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Improving the performance of Vapor compression refrigeration system by using sub- cooling and diffuser

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Abstract: Aim of this paper is to improve coefficient of performance of system. To improve the coefficient of performance, it is to require that compressor work should decrease and refrigerating effect should increase. Modifications in condenser are meant to increase degree of sub-cooling of refrigerant which increased refrigerating effect or more cooling water is required in condenser. The purpose of a compressor in vapour compression system is to elevate the pressure of the refrigerant, but refrigerant leaves the compressor with comparatively high velocity which may cause splashing of liquid refrigerant in the condenser tube, liquid hump and damage to condenser by erosion. It is needed to convert this kinetic energy to pressure energy by using diffuser. By using diffuser power consumption is less for same refrigerating effect so performance is improved.

Keywords: *vapour compression refrigeration system, sub- cooling and diffuser.*

I. Introduction

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.

Jianlin Yu, Hua Zhao, Yanzhong Li [1] Presented a novel auto cascade refrigeration cycle (NARC) with an ejector. In the NARC, the ejector is used to recover some available work to increase the compressor suction pressure. The NARC enables the compressor to operate at lower pressure ratio, which in turn improves the cycle performance.

Yinhai Zhu and Peixue Jiang [2] developed a refrigeration system which combines a basic vapor compression refrigeration cycle with an ejector cooling cycle. The ejector cooling cycle is driven by the waste heat from the condenser in the vapor compression refrigeration cycle. The additional cooling capacity from the ejector cycle is directly input into the evaporator of the vapor compression refrigeration cycle the system analysis shows that this refrigeration system can effectively improve the COP by the ejector cycle with the refrigerant which has high compressor discharge temperature.

N.D. Banker, P. Dutta, M. Prasad and K. Srinivasan [3] present the results of an investigation on the efficacy of hybrid compression process for refrigerant HFC 134a in cooling applications. The conventional mechanical compression is supplemented by thermal compression using a string of adsorption compressors... It is shown that almost 40% energy saving is realizable by carrying out a part of the compression in a thermal compressor compared to the case when the entire compression is carried out in a single-stage mechanical compressor. The hybrid compression is feasible even when low grade heat is available. Some performance indicators are defined and evaluated for various configurations.

Andrea Chesi, Giovanni Ferrara, Lorenzo Ferrari and Fabio Tarani [4] analyze a complex system in which the solar powered ejection machine is used to increase the efficiency of a traditional vapor compression machine by subtracting heat from the condenser. By means of a transient analysis, performed with a reference building and with climate data corresponding to four different system locations worldwide, the year-round performance of such a system in a space cooling application is estimated in terms of energy balance and savings on power costs with respect to the traditional solutions

A. Selvaraju and A. Mani [5] investigate the experimental analysis of the performance of a vapor ejector refrigeration system. The system uses R134a as working fluid and has a rated cooling capacity of 0.5 kW. The influence of generator, evaporator and condenser temperatures on the system performance is studied. For a given ejector configuration, there exists an optimum temperature of primary vapor at a particular condenser and evaporating temperatures, which yields maximum entrainment ratio and COP.

L. Kairouani, M. Elakhdar, E. Nehdi and N. Bouaziz [6] presented an improved cooling cycle for a conventional multi-evaporators simple compression system utilizing ejector for vapour precompression is analyzed. The ejector enhanced refrigeration cycle consists of multi-evaporators that operate at different pressure and temperature levels. A one-dimensional mathematical model of the ejector was developed using the equations governing the flow and thermodynamics based on the constant-area ejector flow model. The theoretical results show that the COP of the novel cycle is better than the conventional system.

Advances in condenser to increase coefficient of performance means to increase degree of sub-cooling , F. W. Yu and K. T. Chan [7] described use of direct evaporative coolers to improve the energy efficiency of air-cooled condenser. This evaporative cooler is installed in front of air-cooled condenser to pre-cool outdoor air before entering the condenser. Results were predicted that the use of the evaporative cooler results in an increase in the refrigeration effect.

Present work deals with the improvement of vapor compression refrigeration system by using sub-cooling and diffuser at inlet of condenser.

II. Theoretical analysis

Simple vapor compression cycle: Dry saturated vapor coming from evaporator is compressed in compressor so pressure is increases superheated vapor is passed through condenser where vapor is condensed by flowing the cooling water in condenser. Dry saturated liquid is passed through expansion valve where expansion takes place so pressure is decrease by expansion after expansion liquid is passed in evaporator where it absorb the heat of storage space and evaporate so cooling process in storage space is achieved, thus cycle is complete.

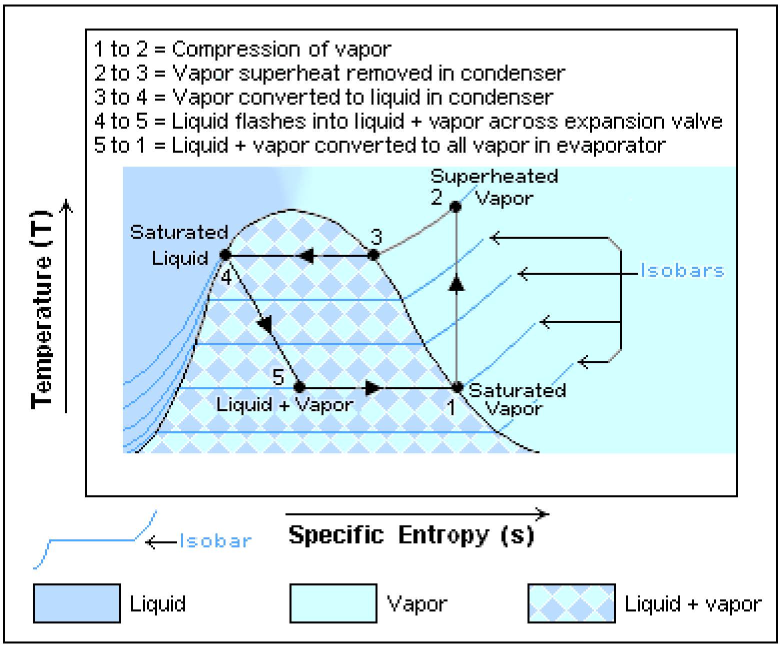

Fig.II.1 T-S diagram for VC Cycle [8]

$$COP = \frac{Refrigerating\ effect}{work\ input}$$

COP (Coefficient of Performance): it is a performance parameter of simple VC Cycle. If refrigerating effect is increases or work input is decreases than performance of simple VC Compression cycle are increases.

Vapor compression cycle with sub-cooling and using diffuser:

In the present cycle, the vapor refrigerant leaves the compressor with high velocity. This high velocity refrigerant directly impinges on the tube of condenser which may damage to it by vibration and erosion. It results undesirable splashing of refrigerant in the condenser tube. It also results a phenomenon called as "liquid hump". Liquid hump refer to a rise in the level of the condensed refrigerant liquid in the central portion of the condenser as compared to the level at the ends of the condenser. It reduces the heat transfer surface area so reduce condenser efficiency. Thus reducing the velocity of refrigerant a diffuser is attached after compressor. Diffuser is a device which converts the velocity into pressure energy. It smoothly decelerates the incoming refrigerant achieving minimum stagnation pressure losses and maximizes static pressure recovery [9]. Due to pressure recovery, at same refrigerating effect compressor to do less work. Hence, power consumption of the compressor will be reduced which results improvement in system efficiency. Superheated vapor is passed through condenser where condensation takes place. More amount of water is flow in condenser so refrigerant vapor is cooled below the condensing temperature at constant pressure thus sub-cooling is achieved. By sub cooling enthalpy of vaporization of refrigerant is increases thus more amount of heat is absorbed by refrigerant in evaporator for evaporation takes place, so refrigerating effect is increases thus performance of cycle is increased. After sub-cooling liquid refrigerant is passed through expansion valve where expansion takes place and passes through evaporator where absorb the latent heat from storage space and evaporate. Thus cooling is achieved in storage space.

III. Result and discussion

By sub-cooling enthalpy of vaporization of refrigerant is increases so refrigerating effect are increases thus COP increases. By using diffuser after compressor high velocity is converted into pressure. Some part of required pressure increases in diffuser and some amount of pressure increases in compressor so compressor work is decreases or power consumption is decreases. Thus performance or COP is increases.

IV. Conclusion

COP of Vapor Compression Cycle is increased by lowering the power consumption /work input or increasing the refrigerating effect. By using sub-cooling and using diffuser at condenser inlet refrigerating effect increases and power consumption or work input decreases. Thus performance of cycle is improved. High velocity refrigerant has various serious affect on vapor compression refrigeration system such as liquid hump, undesirable splashing of the liquid refrigerant in the condenser and damage to the condenser tubes by vibration, pitting and erosion. Diffuser is such a device to reduce high velocity of refrigerant is the conversion of some amount of kinetic energy into pressure energy without work consumption.

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