REVIEW ON HOT GAS DEFROSTING SYSTEM FOR VAPOR COMPRESSION REFRIGERATION SYSTEM

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ABSTRACT

With frost formation on evaporators operating at sub-zero temperatures in a refrigerator or a freezer, the performance of unit degrades .Thus alternative defrosting methods are being extensively studied. This paper presents a literature review of the available defrosting methods. The review includes an ongoing efforts by various researchers to develop and design a hot gas bypass defrosting system (HGBS) for a vapor compression refrigeration system.

***Keywords*: Defrost Methods, Hot Gas Bypass Defrosting, Defrost Efficiency.**

I INTRODUCTION

In vapor compression refrigeration system, there was frost formation on evaporator coils. Frost accumulation on evaporator decreased cooling capacity and COP of domestic refrigerator. Removal of frost or defrosting the evaporator at regular intervals was necessary. In recent years , the various defrosting methods have been used : compressor shutdown , electric heating , reverse cycle, hot gas bypass etc. The application of electric heater required a relatively large size, additional expenses were incurred if system capacity increased . There were some safety issues to consider such as potential for short circuit, electric shock and fire . To solve fundamental problems existing in traditional EHD method,Yang [1] investigated a novel defrost method, defrost heat loss was recycled through air circulation and was reused for defrosting. In the conventional EHD method, frost was heated through conduction heat transfer between frost and evaporator fins and most of the released heat of the electric heater was lost.

The reverse cycle defrosting process [2] was completed by using four way reversing valve. During reverse cycle defrosting the refrigerant flow was reversed, evaporator temperature increases, during the defrosting process hot gas was blown to the evaporator for melting the frost. A sudden pressure shooting & falling in the compressor suction and discharge lines during switching the reversing valves of the RCD cycle caused the mechanical shocks to the compressor and the refrigerant lines.

II. REVIEW OF HOT GAS BYPASS DEFROSTING SYSTEM

The hot gas defrosting method utilize only a hot gas bypass valves to remove the frost from the evaporator coils enabling supply of cooling without any interruption . Yaqub et al. [3] investigated a refrigeration system for HFC-134 a by injecting hot gas and liquid refrigerant in to suction side of compressor.

Fig. 1 shows that during defrosting some amount of hot gas refrigerant from the discharge side of compressor is injected back in to compressor suction side, hot gas mixed with vapors coming out of evaporator. Due to this pressure increases in evaporator, it reduces the flow of refrigerant through the evaporator & hence reduces the capacity of system. The remaining hot gas from compressor passes to the condenser where the process of condensation was carried out. Then the liquid refrigerant from condenser passed through expansion valve, there was pressure drop in expansion valve. Then that low pressure and low temperature refrigerant evaporated in evaporator coils and passed to compressor.

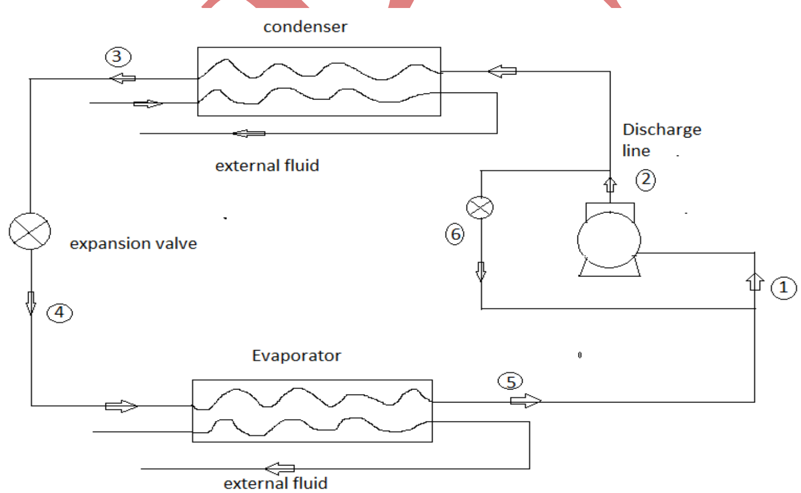

Fig.1. Components for an injection of hot- gas by-pass to compressor suction

Expansion valve was provided to maintain the pressure difference across the compressor. The delivery temperatures may become excessive and result in high superheat in the suction line. This problem avoided by injecting liquid refrigerant from the condenser in to suction line to cool the vapor entering the compressor as shown in fig.2 . It should be noted that vapor entering the compressor should be in vapor form. Therefore ,there is a limiting value for liquid injection. which keeps the refrigerant in saturated vapor form after mixing with the hot gas.

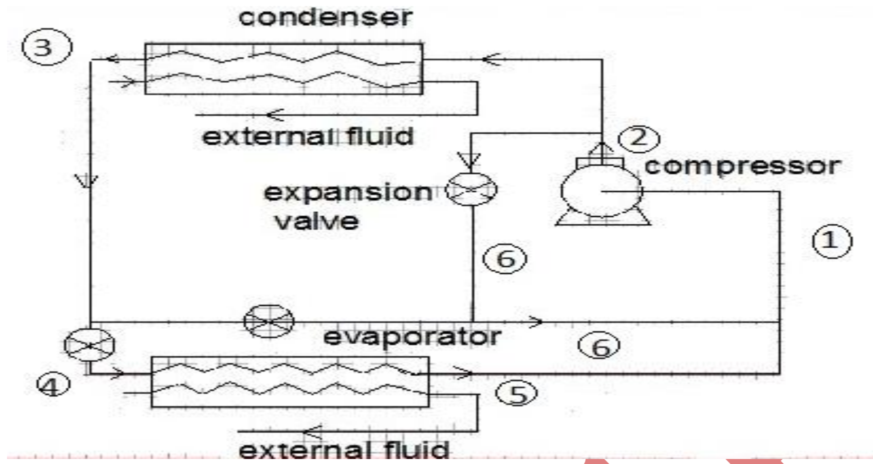

Fig.2 Components for an Injection of Hot Gas and Liquid Refrigerant to Compressor Suction [3].

Fig.3 shows the components for an injection of hot gas directly to the liquid refrigerant before entering the evaporator. The hot gas was passed through expansion valve which caused increased in enthalpy of liquid refrigerant entering the evaporator and thus reduced cooling capacity of evaporator

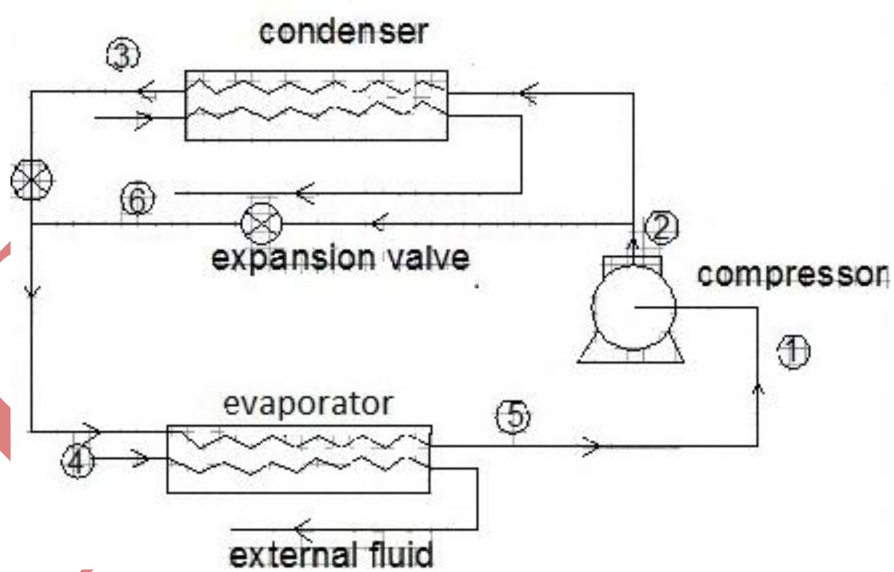

Fig.3 Components for an Injection of Hot Gas in To the Evaporator Inlet [3].

A comparison of the result of three schemes indicates that COP was highest at a given capacity ratio for the scheme in which hot gas injected directly in to evaporator inlet (Scheme III), COP for Scheme III was 50% higher than Scheme I. However, for Scheme II the COP was 10% higher than Scheme I.

M Kapekar et al. [4] found out that condensation of gases in to liquid were formed when hot gases from compressor passed over the evaporators, low temperature zone. If these liquid drops enter in to compressor, compressor could be damaged. The author further suggested a solution by his experimental data that if an intermediate vessel is introduced in between evaporator and compressor, the problem can be eliminated partially.

Norton et al. [5] found out that by passing compressed hot gas to the upstream of evaporator increased pressure in mixing area which causes pressure drop across expansion valve and undesirable fluctuation in refrigerant flow. He suggested solution that by passing compressed hot gas to the evaporator instead of upstream of evaporator, undesirable fluctuation in refrigerant flow could be minimized. Lauterbach et al. [6] passed hot gas from compressor to the eutectic plates because when eutectic plates froze, the velocity of refrigerant within eutectic plates lowered. It caused loss of oil to the compressor. It deposited within plate.

Yaqub et al. [7] investigated the capacity control of a VCRS for three different capacity control schemes. The schemes were 1. Hot gas bypass control 2.Cylinder-unloading 3.Suction gas throttling. In a hot-gas by-pass control scheme, the refrigerant was by-passed from the compressor and injected back into the suction line to decrease the cooling capacity. In cylinder unloading scheme one or more cylinders were unloaded to decrease the refrigerant mass flow rate, and hence decrease in system capacity. However, in suction gas throttling, the suction gas was throttled at the inlet of the compressor. It decreased the refrigerant mass flow rate, and hence a corresponding decreased in system capacity . The results showed that cylinder-unloading scheme was most suitable because of higher COP in comparison with other two schemes at any compression ratio.

Melo et al. [8] studied the performance of defrost systems which were applied to household refrigerators. Three different types of electric heaters (distributed, calrod and glass tube) and three actuation modes (integral power, power steps and pulsating power) were investigated. It was found that all three types of heaters presented practically the same defrost efficiency approximately 48% in each operating mode.

Choi et al. [9] developed a novel cold storage defrosting (DHBD) method to remove frost from the outside heat exchanger of an air-to-air heat pump. The proposed method adopted two bypass lines of hot gas from the compressor: one was connected to the inlet of the outdoor HEX, and the other was connected to the outlet of HEX. The dynamic performance and defrosting time of the conventional reverse cycle defrosting (RCD), Hot gas bypass cycle defrosting (HGBD), and DHBD methods sustained a higher compressor outlet pressure and reduced the defrosting time by 36% compared to the HGBD method. Compared to RCD, the defrosting time was comparable (126%).

Huang et al. [10] studied the comparison between RCD and HGBD methods of frost removal on air-to-water heat pump. The results showed that the amenity for the HGBD method was better than that for the RCD method, due to lower refrigerant noise, smaller indoor temperature fluctuation, and no cold blowing. The suction superheat and discharge superheat for the HGBD method were lower than the RCD method. The HGBD method could overcome the disadvantages of the RCD method.

Jang et al. [11] developed a new technology called continuous heating of an air source heat pump, which utilize only a hot gas bypass valve to remove the frost from the outdoor heat exchanger and thus enabling the supply of hot air to indoors without any interruption. For this, a new high temperature and low pressure gas bypass method was designed which was differentiated from the common hot gas bypass methods by its use of low pressures. It was found that by this technique the total heating capacity was increased by 17% and the input power was increased by 7.8%. Finally the total energy efficiency was increased by 8% compared to RCD, and by 27% compared with system using an electronic heater.

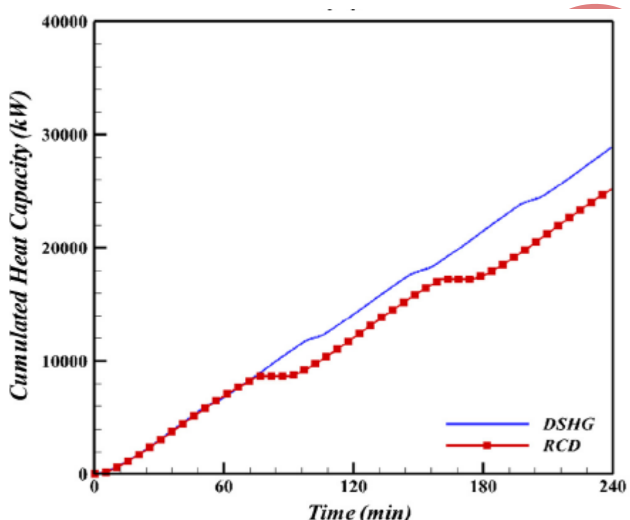

Fig.4 Heat Capacity versus Time [8]

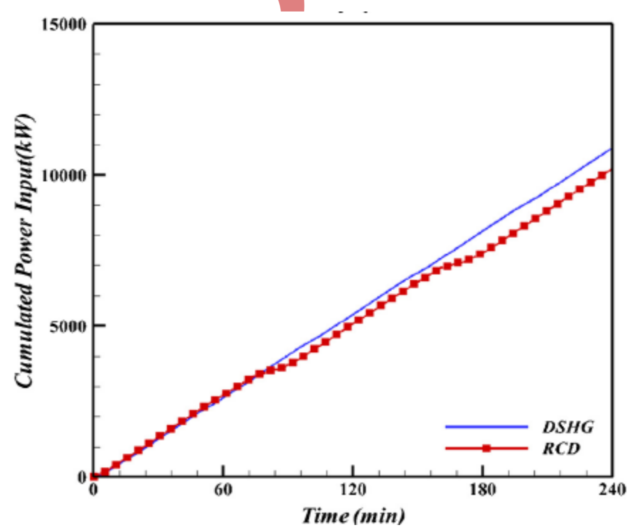

Fig.5 Power Input versus Time [8]

Fig.4 shows heat capacity vs time diagram during defrosting process. In case of dual spray hot gas defrosting the operation of heating and defrosting both were taken place. The heating capacity was almost 50%. During defrosting hot gas from compressor passed on one evaporator at the same time normal VCRS cycle was taken place through another evaporator. In case of RCD the slope was decreased gradually because there was interruption of cooling during defrosting [10-11]. Fig.5 shows cumulated power input vs time diagram during DSHG cumulated power input was 50%. During RCD power input was decreased. Fig. 6 shows COP vs time graph the COP was higher during DSHG while it decreased during RCD and EHD. Fig.6 COP versus Time [8]

III. ONGOING EFFORT

As mentioned earlier, the authors are part of an ongoing research effort to investigate the most economical and effective non-stop cooling cycle with hot gas bypass method, which will utilize only a hot gas bypass valve to remove the frost from the evaporator coils enabling supply of cooling without any interruption. Hot gas defrost method is limited in terms of its capacity to melt the frost layer due to fact that less energy will be provided to the defrosting heat source than in the RCD method, and so the defrosting process must be carried out before the frost layer gets too thick.

IV. CONCLUSIONS

The hot gas bypass defrosting system is one of the most alternative systems , When defrosting on one side is in progress the evaporator on the other side acts as a de-magnified evaporator to provide uninterrupted cooling without any additional equipment. The main disadvantage of other defrosting methods such as compressor shutdown, reverse cycle defrosting, and electric heater defrosting that need to cut off the cooling supply during defrosting can be eliminated with this method. The limitation is that only 50% cooling is obtained during defrosting.

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