METHODOLOGY FOR OPTIMIZING THE OPERATION OF HEATING/COOLING PLANTS WITH MULTI-HEAT SOURCE EQUIPMENTS USING SIMULATION

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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 of multiple heat source equipments to minimize the energy consumption of a heating/cooling plant. The optimal running combination is decided automatically using MATLAB® Stateflow® tool corresponding to cooling and heating loads. The energy consumption at different running combination is simulated using MATLAB® Simulink® tool. A case study is introduced to demonstrate the methodology. An actual district heating/cooling plant located in Osaka Japan, which consist of two absorption chiller/heaters, one centrifugal chiller, one ice chiller, and two air-source heat pumps, is studied to find the optimal operation combination of the heat source equipments,. The optimal running combination found by this method can reduce primary energy consumption by 19.7%, running cost by 12.8%, and carbon dioxide emission by 29.6%, compared to present operation.

KEYWORDS

Optimization, Energy consumption, Running cost, Heating/cooling plant, Running combination

INTRODUCTION

Energy and Environment are the most important issues in this new century. 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) (Scott 1994). In the field of building energy conservation, the idea that commissioning is a viable method to help ensure good 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 (Bonneville Power Administration, 1992). 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 (ASHRAE, 1996).

The concept of commissioning is being gradually refined 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. Especially during operational phase, one of the main commissioning jobs is to optimize the operation of building systems. The optimization of heating/cooling plant, which is the heart and main energy consuming part, is considered to be so important that many researches have been conducted on the operation of heating/cooling plants. Celuch (2001) 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 for a heating/cooling plant (Georges and Lebrun 2004). A program for power generation optimization is developed by SEGA (Anon). Zhang et al. (2000) used SEGA's Energy Optimization Program (EOP) to analyze the operation of a cogeneration power plant and found the optimal operation can save total costs by 10.4% compared to the original operation.

However, research on the method for optimizing the operational combination of heat source equipments in central heating/cooling plants for buildings can seldom be found. Corresponding to a requirement of heating/cooling, many different heating cooling source combinations can satisfy the requirement. It is necessary to select an optimal combination for the purpose of ensuring energy efficiency. However there are so many different combinations of multiple heating/cooling source equipments that it is difficult, even impossible, to check the performance of all the possible combinations experimentally on an actual plant. Therefore it is necessary to find a method to automatically check the performance of all possible combinations and determine the optimal combination. Simulation is considered to be a powerful tool to automatically check the performance of a building and its systems (Wang and Yoshida, 2003). This paper focuses on developing a method for determining optimal running combination of multiple heating/cooling equipments using simulation. For the purpose of validating the method proposed, then the method is applied to an actual district heating/cooling plant located in Osaka Japan, which consist of two absorption chiller/heaters, one centrifugal chiller, one