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Model-based commissioning for filters in room air-conditioners

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Abstract

This paper proposes a model that can estimate filter resistance using estimated air-conditioner indoor unit air flow rate, which is tightly related to filter fouling conditions. Two sorts of value are used as inputs to estimate air flow rate. One is the power consumed by the fan in the indoor unit of a room air-conditioner and the other is the thermal performance of a room air-conditioner. For the room air-conditioners that the real-time indoor unit fan power consumption is available, fan power consumptions are used as inputs to estimate filter resistance. For the room air-conditioners that are equipped with refrigerant pressure and temperature sensors, this model estimates filter resistance using refrigerant pressure and temperature, air temperature or enthalpy difference between supply and indoor air. This model was validated using a really running multi-evaporator Gas-engine Heat Pump (GHP) system. The maximum and average difference between estimated and measured filter resistance are 12.72% and 5.89% when using the fan power consumption as inputs. When using the air-conditioner thermal performance data, the maximum and average estimation errors are 13.12% and 5.96%. The validation results show that this model is accurate enough for estimating filter resistance. Based on this model, the method for commissioning filters in air-conditioner is discussed. This method is useful for automatically estimating filter resistance and reminding users timely to clean or replace a filter to prevent wasting energy and to maintain desirable indoor environment.

Keywords: Automated commissioning; Filter resistance; Modeling; Room air-conditioner

1. Introduction

Most researches about filters in a Heating, Ventilating and Air-Conditioning (HVAC) system study the capability of a filter to retain particles, dust, bacteria and molds [1], survival and growth of microorganisms on a filter [2], releasing Volatile Organic Compounds (VOC) from a filter [3,4]. From Journals and proceedings related to HVAC, such as HVAC&R Research, papers can seldom be found about the influence of filter fouling on energy consumption. However, a measurement done by this research shows that an Gas-engine Heat Pump (GHP) indoor unit fan efficiency decreased 35.8% when the filter resistance increased to twice of initial resistance because of dust accumulation as shown in Fig. 1. Furthermore, this research studied the heat produced by the GHP during winter. The heat production decreased 33.1% when the filter resistance doubled, as shown in Fig. 1. So, filter fouling cannot only decrease fan efficiency, but also decrease the heating/cooling capacity of room air-conditioners. It is important to timely detect an over-fouled filter and clean or replace it. Generally, room air-conditioners are not equipped with pressure sensor to measure air flow resistance through a filter, which represents the filter-fouling situation. So, it is necessary to develop a method to estimate air flow resistance through a filter without the requirement of adding filter pressure sensor for the purpose of saving the cost of pressure sensors, which is relatively expensive.

For the purpose of detecting filters' fouling situations without pressure sensor, this research focuses on developing a model that is able to estimate the air flow resistance through a filter only using air-conditioner's thermal or energy performance data. For the increasingly spreading multi-evaporator air-conditioners, which are equipped with refrigerant pressure and temperature sensor and room air

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