature is attained, by adjusting the expansion. a) Operating VCR's system with single expansion valve with different loads and taking parameters (temperature and pressure readings) at frequent intervals. b) Operating VCR's system with three expansion valve with different loads and taking parameters (temperature and pressure readings) at frequent intervals. 3) The data acquisition system (parameters) at frequent intervals. 4) Temperature at inlet and out let for the components. 5) Pressure at the inlet and exit for the components. Parameters which effect the performance of the system are flow rate of refrigerant, capillary inner diameter, tube length and capillary coil diameter, condensing pressure and sub cooling.

**4.4 VAPOUR COMPRESSION REFRIGERATION SYSTEM WITH MULTIPLE EXPANSION VALVES:**

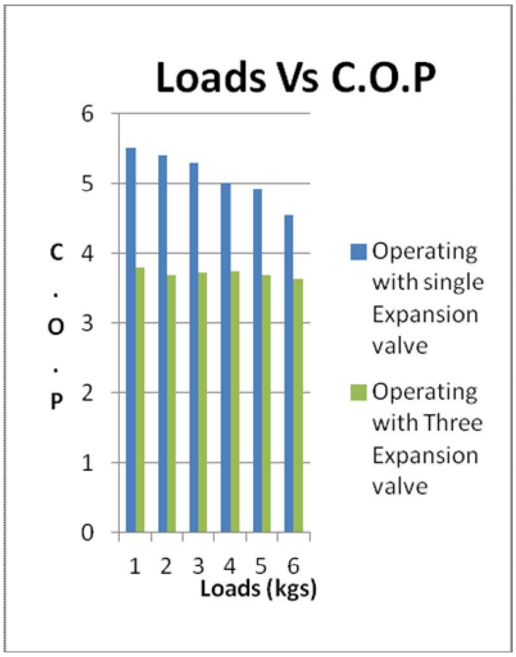



## V. RESULTS AND DISCUSSIONS

**Tabular column 1: Comparing the loads Vs C.O.P with Multiple Expansion valves on VCR System**

| Load's in (kg's) | C.O.P with single Expansion valve | C.O.P with Three Expansion valve |
|---|---|---|
| 1 | 5.51 | 3.80 |
| 2 | 5.40 | 3.70 |
| 3 | 5.30 | 3.73 |
| 4 | 5.01 | 3.75 |
| 5 | 4.92 | 3.69 |
| 6 | 4.55 | 3.63 |

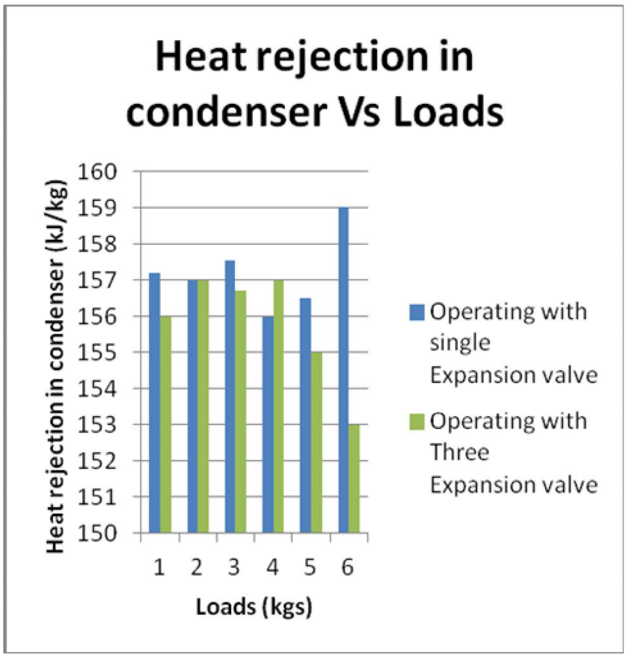
**Graph.1** For Comparing the loads Vs C.O.P with Multiple Expansion valves on VCR system




**Tabular column 2: Comparing the loads Vs Heat rejection in condenser with Multiple Expansion valves on VCR system**

| Load's in (kg's) | Heat rejection in condenser with single Expansion valve....KJ/Kg | Heat rejection in condenser with Three Expansion valve....KJ/Kg |
|---|---|---|
| 1 | 157.2 | 156 |
| 2 | 157 | 157 |
| 3 | 157.52 | 156.7 |
| 4 | 156 | 157 |
| 5 | 156.5 | 155 |
| 6 | 159 | 153 |

**Graph.2 For comparing Heat rejection in condenser Vs Loads of VCR system with Multiple Expansion valves**




### VI. CONCLUSIONS

Experimental studies have been carried out to evaluate the Refrigeration system performance under various operating conditions. A separate experimental set up has been used for determining the pressure, temperature and coefficient of performance with multiple expansion valves. From the investigations, the following conclusions are drawn: In the present work the performance of refrigeration system with R-134a refrigerant is optimized through experimental investigation using multiple expansion valves. Test results shows that the compressor work increases as the number of expansion valves increases. It is seen that mass flow rate of refrigeration system increases as number of expansion valves increases. The compressor pressure decreases as the number of expansion valves increases. It is seen that compressor power decreases as the number of expansion valves increases. Test results shows that the net refrigerating effect decreases as the number of expansion valves increases. Test results shows that the C.O.P decreases as the number of expansion valves increases. It is seen that heat equivalent of work of compressor increases as the number of expansion valves increases.

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