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Review on hot gas defrosting system for an air source heat pump

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Abstract
This study concerned with a hot gas defrosting method for the removal of frost which formed on the evaporator operating at sub-zero temperatures in an air source heat pump, the performance of unit degrades. Thus alternative defrosting methods are being 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 defrosting system (HGBS) for an air source heat pump.

Keywords: various defrosting methods, hot gas bypass defrosting system, efficiency of heat pump with various defrosting method

1. Introduction
In an air source heat pump system there was frost formation on the outdoor heat exchanger, called as evaporator. Removal of frost or defrosting the evaporator at regular intervals was necessary to provide continuous indoor heating, increases energy efficiency and heating capacity of heat pump. In a recent years, the various defrosting methods have been used: compressor shutdown, electric heating (EHD), reverse cycle defrosting (RCD), hot gas bypass etc. The RCD is most common method have been used. 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.

In the reverse cycle defrosting process [2] four way reversing valve was used to complete process. 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.

2. 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. The process causes increases in evaporator pressure, it reduces the flow of refrigerant through the evaporator & hence reduces the capacity of system. The remaining hot gas passes to the condenser where the process of condensation was carried out and convert in to liquid refrigerant. Then the liquid refrigerant from condenser passed through expansion valve, then the low pressure low temperature refrigerant evaporated in evaporator coils and again passed to compressor.

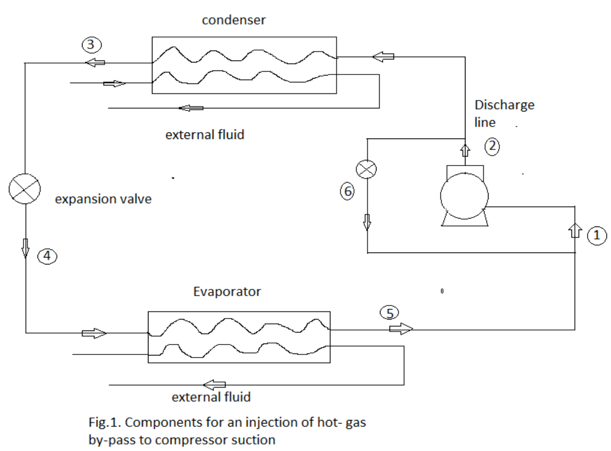

Fig 1

Expansion valve was provided to maintain the pressure difference across the compressor. Due to excessive delivery temperature increases superheat temperature in the suction line, the problem of excessive superheat temperature in the suction line is avoided by injecting liquid refrigerant from the condenser in to suction line to cool the vapor entering the compressor as shown in fig.2. There is a limiting value for liquid injection, which keeps the refrigerant in saturated vapor form after mixing with the hot gas because it is necessary the entering vapor in the compressor should be in the dry form

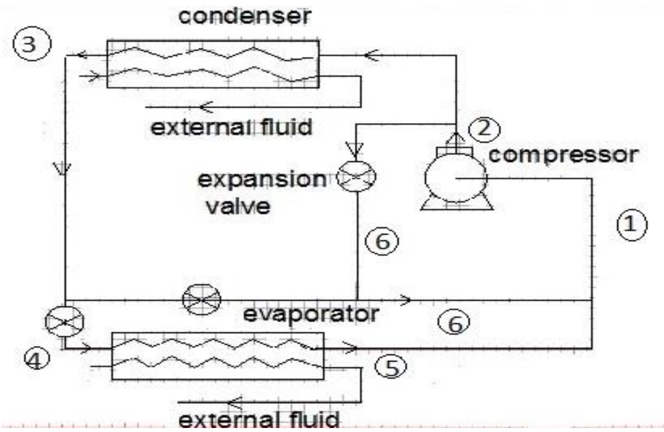

Fig 2: Components for an injection of hot gas and liquid refrigerant to compressor suction [3]

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

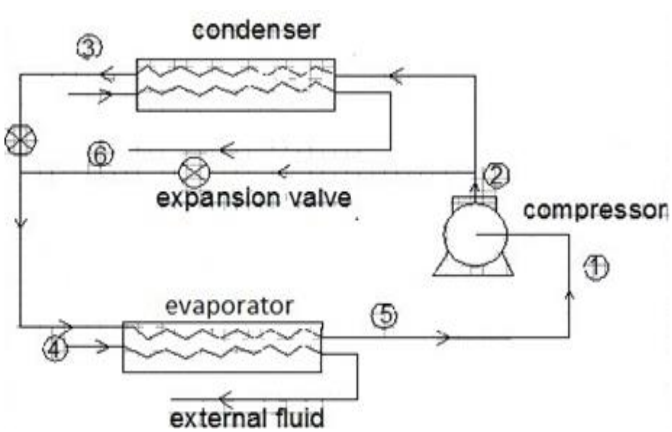

Fig 3: Components for an injection of hot gas in to the evaporator inlet [3].

A comparison of the result of three schemes indicates that COP 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] investigated that there was condensation of gases in to liquid, when hot gases from compressor passed over the evaporator, low temperature zone. If these liquid drops entered in to compressor then compressor could be damaged. The author further suggested that the problem can be eliminated partially by introducing the vessel between evaporator and compressor

Norton *et al*. [5] found out that there was increased pressure in mixing area which causes pressure drop across expansion valve and undesirable fluctuation in refrigerant flow by passing compressed hot gas to the upstream of evaporator. 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.

Choi *et al*. [6] developed a novel cold storage defrosting (DHBD) method which 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 result shows that 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%).

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 where the refrigerant was by-passed from the compressor and injected back into the suction line to decrease the cooling capacity 2.Cylinder-unloading where one or more cylinders were unloaded to decrease the refrigerant mass flow rate, and hence decrease in system capacity 3.Suction gas throttling, the suction gas was throttled at the inlet of the compressor, decreased the refrigerant mass flow rate, and hence a corresponding decreased in system capacity. The results showed that the COP was higher in cylinder-unloading scheme in comparison with other two schemes at any compression ratio.

Huang *et al*. [8] 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 HGBD method could overcome the disadvantages of the RCD method. The suction superheat and discharge superheat for the HGBD method were lower than the RCD method.

Jang *et al*. [9] developed a new technology, 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. 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.

3. Ongoing Effort

As mention earlier, the authors are part of an ongoing research effort to investigate the most economical and effective non-stop heating system for heat pump. 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 indoor heating 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.

4. Conclusions

In this study hot gas bypass system was designed and compared with other defrosting methods. The results shows that the hot gas bypass defrosting system is one of the most effective system, which provide uninterrupted heating in an air source heat pump without any additional equipment. The main disadvantage of other defrosting methods such as compressor shutdown, reverse cycle defrosting, electric heater defrosting that need to cut off the heating supply during defrosting can be eliminated with this method.

5. References

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