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RATIONAL OPERATION OF A THERMAL STORAGE TANK WITH LOAD PREDICTION SCHEME BY ARX MODEL APPROACH

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ABSTRACT

Thermal storage tanks are widely used in Japan mainly to shift electrical energy usage to night time for the purpose of peak demand reduction. However, the operation of the system has not often been accepted with satisfaction in a real field. Authors developed a method ensuring rational operation by utilizing predicted air-conditioning load based on an ARX model derived from building load simulation. The rational operation is achieved considering the predicted load and performance of HVAC components. The proposed method was tested in a real building equipped with a personal computer in which the algorithm was embedded. The results showed that the method has enough feasibility.

INTRODUCTION

For constructing sustainable society and avoiding global warming all the efforts not to increase CO2 emission from the present level are required. One of the ways is to maximize the total performance of power plants by leveling off the consumption of electrical energy. This can in turn reduce the number of power plants to be constructed in future and contribute to preserve nature.

In Japan thermal storage tanks have been widely used for this purpose for many years. The system is normally operated based on the experience of maintenance personnel, however, it has not often been accepted as a satisfactory one. The common way of the operation is to store maximum thermal energy by attaining the lowest temperature level for the period of cooling and the highest temperature level in heating. Most of the time, however, heat load is not large enough to consume all the stored energy, thus, it is obvious that this causes much energy loss through the surrounding constructions and less COP heat-pump operation.

To avoid this energy loss authors developed a method ensuring rational operation. The method utilizes the information of the predicted air-conditioning heating and cooling load of the following day of each day. A model which is built based on building thermal load simulation is used for load prediction, where the parameters are identified by taking the model as a mathematical time series model called an ARX model. The rational operation is performed utilizing the predicted load.

To evaluate the feasibility of the proposed method a test was carried out by equipping real building with a personal computer in which the algorithm was embedded. In this paper the methodology and the results obtained from the field operation are presented and discussed.

METHODOLOGY

The reason why air-conditioning load prediction is indispensable for rational operation of a thermal storage system is that it stores thermal energy used in future. In recent studies Neural Network and other black box type approaches have been widely used as a load prediction scheme. However a physical model approach can also be applied, where the basic algorithm is based on simulation methodology used in load calculation. The method proposed by authors falls in this category and very little works have been done in this field especially with feasibility analysis to a real building.

In a system design stage, a mathematical model which is derived from physical considerations of building thermal properties is used for air-conditioning load calculation. This is called a thermal load simulation. For the prediction of future air-conditioning load, the same method can be applied if weather data and building properties are known. When we try to apply this method to a real building, however, the main problem is that weather data and the building properties are unknown. In the present study we propose a method to estimate them, then to predict or "simulate" future air-conditioning load. The approach is divided into two stages; weather data prediction and thermal load prediction, as follows.

1. Weather Data Prediction

In most buildings the degree of air-conditioning load depends largely on outside weather conditions, especially air temperature, humidity and solar radiation. Predicting future weather data, therefore,