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Research Paper

Feasibility and optimization of defrosting control method with differential pressure sensor for air source heat pump systems

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HIGHLIGHTS

- A novel defrosting control method using differential pressure sensor is proposed.
- Optimum sensor location is set with preliminary experiments and CFD simulations.
- A strategy to deal with several operating conditions and specifications is developed.
- The suggested method is experimentally verified under various frosting conditions.

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ABSTRACT

A defrosting control method with differential pressure sensor is suggested in this study for air source heat pump systems. To maintain the performance of the heat pump system under frosting conditions, it is crucial to determine the start time of the defrosting process properly. Thus, this study investigates the feasibility of using the differential pressure sensors for defrosting control and further optimizes the control method. Firstly, the optimum location of the differential pressure sensor for air flow is determined by preliminary experiments. Secondly, a method to deal with various changes in operating conditions and system specification is developed. Lastly, main experiments are conducted under various frosting conditions to validate the suggested control method using differential pressure sensors. To show the reliability of the control method under various frosting conditions, two different error factors are defined; error on a time basis and a capacity basis. As a result, the root mean square of the error for the defrosting time is 6.4% on a time basis and 5.1% on a capacity basis.

1. Introduction

Air source heat pump (ASHP) has been widely adopted for space heating in buildings and cabin heating in electric vehicles because of its high efficiency and eco-friendly operation [1,2]. However, frost deposition on the evaporator surface is a significant restriction in the heat pump operation [3,4]. Frost is deposited on the fin surface of the outdoor heat exchanger when the temperature of the fin surface is below air dew point temperature and also water freezing temperature. Deposited frost disturbs the air flow through the heat exchanger, and it increases pressure drop of the air flow. Furthermore, the frost layer becomes extra thermal resistance of the heat exchanger [5]. These undesirable factors lead to the performance drop of the heat pump system. Therefore, it is necessary to periodically perform the defrosting process to remove the frost and restore the heating capacity.

There have been various studies about control methods of the defrosting cycle. Prior heat pump systems commonly employed time control (TC) and temperature time control (TTC) due to its simplicity and low cost [6]. However, TC and TTC strategies frequently cause the improper start of the defrosting cycle. Wang et al. [7] classified this 'mal-defrost' into two types. One is that early defrosting cycle is performed under no-frosted or little-frosted conditions, and the other is that the defrosting cycle is not executed even after the frosting has been considerably progressed. According to Wang et al. [8], it was observed that the mal-defrosting control reduced average COP to 40.4% and heating capacity to 43.4%.

To avoid the mal-defrost control, many other studies have proposed more advanced control strategies. Defrosting control using refrigerant flow instability or degrees of superheat (DSH) is suggested to supplement the TTC method [9,10]. Defrosting control using the artificial neural network is also investigated [11]. In addition, Zhu et al. [12] developed a frosting map to guide the defrosting control, and Kim et al.

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