

Temperature Monitoring Solution Using DTSX200 Fiber Optic Distributed Temperature Sensor

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In recent years, needs have been diversifying regarding site safety (fire detection and leak detection) and facilities diagnosis. Regarding temperature monitoring, however, it is difficult to meet these needs with existing point type temperature sensors such as thermocouples and resistance temperature detectors (RTDs). Yokogawa's fiber optic distributed temperature sensors (DTS) can simultaneously, continuously and reliably monitor all temperatures along optic fiber cables that are freely installed over a required area. This paper introduces the advantages of a temperature monitoring solution with the DTS system, provides application examples, and tips on the installation of fiber optic cables.

INTRODUCTION

A temperature monitoring solution for site safety including fire detection and leak detection, as well as for facilities diagnosis, has not been put into practical use, because it is difficult for conventional point type temperature sensors to identify the location at which an unusual temperature is found.

For just such a situation, Yokogawa has developed a fiber optic distributed temperature sensor DTSX200⁽¹⁾, applicable to the above-mentioned temperature monitoring situational needs.

By combining with Yokogawa's production control systems and a substantial amount of powerful engineering technology, the DTSX200 makes integrated temperature monitoring and management easily possible, helping in providing temperature monitoring solutions.

FEATURES OF THE DTSX200

Table 1 summarizes the major specifications of the DTSX200.

The major features of the temperature monitoring solution using the fiber optic distributed temperature sensor (DTS) are described below.

Table 1 Major Specifications of DTSX200

| Item | Specification |
|-----------------------------|--|
| Temperature measuring range | -200 to +800 °C (depends on the performance of the optical fiber used) |
| Temperature resolution | 0.7 °C (10 minutes measurement with 6 km long optical fiber) |
| Spatial resolution | 1 m |
| Operating temperature range | -40 to +65 °C (the range to satisfy all the specifications) |
| Power consumption | 10 W or less (DTSX200 main unit only) |
| Communication interface | Modbus/TCP, SFTP, HTTPS |

High-speed and Wide-range Temperature Monitoring

The DTS can quickly measure a continuous temperature distribution over a wide range and long distance, rather than a single point temperature. It can measure an average temperature at a point along every 1 m length of a fiber optic sensor cable, enabling reliable temperature distribution monitoring with no unmeasured points.

Flexible and Simple Fiber Optic Cable Installation

Multipoint measurement using conventional point type temperature sensors requires the same number of cables as there are of the measurement points, making the system configuration and the installation work complicated. In contrast, because the DTS requires only a single cable, flexibly installed along the path or outline of the temperature measurement object, the system configuration becomes simple. The temperature measurement objects are diverse, ranging from an ultralow temperature object such as liquid natural

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gas (LNG) to a high temperature object such as a furnace surface. Optical fibers used for communication generally cannot withstand such extreme temperature environment, so that special covering materials are used, depending on a low or high temperature application environment. In addition, because the optical fibers are fragile and easily broken by shocks, fibers are stored in protecting tubes to prevent disconnection. Thus, various types of fiber optic cable are selected in each case, depending on the measuring temperature range and its installation environment.

Coordination with Production Control Systems

In the temperature monitoring solutions for site safety including fire detection and leak detection, and those for facilities diagnosis, customer demands are strong for having the monitoring and management functions integrated into the production control systems.

The DTSX200 provides communication functions that can combine with production control systems such as the distributed control system (DCS) or the supervisory control and data acquisition (SCADA) system, which make construction of integrated monitoring and management systems easy.

Figure 1 shows an example with a Yokogawa DCS. As shown in Figure 2, temperatures can be visually monitored on the screen of a human interface station (HIS).

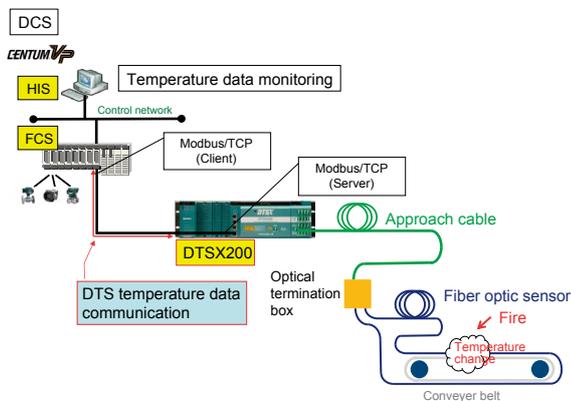


Figure 1 Example with a production control system

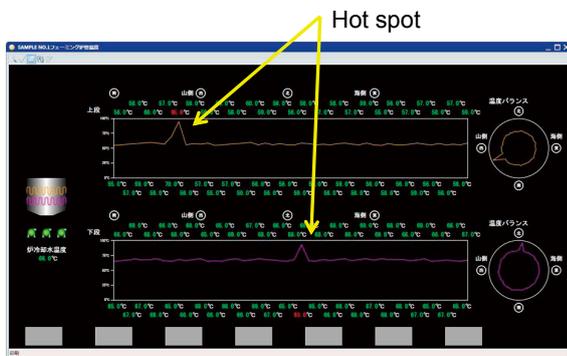


Figure 2 Example of an HIS screen monitoring furnace surface temperature

For linkage with the SCADA, a dedicated function for Yokogawa’s FAST/TOOLS⁽²⁾ has been developed to transfer temperature data by file transfer. This can be made use of in various applications of FAST/TOOLS.

Small to medium scale monitoring systems are also constructed by using the STARDOM network-based control system, or a PLC such as Leading Edge Controller FA-M3V

Resistance to Environment

There is no energy source except for light in the fiber optic sensor cables, which ensures stable measurement even in a strong electromagnetic field without being affected by electromagnetic induced noise. These cables also have no risk of igniting, which allows them to be used in hazardous areas. There is no need for special attachments with explosion proof specifications.

Although the main unit of the DTS is usually located in a computer room, there are cases where it may need to be installed outdoors, depending on measurement objectives⁽¹⁾. Because its operating temperature range is wide, from -40 to +65 °C, and its power consumption is as low as 10 W, it can be installed in an outdoor cabinet in combination with solar panels and storage batteries, where supplying power is difficult.

APPLICATION EXAMPLES

Fire Detection Systems for Coal or Woodchip Conveyers

An outline of the application example and tips on cable and other installations are described below. For specific details, refer to the reference⁽³⁾.

Fires sometimes break out at plant sites, for example, at coal conveyers in steel plants or coal-fired power plants and at woodchip conveyers in paper mills. Figure 3 shows an example of a fire detection system. Fiber optic sensor cables are installed close to the conveyor belts to monitor temperature reliably over the whole range of the conveyers. This system enables early detection of abnormal heating or spontaneous firing and thus helps for necessary initial measures to be taken. DTSs are widely used for this application.

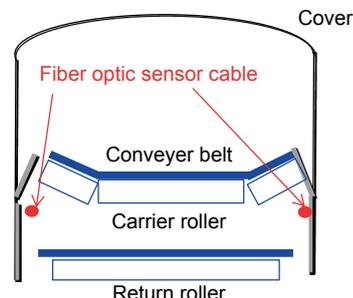


Figure 3 An example of a conveyor belt fire detection system (cross section)

In general, multiple conveyor belts are located in a complex way in steel plants, coal-fired power plants, and paper mills. Although a fiber optic sensor cable can be installed

flexibly, multiple cables are required sometimes to cover all the conveyers. In such cases, to reduce the complexity of the cable installation work, multiple fiber optic sensor cables are joined by fusion splicing into a single cable after the installation, and then the connection points are covered by optical termination boxes. However, too much fusion splicing is not recommended, because the light intensity attenuates at the connection point, and the temperature resolution decreases beyond it.

To confirm the proper position of the fiber optic sensor cable, verification tests to evaluate the position relationship between a firing point and the cable are carried out assuming actual firing.

Abnormal Temperature Detecting System for Cable Racks and the Like

An outline of the application example and the evaluation tests for the adoption at an electric power company are described below. For the specific details, refer to the reference (3).

If the signal cables for generation control in power plants are disconnected by a fire, the power generation can go out of control. Therefore, it is crucial to detect an unusual temperature increase and take measures as early as possible. Especially in nuclear power plants, redundant fire detection methods are imperative; thus a new fire detection method different from a conventional fire alarm is required.

At the request of an electric power company, Yokogawa has conducted performance evaluation tests according to the test items shown in Table 2, which are part of the technical tests defined in an ordinance of the Ministry of Internal Affairs and Communications in Japan entitled, “The ordinance defining technical standards for the detector and transmitter of fire alarm equipment” (4). It was confirmed that all the requirements were satisfied and a report was submitted.

Table 2 Evaluation test items

| Test item | Description |
|--|---|
| Sensitivity test of differential distribution type detectors | Sensitivity test to detect a certain level of temperature increase |
| Sensitivity test of thermal analog type spot detectors | Sensitivity test to detect higher temperature than a certain level at either locations |
| Sensitivity test of fixed temperature detectors | Sensitivity test to follow temperature within a specified time after ambient temperature becomes constant |

A Leak Detection System for LNG Tanks and Pipelines

An outline of the application examples and tips on the cable and other installation are described below. For the specific details, refer to the reference (3).

A LNG tank consists of an inner vessel which contains LNG and an outer vessel which protects the inner vessel. If the LNG leaks out, the leaked LNG of an ultralow temperature flows into the bottom space between the inner and outer vessels. Accordingly, if a fiber optic sensor cable is circularly installed around the bottom of the inner vessel, it can detect

an abrupt temperature fall and its location in the case where an unexpected leak occurs. Figure 4 shows a leak detection application for a LNG tank. As fiber optic sensor cables can be flexibly installed, curved cable installation such as this is easy.

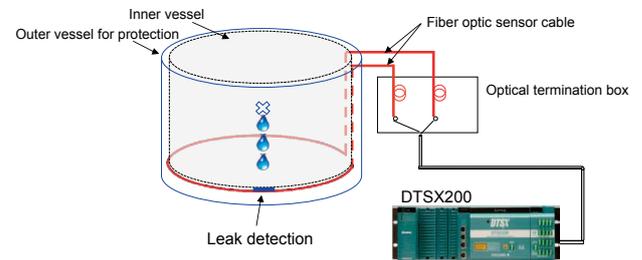


Figure 4 An example of LNG tank leak detection

The DTSs are also used for leak detection for LNG pipelines connecting LNG tanks with LNG carriers, mainly in overseas sites. As shown in Figure 5, the fiber optic sensor cable is placed just beneath the heat insulator covering the pipe, since the natural gas is heavier than air. The fiber optic cable is clamped to the pipe by fixing hardware such as metal straps at regular intervals of 1 m. Temperature measurement intervals must be of less than around 10 sec to detect the leak quickly.

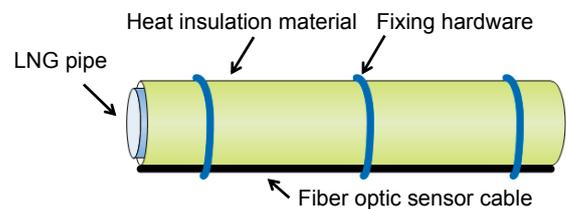


Figure 5 An example of a fiber optic sensor cable installation in a LNG pipeline

Recently, vacuum insulated pipe (VIPs) of which insulation effectiveness is high have begun to be used. If a leak occurs, cold natural gas instantly fills the annular space between the inner and outer pipes near the leak position. Thus, when VIPs are used, the fiber optic sensor cables do not need to be installed beneath the pipes.

Leak Detection Systems for Liquid Ammonia Pipelines

An outline of the application example and tips on the cable and other installation are described below. For the specific details, refer to the reference (3).

In this application example, pipelines needed to be installed under the ground, and so simulated pipe and fiber optic sensor cables were actually buried under ground and verification tests were conducted while ammonia was intentionally leaked. Figure 6 shows the location of the fiber optic cables. The surroundings of the pipe were covered with wrappers made of synthetic fibers or the like, and the fiber

optic sensor cables were located at the proper positions so that the temperature drop caused by the ammonia leak effectively traveled to the sensor cable. It was confirmed that the leak could be detected without fail.

The fiber optic sensor cables are located on the top of the pipe, as ammonia gas is lighter than air.

Because it is not easy to change the fiber optic sensor cable in case of a problem with it, two cables are installed for the sake of redundancy.

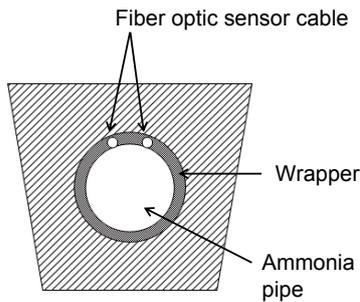


Figure 6 An example of a fiber optic sensor cable installation in an ammonia pipeline

A Furnace Surface Temperature Monitoring System to Detect the Wear of Firebricks

An outline of the application example and tips on the cable and other installation are described below. For the specific details, refer to the reference⁽³⁾.

In this application example, fiber optic sensor cables are placed on the surface of a furnace in a meandering manner as shown in Figure 7. In this way, the temperature distribution and existence of hot spots on the surface of a furnace are monitored, which enables optimum judgment for a replacement cycle time of the firebricks, reducing maintenance costs.

A screen example for surface temperature monitoring when hot spots are detected is shown in Figure 2.

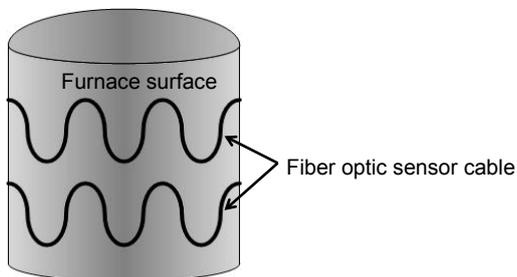


Figure 7 An example of furnace surface temperature monitoring

In the case of a high-temperature furnace, its steel shell is sometimes cooled by water. In order to verify if the temperature increase due to wear or peel-off of firebricks can be detected on the furnace surface even in such a case, a

similar test environment was prepared and verification tests were conducted while heating the inside of the steel shell. As a result, as shown in Figure 8, the temperature increase at the heated spot could be detected on the surface of the steel shell.

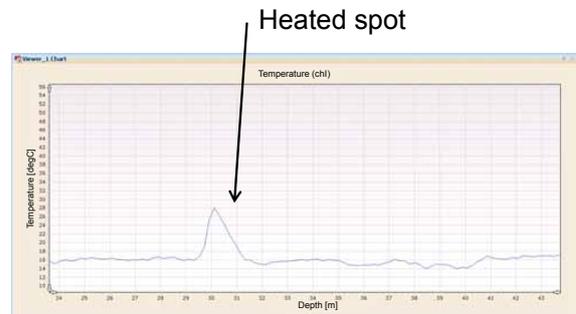


Figure 8 An example of water-cooled furnace surface temperature monitoring

CONCLUSION

Up to here, this paper has described that the DTS was initially adopted to meet the needs in various temperature monitoring contexts such as for site safety and facilities diagnosis, and then described how its use is rapidly expanding.

Besides the examples described above, the DTS is expected to be used in a wider range of applications in the future. Yokogawa believes that the keys for diffusion of the DTS are its integrated management in coordination with various monitoring or production control systems, and the installation of the fiber optic sensor cable at an optimum location. Yokogawa will continue offering solutions to meet the diverse needs in temperature monitoring, while verifying their effectiveness.

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