



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 13, Issue 5, May 2024

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.423

Design and Fabrication of Refrigeration System for Improving Cop by Using Liquid Suction Heat Exchanger

Ganesh M. Dahagawkar, Dr. Sanjay Ikhhar

M. Tech, Department of Mechanical Engineering, K. D. K. College of Engineering, Nagpur, Maharashtra, India

Professor, Department of Mechanical Engineering, K. D. K. College of Engineering, Nagpur, Maharashtra, India

ABSTRACT: This paper shows the comparative study of refrigeration systems using two different refrigerants i.e., R-134a (Tetra Fluoro Ethane) & R-600a (Isobutane) by installing liquid suction heat exchanger in existing systems. Using a heat exchanger will improve the performance i.e., refrigerating effect or COP of the system. Liquid suction heat exchanger is beneficial in providing subcooling to liquid refrigerant prior to entering the expansion valve. Added subcooling will lead to increase in efficiency of the system. Subcooling the liquid refrigerant and superheating of vapour in heat exchanger will improve the refrigerating effect of the system. In this the liquid line is placed in contact with the suction line forming a counter flow heat exchanger. Before the expansion process the heat is transferred from liquid line to suction line. This in turn reduces refrigerant quality and increases the refrigerating capacity of the system. The exit temperature of the suction line increases eliminating suction line sweating and preventing slugging of compressor. It is found that heat exchange between high pressure and high-temperature refrigerant liquid coming from the condenser and low pressure and low-temperature refrigerant vapour coming from the evaporator is having a significant effect on its COP.

KEYWORDS: VCR System, LSHX, R-134a, R-600a, COP, Sub-cooling.

I. INTRODUCTION

The use of heat exchanger has the potential to increase the COP of the VCR system higher than existing. In the VCR system, there are two heat exchangers. One is an evaporator which absorbs the heat and another is a condenser where heat rejection takes place. A study has been done to improve the COP of the VCR system. A liquid suction heat exchanger has a significant effect on COP and is a type of counter-flow heat exchanger which sub cools saturated liquid refrigerant coming from the condenser and superheats the saturated vapour coming from evaporator. Phenomenon of subcooling and superheating is followed in this paper. Two refrigerants are being used in the system i.e., R-134a (Tetra Fluoro Ethane) and R-600a (Isobutane). Log mean temperature (LMTD) method is being used in the following system to calculate the length of heat exchanger.

II. LIQUID SUCTION HEAT EXCHANGER

Liquid Suction Heat Exchanger is introduced in the refrigeration system to improve the performance of the refrigeration system.

The superheated vapour from the compressor goes into the condenser where a phase change occurs & it converts into the saturated liquid. Then this saturated liquid goes into the heat exchanger where it rejects heat to the liquid-vapour mixture coming from the evaporator & gets sub-cooled. Now, this sub-cooled liquid goes into the expansion device where it converts into the low pressure & low-temperature liquid-vapour mixture. Then this liquid-vapour mixture goes into the evaporator where heat addition takes place at constant pressure & refrigeration effect is obtained. The lowpressure & low-temperature liquid-vapour mixture after coming out of the evaporator goes into the heat exchanger where it gains the heat from the sub-cooling of the saturated liquid. After that, it becomes saturated vapour & then enters into the compressor & the cycle continues. In the liquid suction interchanger, cool suction steam is passed through a heat exchanger in counter flow on the hot fluid condenser. That is, two liquid flows in opposite directions. In the heat exchanger, the heat produced by suction gas as much that has lost liquid refrigerant. However, temperature changes are not equal. Specific heat capacity of the refrigerant vapor less than the liquid. Thus, the increase in the temperature of the steam is always greater than the drop in the temperature of the liquid. The schematic Diagram of

VCR System with Liquid Suction Heat Exchanger (LSHX) is shown in fig. 1 and representation of combine superheating and sub-cooling on P-H & T-S coordinate is shown in fig. 2

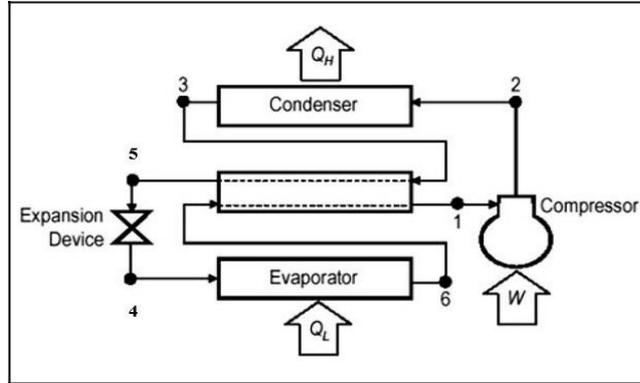


Fig. 1: Schematic of the VCR System with LSHX.

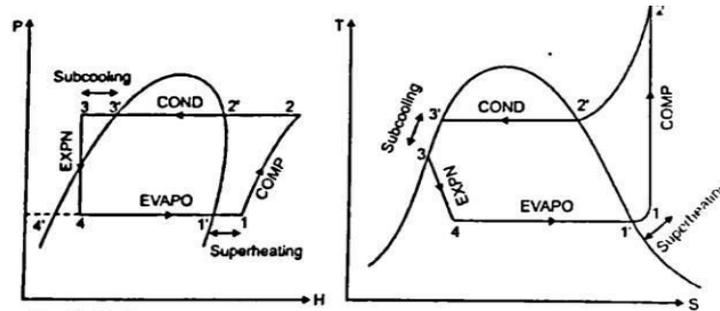


Fig. 2: Representation of Sub-Cooling and Superheating on P-H & T-S Coordinate.

Processes:

- Process 1-2: Isentropic Compression
- Process 2-2': De-superheating
- Process 2'-3': Heat Rejection at constant pressure
- Process 3'-3: Sub-cooling
- Process 3-4: Isenthalpic process
- Process 4-1': Heat addition at constant pressure
- Process 1'-1: Superheating

ABBREVIATIONS AND ACRONYMS

T1	Compressor inlet temp. (°C)
T2	Compressor outlet temp. (°C)
T3	Condenser inlet temp. (°C)
T4	Evaporator inlet temp. (°C)
T5	Condenser outlet temp. (°C)
T6	Evaporator outlet temp. (°C)
T7	Water temp.in bottle
h1	Enthalpy of Super- heated vapour (KJ/kg)
h2	Enthalpy at end of compression process (KJ/Kg)
h3	Enthalpy of saturated vapour at (KJ/kg)

h4	Enthalpy of saturated liquid (KJ/kg)
h5	Throttling process (KJ/kg)
h6	Throttling process (KJ/kg)
mw	Mass of water (kg)
Cpw	Specific heat of water (KJ/Kg-K)
N	Pulse
EMC	Energy meter consumption

III. LITERATURE REVIEW

P.A Domanski, D.A. Didion and J.P. Doyle (1992) targeted the assessment of the liquid line heat exchanger in the refrigeration cycle. The study observed the advantages of the liquid suction heat exchanger that rely upon different conditions and properties of the fluid. The fluids whose behaviour in the primary cycle is fine are hardly concerned by the use of LSHX, and its effect on the coefficient of performance and volumetric capacity can be either positive or negative. Fluids whose behaviour in the primary cycle is below par, are largely helped by the installation of LSHX which results in the improvement of the coefficient of performance and volumetric capacity.

S. A. Klein, D. T. Reindl, and K. Brownell (2000) investigated by assessing the effect of LSHX in simple vapour compression refrigeration system and concluded that by installing liquid suction heat exchanger it leads to the performance improvements for any refrigerant by ignoring the decrement in the mass flow rate of refrigerant. When assessing closely, the LSHX results in the rise in temperature of refrigerant and results in the decrement of the pressure of the refrigerant which is going into the entering the compressor which leads to decrement in the density and volumetric efficiency of the compressor, and suggested that the choice of the heat exchanger must be on the basis of refrigerant properties.

G. Maruthi Prasad Yadav, P. Rajendra Prasad, G. Veeresh (2011) conducted a study on how capillary tubes can be used with VCR System with LSHX. Capillary tubes are cheap and its design is comparatively simple therefore, they are widely used in refrigeration systems.

Shoeb J. Inamdar, H.S. Farkade (November 2016) calculated the effects of heat exchanger in simple VCERS with R-134a varying length and concluded that if the length of heat exchanger increases then heat rejection rate per TR decreased, and the cooling effect increased.

IV. METHODOLOGY

In this study, by using liquid suction heat Exchanger the performance of a vapour compression refrigeration system is analysed. Here the refrigeration effect must increase by keeping the work input to the compressor as constant.

Here refrigerant R-134a and R-600a will be used as heat exchange medium for refrigeration. Mass flow rate of refrigerant is constant. All parameters are kept constant when introduced with heat exchanger.

Formulas used:

$$R. E. = h_6 - h_4$$

$$W. D. = h_2 - h_1$$

$$R. E. = M_w \times C_{pw} \times (T_1 - T_7)$$

$$T \times 60$$

$$W. D. = N \times 3600$$

$$t \times EMC$$

$$LMTD = \frac{\theta_1 - \theta_2}{\ln \frac{\theta_1}{\theta_2}}$$

$$\theta_1$$

$$\theta_2$$



Sr.no.	R.E. (KJ/Kg)	W.D.(KJ/Kg)	COP
R-134a			
1.	0.1465	0.01875	5.57
2.	0.1046	0.01875	5.58
3.	0.1468	0.01875	5.95
R-600a			
1.	0.1046	0.01875	5.57
2.	0.1116	0.01875	5.95
3.	0.1186	0.01875	6.32

Table no. 1: Analysis without heat exchanger.

Sr.no.	R.E. (KJ/Kg)	W.D.(KJ/Kg)	COP
R-134a			
1.	0.1571	0.01875	5.96
2.	0.1186	0.01875	6.32
3.	0.1256	0.01875	6.69
R-600a			
1.	0.1258	0.01875	6.70
2.	0.1395	0.01875	7.44
3.	0.1325	0.01875	7.06

Table no. 2: Analysis with a heat exchanger.

Sr. no.	COP without heat exchanger	COP with heat exchanger	Percentage of increase in COP (%)
R-134a			
1.	5.57	5.96	7
2.	5.58	6.32	12.12
3.	5.95	6.69	12.25
R-600a			
1.	5.87	6.70	14.1
2.	5.95	7.18	19.8
3.	6.32	7.06	11.78

Table no. 3: Comparison of COP's.

V.CONCLUSION

From the analysis, it can be summarised that increase in sub-cooling of refrigerant before entering to the expansion device has a positive impact on COP of the system.

Installation of Liquid Suction Heat exchanger with existing Refrigeration is a very easy process. And costing is very less compared to the improvement in the refrigeration effect.

Sub-cooling of Refrigerant also increases superheating of refrigerant entering the compressor hence it is not one way.

Due to the superheating process, the mass flow rate of refrigerant going into the compressor decreases. But keeping the mass flow rate constant, according to our study, we concluded that on increasing the temperature of sub-cooling, the COP of the VCR system is increased by installing a liquid suction heat exchanger in case of R-134a and R-600a refrigerant.

Therefore, the study shows, installing liquid suction heat exchanger improves the performance in refrigeration effect and is having significant impact on evaporator which has reported 10% – 20 % increase in the COP

REFERENCES

1. R.S. KHURMI, J.K. GUPTA, A Textbook of Refrigeration and Air Conditioning, S. CHAND Publications.
2. Arora CP, A textbook of refrigeration and Air Conditioning, Tata Mc-Graw-hill Publications.
3. M.L. MATHUR and M.S. MEHTA Refrigerant and Psychrometric Properties (Tables and Charts) Jain brother Publications.
4. P.A Domanski, D.A. Didion and J.P. Doyle (1992) targeted the assessment of the liquid line heat exchanger in the refrigeration cycle. The study observed the advantages of the liquid suction heat exchanger that rely upon different conditions and properties of the fluid. The fluids whose behaviour in the primary cycle is fine are hardly concerned by the use of LSHX, and its effect on the coefficient of performance and volumetric capacity can be either positive or negative. Fluids whose behaviour in the primary cycle is below par, are largely helped by the installation of LSHX which results in the improvement of the coefficient of performance and volumetric capacity.
5. S. A. Klein, D. T. Reindl, and K. Brownell (2000) investigated by assessing the effect of LSHX in simple vapour compression refrigeration system and concluded that by installing liquid suction heat exchanger it leads to the performance improvements for any refrigerant by ignoring the decrement in the mass flow rate of refrigerant. When assessing closely, the LSHX results in the rise in temperature of refrigerant and results in the decrement of the pressure of the refrigerant which is going into the entering the compressor which leads to decrement in the density and volumetric efficiency of the compressor, and suggested that the choice of the heat exchanger must be on the basis of refrigerant properties.
6. G. Maruthi Prasad Yadav, P. Rajendra Prasad, G. Veeresh (2011) conducted a study on how capillary tubes can be used with VCR System with LSHX. Capillary tubes are cheap and its design is comparatively simple therefore, they are widely used in refrigeration systems.
7. Shoeb J. Inamdar, H.S. Farkade (November 2016) calculated the effects of heat exchanger in simple VCERS with R-134a varying length and concluded that if the length of heat exchanger increases then heat rejection rate per TR decreased, and the cooling effect increased.

BIOGRAPHIES

Ganesh M. Dahagawkar

Project Guide

Dr. Sanjay Ikhar

Professor of Mechanical

Engineering Department

K. D. K. college of Engineering, Nagpur



INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details