BUILD SIMUL
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Thermo-economic optimization of rooftop unit's evaporator coil for energy efficiency and thermal comfort

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Abstract

In this paper, the optimization-simulation approach is proposed to investigate energy saving potential of an air-cooled direct expansion rooftop package air conditioning system by refining the model of the HVAC system components and deriving optimal configuration for evaporator coil subject to technical constraints. In this method the frontal area of the evaporator coil is maintained as constant and the variation of other geometrical parameters on the thermal and economical performance of the system is investigated. An actual air-cooled rooftop package of a real-world commercial building in hot and dry climate conditions is used for experimental data collection. Both inputs and outputs are measured from the field monitoring in two summer weeks. Based on the mathematical models and using collected data, modules incorporating the proposed optimal redesign procedure were embedded in a transient simulation tool. A mixed heuristic-deterministic optimization algorithm was implemented in the transient tool to determine the synthesis and design variables that influence the cost and energy efficiency of each configuration. Available experimental results were compared to predicted results to validate the model. Afterwards, the computer model was used to predict how changes in cooling coil geometry would affect the building thermal comfort, the cost and energy consumption of the system.

Keywords

direct expansion evaporator coil,
design optimization,
HVAC,
energy saving,
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Article History

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1 Introduction

Nowadays, the increased consumption of energy in modern industrial societies has, in addition to the risk of quick exhaustion of fossil resources, brought about irreversible and threatening environmental changes faced by the world. Heating, ventilation and air conditioning (HVAC) systems typically account for around 40% of total electricity consumption of buildings (Council of Australian Governments 2012). Global warming is another major problem made by conventional HVAC systems which rises world-wide average temperature. Therefore, energy-efficient and sustainable design of HVAC systems are critical components of research and development. For air conditioning, one commonly-used type of HVAC systems is the direct expansion (DX) rooftop package plant with a vapor compression cycle. In fact, the typical value of coefficient of performance (COP) for vapor compression systems is between 2 to 3 (Afonso 2006). However, comparing with water-cooled vapor compression air conditioning systems which cannot work efficiently in humid climatic conditions, air-cooled systems are able to work in different weather conditions. However, air-cooled air conditioning systems are less energy efficient than water-cooled air conditioning systems (Yik et al. 2001) and thus finding novel ways to reduce their energy consumption in buildings without compromising comfort and indoor air quality is an ongoing research challenge. Furthermore, as rooftop package air conditioning systems have obviously great potential for energy efficiency, research efforts have been devoted to further improving of their performance

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