FAULT DETECTION AND DIAGNOSIS METHOD FOR VAV TERMINAL UNITS

Masato Miyata*, Harunori Yoshida*, Masahiko Asada*, Fulin Wang*, and Shiro Hashiguchi**
** Department of Urban and Environmental Engineering, Kyoto University, ** Yamatake, Co., Ltd*

Summary: This paper proposes two fault detection and diagnosis methods for VAV units without a sensor of supply air volume, and the results of applying these methods to a real building are presented. One method detects faults by applying a statistical method to four values calculated using the room air temperatures and the demand values of VAV damper opening of each unit during a steady state operation period. From the results of case studies, the method can reduce the number of units to be checked as faulty ones down to 12% of the total number and all the units that really have a fault are included in this group. The other method judges the faults by applying dynamic system analysis to the operational data when the VAV system starts up. From the result of the case studies, the method can reduce the number of units down to 30%, among which five units actually have a fault and only one faulty unit was not included in this group. Both methods can reduce time and cost for commissioning of VAV units significantly by the help of BEMS.

Keywords: Commissioning, VAV terminal unit, Fault detection and diagnosis method

1. INTRODUCTION

Variable Air Volume (VAV) Air Conditioning Systems are widely used all over the world because of the high energy saving feature. However it is reported that the possibility of faults occurrences, such as damper and actuator stuck, and defects in control logic, is unfortunately high [1) 2)]. Especially since the number of VAV units installed in large buildings is sometimes more than one thousand, detecting the faults is becoming an important issue. For example in a building, which the authors investigated, all the VAV units are manually and routinely checked every year spending a great deal of budget and manpower and quite many faults have been actually detected.

To cope with this issue, it is needed to develop an automatic fault detection and diagnosis (FDD) technology. In the past a few types of FDD methods, such as, an Exponentially Weighted Moving Average (EWMA) method by J. Seem et al. and an RARX model method by H. Yoshida et al., were proposed [3) 4) 5) 6)]. These methods require the airflow rate of each VAV unit for FDD, however, it is not available in old type VAV units because of no installation of an airflow rate sensor. This paper proposes two kinds of FDD method for this type of VAV units. One method (Method A) is based on a statistical detection of outlier data among control signals of VAV opening ratio during steady state period (non-startup and lunch time period). The other method (Method B) is based on applying dynamic system analysis to startup period data. The both methods are verified using operation data obtained at a real office building.

2. FDD METHOD USING THE DATA OF STEADY STATE PERIOD (METHOD A)

Figure-1 represents a general model of a VAV system that is used to describe proposed FDD methods. The system has an air-handling unit and $M \times N$ zones, each of which has one VAV unit. Each zone is named as $Z(i, j)$ and each unit is named as $U(i, j)$ (i =1,2,..., M , j =1,2,..., N). The zones surrounding Z (1,1), for example, are defined as Z (2,1) and Z (1,2). The zones surrounding Z (2,1) are defined as Z (1,1), Z (2,2) and Z (1,3). In the case of the zone Z (2,2), the surrounding zones are defined as Z (1,2), Z (2,1), Z (3,2) and Z (2,3). All units do not have an airflow sensor. This assumption is not proper for the recent VAV products but there are still a great number of AHU systems equipped with old type VAV units like the building studied by present research.

In this paper, two kinds of fault are analyzed, which are fully-close damper and fully-open damper. The reason of selecting these two faults is that the other kinds of faults, for example damper stuck at middle-range positions, were not found in the building that the authors investigated.

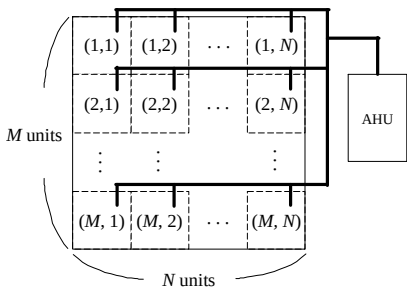

Figure-1 Assumed VAV system

2.1 Definition of FDD Parameters

The following four FDD parameters are defined for each unit using the zone air temperature $q_{r(i,j)}$, the set point of room temperature q_{rs} and the