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# Analysis on performance of a novel frost-free air-source heat pump system

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ABSTRACT

Heating capacity of an air-source heat pump (ASHP) system often decreases due to frost on the air-side heat exchanger (evaporator) when the air temperature drops in winter. If the amount of frost accumulates to a certain value, performance of the system will degrade. Therefore, defrosting mode needs to be operated periodically. In order to solve the above problems, heat transfer enhancement or advanced defrosting methods should be adopted, but all these methods cannot solve the problems mentioned in essence. A novel frost-free air-source heat pump system is proposed, the new system can realize heating which does not need defrost in winter. In this new system, extracting heat process from environment includes two steps: the first one is extracting heat from the environment and then to the solution, the second one is releasing heat to the evaporator from the solution, avoiding frosting on the evaporator surface. A theoretical model is established to analyze the performance of the system. Results indicate that the novel system can operate more efficiently than the conventional air-source heat pump in winter. In addition, the new system does not need to run in defrosting mode periodically.



## 1. Introduction

Air-source heat pump (ASHP) system as cooling and heating source for building heating, ventilating and air conditioning (HVAC) systems becomes increasingly popular in central and south China [1]. In these regions, heating requirements will represent a challenge for air-source heat pumps, since the ambient air temperatures in this region will be subzero in winter. During the heating season, ASHP systems extract heat from the outside cold air and release the heat inside the living space. Under certain weather conditions, frost will form on the outdoor heat exchanger surface that is one of the main problems for ASHP systems. Frost depositing and accumulating on the outdoor heat exchanger surface will act as thermal insulator between the surface and the humid ambient air, and the growth of the frost layer will degrade the ASHP's performance. Therefore, the frost needs to be removed periodically to improve the efficiency of operation.

Many studies on the performance of the ASHP system under frosting conditions were reported. Ma Guoyuan et al. [2] developed an improved ASHP system for cold regions, in which a subcooling system employing scroll compressor with supplementary inlet was used. Yi-guang Chen et al. [3] experimentally investigated on the reverse-cycle defrosting characteristics of a split-type ASHP system, and effects of the outdoor air parameters on defrosting cycle performance and dynamic defrosting characteristics of the ASHP unit are discussed. S.M. Sami and P.J. Tulej [4] presented a combined cycle fully integrated air/air heat pump, which is a fully integrated unit and the evaporator and condenser are placed indoors. Laboratory tests and field testing showed that this heat pump out performs existing air/air heat pumps under similar conditions for heating modes. Yang Yao et al. [5] investigated on the characteristic of the air-side heat exchanger in an ASHP system under frosting in order to optimize its structural layout, which can increase its energy efficiency and operational reliability. Wang Zhiyi et al. [6] developed a new heat pump defrost system with a refrigerant charge compensator, which is a key component for the frosting cycle performance, and test data on several engineering units showed that the compensator worked as expected. Zhiqiang Liu et al. [7] simulated the dynamic performance of air-source heat pump during hot-gas defrost. Yanjun Ding et al. [8] proposed using a bypass solenoid valve in the ASHP system which can bypass the thermal expansion valve when it is used in the reverse-cycle defrosting mode. Yanjun Ding et al. [9] also proposed a new subcooling system employing a scroll compressor with supplementary injections in ASHP system and the relevant dynamic performance was tested. Di Liu et al. [10] used heat recovery facility in ASHP system to prolong the heat pump frost time and reduce its growth, which mixed the exhausted indoor and outdoor air before entering

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