(8) Statistical Classification of Electrically Controlled Valves In an Advanced Water Supply Networks

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1. Introduction

Fukuoka Metropolitan Area, a fast growing economic and cultural center in Kyushu, was struck by a severe drought in 1978 resulting in water rationing which lasted for 287 days. The drought showed that the region is vulnerable to water shortage unless development and management of water resources are planned properly to meet growing water demands of population and industry.

In order to meet increasing water demand in areas with scarce water resources, water resources development and management projects with innovative ideas have been carried out. As one of the project, Fukuoka city has set up water supply control system for controlling the flow and pressure from purification plants to taps. It aims to equalize tap water supply over the entire city.

Therefore in this study, the present efficiency of pressure regulation in terms of water distribution control is highlighted. A case study of block number 12 in the Fukuoka city water supply network is presented showing the different classification of motor valves from a statistical point of view.

2. Water Supply Control

Water pressure control by this system begins in 1981 after completing the Water Control Center. Fukuoka City was the first city to introduce this system in Japan. This system includes 120 water pressure gages, 68 flow meters, and 149 electric control valves all at important points along the water distribution pipes (April, 2000). An engineer can by visual control operate electric valves by remote control in order to secure the necessary water pressure through the pipe system. By utilizing this system, it has become possible to reduce excessive high water pressure and to secure a proper and constant water pressure in order to provide better service and reduce water leakage from the pipes.

The water pressure can be controlled as seen in Fig. 1 which compare between three different cases for pre control system, normal 24-hour operation and supply restriction in force during 1994 drought.

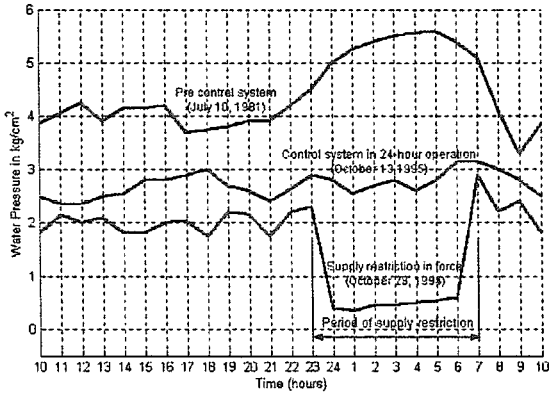

Fig.1 water pressure regulation time series graphs

3. Block 12 Description

The water supply network of Fukuoka city is divided into 21 blocks. In Block 12, there are 20 motor valves, 7 flow meters, and 11 pressure gauges. This block is located in the center of Fukuoka city. Fig. 2 shows the different elements of Block 12.

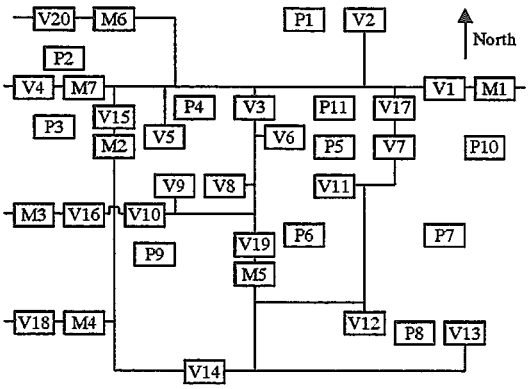

Fig. 2 Block 12 of the Fukuoka city water supply network (Pipes diameters in this figure are from 45 cm and above)

Motor valves are operated by remote control while pressure gauges and flow meters fitted to distribution pipes are monitored. The values of flow rate passing each flow meter, the opening percentage of each motor valve, and the pressure intensity at each pressure gauge are recorded every minute.

4. Available data and data type

Hourly data are available for all flow meters, pressure gauges, and motor valves since 1st April 1998 to 31st march 2001. This makes the total number of data for each telemeter 26304 (number of hours during this period), taking into consideration that the percentage of missing data for this period is 6.2%.

5. Analysis

In order to guarantee a good service in the network, pressure regulation and to meet the specific flow needs in the whole network, Statistical classification of valves should be done to facilitate the operation of the network.

Fig. 3 shows the collection of correlation coefficient computed for various lags which named autocorrelation function (ACF) for the typical three types of valves in this network. Figs. 4, 5 and 6 shows a box-whisker plot of the statistical distribution of hourly degree of valve opening for the classified three types of valves in block12. The box-whisker plot shows the median, upper and lower quartiles, upper and lower 5% of events and also the maximum and lower valve opening recorded for each type of the motor valves. V1, V2 and V16 are selected as representative of type 1, type 2 and type 3 respectively.

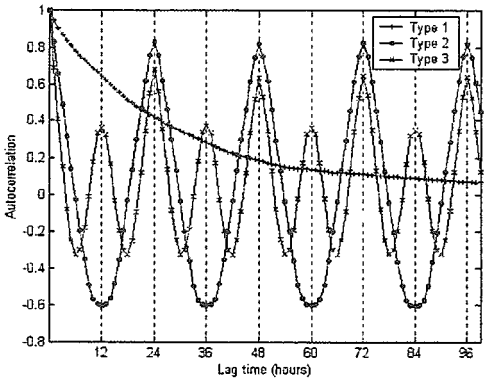

Fig. 3 Autocorrelation function of the typical three types of motor valves in Block 12

6. Discussions

The followings are the main characteristics of the three types of valves.

Type 1: Six valves of this network falls in this type and they are Valves 1, 4, 14, 15, 18 and 19. All these valves are connected to the main entrances of the network and have approximately constant percentage of opening during the different hours of the day (see Fig. 4).

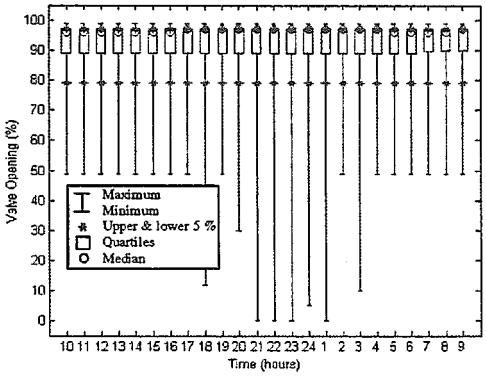

Fig. 4 Box-whisker plot of Valve 1 in Block 12 (Example of Type 1)

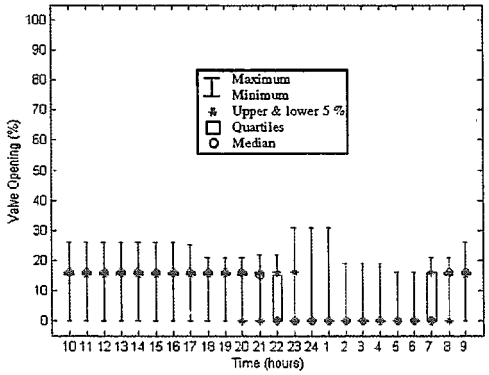

Fig. 5 Box-whisker plot of Valve 2 in Block 12 (Example of Type 2)

Type 2: Valves 2, 3, 13 and 17 are classified in this type. This type of valves is completely closed during night time (from 10.00 p.m. to 6.00 a.m.) and they have approximately constant percentage of opening during the rest hours of the day. This type is connected to the internal pipes of the block to reduce pipe-leakage through the network, and also to decrease the pressure during the night time when the water demand is at minimum (see Fig. 5).

Type 3: The remains 10 valves are considered of this type. This type of valves is used to maintain the pressure value between 2.5 kg/cm^2 and 3.0 kg/cm^2. Therefore those valves are slightly opened around the rush-hours (7.00 a.m. and 8.00 p.m.) and they are completely closed during the late night hours (see Fig. 6).

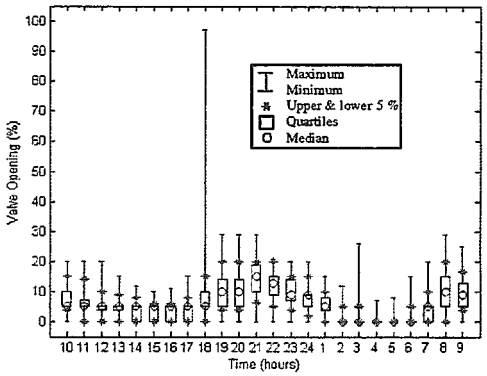

Fig. 6 Box-whisker plot of Valve 16 in Block 12 (Example of Type 3)

7. Conclusions

For constructing a good valve operation support based on the planned valve operation for flow and pressure regulation, and the operation knowledge database which is constructed on the basis of past experience, this paper present a statistical classification of the different types of valves connected to a water supply network.

Based on the autocorrelation function showed in Fig. 3 for the different three types of valves, an on-line prediction and efficiently control of valves opening could be carried out.

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Key Words: Water Supply Network, Water Resources Management, Fukuoka City, Valve Control, Classification of Valve Operation.