# Instrumentation, Control and Sensor Technology for Sewage Treatment Plants

Jun Umetsu

## 1. Introduction

Many sewerage facilities are being built recently and their use is becoming more widespread. The technologies used in these facilities, such as sensors, instrumentation systems and control systems, is also improving day-by-day. This paper will describe these latest technologies for sewerage facilities.

## 2. Sensor

A sensor is equivalent to the human sense of sight and hearing. Various types of sensors are used in sewerage facilities to measure water flow, water pressure, water level and water quality. These sensors are expected to be improved upon in the future, with advanced precision and easier maintenance.

On the other hand, new principles of instrumentation have been put to practical use, and the development of various new sensors is promoted. These new sensors for sewerage facilities will be described below.

### 2.1 Biosensor

The biosensor is a type of sensor that employs a molecule identification function for biomaterials (enzyme, microbes). The measuring method utilizes the characteristics of biomaterials that catalyze the reaction of a specific chemical substance, and detects with an electrode the change (consumption, generation) in the chemical substance passing through a biomaterial immobilized membrane. The configuration of the enzyme sensor includes the enzyme-immobilized membrane, an electrode transducer and a simple module.

Some biosensors have been already used in the field of medical care to measure blood sugar values and in the field of food. In the field of the sewerage, a water quality meter that uses a nitrifying bacteria biosensor and other water quality biosensors for sensing ammonia, nitrogen and phosphorus is now under development. Biosensors are expected to be used widely in the future.

### 2.2 Coagulation sensor for sewage dehydration

To efficiently, steadily and continuously process sludge generated from sewage treatment, determination of the following is necessary: the type of dehydrator, the type of coagulant compatible to properties of the sludge and performance of the dehydrator, and a coagulant injection rate suitable for the concentration of desiccated solids (SS concentration) in the sludge.

Fuji Electric is now developing a coagulant injection control system for sewage dehydration. Corresponding to changes in the condition of the sludge, the system automatically and continuously controls online the injection of coagulant by using a coagulation sensor for sewage dehydration.

The measurement principle of the coagulation sensor utilizes the analysis method of infrared absorbency fluctuation. The coagulation sensor computes and outputs a volume factor by irradiating far-infrared light to an object and then calculating the mean diameter and numeric concentration of flocculated particles in that object from the degree of light absorbance.

## 3. Instrumentation System

During the treatment process at sewerage facilities, various quantities such as water level, pressure and water quality, including flow rate, are measured and the systems that monitor and control such quantities are configured. These latest systems for the sewerage will be described below.

### 3.1 Optical instrumentation technology

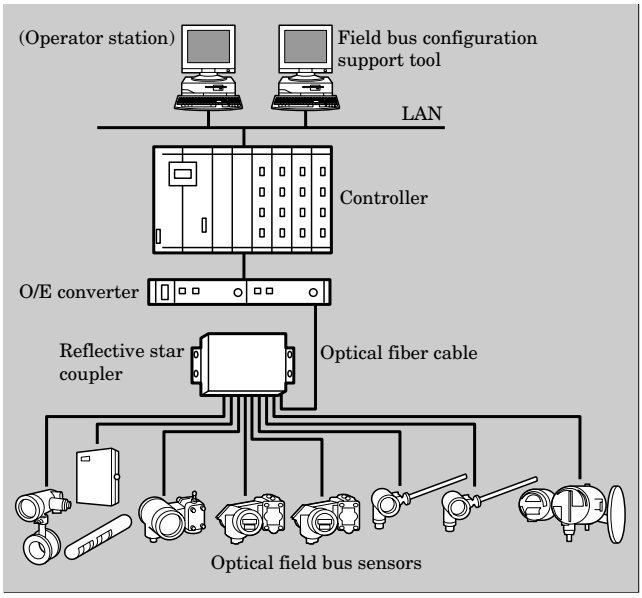
With the development of low-loss optical fiber in 1970, the application of optics to instrumentation technology suddenly became a leading field of high technology. Optical instrumentation technology is roughly divided into (1) measurement with applied optics and (2) optical measurement using optical fibers. The former category includes point sensors such as the turbidimeter, infrared thermometer, Fourier transformation infrared analyzer, and image sensors for vision-sensing robots and quality inspection or the selection of goods. The latter is an instrumentation system that uses optical fiber cable instead of conventional copper wire. Use of optical fibers has given this technology

broadband characteristics and resistance to lightning, noise and explosions, resolving various problems that had previously held back this technology.

Figure 1 illustrates the optical field bus system in which the FFI system, developed as the world's first optical fiber instrumentation system, is even more open. The sophisticated sensors use microcomputers and their output signals are transmit in digital form.

The advantages, as compared with conventional systems, are as follows: (1) resistance to noise (lightning surge, electromagnetic induction), (2) intrinsically safe explosion-proofing, (3) high accuracy through digitization, (4) realization of self-diagnostic functions and centralized maintenance (remote adjusting from a central location), (5) reduction in the number of cables by using a star coupler, (6) simplified operation (allowing mixed communication cables with power cables in the same cable root), and (7) an open (internationally standard) multi-vendor network.

Fig.1 Optical field bus system




### 3.2 Network system

The sewerage facilities have equipment both inside and outside of the treatment plants and networks configured for the exchange of information and control among facilities.

#### 3.2.1 Local area network

A local area network is used to transmit information as well as instrumentation and control signals for each piece of equipment inside the plant. Using a local area network, many treatment plants employ a centralized monitoring and distributed control system as shown in Fig. 2.

#### 3.2.2 Regional network

Network systems using telephone lines and optical fiber cables are employed to transmit the instrumentation and control signals of wastewater booster pump stations scattered throughout a wide area and of main line flow rate measuring equipment, and to perform centralized monitoring in the treatment plants.

(1) Small-scale monitoring system

This system monitors and transmits data at fixed time intervals using an ordinary public telephone line as shown in Fig. 3. The cost performance of this system is enhanced through partnered management with neighboring towns and villages.

(2) Remote supervisory control system

This system performs supervisory control with data loggers and CRTs of a remote monitor office by continuously transmitting instrumentation and control data via the private line of a telephone company as shown in Fig. 4. Many such systems are commonly and

Fig.2 Centralized monitoring and distributed control system

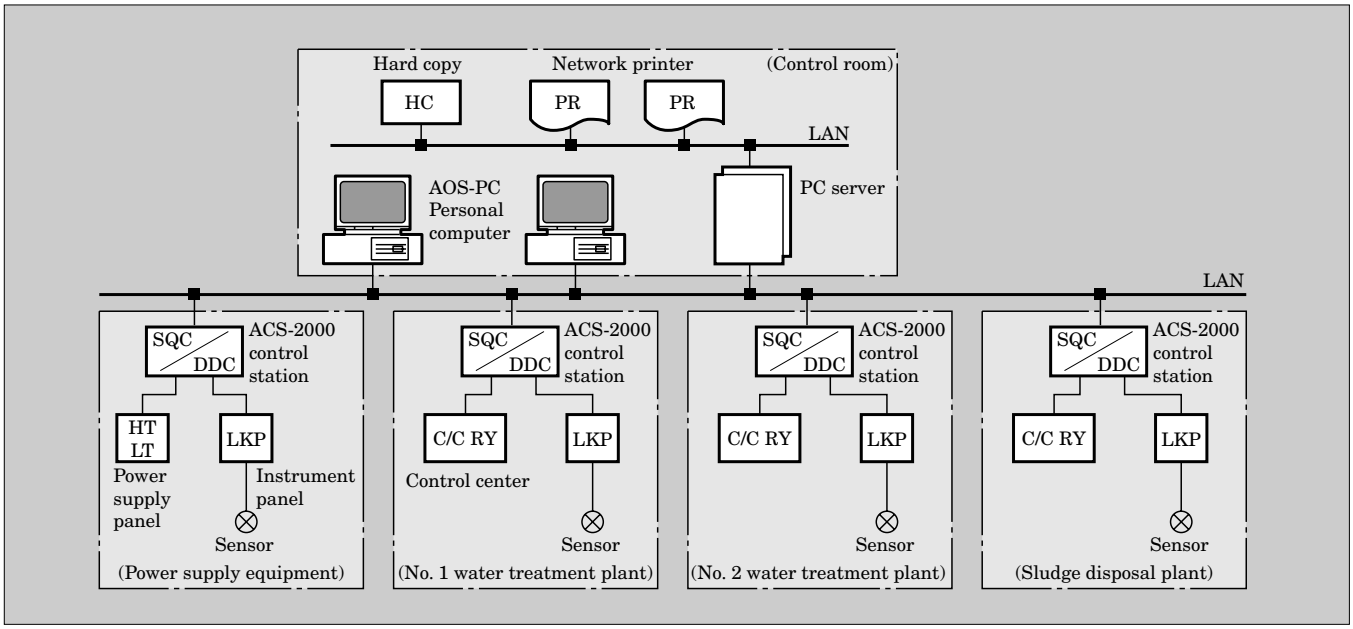


Fig.3 Small-scale monitoring system

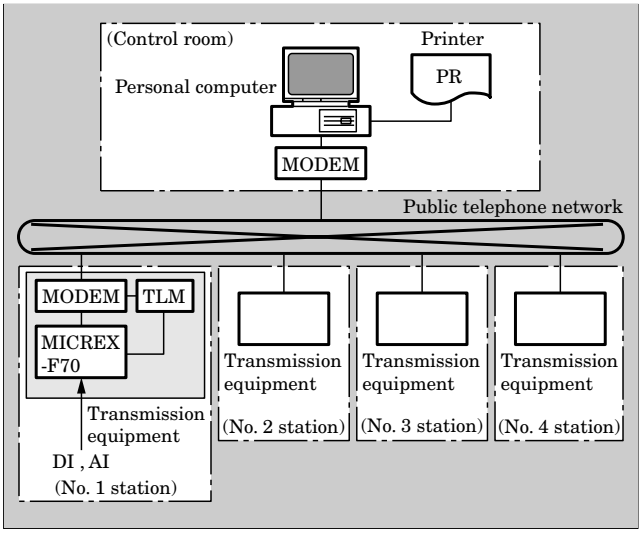
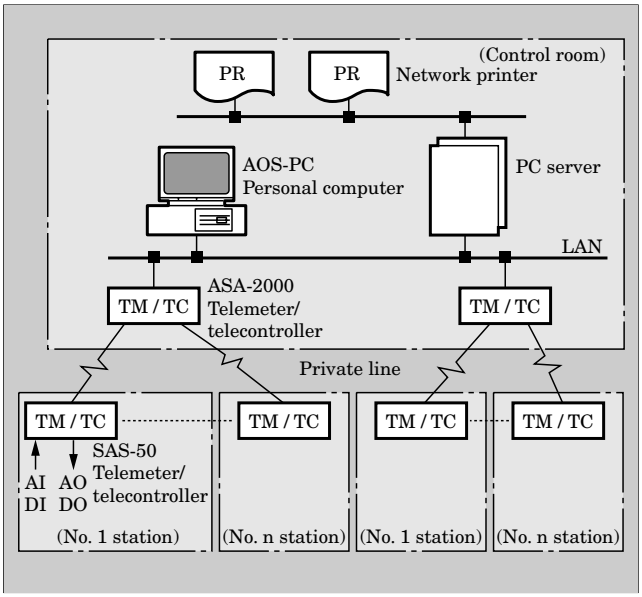



Fig.4 Remote supervisory control system




widely employed at present.

(3) Optical fiber network system

Systems have recently been employed that exchange data through optical fiber cables laid in underground sewerage pipes. This allows construction of a wide area network along with the sewage piping network, and implementation of advanced information exchange. Features of such networks are listed below.

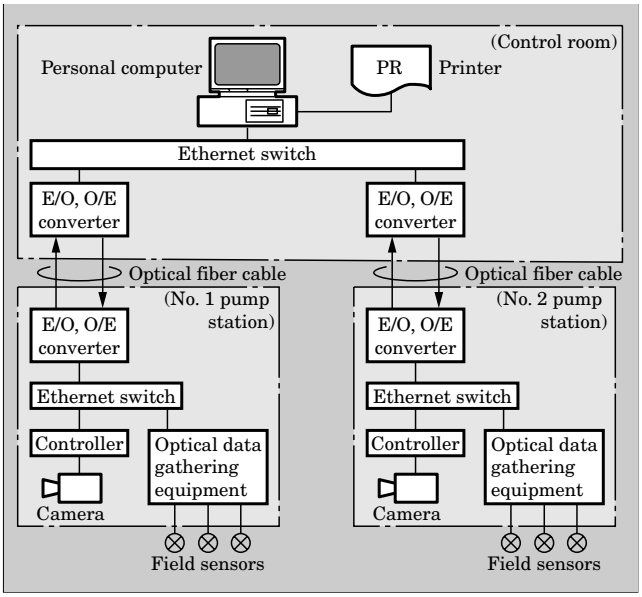
① Does not require construction of a special path because vacant space in the sewage pipes can be used.

② Resistant to disasters and faults and the reliability is high.

③ Can exchange information that is highly dense over a wide area.

These networks are expected to play a big role in the future information society.

Fig.5 Optical fiber network system




The system configuration employs the aforementioned optical field bus system or an Ethernet as shown in Fig. 5.

### 3.3 System power source

A good-quality power source is necessary to normally run the aforementioned network. A UPS (uninterruptible power supply) is often used as the power source of the network.

## 4. Process Control

The appropriate control is performed in each treatment process of the sewerage facilities. The recently used new control systems will be described below.

### 4.1 Advanced control

PID control is extensively used even now for lower-order single loop control. However, there is a limitation on its application to higher-order systems or remarkably non-linear systems such as a time variable system with large dead time, multivariate systems and distributed constant systems. (It can be said that the water treatment process essentially has these characteristics.)

With the utilization of digital controllers, higher-level control systems came to be extensively used. Along with advances in modern control theory and in applications to control technology, the application of such advanced control methods to process control has become possible by utilizing the functions of computers and these controllers. The various control systems that aim at such high-level control are commonly referred to as advanced control systems.

Fuzzy-logic based control is performed in the wastewater pump station of the sewerage facilities.

With fuzzy-logic control, controllers are used to provide proper pump and gate control by: subdividing the process of inflow control into several control rules (previously a task which only skillful operators could perform), judging the circumstances based on rainfall intensity and pump discharge, and understanding the variation rate of the water level.

#### 4.2 Application of AI (artificial intelligence)

Research on AI and its application has centered around the United States since the 1960's. Since the 1980's, applications such as expert systems and machine translation systems have been put to practical use one after another. A system in which problems are solved with using a human rule of thumb (knowledge) is referred to as a knowledge based system.

Various development support systems and tools for knowledge base systems have been already introduced. In the industrial field, centering on expert systems, the range of applications is rapidly broadening.

In sewerage facilities, neural network systems are actually employed in the inflow prediction system. These systems use personal computers and modify the setting values of various parameters based on the deviation between predicted inflow values and actual measured values. The computers ultimately learn from data to minimize the deviation between predicted and measured values.

## 5. Conclusion

In addition to the original purpose of sewage treatment, sewerage facilities are deeply concerned with community developments such as advanced information networks. It is believed that these networks will to continue to advance in the future. Therefore, Fuji Electric will not fall behind and will also contribute to social development.