“ZP Series” of Small, High-sensitivity Infrared Gas Analyzers

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ABSTRACT

Fuji Electric provides two types of infrared gas analyzers: small single beam types with a simple construction, and double beam types that have high sensitivity but are large and require complicated adjustments, and has developed a small, high sensitivity infrared gas analyzer with a single beam. By creating a measuring section with higher sensitivity and employing sample switching (SSW), the analyzer achieves low density measurements that surpass the double beam measurement range. The analyzer can be used in a wide range of applications from metal heat treatments and monitoring applications for biomass-/waste-related generated fuels that require high density measurements, to low density exhaust gas monitoring and monitoring impurities in pure gases that require low density measurements.

1. Introduction

Fuji Electric’s gas analyzers have been used extensively in various industries for applications involving the measurement of gas concentrations, such as for combustion control, emissions gas monitoring and process control in various plants. In these applications, infrared gas analyzers are used to measure nitrogen oxides (NO_x), sulfur dioxide (SO_2), carbon monoxide (CO) and carbon dioxide (CO_2) concentrations, and are used as environmental monitors to measure the combustion exhaust gases emitted from various industrial furnaces including garbage incinerators, boilers, steel production plants, cement production plants, and for the monitoring and control of gases inside furnaces.

With recent advances in control technology for combustion furnaces and incinerators and advances in techniques for removing toxic substances, the concentrations of NO_x, SO_2 and CO_2 in exhaust gases are tending to decrease. Thus, the purpose of measurement, in addition to the conventional goal of controlling and monitoring exhaust gas, is often to prove that exhaust gas is not being emitted or is at low concentrations, and the ability to provide stable measurements of low concentrations of gas is increasingly sought.

Overseas, particularly in emerging nations such as China and India that are experiencing remarkable economic growth, large markets have been created in this field. To promote the widespread usage of gas analyzers overseas, performance improvements, as well as standardization and simplification of the usage methods are needed.

This paper describes Fuji Electric’s new type of gas analyzer that realizes high performance and ease of use. Representative application examples are also discussed below.

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2. Product Overview

Fuji Electric’s lineup of infrared gas analyzers include small single-beam types having a simple construction, and double-beam types that have high sensitivity but are large and require complex adjustments. Figure 1 shows the structure of the measurement unit of a single-beam type, and Fig. 2 shows the structure of

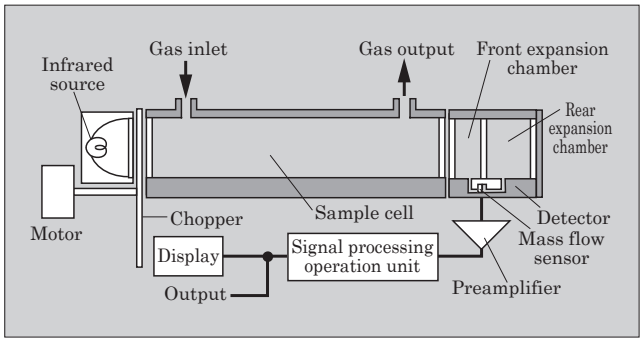

Fig.1 Configuration of single-beam type measurement unit

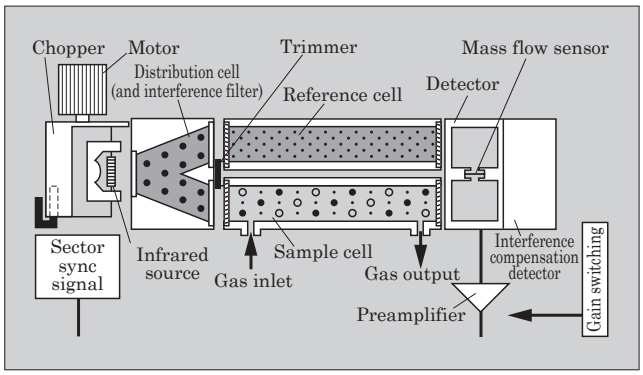

Fig.2 Configuration of double-beam type measurement unit

the measurement unit of a double-beam type.

Fuji Electric has newly developed the "ZP series" of small high-sensitivity infrared gas analyzers which aim to achieve performance superior to that of the conventional double-beam type.

By increasing sensitivity of the measurement unit and adopting a method of sample switching, Fuji Electric successfully developed an analyzer that achieves improved stability, is capable of measuring low concentrations and is easy to use. Additionally, component parts were made standardized so as to create a flexible product lineup able to support requirements for measurements ranging from low to high concentrations.

3. External Appearance and Specifications

Figure 3 shows the external appearance and Table 1 lists the main specifications of the ZP series. The series is provided as a general-purpose model (model: ZPA) that covers the conventional single-beam measurement range (0 to 200 ppm), a high-end model (model: ZPB) that covers the conventional double-beam range (0 to 50 ppm), and a low concentration model (model: ZPG) that enables measurement of even lower concentrations of 0 to 5 ppm.

4. Product Features

(1) Small-size, high sensitivity measurement

The thickness of the sensor film of the mass flow sensors used in the detectors of conventional infrared gas analyzers was reduced to improve detector sensitivity. Moreover, the smaller size and increased sensitivity of the measurement unit enabled the single-beam minimum measurement range (conventionally 0 to 200 ppm) to be reduced to 0 to 5 ppm, which is a 40-fold improvement.

With the smaller size of the measurement unit, even when equipped with a sample switching function

Fig.3 Appearance of "ZP series"

Table 1 Main specifications of the ZP series

Item	ZPA	ZPB	ZPG
Measurement principles and measured components	NO, SO_2, CO_2, CO, CH_4: Non-dispersive infrared absorption method, O_2: Selected from among magnetic, galvanic cell and custom zirconia methods		
Measurement method	Standard	Sample switching	
Range ratio	1:10 max.		
Minimum measurement range	NO : 0 to 200 ppm SO_2 : 0 to 200 ppm CO_2 : 0 to 100 ppm CO : 0 to 200 ppm CH_4 : 0 to 500 ppm	NO : 0 to 50 ppm SO_2 : 0 to 50 ppm CO_2 : 0 to 50 ppm CO : 0 to 50 ppm	NO : 0 to 10 ppm SO_2 : 0 to 10 ppm CO_2 : 0 to 5 ppm CO : 0 to 5 ppm
	O_2: 0 to 5 vol% (in the case of magnetic or custom zirconia methods)		
Maximum measurement range	NO : 0 to 5,000 ppm SO_2 : 0 to 10 vol% CO_2 : 0 to 100 vol% CO : 0 to 100 vol% CH_4 : 0 to 100 vol%	NO : 0 to 5,000 ppm SO_2 : 0 to 5,000 ppm CO_2 : 0 to 25 vol% CO : 0 to 5,000 ppm	NO : 0 to 100 ppm SO_2 : 0 to 100 ppm CO_2 : 0 to 50 ppm CO : 0 to 50 ppm
	O_2: 0 to 100 vol% (in the case of the magnetic method)		
Warm-up time	4 hours	2 hours	
External I/O	Analog output DC4 to 20 mA, 550 Ω or less, 12 points Analog input 0 to 1 V, 1 point Contact output 24 V DC, 1 A 15 points max. Contact input 12 to 24 V DC, 5 to 20 mA 9 points max.		Same as the left, 4 points max. Same as the left, 1 point Same as the left, 15 points max. Same as the left, 6 points max.
Power supply/ power consumption	AC100 to 240 V		
	50/60 Hz, approx. 100 VA	50/60 Hz, approx. 120 VA	50/60 Hz, approx. 100 VA
Dimensions (mm)	483 (W) × 418 (D) × 132.5 (H)		
Linearity	±1.0%FS or less		
Repeatability	±0.5%FS or less (0 to less than 200 ppm is ±1.0%FS or less)		
Drift (zero point)	±2.0%FS or less per week (total of NO & SO_2 drift for no more than 0 to 500 ppm is ±2.0%FS or less per day)	±0.5%FS or less/week	
Drift (span)	±2.0%FS or less/week		
Response speed (90% response)	30 seconds or less		

(described below) is installed, the size remains the same as that of a conventional single-beam analyzer and the volume is less than one-half that of a conventional double-beam analyzer (see Fig. 4).

(2) Cancellation of zero point drift

Previously, low concentration measurements using a single-beam type analyzer incurred significant drifting of the zero-point due to the effect of ambient temperature changes, contamination inside the measurement cell and the like, and in order to maintain stability (refer to "Zero-point drift performance" (Explanation 4 on page47)), measurements were limited to the range of 0 to 200 ppm. With the ZP series of products, however, a sample switching method is used and stable measurements can be obtained even when measuring low concentrations.

Figure 5 shows the configuration of the sample switching method.

In the sample switching method, a sample gas and a reference gas corresponding to a zero gas are switched at a certain period, introduced to the measurement unit, and alternatively measured to obtain measurements while continuously monitoring the zero-point. As a result, in principle, the drift of the zero-point is cancelled. Fig. 6 shows the mechanism for cancelling the zero-point drift. The measured values correspond to "concentration amounts," and even if the zero-point drifts, only the change in output is seen, and therefore the amount of drift is negligible.

Consequently, stable measurements can be obtained even in the vicinity of the zero-point.

(3) Simple maintenance

Because a single-beam is used, there is no need for the optical balance adjustment that is required with the double-beam method. Additionally, the measurement unit has a simple structure that facilitates maintenance such as cell cleaning.

(4) Product series that supports a wide range of measurements

The ZP series is suitable for a wide range of applications ranging from the monitoring of metal heat treatments and of the generation of fuel from biomass and waste where measurement of high concentrations of gas is required to the monitoring of low concentrations of exhaust gas, the monitoring of impurities in pure gas, and so on where measurement of low concentrations of gas is required.

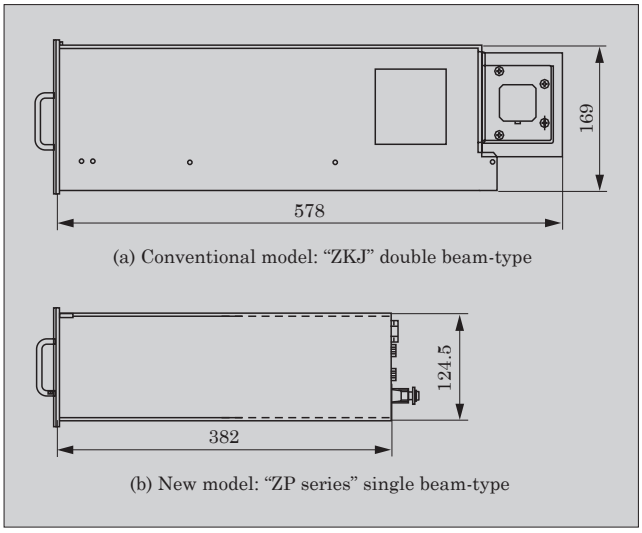

Fig.4 Comparison of conventional and new models (side view drawings)

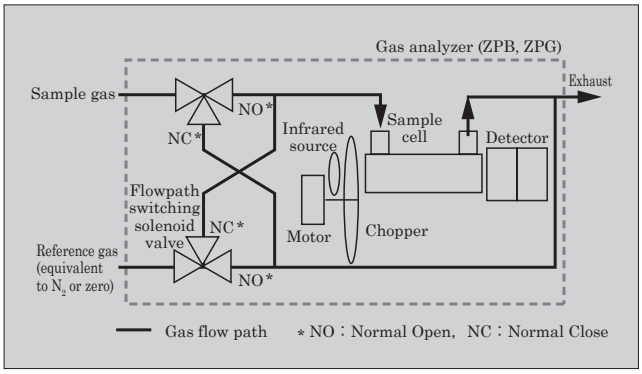

Fig.5 Configuration of sample switching method

5. Application Examples

Application examples that use this analyzer are introduced below.

In actual-use scenarios, pre-treatment equipment provided with dust removal and dehumidification functions must also be used. Table 2 lists main application examples and models of the ZP series.

(1) Thermal power boiler

Figure 7 shows an example of the application of an analyzer in a thermal power station.

Thermal power plants generate electricity by combusting various types of fuel such as heavy oil, coal and natural gas to boil off steam in a boiler, thereby causing a turbine to rotate and generate electricity. Gas analyzers are used to measure O_2 and CO levels for the control of boiler combustion, to measure pre- and post-NO_x levels of equipment for the control and monitoring of NO_x removal equipment that removes nitrogen

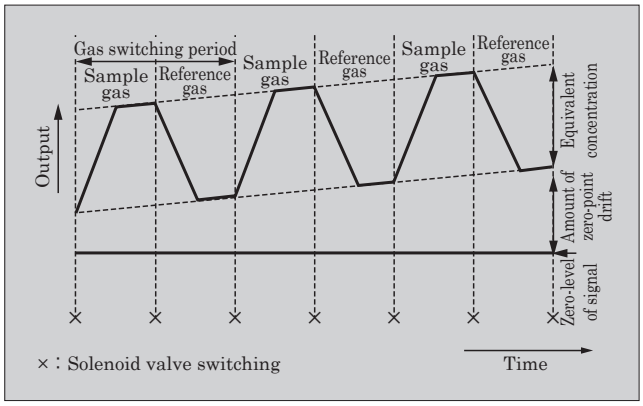

Fig.6 Mechanism for cancelling zero-point drift

oxides from exhaust gas after combustion, and to measure NO_x, SO_2 and O_2 levels for monitoring exhaust gas discharged from chimneys. In recent years, as a result of improvements in desulfurization and denitration processes and higher quality raw materials, the exhaust gases discharged from chimneys have become cleaner, and NO_x and SO_2 levels have decreased to about 10 ppm.

In addition, gas boilers and gas turbines that use natural gas as fuel and have relatively lower CO_2 emissions have been watched closely, and concentrations of these emissions have been reduced to even lower levels.

With the sample switching method, the ZP series that is capable of stable low-concentration measurements, is able to meet market needs for the measurement of such low concentrations.

(2) Iron and steel industry

Figure 8 shows an example of the application of analyzer in an ironworks.

In iron and steel plants, CO, CO_2 and O_2 concentrations are monitored, where CO gas concentrations are measured for the purpose of combustion control of various types of furnaces such as blast furnaces, converters, and coke ovens and for the recovery of exhaust gas, and O_2 concentrations are measured in order to prevent explosions, and so on. Concentrations are measured in the ranges of 0 to 100% for CO, 0 to 50%

Table 2 Main application examples and models of the ZP series

Market & Business sector	Target	Components and range* to be measured		Model
Waste incineration	Pollution monitoring (Exhaust gas measurement)	NO_x SO_2 CO CO_2 O_2	0 to 50...200 ppm 0 to 50...500 ppm 0 to 50...1,000 ppm 0 to 10...20 vol% 0 to 10/25 vol%	ZPB
	Incinerator combustion control	CO O_2	0 to 1,000 ppm 0 to 5.....25 vol%	ZPA
Iron and steel	Pollution monitoring (Hot oven, boiler exhaust gas measurement)	NO_x SO_2 CO CO_2 O_2	0 to 50...200 ppm 0 to 50...500 ppm 0 to 1,000 ppm 0 to 10...20 vol% 0 to 10/25 vol%	ZPB
	Hot oven, boiler combustion control	CO O_2	0 to 1,000 ppm 0 to 5.....25 vol%	ZPA
	Desulfurization/ denitrification equipment monitoring and control Monitoring of gas generated by blast furnace, monitoring of gas generated by converter, monitoring of gas generated by coke oven, monitoring of vacuum degassing	CO CO_2 O_2	0 to 20...100 vol% 0 to 10...50 vol% 0 to 1.....25 vol%	ZPA
Cement production	Pollution monitoring (Exhaust gas measurement)	NO_x SO_2 O_2	0 to 100 ppm 0 to 100...1,000 ppm 0 to 10/25 vol%	ZPB
	Gas monitoring inside a kiln, coal grinder outlet, etc.	CO O_2	0 to 2,000 ppm 0 to 5.....10 vol%	ZPA
Heat treating furnace	Heat treating furnace atmosphere monitoring and control	CO CO_2 CH_4 O_2	0 to 20...25 vol% 0 to 1.....5 vol% 0 to 10...30 vol% 0 to 1.....10 vol%	ZPA
Electric power	Pollution monitoring (Exhaust gas measurement) Oil boiler	NO_x SO_2 O_2	0 to 50...1,000 ppm 0 to 50...2,000 ppm 0 to 10/25 vol%	ZPB
	Pollution monitoring (Exhaust gas measurement) Gas turbine	NO_x O_2	0 to 10...100 ppm 0 to 10/25 vol%	ZPG
Gas supply	Product monitoring, impurity monitoring	CO CO_2	0 to 5.....10 ppm 0 to 5.....10 ppm	ZPG

* : NO_x is converted into NO with a converter and then measured as NO with an analyzer

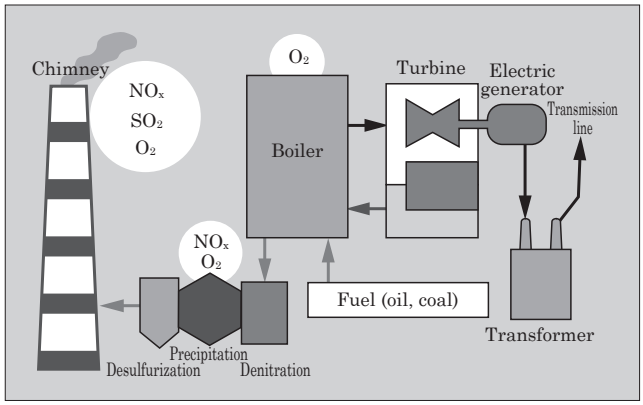

Fig.7 Example application of analyzer in a thermal power station

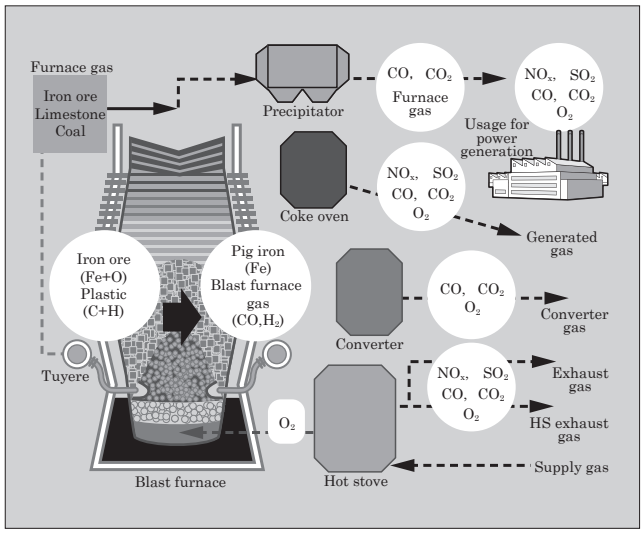

Fig.8 Example application of analyzer in an ironworks

for CO_2, and 0 to 25% for O_2.

Additionally, in order to conserve energy, the exhaust gases from these furnaces are typically used as fuel to generate electrical power that is provided to the plant. Here, NO_x and SO_x are measured to monitor combusted exhaust gas, which is used as a fuel for generating electricity.

All of these measurements involve low emissions levels of around 10 ppm, and therefore, the capability to measure low concentrations is needed.

The ZP series supports measurements ranging from low to high concentrations of furnace gas. Accordingly, the ZP series provides significant merits in terms of management and maintenance since the maintenance parts are standardized and there is no need to learn how to operate various types of analyzers.

(3) Cement production process

Figure 9 shows an example of the application of analyzer in a cement manufacturing process.

In the manufacture of cement, the raw materials of limestone, clay, silica, iron oxide and gypsum are dried and are then injected into a grinder where they are pulverized.

These materials are then placed into a cyclone, mixed uniformly and stored in a silo. The mixed materials are heated by a preheater and then baked by a burner in a rotary kiln to form clinker. The clinker is cooled and then pulverized again, and a separator is used so that the clinker powder particles are of uniform size. The control of the cement plant requires combustion control inside the rotary kiln, safety monitoring of the coal that forms the fuel for firing, and pollution monitoring of the exhaust gas. Combustion control is an especially important factor for determining the quality of the cement.

To control combustion in the rotary kiln, CO, CO_2 and O_2 are measured and to monitor exhaust gas pollution of the overall plant, NO_x, SO_2, CO, CO_2 and O_2 are measured

(4) Waste treatment plant

Fuji Electric's gas analyzers have been used successfully in many applications in waste treatment plants. Fig. 10 shows an example application of analyzer in a waste treatment plant.

In a waste treatment plant, gas analyzers are used to monitor emissions generated by the incineration of waste.

The components to be measured are NO_x, SO_2, CO and O_2. CO levels are measured as a reference value for preventing the generation of dioxins from incineration, and the CO concentration is usually limited to several ppm. With the installation of exhaust emission cleaning equipment, NO_x and SO_2 are reduced to levels ranging from about several ppm to several tens of ppm. Thus, the ZP series, which is capable of measuring low concentrations, can be used effectively.

Biomass power generation using fermented waste has attracted attention recently, and analyzers are also used to monitor the generation of CO_2 and methane (CH_4).

(5) Gas supply equipment

In semiconductor and petrochemical plants, gas purification and supply equipment is installed for such gases as nitrogen, argon and oxygen. Devices are attached to this equipment for monitoring CO_2 and CO impurities contained within the supplied gas. These impurities affect the quality of products made in the plant and their manufacturing processes, and stable measurement of the purity levels is required. The targeted gases, CO and CO_2, are to be measured in the range of 0 to 5 ppm or to 10 ppm, and the ZP series of analyzers is suitable for this application.

(6) Air quality measurement

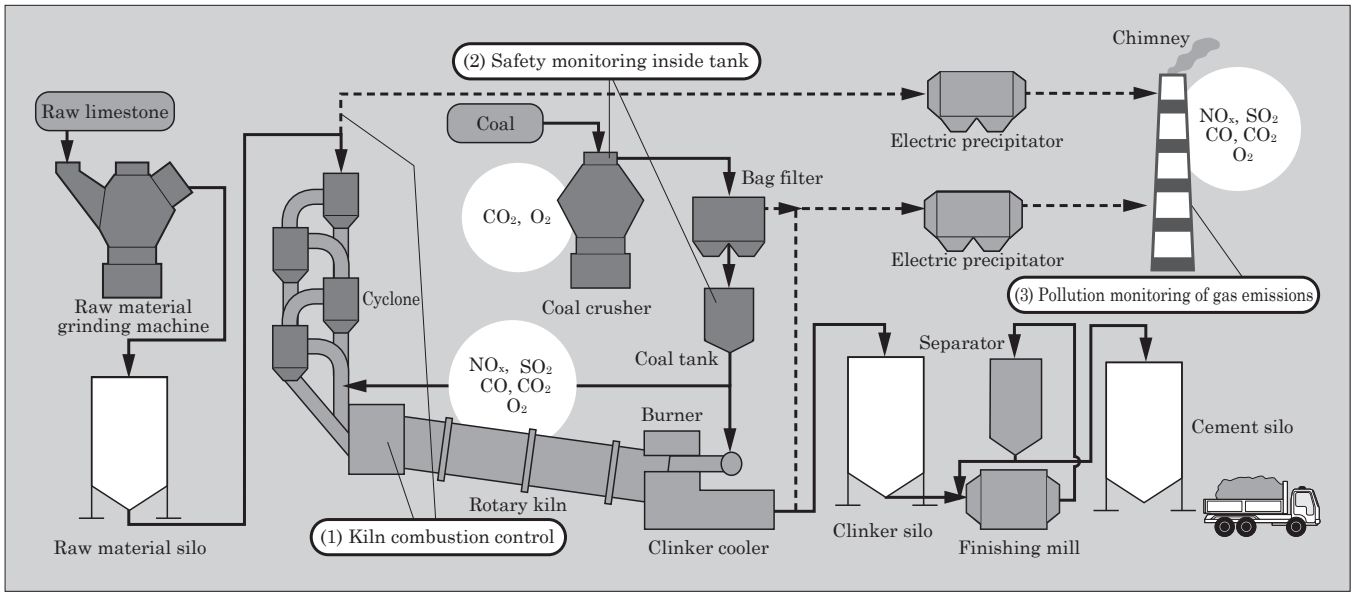

Fig.9 Example application of analyzer in a cement manufacturing process

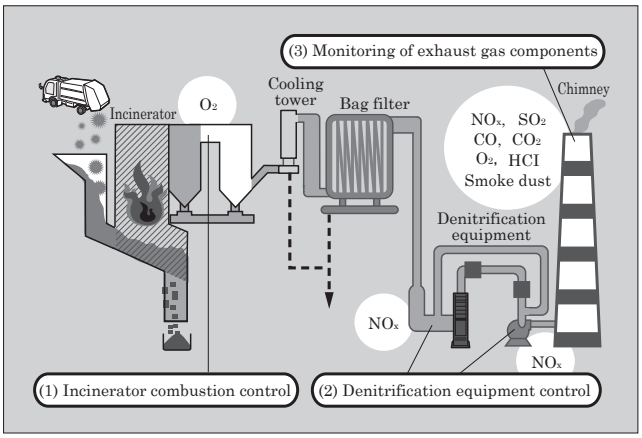

Fig.10 Example application of analyzer in a waste treatment plant

Recently, attention has focused on preventing global warming which is caused by greenhouse gases. Greenhouse gases include CO_2, CH_4 and the like. Infrared CO_2 meters are being used for the purpose of long-term observation of the global environment. The ZP series, with its excellent long-term stability, is well suited for the long-term continuous measurement of CO_2 in the atmosphere.

6. Postscript

The ZP series of compact, high-sensitivity infrared gas analyzers use single infrared beam, improved sensitivity and zero-point drift cancellation to achieve the capability for measurement of low concentrations. Additionally, the handling of all the ZP series equipment has been standardized. The products introduced herein are suitable for use in a wide range of applications for combustion control and exhaust gas measurement in various plants. Fuji Electric has developed the measurement unit of this series to create a line of products.

In the future, Fuji Electric intends to develop gas analysis equipment optimized for these applications, such as by pre-treating the reference gas, and to advance the commercialization of explosion-proof products in order to expand the range of applications.