The Continuous On-line Steam Quality Monitoring System of the Bacman Geothermal Production Field, Philippines

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ABSTRACT

In any operating geothermal power plant, steam quality is one of the most important parameters being monitored. In the Bacon-Manito Geothermal Production Field (BGPF), an on-line steam quality monitoring system have been installed in two operating power plants which provides an accurate, efficient and continuous real-time data which is more responsive to the various requirements of the field operation.

The system utilizes sodium as an indicator of steam purity. Sodium concentration is read by the flame photometer located at the interface after aspirating a sample of the condensed steam through a continuous condensate sampler. The condensate has been degassed through a condensate-NCG separator. The flame photometer analog signal is then converted by a voltage-to-current converter/ transmitter and relayed to the processor which is located at the control center through electrical cable to give a digital sodium concentration read-out at the control panel. The system features a high and high-high sodium level alarm, a continuous strip-chart recorder and a central computer for data capture, retrieval, and processing for further interpretation. Safety devices, such as the flame-off indicator at the control center and the automatic fuel cut-off device along the fuel line, are incorporated in the system.

The system is accurate and achieved high precision of ± 0.011 mg/L (± 1.1%) for the 1.00 mg/L sodium standard at full scale and ± 0.003 mg/L (± 2.7%) for the 0.10 mg/L sodium standard.

Introduction

In any operating geothermal power plant, the quality of steam is one of the most important parameters being monitored. The availability of a real-time continuous data for monitoring the quality of steam which is being supplied to the power plant, provides utmost importance to the operators for an efficient operation of the system.

Regular measurements of steam quality have been conducted since the commissioning of the 110 MWe Bacman-1 power plant in November 1993. The main objective is to continuously monitor the steam quality to ensure that the levels of impurities in steam does not exceed the contract limit, as agreed with the National Power Corporation, the power plant operator.

The conventional method of steam quality monitoring is by manual sampling for the spot and cummulative samples for every four-hour interval. The results of the analyses are only available after 24 hours. These conventional method of monitoring steam quality, however, is not adequate to provide immediate results to the field and power plant operators in the event of any transient or continuous deterioration in steam quality. In all of the past experiences of steam quality upsets, data transmitted to the control room Engineers are historical. Hence the supposed remedial action for the protection of the turbine against these impurities in steam has not been done.

In the Bacman Geothermal Production Field (BGPF), Philippines, a new system, the Continuous On-line Steam Quality Monitoring System, has been installed, tested and used in routine fluid collection and disposal system operations at the Bacman-I and Bacman-II Cawayan module power plants since January 1996. The new system of monitoring steam quality is now integrated into the FCDS control panel, and provides a continuous real-time data which is more responsive for controlling process operations and in meeting the various requirements of the FCDS and power plant operations. This is because the sodium concentration is read and displayed at the control room. The new system is also used in determining the efficiency of the separator vessels and the scrubbing efficiency of the drainpots located along the steam lines during steamline scrubbing efficiency tests. As an additional advantage in cost, the system is designed to be operated without an operator continuously manning the system.

The Continuous On-line Steam Quality Monitoring System

The overall system is illustrated in Figure 1. The steam is collected through an isokinetic probe at the steam line and flowed to the condenser (ASTM, 1994). The steam condensate passes through a degasser to degas the flowing condensate sample. The separated gas is vented to the atmosphere. This ensures a laminar flow of the sample, prevent the formation of gas pockets within the sample stream, and prevent pressurization within the continuous condensate sampling system, for a more representative and uniform sample nebulization. The degassing process also ensures a stable flame photometer reading and prevent the flame from being extinguished.

The system utilizes sodium as an indicator of any water carry-over along the steam line hence, an indicator of steam quality. Sodium concentration is read by the flame photometer after aspirating a degassed stream of sample of the condensed steam through a continuous condensate sampler. The stream of condensate that passes after the nebulizer goes to the drain. The flame photometer output analog signal in voltage is then converted to a standard instrumentation signal in current by a converter/transmitter. This signal is relayed to the intelligent loop processor at the control center located several hundred meters away from the flame photometer through an electrical cable. The processor does the computation and ranging to give a digital sodium concentration read-out in ppm. A typical program loop diagram of the intelligent loop processor for the digital sodium concentration display, chart recorder and annunciator alarm outputs is shown in Figure. 2.

The system features a visual and audible high and high-high sodium level alarm to alert the operator of any impending steam quality deterioration due to system upset, hence remedial actions can be done to prevent further deterioration in the quality of steam. The system was developed to be a proactive device such that the alarm levels were set lower than the contractual limit. It also has a strip-chart recorder for continuous data logging and a central computer for perpetual data capture, retrieval, downloading and data processing for further interpretation.

Safety devices, aside from that inherent in the flame photometer instrument, such as the flame-off indicator at the control panel and the automatic fuel cut-off device along the fuel line, are incorporated in the system.

Equipment Calibration, Precision and Accuracy

Four working sodium standard solutions were used during routine calibration of the flame photometer. These are: 0.10 mg/L, 0.20 mg/L, 0.40 mg/L, 1.00mg/L (APHA-AWWA-WPCF, 1976). The instrument is set at full scale using the 1 mg/L standard (Corning, 1984).

Below are examples of calibration runs using the working sodium standard solutions.

Na standard (mg/L)	Digital Read-Out At The Control Room Ave. (mg/L)	n	S. D. (mg/L)	% COV
1.00	1.020	8	0.011	1.1
0.40	0.394	7	0.011	2.8
0.20	0.194	7	0.004	2.1
0.10	0.110	11	0.003	2.7

note: S.D.-standard deviation % COV-coefficient of variation n - no. of data

Figure 3 shows an example of a typical real-time plot of sodium concentrations along the steamline for a 24-hour monitoring period as displayed on the central computer screen at the control center.

Maintenance Requirements

The major instruments and equipment housed in the monitoring shed are: the flame photometer, air compressor, signal

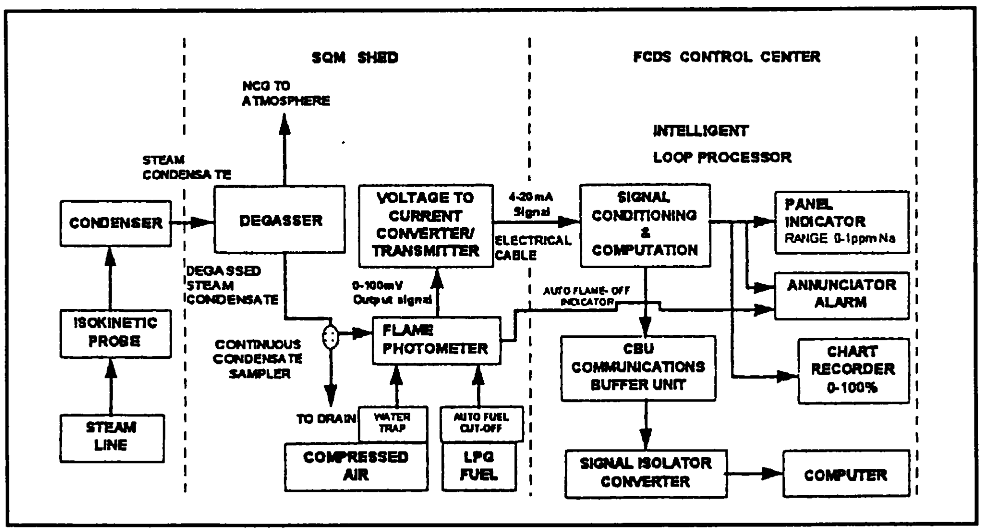

Figure 1. BGPF continuous on-line steam quality monitoring flow diagram.

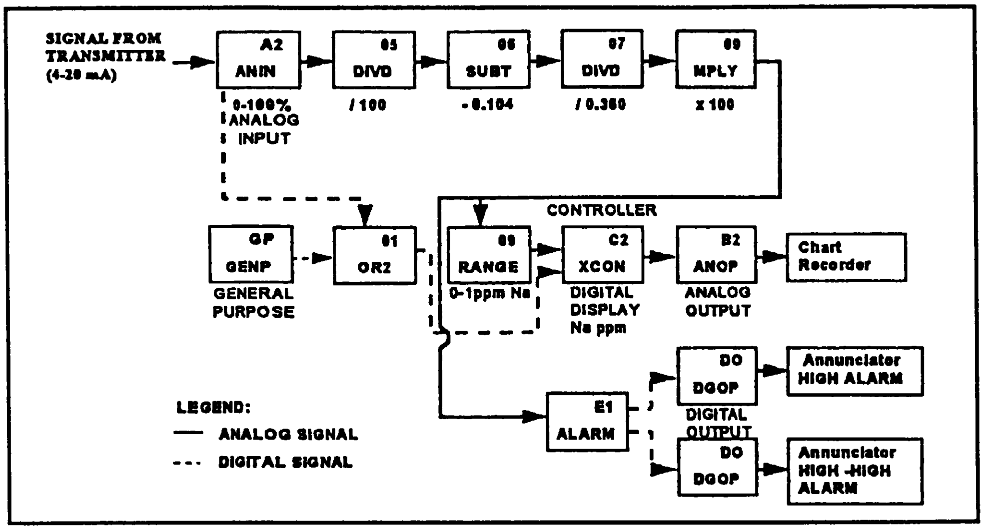

Figure 2. Typical program loop diagram of the TCS 6382 intelligent loop processor.

converter/transmitter, dehumidifier unit, automatic voltage regulator, and the automatic fuel cut-off device. These need to be maintained regularly.

For the flame photometer, maintenance works are to be performed daily. This should be done as specified in the operation manual of the instrument. Instrument performance and calibration have to be checked twice a day at 12-hour interval for a 24-hour continuous operation.

Also as part of calibration procedure, mV output of the instrument for the different sodium standards are measured and these are checked against typical values weekly. The processor is to be reprogrammed when necessary. All these should be done as quickly as possible to limit the off-line period of the instruments. Everytime the flame photometer is calibrated, the air compressor is to be drained off of accumulated moisture.

To minimize longer system downtime, such as the weekly cleaning of the burner and the glass chimney, a spare flame photometer, which costs about US $3,000, and a spare signal converter/ transmitter, which costs about US $580, should be made readily available. As experienced a readily available spare parts for the flame photometer such as: a mother board unit (US $1,100), igniter assembly (US $150) and a photocell assembly (US $120), are more desirable under the corrosive environment at the power plant. It is a requirement that the mother board of the flame photometer be coated with a protective film to protect the circuitry from corrosion. The type of flame photometer used is the clinical type which is actually not designed for continuous operation. As experienced, the igniter assembly was the first component to give way after about six months of continuous operation. A rigid or an industrial type flame photometer should be used if it is already available in the market.

It is also necessary to have a spare dehumidifier unit. This is because the unit has to operate 24 hours continuously to maintain the required environment inside the instrument room, which is low in humidity.

The instruments at the control center are: the intelligent loop processors, strip-chart recorders, central computer and the annunciator alarms. These instruments require little maintenance and spare units are always available.

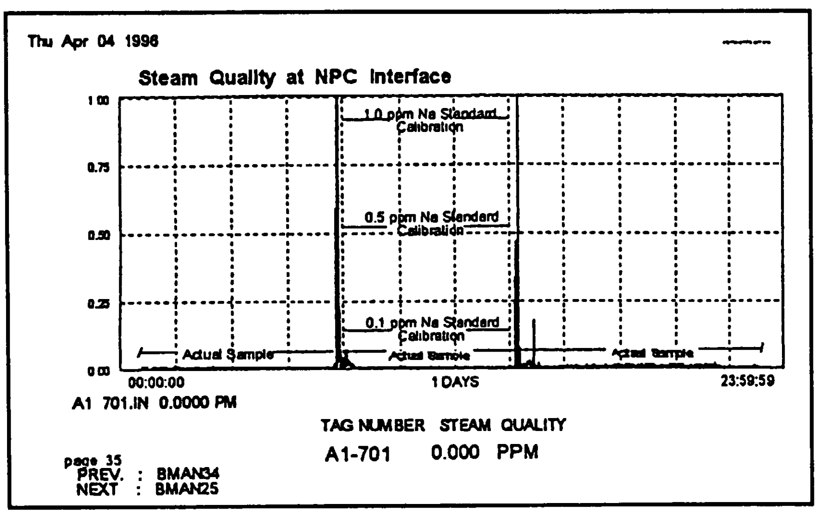

Figure 3. Typical sodium concentrations along steamline STL-701 and calibrations using Na standard solutions.

Maintenance Cost

After a year of experience, the total maintenance cost per module reached about US $2,000 per year. This is way below the cost of manpower assigned at the monitoring shed on a 24-hour basis, doing the conventional method of monitoring steam quality.

Conclusions

The installation and application of the continuous on-line steam quality monitoring system is first in the Philippines and in the world. The system is applicable: 1) to all geothermal power plants which are base- or peak-loaded, 2) in situations where the sampling points for steam quality are situated far from the control center of the FCDS and 3) to situations where there is poor separation efficiency of the separator, minimal steam scrubbing of water carry-over along the steamline and the absence of a demister before the power plant.

The system is accurate and achieved high precision of ±0.011 mg/L (±1.1%) for the 1.0 mg/L Na standard at full scale and ±0.003 mg/L (±2.7%) for the 0.10 mg/L Na standard.

The continuous on-line steam quality monitoring system provides an accurate, fast, efficient, cost-effective and continuous real-time data, which is more responsive in controlling process operations and in meeting the various requirements of the FCDS.

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