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Methodology for optimizing the operation of heating/cooling plants with multi-heat-source equipments

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ABSTRACT

A methodology for optimizing the operation of heating/cooling plants with multi-heat-source equipments is proposed. The methodology decides the optimal combination of the running machines to minimize the energy consumption of a heating/cooling plant. The energy consumption, energy cost and carbon dioxide emission are simulated using a tool developed in the MATLAB® Simulink® environment, embedded with a module developed using MATLAB® Stateflow® that can automatically decide the on/off states of heat source machines corresponding to cooling and heating loads and an operational priority order of heat source machines. A case study is introduced to demonstrate the methodology, which is an actual heating/cooling plant located in Osaka, Japan. The plant consists of two absorption chiller/heaters, one centrifugal chiller, one ice chiller, and two air-source heat pumps. The proposed methodology is used to simulate the plant performance at six different operational priority orders of heat source machines. The best operational combination can reduce primary energy consumption by 19.7%, energy cost by 12.8%, and carbon dioxide emission by 29.6%, compared to present operation.

1. Introduction

Energy and environment are the most important issues in nowadays. Efficient energy use is considered to be a solution of addressing fossil fuel depletion, energy security, and global warming. The comprehensive study on energy efficiency started since the Energy Crisis caused by the Middle East War in 1973 to 1974. The urgent need for oil security management and energy policy co-operation led to the establishment of International Energy Agency (IEA) [1]. Because approximately one third of primary energy is consumed in non-industrial buildings for space heating and cooling, lighting and the operation of appliances, IEA has established an Implementing Agreement on Energy Conservation in Buildings and Community Systems (ECBCS) to undertake research and provide an international focus for building energy efficiency [2]. In the researches about building energy efficiency, the idea that commissioning is a viable method to help ensure the performance of buildings and their Energy Conservation Measures (ECM) was gradually conceived since 1989, because some analyses on the data from the buildings participating in the energy conservation program revealed that many of the installed energy efficiency measures were not performing as expected [3]. Building commissioning is the process of ensuring that systems are designed, installed, functionally tested, and capable of being operated and maintained to perform in conformity with the design intent [4].

The concept of commissioning is under developing since its birth. Now commissioning is not only to verify whether building systems are in conformity with design intent, but also to verify and improve the design itself. Furthermore the commissioning work is extended to the operational phase and is named on-going commissioning [5]. One of the main jobs of on-going commissioning is to optimize the operation of building systems. The heating/cooling plant, which is the heart and main energy consuming part of building systems, is considered to be very important so that many researches have been conducted on optimizing the operation of heating/cooling plants. Celuch [6] analyzed the issues of energy efficiency, cost, and operation on upgrading an actual central chiller water plant. Modeling of an actual cooling plant is also studied and the model is used for simulation and fault detection during the commissioning of a heating/cooling plant [7]. A program for power generation optimization is developed by SEGA [8]. Zhou et al. [9] used SEGA's Energy Optimization Program to analyze the operation of a cogeneration power plant and found that the optimal operation can save total costs by 10.4% compared to the original operation.

However, research can seldom be found on the method for optimizing the operational combination of heat source equipments in the heating/cooling plants that produce and deliver hot/chilled water for buildings' Heating, Ventilation and Air-Conditioning

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