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Pipeline Inspection by Ultrasonic and Mapping Tools†

1. Introduction

Pipelines have been laid in large numbers in Japan and other countries and are actively utilized as an efficient means of transporting natural gas, petroleum, and other resources. However, it is an unavoidable fact that the reliability of pipelines is reduced by various factors as time passes after pipe laying. These include corrosion, deformation, and displacement of the original position of the pipeline by earthquakes, land subsidence, and the like. In 1988, JFE Engineering developed a practical ultrasonic tool for pipeline inspections and began corrosion/deformation inspection services. In 2003, the company developed a practical mapping tool and began 3-dimensional (3D) position inspection services. This report presents an outline of these inspection tools and describes the method of using data obtained with the tools.

2. Corrosion Inspection by Ultrasonic Tool

2.1 Outline of Ultrasonic Inspection Tool

The ultrasonic tool is applied in corrosion and deformation inspections of liquid pipelines, mainly for petroleum, fuel oils, and the like. An example of an ultrasonic tool is shown in **Photo 1**. As an advantage of the ultrasonic tool, high accuracy inspections are possible because the tool makes direct ultrasonic measurements of the remaining thickness of the pipe while traveling inside the pipe[1].

2.2 Content of Corrosion Inspection Results

The data obtained by the ultrasonic tool is analyzed by Ultra View, which is a dedicated program developed by JFE Engineering. The inspection results are reported in a "Corrosion List," which shows the corrosion depth, position, size, etc., and a "Features List," which shows features on the pipeline, such as weld lines, bends, tees, valves, etc. An example of a data display by Ultra View is shown in **Fig. 1**.

Photo 1 Ultrasonic tool

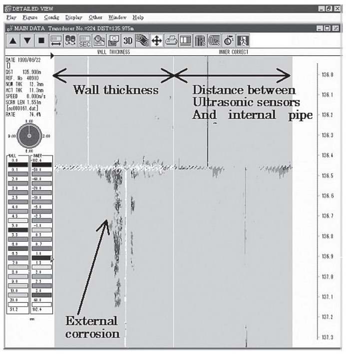

Fig. 1 Color plan view

2.3 Use of Corrosion Inspection Results

2.3.1 Pipeline integrity assessments

Together with the report of the corrosion inspection results, an assessment of the integrity of the corroded parts is also made. Although all domestic pipelines in Japan are regulated under the applicable legal regulations, there are no concrete regulations for methods of assessing the integrity of corroded pipelines. Therefore, at present, pipeline owners respond in consultation with the supervisory authorities. In cases where the remaining thickness of corroded parts obtained from the analysis results is less than the "minimum thickness" or the "necessary thickness based on stress calculations" provided in regulations, a report as to whether repairs are necessary or not is provided. Because the shape of the corrosion can be determined from the analysis results, a more detailed analysis by the finite element method (FEM) is also possible.

2.3.2 Corrosion growth assessment and remaining life assessment of pipelines

Periodic corrosion inspections are recommended in order to investigate the growth of corrosion. In recent cases, corrosion inspections are usually carried out at intervals of 3 to 10 years. In this JFE Engineering's sys-

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tem, the progress of corrosion (corrosion growth rate) is analyzed by a detailed comparison of two sets of corrosion data (depth and size of corrosion), which is performed by an analytical program.

In many cases, remaining life assessments of pipelines assess the remaining life until the remaining thickness of a corroded part reaches the minimum necessary thickness based on stress calculations, as provided in legal regulations. Taking advantage of JFE Engineering's extensive past experience in pipeline engineering, the company estimates the cause of locations with rapid corrosion growth rates and recommends countermeasures. The company also proposes a schedule for the next inspection based on the results of remaining life assessments.

3. Dimensional Position Inspection by Mapping Tool

3.1 Outline of Mapping Tool

With the mapping tool, inspections of both liquid pipelines and gas pipelines are possible. An example of a mapping tool is shown in **Photo 2**. A 3D gyroscope is mounted in the mapping tool and makes 3D positional measurements of the pipeline through which it is traveling[2)].

3.2 Content of Mapping Inspection Results

Global positioning system (GPS) measurements are made at the starting point, end point, and intermediate points in the pipeline, and the absolute positions of these respective points are measured. By combining these GPS absolute positional measurement results and the results of the relative positional measurements measured by the mapping tool, the system determines the 3D position of the entire pipeline. JFE Engineering's mapping tool inspection accuracy is on the top level in the industry.

3.3 Use of Inspection Results

3.3.1 Assessment of pipeline integrity

The degree of local strain can be confirmed from the 3D position of the pipeline analyzed by JFE Engineering. In cases where strain shows a large value, a separate detailed analysis using FEM is proposed, the cause is estimated, and an integrity assessment is performed.

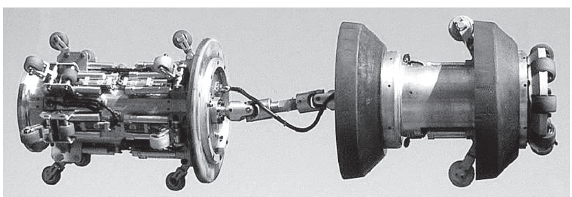

Photo 2 Mapping pig

Fig. 2 Mapping data

By performing inspections periodically, it is also possible to measure the amount of displacement of the pipeline due to ground subsidence, earthquakes, ground liquefaction, and similar causes and assess the integrity of the pipeline.

3.3.2 Pipeline maintenance consultation (Pipeline integrity system)

Display of the position of the pipeline measured by the mapping tool with a geographic information system provides an easily-understood visual representation of the pipe laying position.

A pipeline integrity system can be constructed by databasing and recording a wide range of other information, in addition to the pipeline position, using the geographic information system. This information includes basic pipeline information (pipe data, valve data, fitting data, welding data, etc.), reports of the results of inspection tool results (corrosion data, deformation data, etc.), maintenance information (protection potential data, subsidence measurement rod data, coating inspection data, etc.), excavation result data and repair history information, etc. **Figure 2** shows an example of pipeline integrity system display.

Changes over time can also be assessed by accumulating data in a database. Examples of this data include the location/amount of pipeline displacement, changes in corrosion over time, and data on protection potential, subsidence rod measurements, coating defects, etc.

The pipeline integrity system enables integrated management and visual display of a large volume of data, pinpoint designation of the locations of events, and similar high-level pipeline management.

4. Conclusion

The outlines of an ultrasonic tool and mapping tool developed by JFE Engineering and the methods of using the results of inspections with these tools were introduced. Pipeline inspection and diagnosis technologies using inspection tools have gradually expanded and are now becoming firmly established technologies.

In the future, JFE Engineering plans to promote the development of technologies applicable to lines where inspection tools are currently difficult to use, and advanced integrity assessment techniques for comprehensive assessment of corrosion inspections, 3D position inspections, and various pipeline data, and thereby contribute to improved maintenance control of pipelines.

References

1) Kondo, Munetaka; Kobayashi, Motoi; Nakano, Naruhi. Inspection and assessment technology for oil pipeline. JFE Giho. 2006, no. 11, p. 34–38.
2) Kondo, Munetaka. Inspection and assessment technology for pipelines. The Piping Engineering. 2005-12, vol. 47, no. 14, p. 36–40.

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