Design and Analysis of Thermostatic Expansion Valve to increase COP of VCR system

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Abstract-Thermal expansion valve is used many vapor compression refrigeration system such as refrigerator, air- conditioner etc. Hence many techniques have been investigated on thermal expansion valve to increase COP of VCR system. COP of thermal expansion valve can be increased either by controlling the bulb pressure or by decreasing compression work. This is an attempt to design expansion valve for increased COP with respect to mass flow control of refrigerant and the particular thermal parameter which are affecting to COP. The validation of design of thermal expansion valve is planned to validate by CFD analysis.

Keyword- Thermal expansion valve, VCR system, COP, Bulb pressure

1 Introduction

VCR system

This refrigeration cycle is approximately a Rankin cycle run in reverse. A working fluid (often called the refrigerant) is pushed through the system and undergoes state changes (from liquid to gas and back). The latent heat of vaporization of the refrigerant is used to transfer large amounts of heat energy, and changes in pressure are used to control when the refrigerant expels or absorbs heat energy. However, for a refrigeration cycle that has a hot reservoir at around room temperature (or a bit higher) and a cold reservoir that is desired to be at around 34°F, the boiling point of the refrigerant needs to be fairly low. Thus, various fluids have been identified as practical refrigerants. The most common include ammonia, Freon (and other chlorofluorocarbon refrigerants, aka CFCs), and HFC-134a (a non-toxic hydro fluorocarbon).

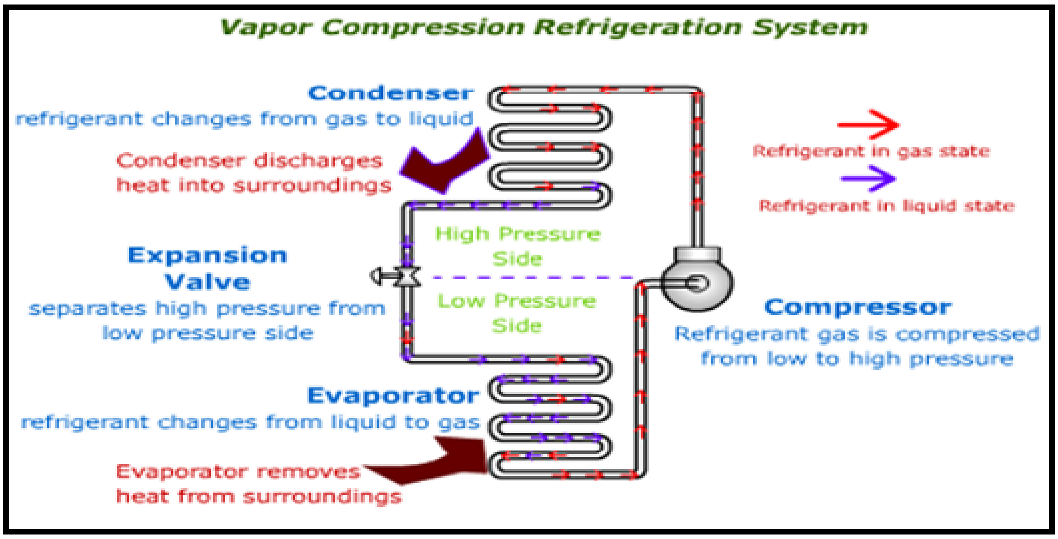

Fig 1 VCR system

2 .Thermostatic Expansion Valve

Thermostatic expansion valve or TEV is one of the most commonly used throttling devices in the refrigerator and air conditioning systems. The thermostatic expansion valve is the automatic valve that maintains proper flow of the refrigerant in the evaporator as per the load inside the evaporator. If the load inside the evaporator is higher it allows the increase in flow of the refrigerant and when the load reduces it allows the reduction in the flow of the refrigerant. This

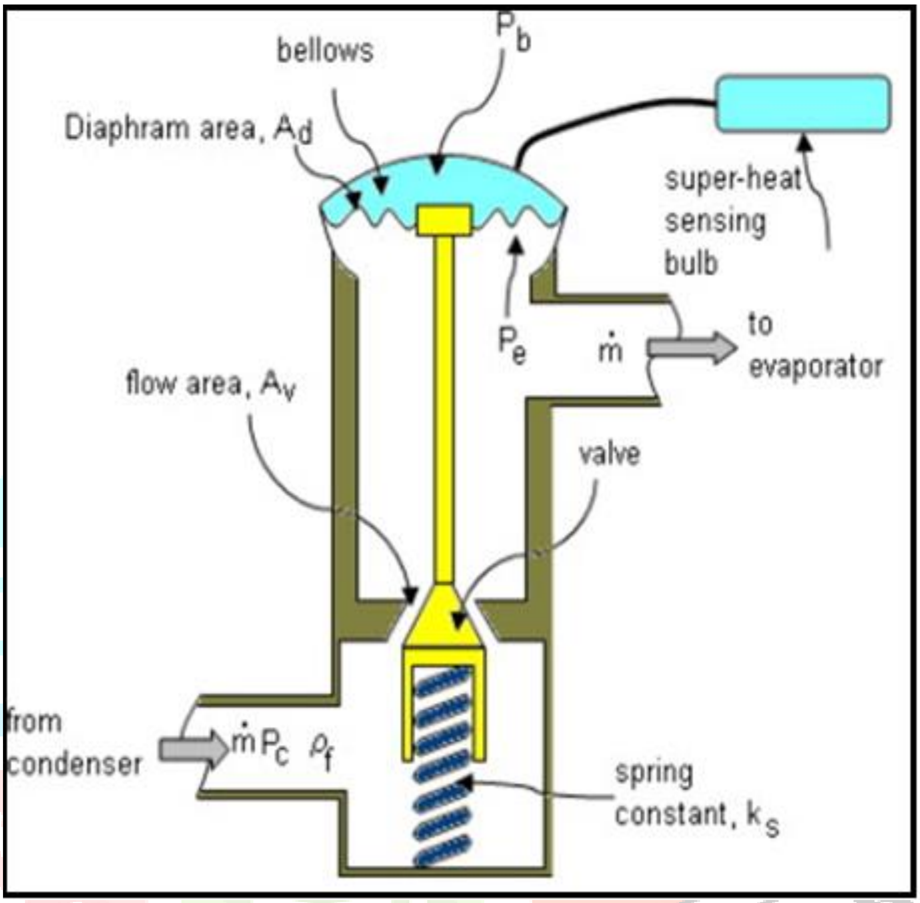

Fig 2 Thermostatic Expansion Valve

leads to highly efficient working of the compressor and the whole refrigeration and the air conditioning plant.

Two parts the thermostatic expansion valve elements of the body with its inner elements and the body with the inner elements. the thermostatic element motor of the valve; a sensing bulb is connected to the diaphragm assembly by 1.5meter length of capillary tubing. Which transmit bulb pressure to thee top of the valve diaphragm. The sensing bulb pressure is a function of the temperature of the thermostatic charge that is the substance within the bulb. The body is made from forged brass with connection in angle configuration. The interchangeable orifice assembly can be replaced through the inlet connection .A steel rod, inside the body, transfer the diaphragm movement to the plug inside the orifice assembly. When the thermostatic charge pressure increase, the diaphragm will be deflected from seat and allow the liquid passing through orifice. Spring oppose s the force underneath the diaphragm and the side spindle can adjust its tension. Static superheat increase by turning the side spindle clockwise and decreased by turning the spindle counter clockwise. The thermostatic expansion valve is hardly connected by brazing to the forged brass body avoid to leakage.

3 Working Principle

In thermostatic expansion valve opening and closing condition depend on three main pressure like bulb pressure (P_b), evaporator pressure(P_e), and spring pressure (P_e).so when the temperature and pressure variation take place in expansion valve than is workin

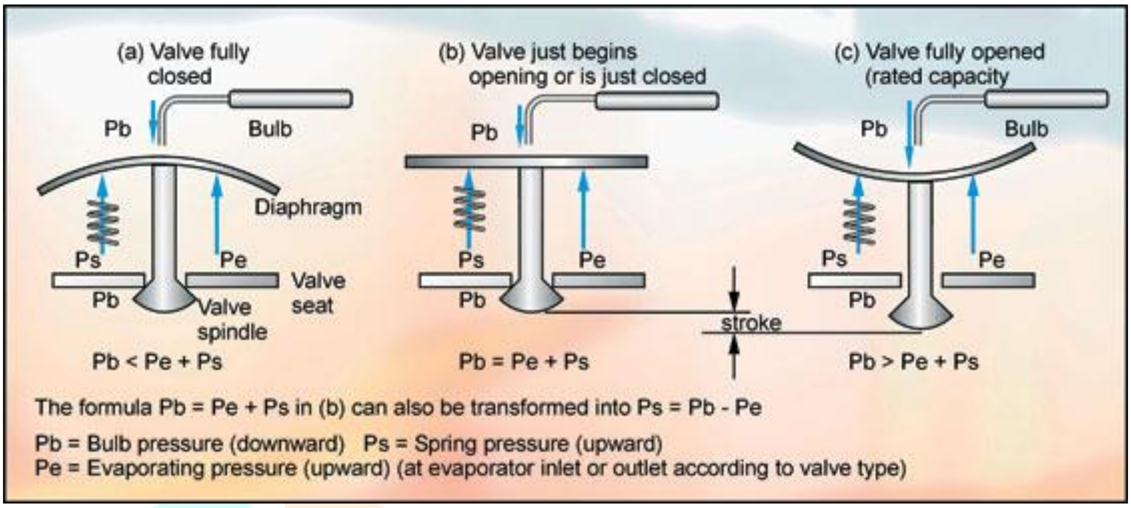

Fig 3 working of VCR system

Opening condition for valve:-

In this condition bulb pressureP_b is more than the spring pressure(P_s) and evaporating pressure(P_e) so that diaphragm take place downward direction than valve is open. In this case throttling temperature and evaporating temperature are not same. so the valve is partially close.

$$P_b > P_s + P_e$$

Closing condition for valve:-

In this condition bulb pressure is less than the spring pressure and evaporating pressure so that diaphragm take place upward direction and valve is close. In this case throttling temperature and evaporating temperature are closely same so the valve is partially open.

$P_b < P_s + P_e$

4 Modeling of Thermostatic Expansion Valve

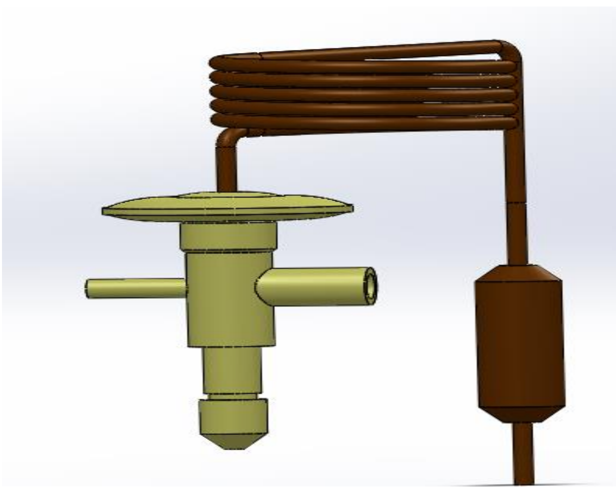

Fig 4 Thermostatic Expansion valve

Geometry Data

Sir no	Parts	Data
1	Capillary tube Length	1 to 1.5 m
2	Diaphragm Diameter	18mm
3	Inlet tube Diameter	12mm
4	Outlet tube Diameter	5mm
5	Thickness	2mm
6	Filler Bulb Diameter	25.5mm

Table 4.1 Geometry data of TXV

Calculation of COP

Sir no	Temperature Difference	COP
1	**-10**	**0.25**
2	**15**	**0.5**
3	**18**	**0.66**
4	**20**	**0.833**

Table 4.2 Variation of cop at different Temperature

Acceptance of accuracy variation in measurement

By any method like experimental setup or CFD analysis this type of experiment are done and increase COP of VCR system.

5 Literature review

A literature review surveys scholarly articles, books, dissertations, conference proceedings and other resources which are relevant to a particular issue, area of research, or theory and provides context for a dissertation by identifying past research. Various research papers were reviewed regarding my project "Design of Thermostatic Expansion Valve to Increase COP of VCR system"

Ian.W.James studied this paper describes and evaluates the development of generalised steady state and transient mathematical models for thermostatic expansion valves (TEVs) of the types used in commercial refrigeration systems. The model is of a nature, because it is not necessary to input performance or geometrical data for a particular valve to operate the
model. However, if required, the models can provide an accurate correlation of valve manufacturer's data. Derivations are provided and validating data is presented. The
mathematical models described in the paper form part of computer software that simulate
The thermal operation of whole refrigeration systems. The software is titled Vapor Compression Refrigeration System (VCRS) simulator, and by way of example the paper presents results from the VCRS simulator which are used to aid a discussion of operating faults, such as hunting and under damping and their possible causes, where these can be attributed to the expansion valve.

Amir tertian Two new ideas for the expansion valve and control valves of an adsorption cooling system (ACS) for vehicle air conditioning applications are suggested to reduce its weight and parasitic power consumption, and simplify its control system. A check valve with cracking pressure of 3.5–7 kappa is proposed for the expansion valve and a combination of low cracking pressure check valves and solenoid valves with an innovative arrangement is proposed for the control valves. These new designs are installed on a two absorber bed silica gel/CaCl2-water ACS and tested under different operating conditions. These designs result in reducing the total mass of the ACS up to 10.5 kg and the parasitic power consumption of the control valves by 50%. The results show that the expansion valve and control valves operate effectively under the heating and cooling fluid inlet temperatures to the absorber beds of 70–100 °C and 30–40 °C, Respectively, the coolant water inlet temperature to the condenser of 30–40 °C, and the chilled water inlet temperature to the evaporator of 15–20 °C. Also, an ACS thermodynamic cycle model is developed and compared against the experimental data for prediction and further improvement of the ACS performance. The results of the numerical modeling show that by increasing the absorber bed heat transfer coefficient and surface area, the specific cooling power of the system increases up to 6 times.

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A.A.A Rashid Decsribe This paper presents a comparable evaluation of R600a (isobutane), R290 (propane),R134a, R22, for R410A, and R32 an optimized finned-tube evaporator, and analyzes the evaporato reffect on the system coefficient of performance (COP). Results concerning the response of arefrigeration system simulation software to an increase in the amount of oil flowing with the refrigerantare presented. It is shown that there is optima of the apparent overheat value, for which eitherthe exchanged heat or the refrigeration coefficient of performance (COP) is maximized: consequently,it is not possible to optimize both the refrigeration COP and the evaporator effect. The obtained evaporator optimization results were incorporated in a conventional analysis of the vapor compression system. For a theoretical cycle analysis without accounting for evaporator effects, the COP spread for the studied refrigerants was as high as 11.7%. For cycle simulations including evaporator effects, the COP of R290 was better than that of R22 by up to 3.5%, while the remaining refrigerants performed approximately within a 2% COP band of the R22 baseline for the two condensing temperatures considered.

CONCLUSION

The present work has undertaken with the objectives of the understanding the proper installation of the measuring devices for measurement of the accurate data. And give some basic understanding of thermostatic expansion valve. After completed design and calculation cop increase with changing diameter of inlet and outlet.

REFERANCES

(1) "Modelling of thermostatic expansion valve"-Interatonal journal feb 2014[I.W Eames]

(2) "Investigation of influence of the various expansion devices on the performance of a refrigerator using r407c refrigerant." ISSN 0976/3945 [A.H.Dhumal,H.M.DAdange]

(3) "Control with thermostatic expansion valve" IJCSI International Journal of Computer Science Issues, Vol. 9, Issue 5, No 2, September 2012[Lio chunling]

(4) Cyclic in climate control system with orifice tube and thermostatic expansion valve International Conference on Recent Advancement in Air Conditioning and Refrigeration, RAAR
2016, 10-12 November 2016, Bhubaneswar, India[Sachin Pandure]

(5) Thermostatic expansion valve having a restricted flow passage for attenuation.

(6) "Experimental investigation on the use of capillary tube and thermostatic expansion valve in storage-enhanced heat recovery room air conditioner. "-IJSEAS- vol-2 issue 6 june 2016 [Rohit joshi,vijay patil,atul patil]

(7)"Effect of evaporator temperature on vapour compression refrigeration system"- elsvere Alexzandria Engineering Journal 16 aug 2010[Abdullah A.A.A Al Rashed]

(8) "Experiment analysis and performance testing of capillary tube and thermostatic expansion valve". ISSN volume 02 june5 2014 [Rahul Bhagore]

(9) Improve the cop of vapour compression cycle with change in evaporator and condenser-IJSSE issn 2229-5516 volume 6 may 2015 [Soyab hussain]

(10) "Identification of a thermostatic expansion valve."IFCA Identification and system parameter USA 1982 [P.M.T Brosen]

(11) "Experiment analysis of thermostatic expansion vale, constant expansion device & cap tube on vapour compression refrigeration system."-vol 2 ISSUE05 june2014[Amol A gavali,Mahadev joshi]

(12)" Thermostatic expansion valve fitter notes "[Thomas E Watson.ASHRAE]McQuay international staunion,virginia USA

(13) "Exergy analysis of refrigeration system using an alternative refrigerant (hfo-1234yf) to r-134a"-International Journal of low carbon Technology advance access published december 28,2013[Arif emre ahmet kabul]