Application of non-contact magnetic corresponding on the detection for natural gas pipeline

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Abstract: This study examined natural gas pipeline by the non-contact magnetic corresponding. To confirm the reliability for the examination of natural gas pipelines by non-contact magnetic corresponding, three abnormal nodes were detected by the appearance inspection and ultrasonic testing. The results suggested that the grade of abnormal nodes by non-contact magnetic corresponding were not absolutely agree with that of the corrosion by ultrasonic testing. However, there was an obvious relevance between the comprehensive index of F by non-contact magnetic corresponding and the maximum degree of corrosion by ultrasonic testing. To sum up, the magnetic corresponding was an effective non-contact detection technology for the natural gas pipeline, while it was necessary to rationally grade the abnormal node according to the comprehensive index of F.

1 Introduction

Detecting the natural gas pipeline was essential for the safe production of natural gas industry[1]. The conventional detecting technologies included the low frequency long distance ultrasonic testing, high frequency guided wave detection, the C-SCAN, ultrasonic wall thickness measurement, magnetic flux leakage testing and the remote field eddy current technology [2]. Although the above technologies could accurately detect the state of natural gas pipelines, they were contacting technologies [3,4]. Therefore, it was necessary to develop a non-contact detection technology, which could meet the acquirement of simple operation and accurate detection.

Recently, the non-contact magnetic corresponding of ferromagnet for the steel in the geomagnetic field had been used for the detection of materials. There were few reports about the application of non-contact magnetic corresponding for petroleum pipeline [5]. While there was no study on the detection by non-contact magnetic corresponding. Herein, this study investigated the application of non-contact magnetic corresponding on the detection of natural gas pipeline. And the reliability by non-contact magnetic corresponding was verified by appearance inspection and ultrasonic testing.

2 Basic information

The natural gas pipeline was gas gathering flow line with a length of 6.35 kilometer and an operation pressure of 5.7 Mpa, being made of 20# steel. The diameter and thickness of gas gathering flow line were 114 mm and 12 mm. Additionally, the it was laid out along the hills (Figure 1).

3 Detection by the non-contact magnetic corresponding

3.1 Detection index by non-contact magnetic corresponding

Generally, the degree of defect for a pipeline could be evaluated by the comprehensive index of F by the non-contact magnetic corresponding, being expressed as in equation (1).
Where, $A$ is a corrected coefficient, which implied an influence of geomagnetic field on the pipeline; $Q_m$ and $Q_f$ are the densities of magnetic intensity alone with the direction of $Z$ axle and background of pipeline, respectively.

$$F = A \exp(1 - Q_m/Q_f)$$

The degree of defect was graded by the comprehensive index of $F$ and listed in the Table 1.

### Table 1. Degree of defect and grading for the pipeline by non-contact magnetic corresponding

| Grade | Comprehensive index of $F$ by the non-contact magnetic corresponding | Degree of defect |
|-------|---------------------------------------------------------------|-----------------|
| I     | 0~0.2                                                         | High            |
| II    | 0.2~0.55                                                     | Medium          |
| III   | 0.55~1.0                                                     | Low             |

#### 3.2 Results of detection by non-contact magnetic corresponding

The Figure 2 was the distribution of abnormal nodes for the gas gathering flow line by non-contact magnetic corresponding. It showed that there were 15 abnormal nodes with a grade of II and 63 abnormal nodes with a grade of III, indicating that there was about 20% of abnormal nodes for the gas gathering flow line was in medium risk.

![Distribution of abnormal nodes](image)

**Figure 2.** Abnormal nodes for the gas gathering flow line by non-contact magnetic corresponding

#### 4 Verification

In order to verify the reliability by the non-contact magnetic corresponding, there were 3 abnormal nodes were examined by the appearance inspection and ultrasonic testing on. It should be noted that the direction of ultrasonic testing was clockwise.

The Figure 3 was the wall thickness distribution by ultrasonic testing and magnetic intensity distribution by non-contact magnetic corresponding for the 3 abnormal nodes. At 1# abnormal node, the length of pipeline was 0.53 m, the magnetic intensity (DQ) was 981 nT/m, and the comprehensive index of $F$ was 0.575. The verifying examination showed that the minimum wall thickness was 10.60 mm, corresponding a corrosion degree of 11.67%. Although there was no obvious corrosion, the minimum wall thickness was only 9.92 mm, corresponding a reduction degree of 17.33%.

![Wall thickness detection](image)

**Figure 3.** Wall thickness detection by ultrasonic testing and magnetic intensity distribution by non-contact magnetic corresponding for the 3 abnormal nodes (a, b and c were the results of 1#, 2# and 3# abnormal node, respectively.)

#### 5 Analysis

The appearance inspection and ultrasonic testing suggested that the wall thickness reduction was a common phenomenon. According to the standard of SY/T 0087.2, the corrosion degree of 1# and 3# abnormal nodes were middle, while the corrosion degree of 2# abnormal node was light. However, the detection by non-contact magnetic corresponding indicated that the degree of defection for 1# and 2# abnormal nodes were middle, but it was light for 3# abnormal node. Therefore, the grading by non-contact magnetic corresponding for the gas gathering flow line was not agree well with that of conventional technology.

However, it was also found that the comprehensive
index of F was negatively relative with the maximum reduction degree for the gas gathering flow line significantly (Figure 4).

Figure 4. Linear fitting between the comprehensive index of F by non-contact magnetic corresponding and the maximum corrosion degree by ultrasonic testing for the G-A gas gathering flow line

6 Conclusion

In summary, this study applied the non-contact magnetic corresponding on the detection of natural gas pipeline (G-A gas gathering flow line). It was found that there were few abnormal nodes with a grade of II and a lot of nodes with a grade of III, while without the abnormal node with a grade of I. Although the grading by the non-contact magnetic corresponding for the G-A gas gathering flow line was not agree well with that of verified examination by ultrasonic testing, there was a significant correlation between the comprehensive index of F and the maximum corrosion degree for the G-A gas gathering flow line. Therefore, the non-contact magnetic corresponding could be used for the detection of natural gas pipeline with a condition of corrected grading according to the special natural gas pipeline.

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