Review of Vapour Compression Refrigeration System

Neel Joshi, Yadav Rajesh, Patel Rutvik, Patel Shlok, Patel Siddh, Solanki Shubham, Nemichandji, Patel Utsv, Shah Shubham Ketankumar

.

A B S T R A C T

This paper focuses and presents literature studies on recent development in ejector or diffuser cooling system also the enhancement of the performance. To improve the coefficient of performance, it is to require that compressor work should decrease and refrigerating effect should increase. Initially the diffuser of increasing cross-sectional area profile was designed, fabricated and introduced. Some of researches have conducted and categorized in working fluid selections, simulation and mathematical modeling of the ejector, geometrical and operation conditions optimization. However, most of the experimental studies which have been done in last two decades are still insufficient if compared with simulation modeling; more experiments studies and big scale work are required in order to come out with good understanding in real application.

Review of Vapour Compression Refrigeration System

Keywords: Vapor Compression Refrigeration Cycle, COP, Diffuser, Ejector, Sub-cooling

1. Introduction

Refrigeration may be defined as lowering the temperature of an enclosed space by removing heat from that space and transferring it elsewhere. The most frequently used refrigeration cycle is the vapor compression refrigeration cycle. Ideal vapor compression refrigeration cycle results, by eliminating impracticalities associated with Reversed Carnot cycle such as vaporizing the refrigerant completely before compression, replacing turbine with throttling device (expansion valve or capillary tube) and process is going on after this work. Then next step is taken for further process. Vapor compression refrigeration system is based on vapor compression cycle. Vapor compression refrigeration system is used in domestic refrigeration, food processing and cold storage, industrial refrigeration system, transport refrigeration and electronic cooling. So improvement of performance of system is too important for higher refrigerating effect or reduced power consumption for same refrigerating effect. Many efforts have to be done to improve the performance of VC refrigeration system.

The reason to improve the performance and efficiency of the system is that the conventional fuel sources are getting depleted due to continuous use of it. Conventional energy sources are not long lasting. Nowadays energy is continuously in demand and the world is on the one hand facing problem with limited availability of conventional energy sources and on the other hand global warming because of pollutants from fossil fuels. Refrigeration systems are indispensable for human beings in the modern life. Currently, the mechanical vapour compression systems used for this purpose, use large amounts of electrical power that is produced in great proportion by fossil fuel combustion, which is a cause of the global warming. Global warming makes imperative need to develop alternative technologies that will allow carrying out cooling applications reducing the use of electrical energy. Electrical energy can be remarkably saved by incorporating high efficiency devices or occupying other energy sources such as thermal energy.

Vapor compression refrigeration system is based on vapor compression cycle. Vapor compression refrigeration system is used in domestic refrigeration, food processing and cold storage, industrial refrigeration system, transport refrigeration and electronic cooling. Coefficient of performance of performance of refrigeration system is the ratio refrigerating effect to the work done. So improvement of performance of system is too important to increase refrigerating effect or to reduce work done by compressor. Many efforts have to be done to improve performance of vapor compression refrigeration system.

Nomenclature

Roman
- COP Coefficient of performance [-]
- q Evaporator/heat sink heat transfer rate [W]
- qc Condenser heat transfer rate [W]
- R Thermal resistance [ºC W^{-1}]
- T Temperature [ºC, K]
- w Compressor power [W]

Greek
- η Efficiency [-]

Subscripts
- amb Ambient
- C Carnot
- cond Condenser/condensing refrigerant
- evap Evaporator/evaporating refrigerant
- E External
- I Internal
- j Chip/junction/copper block/chilled water

1.1. Literature Review

Files must be in MS Word only and should be formatted for direct printing, using the CRC MS Word provided. Figures and tables should be embedded and not supplied separately.

Xu Shuxue et al. (2013) [1], A thermodynamically analytical model on the two-stage compression refrigeration/heat pump system with vapour injection was derived. The optimal volume ratio of the high-pressure cylinder to the low pressure one has been discussed under both cooling and heating conditions. Based on the above research, the prototype was developed and its experimental setup established. A comprehensive experiment for the prototype have been conducted, and the results show that, compared with the single-stage compression heat pump system, the cooling capacity and cooling COP can increase 5%-15% and 10-12%, respectively. Also, the heating capacity with the evaporating temperature ranging from 0.3 to 3OC is 92-95% of that under the rate condition with the evaporating temperature of 7 OC, and 58% when the evaporation temperature is between 28 ºC and 24 ºC.

Christian J.L Hermes, (2014) [2], reports a study on reduction of refrigeration charge in vapour compression refrigeration system with a liquid to suction heat exchanger the analysis was carried out for different refrigerant and it was found that reduction of refrigerant charge depends on thermodynamic properties of refrigerant and working conditions.

Xiaoui she et al. (2013) [3], proposed a new sub-cooling method for vapour compression refrigeration system depending on expansion power recovery. To drive a compressor of sub-cooling cycle, expander output power is employed. Liquid refrigerant is sub-cooled by using evaporative cooler. This makes a hybrid refrigerant system. Analysis is to done by using different refrigerants and results shows that hybrid vapour compression refrigeration have more (C.O.P) than conventional vapour compression refrigeration system.

N K Mohammed sajid et al. (2012) [4], studied the performance of air conditioning system with and without matrix heat exchanger. Experiment is conducted to do comparative analysis of split air conditioning system. Initially performance of conventional split type air conditioning system is evaluated and then the performance of split type air conditioning with matrix heat exchanger is evaluated for different load conditions .result indicates that coefficient of performance of air conditioning system with matrix heat exchanger is better than coefficient of performance of split air conditioning system without matrix heat exchanger. It is observed that power consumption with matrix heat exchanger will also reduce.

S.A.Klein et al. (2013) [5], Heat transfer devices are provided in many refrigeration systems to exchange energy between the cool gaseous refrigerant leaving the evaporator and warm liquid refrigerant exiting the condenser. These liquid-suction or suction- line heat exchangers can, in some cases, yield improved system performance while in other cases they degrade system performance. Although previous researchers have investigated performance of liquid-suction heat exchangers, this study can be distinguished from the previous studies in three ways. First, this paper identifies a new dimensionless group to correlate performance impacts attributable to liquid- suction heat exchangers. Second, the paper extends previous analyses to include new refrigerants. Third, the analysis includes the impact of pressure drops through the liquid-suction heat exchanger on system performance. It is shown that reliance on simplified analysis techniques can lead to inaccurate conclusions regarding the impact of liquid-suction heat exchangers on refrigeration

system performance. E Hajidavalloo et al. [6] , in this paper to reduce the challenging problem of increase of coefficient of performance of air-conditioning system evapouratively cooled air condenser is used instead of air cooled condenser. Experimental results show that evaporative condenser has better performance than air cooled condenser.N. Upadhyay, (2014) [7], this paper presents a concept of effect of sub-cooling on performance of refrigeration system. In this a diffuser is used after condenser which converts kinetic energy in to the pressure energy of refrigerant it results in reduction of power consumption and it results in reduction of condenser size.
The necessity of high effectiveness in a small volume has led to the development of perforated plate matrix heat exchangers (MHE) for refrigeration applications. Although the basic principles have remained the same, the techniques of fabrication and bonding have changed considerably during the last four decades. The large surface area of each perforated plate gives the matrix heat exchanger a large surface area to volume ratio, enabling compact exchangers with high heat transfer.

1.2. Design and modeling of system

The necessity of high effectiveness in a small volume has led to the development of perforated plate matrix heat exchangers (MHE) for refrigeration applications applications. Although the basic principles have remained the same, the techniques of fabrication and bonding have changed considerably during the last four decades. The large surface area of each perforated plate gives the matrix heat exchanger a large surface area to volume ratio, enabling compact exchangers with high heat transfer.

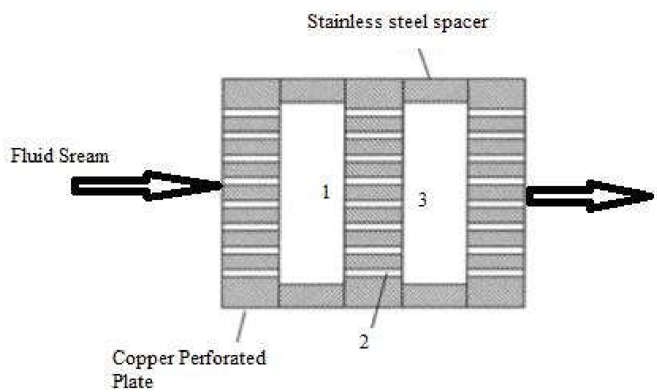

Figure 1 ***Cross section of a matrix heat exchanger***

Section headings should be left justified, bold, with the first letter capitalized and numbered consecutively, starting with the Introduction. Sub-section headings should be in capital and lower-case italic letters, numbered 1.1, 1.2, etc, and left justified, with second and subsequent lines indented. All headings should have a minimum of three text lines after them before a page or column break. Ensure the text area is not blank except for the last page.
1) The front face of the plates
2) The tubular surface of the perforations
3) The back face of the plates

Figure 1 shows a cross section of a matrix heat exchanger to indicate the three different convective heat transfer surfaces. While efficient, the heat transfer process in a matrix heat exchanger is complex, as there are two conduction paths (along the perforated plates, and across the spacer plates), as well as three convection surfaces (upstream of the plates, downstream of the plates, and the inner wall surface area of each perforation). The total heat transfer of a matrix heat exchanger is composed of five components: 1) Convective heat transfer between hot fluid streams and perforated plates. 2) Conductive heat transfer along the perforated plates up to the separation wall. 3) Conductive heat transfer across the separation wall. 4) Conductive heat transfer along the perforated plates from the separation wall. 5) Convective heat transfer between perforated plate and cold fluid stream. All these modes of heat transfer (convection on three different surfaces and conduction in two different directions) are coupled, requiring them to be determined together. This project surveys the available literature for applications of matrix heat exchangers in steam generation, which will result in the ability to design a more efficient and more compact refrigeration system.

1.3. Thermodynamic analysis and critical assessment of technology

R-134a has been, by far and large, the most widely used refrigerant in small-scale refrigeration applications (e.g., electronics and personal cooling). This is due to its well-know physical properties, safe handling (non-flammable, non-toxic), low cost and compatibility with many products and parts already available in the market. For cooling of electronics, since R-134a is not dielectric, some form of electrical insulation is needed between the refrigerant and the circuits or microprocessors.
Except for the studies of Coggins and co-workers [20, 21] and Wadell [22], only single-stage cycles have been investigated for electronics cooling. The main advantage of a two-stage cascade system is that lower evaporating temperatures can be achieved at moderate (i.e., around atmospheric) evaporating pressures by using a low normal boiling temperature refrigerant in the low-stage cycle. However, this benefit comes at the expense of operating with an

intrinsically less efficient, more expensive and potentially noisier cycle due to the operation with two compressors and an inter-stage heat exchanger. Phelan et al. [39] performed a comparison of four alternative system designs and concluded that the cycle with the smallest energy consumption for their application was a cascade system in which the electronic device was cooled by a pumped loop that is connected to a conventional vapor compression cycle. This concept is also being pursued in personal cooling applications, whereby the refrigerant cools a secondary fluid (water) that comes into contact with the human body in a cooled garment [40].

More recently, Marcinichen et al. [41] proposed three alternative cycles (one with a pump, one with a compressor and a hybrid of the two) for cooling computer blades in high-end servers. The hybrid cycle is characterized by the interchangeability between the first two cycles. The authors suggested that the best cycle for a specific application should be decided based on the overall cycle efficiency, which is defined as the ratio of the recovered energy in the condenser and subcooler to the energy required to pump the refrigerant. This enables a more integrated design, which will lead to a more economic operation of high performance data centers.

Ribeiro et al. [42] introduced a hybrid cooling system in which the evaporator of a miniature refrigerator with characteristics similar to those of Mongia et al. [9] is connected to the condenser region of the heat pipes used for chip cooling. A model for the evaporator/heat pipe assembly was proposed, and an evaporator prototype was designed, fabricated and tested with R-600a at saturation temperatures of 45 and 55°C, mass flow rates between 0.5 and 1.5 kg h-1 and heat transfer rates between 30 and 60 W. It can be argued on the grounds of thermal performance alone that the evaporator/heat pipe assembly is feasible only if the overall thermal resistance from the chip surface to the evaporator fluid is less with the heat pipe in place. However, as will be seen later, there are several issues related with the implementation of the vapor compression technology in portable computers which are driven by aspects such as compressor and fan noise, vibration, robustness and reliability, refrigerant leakage etc. While these issues are not fully addressed and the associated technical challenges not duly overcome, the proposed heat rejection assembly may act as a possible solution before a more definite one becomes available. Simpler types of expansion devices, like capillary tubes and orifices, have been preferred by the majority of the studies reviewed here.

1.4. Conclusion

Vapour refrigeration system requires large amount of energy to operate. As energy crisis is big problem in the world there is a need of decreasing power consumption of electricity. Energy consumption can be reduced by using counter flow matrix heat exchanger. As energy consumption is reduced coefficient performance of refrigeration system may increase.

Power consumption can be reduced by effective cooling and better heat rejection method. In this matter copper can be more effective compare to other metal as heat transfer rate and also in term of price also for the human society.

Acknowledgements

I am really thankful to all team members to support and make a this review paper and also other faculty members to help for the same.

REFERENCES

[1] X.Shuxue, M.Guoyuan, 2013 "Experimental study on two-stage compression refrigeration/heat pump system with dual-cylinder rolling piston compressor", Journal of applied thermal engineering , volume 62, 803-808.

[2] Christian, J.L Hermes,2014 "Refrigerant charge reduction in vapour compression refrigeration cycle via liquid –to-suction heat exchanger ",International journal of refrigeration , volume 52, 93-99.

[3] X. She, Yonggao, X. Zhang, 2014"A proposed subcooling method for vapour compression refrigeration cycle based on expansion power recovery ", International journal of refrigeration , volume 43, 50-61.

[4] N.K.Mohammed Sajid, K.S. Ram and K.A.Shafi,2012 "Performance improvement of an air conditioning system using matrix heatnexchanger", International journal of engineering research and development, volume 2,issue11(August 2012), 66-70

[5] S.A.Klein, D.T.Reindl and K.Brownell, 2000 "Refrigeration system performance using liquid suction heat exchangers", Internationalvjournal of refrigeration , volume 23, 588-596.

[6] E. Hajidavalloo, H. Eghtedari, 2009"Performance improvement of air-cooled refrigeration system by using evapouratively cooled air condenser", International journal of refrigeration, volume 33, 982-988

[7] N. Upadhyay, (2014) "Analytical study of vapour compression refrigeration system using diiffuser and subcooling",journal of mechanical and civil engineering ,volume 11,issue 3, 92-97.