Journal of Engineering Mechanics and Machinery (2024)
Clausius Scientific Press, Canada

DOI: 10.23977/jemm.2024.090117
ISSN 2371-9133 Vol. 9 Num. 1

Evaluation of the application effect of magnetic leakage detection technology in gas field gathering and transmission pipeline

Wen Cheng[1], Meng Wang[1], Daoquan Ding[1], Jing Ge[2], Xiaojun Tong[1]

[1]*Shunan Gas Mine, Southwest Oil & Gas Field Company, PetroChina, Luzhou, 646000, China*
[2]*Chuanbei Gas Mine, PetroChina Southwest Oil & Gas Field Company, Dazhou, 635000, China*

Keywords: Gathering and transportation pipelines, magnetic flux leakage detection, application effect

Abstract: Gas field gathering and transportation pipelines are susceptible to damage and corrosion damage during production and operation, and magnetic flux leakage detection technology is one of the effective methods to realize pipeline detection and ensure pipeline safety. The results of this study show the practical application of magnetic flux leakage detection technology in Shunan gas mine, expound the basic principle of magnetic flux leakage detection technology, summarize the adaptability of magnetic flux leakage detection, and recommend the working conditions adapted to magnetic flux leakage detection, which provides a reference for further improving the accuracy of magnetic flux leakage detection in gas field gathering and transportation pipelines in the future.

In-pipeline inspection is an important content and core technology of pipeline integrity management, and it is a necessary means to determine the operation status of pipelines, make pipeline maintenance decisions, and ensure pipeline safety and integrity [1-2]. At present, the commonly used internal detection technologies for gas field gathering and transportation pipelines include magnetic flux leakage detection technology, eddy current detection technology, etc. Among them, magnetic flux leakage detection is widely used due to its simple structure, fast detection speed, and strong adaptability [3]. The results of magnetic flux leakage detection are affected by factors such as detector operating speed and pipeline operating pressure [4], however, there are relatively few studies on this aspect, so this study evaluates the magnetic flux leakage detection technology based on the practical application of magnetic flux leakage detection technology in Shunan gas mine, so as to provide technical reference for magnetic flux leakage detection in other gas fields.

1. Principle of magnetic flux leakage detection technology

Magnetic flux leakage detection technology uses the magnet pole of the detector to magnetize the tube wall through which it passes, and if the tube wall is not defective, the magnetic field lines will be confined to the inside of the pipe wall. If there is a defect in the pipe wall (e.g., corrosion, cracks, etc.), the magnetic field lines will bypass the defect and cause distortion, and some of the magnetic field lines will leak out to the pipe surface, resulting in magnetic flux leakage [5-6], as shown in

Figure 1. Based on this principle, corrosion and defects in pipelines can be determined.

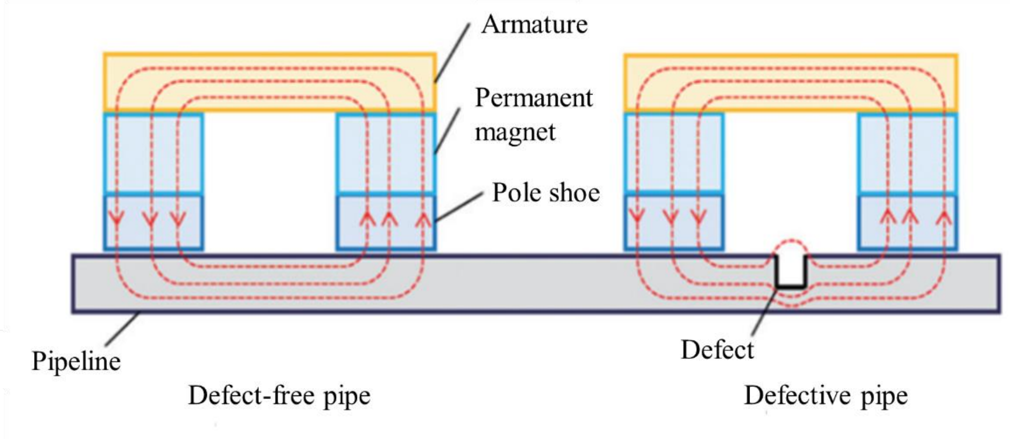

Figure 1: Schematic diagram of magnetic flux leakage detection technology

2. Practical application of magnetic flux leakage detection technology

Since 2017, Shunan Gas Mine has carried out magnetic flux leakage detection of DN200 and above pipelines, with a total of 6 pipelines of 272km detected, 1,508 pipe defects found and repaired, and a large number of potential safety hazards have been eliminated. Taking Gaolong line B break and Ning double line as an example to evaluate the application effect of magnetic flux leakage detection technology, the working conditions suitable for magnetic flux leakage internal detection technology are screened out, the accuracy of internal detection of pipelines is improved, and scientific basis is provided for the preventive and targeted maintenance of pipeline defects, so as to ensure the intrinsic safety of pipelines.

2.1. Analysis of the detection results of section B of the Gaolong line

Section B of the Gaolong Line was put into operation in December 2017. The diameter of the pipe is D508×15mm, 18mm, 21mm, the pipe material is L360QS, the total length of the pipeline is 21m, the design pressure is 8.5MPa, and the operating pressure is 6.35MPa.

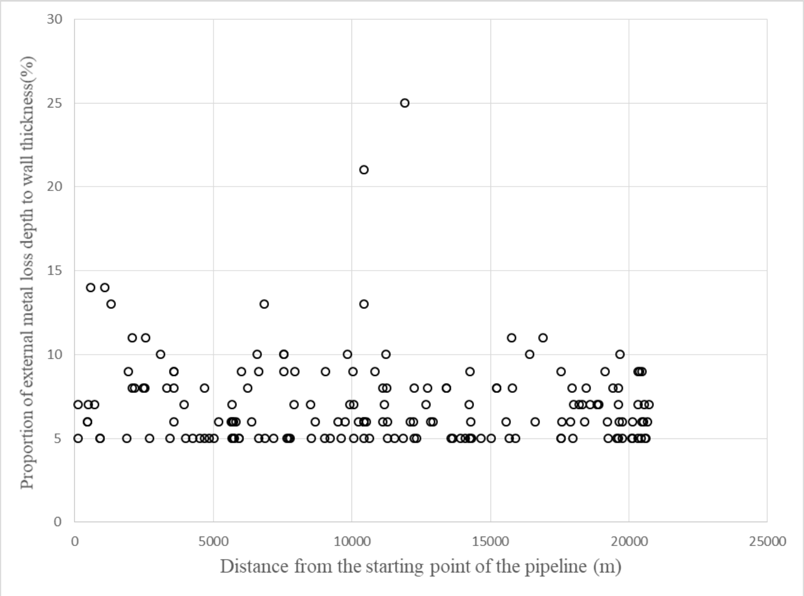

Figure 2: Histogram of external metal loss distribution (section B of the Gaolong Line)

The Shunan Gas Mine used a magnetic flux leakage detector to detect the B section of the Gaolong Line. In this test, the operating pressure is 6.35MPa, the operating speed of the detector ranges from 1m/s to 4m/s, and the average speed is 2.6m/s. The results of this test and analysis are shown in Fig. 2 to Fig. 3, and the results show that there are 292 metal loss characteristics on the pipe section, including 115 internal metal losses and 177 external metal losses, mainly external metal losses. The most severe metal loss depth is 25% of the nominal wall thickness at the inspection mileage of 11897.155m, which is the external metal loss.

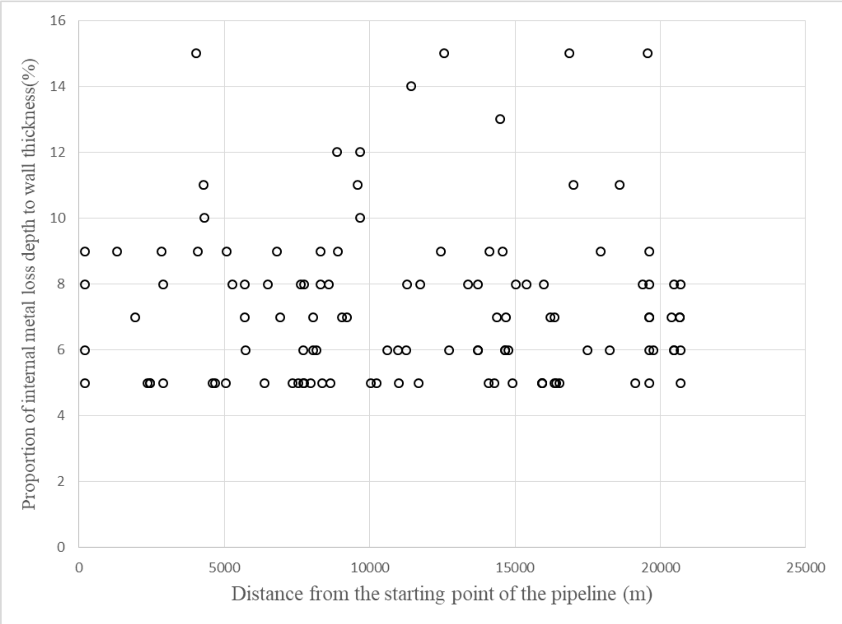

Figure 3: Histogram of internal metal loss distribution (section B of the Gaolong Line)

In order to verify the accuracy of the test results, excavation verification was carried out. There is a total of 9 excavation verification points, and the defects are basically in line with 9. There are 9 defect locations and 9 excavation verifications (3 internal metal losses, 3 external metal losses, 2 girth weld anomalies, and 1 depression). From the situation of 9 defect points verified by excavation, there is no error in ground positioning, therefore, it is considered that the mileage accuracy of the internal detection data is higher, and meets the use requirements.

Through the above analysis, the operating pressure of section B of the Gaolong line is 6.35MPa, and the detection speed is 1m/s~4m/s, and good detection results are obtained.

2.2. Analysis of the results of Ning double-line detection

The specifications of Ningshuangxian pipeline are D457×6.3 (7.1, 8.8) mm, the design pressure is 6.3MPa, the design gas transmission capacity is 450×104m3/d, the material is L415M, and the operating pressure is 2.4~2.8MPa.

The high-definition magnetic flux leakage detector was used to carry out the detection of Ningshuang line. The operating speed range of high-definition flux leakage detector is: 1m/s~3.0m/s. During the detection, the detector ran smoothly, with an average speed of 2.60m/s, which met the speed requirements of the detector.

A total of 6,146 external metal metal losses were distributed throughout the pipeline. Among the external metal losses, 95.8% of the metal loss defects were made with a depth of 0-9% wall thickness, 4.17% with a wall thickness of 10%-19%, and 0.03% with a wall thickness of 20%-29%, as shown in Figure 4. There was a total of 10,761 internal metal losses, and 95.72% of the internal metal losses were metal loss defects with a depth of 0-9% wall thickness, 3.78% of the wall thickness with a depth of 10%-19%, and 0.5% of the wall thickness with a depth of 20%-29%, as shown in Figure 5.

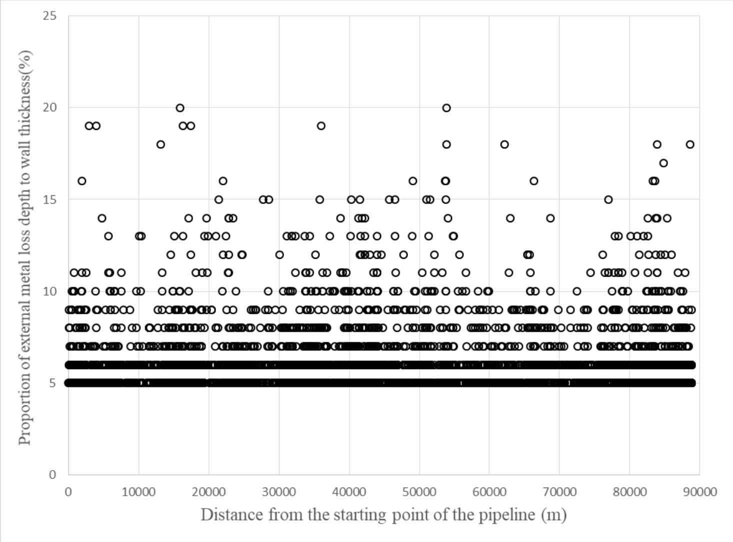

Figure 4: Statistical diagram of external metal loss, metal loss distribution

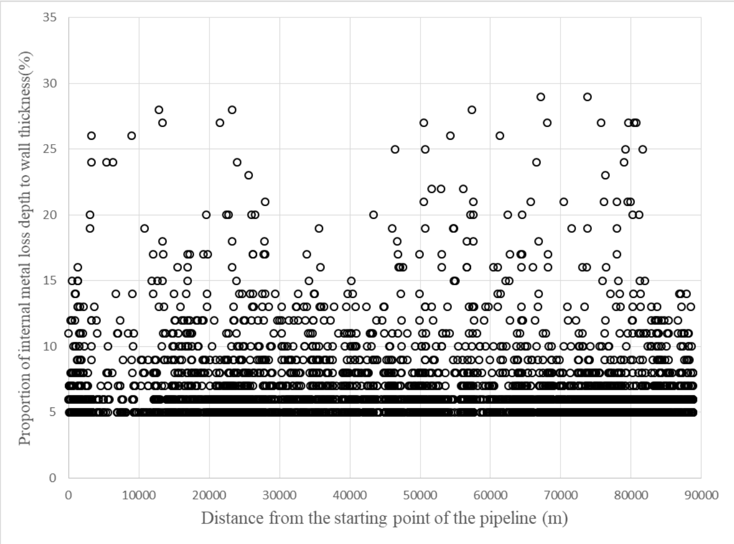

Figure 5: Statistical chart of metal loss distribution of internal metal loss

In order to verify the accuracy of the test results, excavation verification was carried out. A total of 10 excavation verification tests were completed, including 7 depressions and 2 metal losses. It can be seen from the verification and detection that the depressions are all located at the bottom of the pipeline (clock azimuth 4-7 o'clock), mainly caused by hard objects such as stones at the bottom of the pipeline, and the pipe body has partially rebounded after the excavation removes the bottom constraints, but there are still 6 depressions that exceed the allowable limit, and repair measures need to be taken after evaluation. The overall result is more accurate, and the detection accuracy of the internal detection device is better.

Through the above analysis, the operating pressure of Ningshuang line is 2.4~2.8MPa, and the detection speed is 2.6m/s, and good detection results are obtained.

3. Evaluation of application effects

To sum up, combined with the current test results, the test data is more ideal pipeline operating conditions: pipe diameter ≥DN200, pressure ≥ 2MPa, running speed ≥ 1m/s (corresponding to gas volume). At the same time, through the above analysis, it can be found that the operating pressure of the B section of the Gaolong line is 6.35MPa, and the operating pressure of the Ningshuang line is 2.4~2.8MPa, so the operating speed of the optimal detector in different pressure ranges can be determined. Combined with the actual pipeline test results, the speed control requirements of the testing equipment under different pressures are recommended, as shown in Table 1.

Table 1: Speed control requirements for testing equipment under different pressures

Pipeline operating pressure(MPa)	Speed(m/s)	Remark
2.0~3.0	2.5~4.0	The test data is good
>3.0	1.0~4.0	The test data is good

The speed is affected by the pressure, pipe diameter and air flow, so according to the requirements of the speed, the minimum air volume corresponding to different pressures and pipe diameters can be obtained, as shown in Table 2.

Table 2: Requirements for minimum gas volume control under different pressures and pipe diameters

Pipe Diameter / Pressure	DN200	DN250	DN300	DN400
2.0MPa	13.4 M/Day	21.7 M/Day	31.1 M/Day	55.8 M/Day
3.0MPa	20.1 M/Day	32.5 M/Day	46.7 M/Day	83.8 M/Day
4.0MPa	10 M/Day	17.3 M/Day	24.9 M/Day	44.7 M/Day
5.0MPa	13.4 M/Day	21.7 M/Day	31.1 M/Day	55.8 M/Day
6.0MPa	16.08 M/Day	26.04 M/Day	37.32 M/Day	66.96 M/Day
7.0MPa	18.76 M/Day	30.38 M/Day	43.54 M/Day	78.12 M/Day
Pipe Diameter / Pressure	DN500	DN600	DN700	DN800
2.0MPa	86.5 M/Day	124.7 M/Day	168.9 M/Day	221.4 M/Day
3.0MPa	129.75 M/Day	187.05 M/Day	253.35 M/Day	332.1 M/Day
4.0MPa	69.2 M/Day	99.76 M/Day	135.12 M/Day	177.12 M/Day
5.0MPa	86.5 M/Day	124.7 M/Day	168.9 M/Day	221.4 M/Day
6.0MPa	103.8 M/Day	149.64 M/Day	202.68 M/Day	265.68 M/Day
7.0MPa	121.1 M/Day	174.58 M/Day	236.46 M/Day	309.96 M/Day

4. Conclusion

(1) The current test is mainly for pipelines above DN200, and the overall test results are good.

(2) The detection accuracy will be affected by the pressure and the running speed, and the test data is more ideal for the pipeline operating conditions: P≥2MPa, and the running speed ≥1m/s (corresponding to the gas volume).

(3) Combined with the actual pipeline testing results, the speed control requirements of the testing equipment under different pressures are recommended. When the pipeline operating pressure is in the range of 2.0~3.0MPa, the control speed is 2.5~4.0m/s, the detection data is better, and when the pipeline operating pressure is greater than 3.0MPa, the control speed is 1.0~4.0m/s, the detection data is better. At the same time, according to the requirements of speed, the minimum gas volume corresponding to different pressures and pipe diameters can be obtained.

References

[1] Dai Lisha, Zhang Shimin, Lai Xiaoxiao, et al. Research Progress on Oil and Gas Pipeline Bore Detector Technology[J]. Oil & Gas Storage and Transportation, 2012, 31 (11): 808-813.
[2] Wang Jinlong, He Renyang, Zhang Haibin. The latest technology and development direction of submarine pipeline detection[J]. China Petroleum Machinery, 2016, 44 (10): 112-118.
[3] Bai Gangsheng, Xu Zhi, Wu Nandong. Development of Triaxial High Definition Magnetic Flux Leakage Corrosion Detector[J]. China Petroleum Machinery, 2014, 42 (10): 103- 106.
[4] Peng Lisha, Wang Shen, Liu Huan, et al. Improved Gray Level-Color Transformation Method for Magnetic Flux Leakage Images[J]. Journal of Tsinghua University (Natural Science Edition), 2015, 55 (5): 592-596.
[5] Yu Chao, Zhang Yongjiang, Li Yanchun, et al. Development of Pipeline Transverse Excitation Magnetic Leakage Internal Detector[J]. Oil & Gas Storage and Transportation, 2020, 39 (9): 1037- 1041.
[6] Liu Chuanqing. Application of internal detection technology in urban gas pipelines[J]. GAS & HEAT, 2021, 41(01): 32-35.