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Water Distribution Operation Systems Based on Smart Meter and Sensor Network

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Abstract

In this study, smart meter, water quality measuring sensors, and major operation skills are developed on the basis of real-time operation and management environment. Smart meter is designed by improvement of conventional water meter to secure accuracy and communication function. Finally, in order to obtain the information for the effective operation and management of water distribution systems, forecasting algorithm of abnormality water use is developed using Kalman filter and principal component analysis. Developed model is then implemented for real on-line measurement of the flow at the test district metered area (DMA) in southern city of Korea.

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Keywords: Smart meter, water quality sensors, water distribution, operation and management

1. Introduction

Interests of smart technologies based on ICT in water supply have been growing for the purposes of enhanced pipe network operation and management through real time monitoring equipment and software programs.

In Korea, the request for clean water has been increasing due to industrial and urban development and the rise in per capita water consumption. The high pressures in water supply systems mains mean that a burst may cause significant economic losses and leak. Also, water quality in pipe is a major concern of customers whether colored water or bio-film appears in supplied water or not. Network reliability, or supply security can be seen as a measure of how well this service is performed by waterworks and the water system is said to be reliable if it functions properly

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for the specified evaluation time with adequate quantity, appropriate pressure and water quality. The goal of waterworks is to supply their customers with good quality drinking water. Modern service systems, such as water supply systems are highly inter-dependent, formulating a networked supply chain system. The substances supplied include hydraulic, water quality, material and energy.

The trend moving to introduce the concept of intelligent water distribution is rising for effective operation and management. To implement the intelligent water distribution smart metering and sensoring systems are developing with measuring equipment and devices. In this study, localized smart meters and water quality sensors as measuring equipment are developed and applied to test bed for enhanced integration with water distribution operation and management for real time leakage detection, water quality management by application of the equipment and devices

2. Smart metering systems

To achieve remote automated meter reading, an improvement is carried out to complement the shortcomings of conventional water meter. An injection mold is built to improve the flow meter accuracy through repetitive performance of error experiments for the flow unit. In addition, Maximize the advantage of the analog meter using semi-electronic L/C sensor is used to take advantage of both analogue and digital water meters. Test equipment for wireless communication frequency depending on the specific environmental conditions was carried out to transfer the measured flow value.

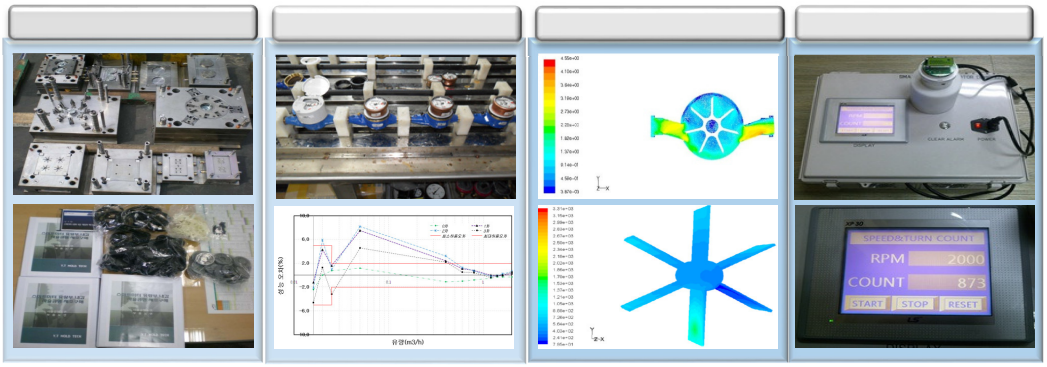

Fig. 1. Design and performance test for developing smart meter.

3. Smart metering systems

Water quality sensors for the management in water distribution systems are developed to secure and localize domestic manufacturing technologies. It can give important information to waterworks on the basis of real-time operation and management environment.

A multi-parameter water quality monitoring system was developed for measuring water quality in water distribution system. Among multi-parameter water quality measurement system, promote localization of turbidity and residual chlorine sensor technology. The diaphragm 2-electrodes type is adopted for the specification of residual chlorine sensor which is working in the range of 0°C ~60°C temperature and 4.0~10.0 pH. The information of working status can be seen on the touch panel and the calibration is executed by using colorimetric method. Also, turbidity sensor is localized with exclusive application in water pipes with adoption of LED lamp for light source and performance test is carried out with comparison of foreign products.

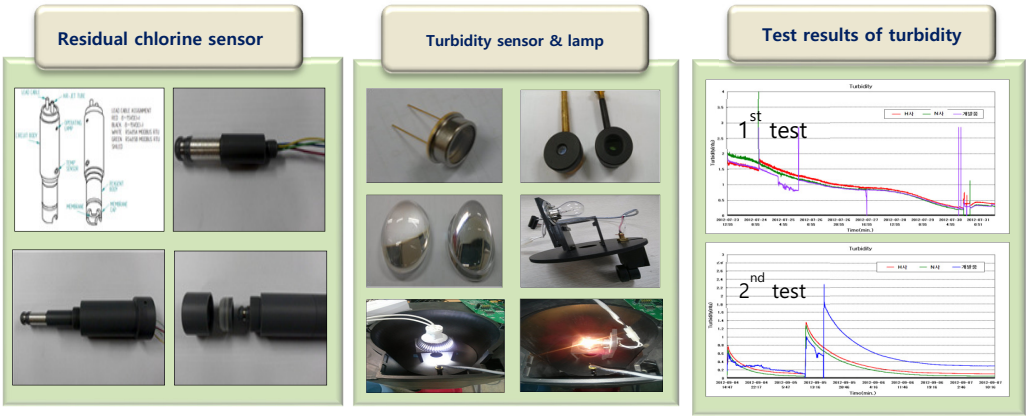

Fig. 2. Design and performance test for developing water quality sensors.

4. Abnormality detection algorithm

Water utility companies usually become aware of bursts and leaks through customer phone calls, such as complaints of low pressure, service interruption, and spotting of surface water. However, not all bursts and leaks in water supply networks are reported through customer contact because the leaked water sometimes seeps underground. These can cause significant unplanned service interruptions over a large service area after the latent period, i.e., the period from the occurrence of a burst and appearance of leak symptoms to when water supply to customers is cut off. Therefore, many water utility companies are making an effort to develop a more proactive approach through the analysis of abnormal hydraulic conditions (flow and pressure) based on online measurement data.

A Kalman filtering method is introduced to detect abnormal water usage, including bursts and leaks, based on hydraulic measurements of flow and pressure in water supply networks. The proposed method consists of two-step processes. In the prediction process, the Kalman filter estimates the current state variables along with their uncertainties. These estimates are then updated using a weighted average. In addition, the model's prediction accuracy is improved by automatically calibrating the covariance of noise through innovation sequence. For burst and leak detection, the noise of the filter is used to determine the abnormal water usage owing to the bursts and leaks. The developed model is first validated by a series of engineering tests in northern England, where the previous study was conducted. The model is then implemented for real online measurement of the flow at the JE district metered area (DMA) in southern Korea. To evaluate the numerical accuracy of the predicted DMA results, the predicted amount of leaks every month is compared with the monthly rate of accounted water using regression analysis. The regression plot shows a strong relationship between the real and estimated results. The model is expected to serve as a tool to raise an alarm over pipe failure and reduce water losses and service interruptions

5. Abnormality detection algorithm

Water meter is designed and developed for the implementation of smart metering system including wireless and wire communication and real time monitoring. It can enhance the efficiency of water pipe system operation. Water quality sensors and monitoring system are developed for the upgrade of sensor manufacturing technologies and for real time operation and management in water distribution systems. On-line detection methods of abnormal water usage, including bursts and leaks are proposed which is based on hydraulic measurements of flow and pressure in water supply networks. For the evaluation of detection validity, proposed method is applied into two real DMA in JE city and the application results show a strong relationship between the measured and estimated flow data.

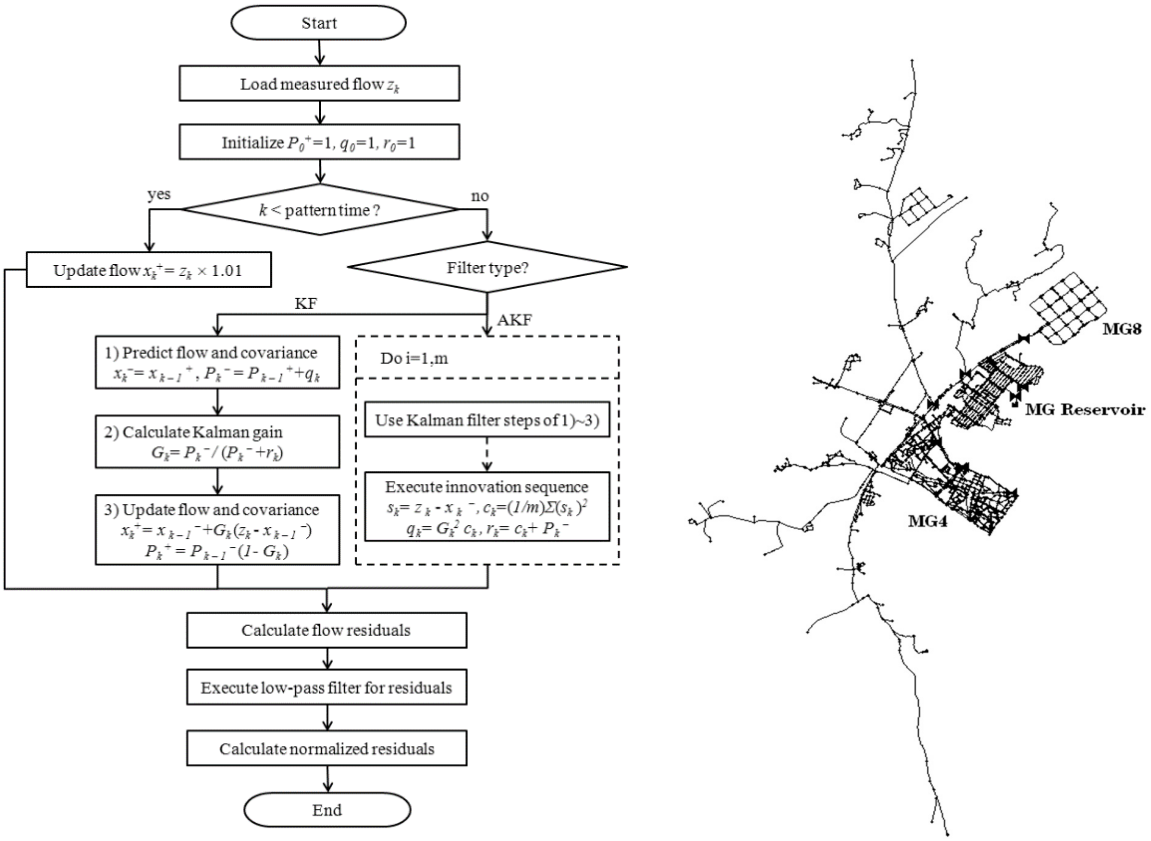

Fig. 3. Detection algorithm of abnormal water use and application area.

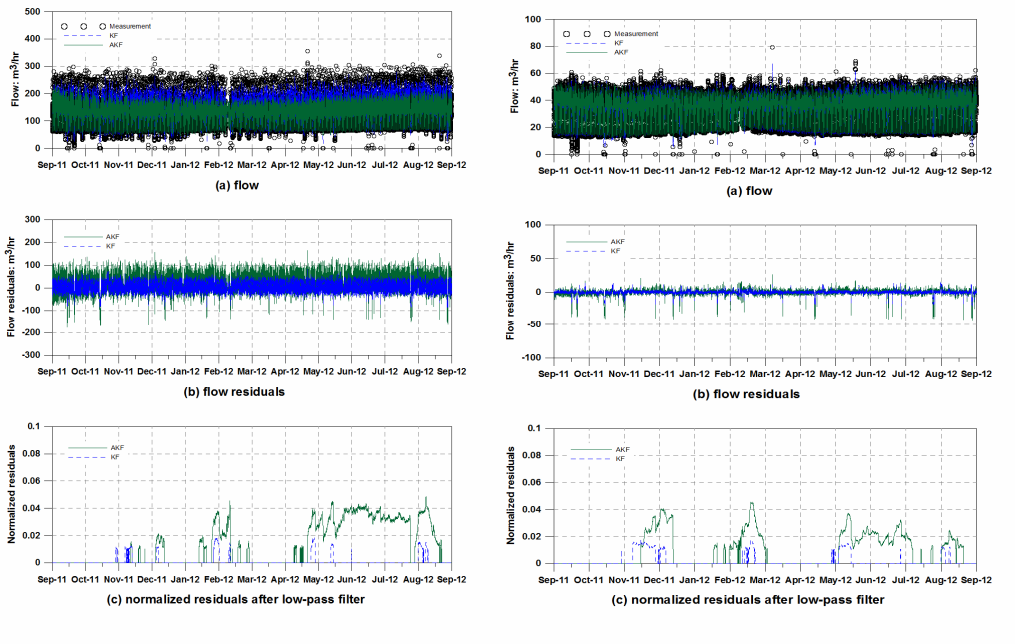

Fig. 4. Flow data and detection result in MG4 (left) and MG8(right) DMA of JE city.

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