A Review: Increase in Performance of Vapour Compression Refrigeration System Using Fan

Shireesha Mary Ch, Nandini Ch, Divya Samala, Siva Kumar B, Parthasarathy Garre

Abstract— **Refrigeration is the process of removing heat from a closed body or space enclosed so that its temperature is first lowered and then maintained at a required level which is below the temperature of surroundings. There are many types in refrigeration cycle the vapour compression cycle is taken for the case study, because the vapour compression refrigeration syster is by far the most popular and widely used system i refrigeration for both industrial and domestic applications.**

In vapour compression refrigeration system a refrigeran readily evaporates and condenses depending up on the pressur and temperature during the cycle, therefore, refrigeran undergoes a change of phase alternately between liquid an vapour phase without leaving the system.

In this case several assumptions were made in order t analyze the system, like isentropic process at the compressor, isenthalpic expansion in the throttling valve. It is found that thi may have been because at higher fan speed, convectio coefficient increased, increasing heat transfer in the evaporato and condenser with the surroundings, thus reducing the work o the compressor to the refrigerant. Vapor compression cycle wa more efficient with fans of evaporator and condenser at highes speeds.

Index Terms—**VCR, Condenser, Evaporator, T-S Diagran VCC, COP.**

I. INTRODUCTION

Refrigeration systems refer to the different physica components that make up the total refrigeration unit. Th different stages in the refrigeration cycle are undergone i these physical systems. These systems consist of a evaporator, a condenser, a compressor and an expansio valve. The evaporator is the space that needs to be cooled b the refrigerant; the compressor compresses the refrigeran from the low pressure of the evaporator to the pressure at th condenser. The heat gained by the refrigerant is rejected a the condenser and at the high pressure. Refrigerant i expanded into the low pressure evaporator by the expansio valve.

The term refrigeration refers to cooling an area or substanc below the environmental temperature, the process o removing heat. Mechanical refrigeration uses the evaporation of a liquid refrigerant to absorb heat. The refrigerant goes through a cycle so that it can be reused, the main cycles are vapour-compression, absorption, steam- jet or steam-ejector, and air.

In this study, by using different refrigerants the vapour compression cycle (VCR) performance is theoretically analyzed. Hydrocarbon refrigerants such as R290 and R600a are considered as a refrigerant by mixing of these at different mass fractions about 20%+80%, 25%+75%, 50%+50% and 75%+25% respectively. The performance parameters like compressor discharge temperature, pressure ratio, volumetric cooling capacity (VCC), volumetric efficiency, coefficient of performance (COP) and mass flow are analyzed. As mentioned above Refrigerants, the mixture of both refrigerants at concentration of 50% each has optimum performance in terms of higher refrigeration effect, better heat transfer and COP [1]. To increase the performance of VCR, it is required that the compressor work should decrease and the effect of refrigerating should increase. It is studied that the advancement in the technology of compressors, it is noticed that work on compressors will be decreases. The purpose of a compressor in vapor 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, liquid hump and damage to condenser by erosion [2, 3]. Generally vapour 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. The hybrid compression is feasible even when low grade heat is available. Some performance indicators are defined and evaluated for various configurations [4]. Theoretically, the pressure drop is considered as an isenthalpic process (constant enthalpy). However, isenthalpic process causes a decrease in the evaporator cooling capacity due to energy loss in the throttling process. To recover this energy loss, an ejector can be used to generate isentropic condition in the throttling process and the cycle is called as ejector expansion refrigeration cycle [5]. This review consisting of discussion on basic vapour compression system and the effect of performance characteristics studied on introducing fan near to the evaporator.

II. THE VAPOUR COMPRESSION REFRIGERATION SYSTEM

The vapour compression refrigeration system is by far the most popular and widely used system in refrigeration and air conditioning both for industrial and domestic applications. In

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this system the working substance is a refrigerant like NH3, R-11,R-12 etc. The schematic diagram of a vapour compression refrigeration system is shown in below Fig. 1.

The system mainly consist of a refrigerant compressor, a liquid receive, a refrigerant control valve also called as expansion valve and an evaporator. Working of the system includes when a compressor is started, it draws the low pressure vapour from the evaporator at compressor and compresses it isentropically to a sufficiently high pressure up to the condenser since the compression work is done on the vapour, and its temperature also increases. Hot vapour from compressor under pressure is discharged in to the condenser where it is cooled at constant pressure by rejecting heat to condenser cooling medium usually water or surrounding air. This converts the hot vapour in to liquid and the liquid is collected in the liquid receiver at condenser reservoir. The liquid from the liquid receiver at high pressure is then piped to a refrigerant control valve which regulates the flow of liquid in to the evaporator. This control valve, while restricting the flow, also reduces the pressure of the liquid with the result of the liquid change in to vapour of low dryness fraction represented by expansion valve. During this process the temperature of the refrigerant reduces corresponding to its pressure. Finally, the low pressure, low temperature refrigerant passes through the evaporator coil where it absorbs its latent heat from the cold chamber or from the brine solution at constant pressure and converts in the vapour at compressor. It is again supplied to the compressor. Thus, the cycle is completed.

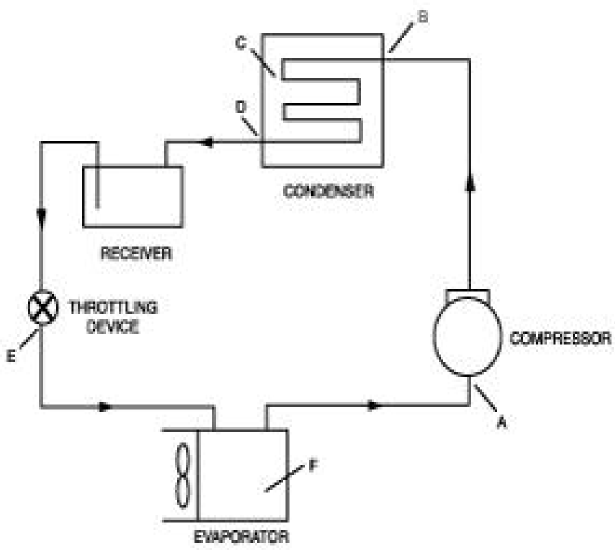

Fig. 1: Vapour Compression Refrigeration System

Advantages of vapour compression cycle are small size, low running cost, high COP and required refrigeration temperatures are achieved easily. Disadvantages of vapour compression cycle are its high initial cost required safety and prevention of leakages. COP of the cycle can be defined as the ratio of refrigerating effect to the work of compression.

Assumptions in theoretical vapour compression cycle are no pressure losses in condenser, evaporator and piping, no heat losses, friction is neglected and all processes are reversible. Wet compression cycle is not preferred since liquid droplets of refrigerant will damage the valves and moving parts of the compressor, liquid refrigerant carrying lubricating oil from compressor would adversely affect the heat transfer rates, has low volumetric and mechanical efficiency. Effect of operating variables on performance of vapour compression cycle are super heating of suction vapour increase refrigerating effect, increase work of compressor, increase heat rejection in condenser and COP may increase or decrease, liquid sub cooling: increases refrigerating effect and COP, increased suction pressure reduces refrigerating effect, increases work of compressor, reduces COP and increased discharge pressure reduces refrigerating effect, increases work of compressor and reduces COP.

III. THERMODYNAMIC ANALYSIS OF THE VAPOUR COMPRESSION REFRIGERATION

The vapor-compression uses a circulating liquid refrigerant as the medium which absorbs and removes heat from the space to be cooled and subsequently rejects that heat elsewhere. Fig. 2. depicts a typical, single-stage vapor-compression system. All such systems have four components: a compressor, a condenser, a thermal expansion valve (also called a throttle valve or metering device), and an evaporator. Circulating refrigerant enters the compressor in the thermodynamic state known as a saturated vapor and is compressed to a higher pressure, resulting in a higher temperature as well. The hot, compressed vapor is then in the thermodynamic state known as a superheated vapor and it is at a temperature and pressure at which it can be condenser with either cooling water or cooling air. That hot vapor is routed through a condenser where it is cooled and condensed into a liquid by flowing through a coil or tubes with cool water or cool air flowing across the coil or tubes. This is where the circulating refrigerant rejects heat from the system and the rejected heat is carried away by either the water or the air.

The condensed liquid refrigerant, in the thermodynamic state known as a saturated liquid, is next routed through an expansion valve where it undergoes an abrupt reduction in pressure. That pressure reduction results in the adiabatic flash evaporation of a part of the liquid refrigerant. The auto-refrigeration effect of the adiabatic flash evaporation lowers the temperature of the liquid and vapor refrigerant mixture to where it is colder than the temperature of the enclosed space to be refrigerated.

The cold mixture is then routed through the coil or tubes in the evaporator. A fan circulates the warm air in the enclosed space across the coil or tubes carrying the cold refrigerant liquid and vapor mixture. That warm air evaporates the liquid part of the cold refrigerant mixture. At the same time, the circulating air is cooled and thus lowers the temperature of the enclosed space to the desired temperature. The evaporator is where the circulating refrigerant absorbs and removes heat which is subsequently rejected in the condenser and transferred elsewhere by the water or air used in the condenser.

To complete the refrigerant cycle, the refrigerant vapor from the evaporator is again a saturated vapor and is routed back into the compressor.

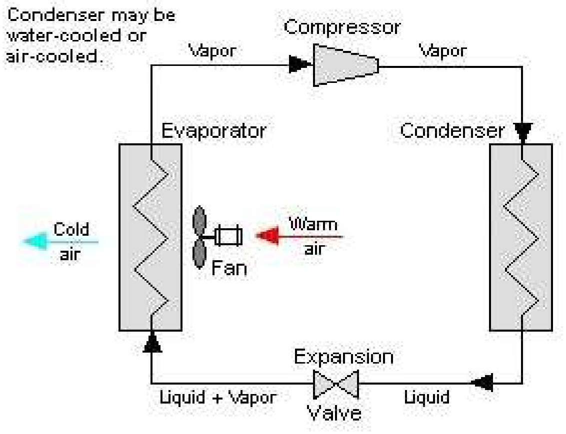

Fig. 2: VCR System Using Fan

From point 2 to point 3, the vapor travels through part of the condenser which removes the superheat by cooling the vapor. Between point 3 and point 4, the vapor travels through the remainder of the condenser and is condensed into a saturated liquid. The condensation process occurs at essentially constant pressure. Between points 4 and 5, the saturated liquid refrigerant passes through the expansion valve and undergoes an abrupt decrease of pressure. That process results in the adiabatic flash evaporation and auto-refrigeration of a portion of the liquid (typically, less than half of the liquid flashes). The adiabatic flash evaporation process is isenthalpic (i.e., occurs at constant enthalpy). Between points 5 and 1, the cold and partially vaporized refrigerant travels through the coil or tubes in the evaporator where it is totally vaporized by the warm air (from the space being refrigerated) that a fan circulates across the coil or tubes in the evaporator. The evaporator operates at essentially constant pressure and boils of all available liquid there after adding 4-8 deg K of super heat to the refrigerant as a safeguard for the compressor as it cannot pump liquid. The resulting refrigerant vapor returns to the compressor inlet at point 1 to complete the thermodynamic cycle. It should be noted that the above discussion is based on the ideal vapor-compression refrigeration cycle which does not take into account real world items like frictional pressure drop in the system, slight internal irreversibility during the compression of the refrigerant vapor, or non-ideal gas behavior.

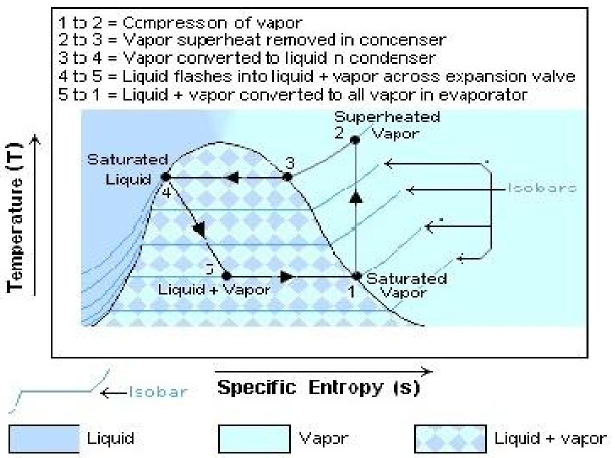

Fig. 3. T- s Diagram

IV. Conclusion

In this review vapour compression refrigeration system, by introducing fan near the evaporator, the performance of whole system will increase. The compressor work is decreased due to the pressure drop due to isenthalpic process. Hence we conclude that this process is effective.

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