Energy Consumption Estimation for Room Air-conditioners Using Room Temperature Simulation with One-Minute Intervals

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Abstract: For the purpose of developing optimized control algorithm for room air-conditioners to ensure their energy efficiency, a short time interval (i.e., one minute) simulation of building thermal performance is necessary because the sampling time interval for room air-conditioner control is one minute in general. This paper studies the short-time interval room air temperature simulation method using the response factor method. Using the simulated room air temperature, an air-conditioner's running time can be known so that its energy consumption can be estimated accurately. In order to verify the simulation accuracy, an actual room equipped with a gas-engine heat pump (GHP) air-conditioning system is studied by both simulation and measurement. The cooling amount produced by the GHP is calculated using measured refrigerant pressure and temperature at condenser and evaporator respectively. The Root Mean Square Error (RMSE) between measured cooling amount and simulated cooling load is 18.9 percent of the average measured value. The profile of simulated room air temperature in both air-conditioned daytime and nighttime without air-conditioning can match the measured room air temperature. With respect to the estimated energy consumption, the profile of simulated energy consumption can match the measured data. The simulation accuracy of room air temperature and energy consumption during the air-conditioner start-up period is not good and needs to be improved in future research. But in general, the verification shows that this energy consumption simulation method is acceptable for evaluating the energy performance of a room air-conditioner, and can also be a useful tool for commissioning room air-conditioners.

Key words: Energy Consumption, Room Air-conditioner, Simulation, Commissioning

1. INTRODUCTION

The energy efficiency of buildings' Heating, Ventilating and Air-Conditioning (HVAC) system is an important issue because approximately one third of primary energy is consumed in non-industrial buildings such as dwellings, offices, hospitals, and schools where it is used for space heating and cooling, lighting and the operation of appliances [[1]. The energy efficiency of HVAC system devotes to both energy saving and reducing carbon dioxide discharge, which is considered to be one of the main reasons for global warming. Therefore the energy efficiency of HVAC systems is studied at a lot of respects, such as isolation of building envelopes, free cooling by natural ventilation, optimizing the operation of HVAC systems, commissioning for HVAC systems, etc. With respect to room air-conditioner, high Coefficient Of Performance (COP) air-conditioners are increasing and optimization of the air-conditioner control algorithm is also a focus of air-conditioner manufacturers.

However the newly developed air-conditioner control algorithm has to be verified through a year-round operation at different types of buildings, which takes too much time and cost. Simulating the thermal performance of an air-conditioner controlled by the newly developed control algorithm considering the thermal performance of the building where the air-conditioner is installed is a viable way that can verify the performance of the control algorithm but do not take much time and cost. However most of now available building thermal performance simulation methods are one-hour interval, which does not match the control time