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Application and Effect Evaluation of Pipeline Detection Technology in Block 410 of WQ Reservoir

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Abstract

With the continuous deepening of the new two laws, the safety and environmental protection situation has become increasingly severe. As the blood of the oilfield, the gathering and transportation pipeline network has the characteristics of wide distribution, many hidden dangers, and difficult prevention and control. It is the main safety and environmental protection hidden danger factor in oilfield production. How to discover hidden dangers in pipelines in a timely manner, take cost-effective measures to implement governance, and eliminate hidden dangers to ensure safe and stable operation is one of the main research tasks for each oil production unit to deal with the pressure of safety and environmental protection. Starting from the idea of combining the management and prevention of pipeline hidden dangers, this paper analyzes the commonly used mature pipeline corrosion detection and evaluation technologies in China, compares the advantages and disadvantages, and optimizes the appropriate detection technology according to the actual production. According to the detection results, a variety of governance measures are taken, and a targeted governance plan is formulated to improve the effect of pipeline hidden danger management, save governance funds, and effectively guide pipeline hidden danger management work.

Keywords

Pipeline; Cause of corrosion; Corrosion detection.

1. INTRODUCTION

With the implementation of the new two laws, the situation of normal production safety and environmental protection in oilfields has become increasingly severe. As the blood vessels of oilfields, pipelines have the characteristics of wide distribution, long pipelines, and complex regions. They are pressure pipelines, and the conveying medium is generally crude oil. Once damaged and leaking crude oil, it may lead to major safety and environmental pollution accidents. arouse media attention. In this environment, it is imperative to understand the current status of pipeline operation, take necessary governance measures, eliminate pipeline hidden dangers in time, reduce pipeline governance costs, and improve pipeline safety, controllability and economic operation.

2. STATUS OF THE PIPELINE

Changqing Oilfield WQ Reservoir 410 has a total of 1,454 pipeline networks of various types, with a total of 1,909km and an average service time of 4.7 years. Among them, pipelines with a service time of more than 5 years are 738.5km, accounting for 38.7%, of which: 429 gathering pipelines, total 1230km; 1018 supply and injection pipelines, totaling 627km; associated gas pipelines: 7, totaling 52km.

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Table 1. Classification statistics of gathering and transportation pipeline categories

Oil and gas gathering and transportation system					Water supply (note) system		Non-Metal	Subtotal (km)
Oil out (km)	Oil collection (km)	Oil(km)	Long lost (km)	Associated gas (km)	Clean water (km)	Produced water (km)	Polymer,etc. (km)	
810	252	168	0	52	437	82	108	1909
		1282 (67%)			519 (27%)			

3. CAUSE ANALYSIS OF PIPE CORROSION

3.1. Ion Corrosion

The water type of the Triassic formation is mainly $CaCl_2$, and the main corrosion factor is Cl-, which is mainly reflected in the Chang 2 and Chang 4+5 areas in the Liumao plateau area. The water type of the Jurassic formation is mainly NaHCO3, and the main corrosion factor is For HCO_3^-

3.2. Gas Corrosion

Mainly in the Wuqi and Pengyang Jurassic blocks, the corrosion factors are CO_2 and H2S:

$CO_2+H_2O \rightarrow H_2CO_3$ $H^{+}+HCO_3^- \rightarrow 2H^{+}+CO_3^{2-}$ $Fe+2H^{+}+CO_3^{2-} \rightarrow FeCO_3+H_2$

H_2S Electrochemical Gravity Corrosion: Electrochemical reaction occurs when metal and sulfur-containing natural gas come into contact, forming pits, spots and large-area corrosion. The hydrogen produced during the electrochemical reaction penetrates into the metal, making the material brittle.

3.3. Corrosion Under Scale

The regional produced water has high salinity, strong scaling tendency, and obvious corrosion under scale.

Figure 1. The corrosion characteristics of the oil collecting pipeline under the scale are obvious

3.4. Corrosion Acceleration Effect

It mainly refers to the influencing factors of operation. The sand-containing scouring and abrasion of the conveying medium is an important factor to accelerate the corrosion, while the operation of intermediate transportation and frequent start and stop increases the factors such as local corrosion and flow rate corrosion. Oil production in Block 410 is the operation mode of "adding chemicals at the end point and breaking the pipeline demulsification". The medium is initially separated from oil and water in the pipeline. As shown in Figure 2, the common corrosion points in the pipeline are divided into four types: 1, 2, 3, and 4. Among them, 1 is the effect of gas corrosion, 2 is the effect of ion corrosion, and 3 and 4 are the combined effects of various corrosion factors, of which ion corrosion and under-scale corrosion are the main factors.

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At the same time, the instantaneous acceleration of the flow velocity is also the main factor for the aggravation of pipeline corrosion, as shown in Figure 3.

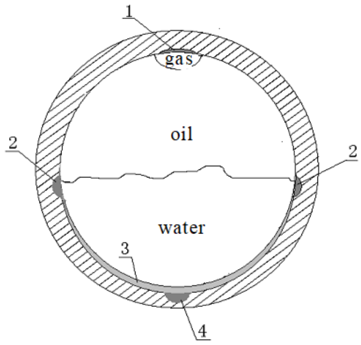

Figure 2. Schematic diagram of the distribution of common corrosion points in pipelines

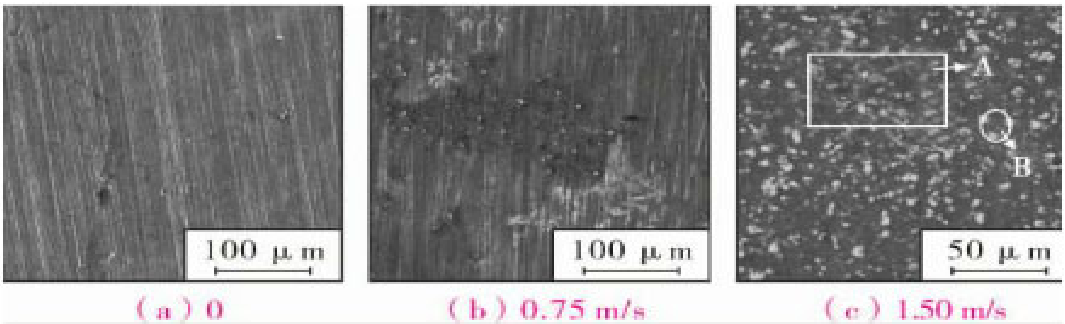

Figure 3. Accelerated effect of flow velocity on pipeline corrosion

4. OPTIMIZATION OF PIPELINE DETECTION TECHNOLOGY

The detection technology is mainly divided into two types: trenchless detection technology and development detection technology. At present, there are 10 commonly used and mature detection technologies such as in-line detection technology for magnetic flux leakage, among which 3 are more accurate and commonly used.

4.1. In-line Detection Technology of Magnetic Flux Leakage

Technical principle: Determine the size of corrosion defects by measuring the magnetic field strength leaked from the surface of the magnetized ferromagnetic material. If the measured object has no defects and no inclusions inside, the magnetic flux will all pass. If there is a defect, the magnetoresistance at and near the defect will increase, and the magnetic field near the defect will be distorted. Advantages: The detection instrument can enter the pipeline, implement all-round accurate detection and evaluation of the pipeline, and the detection conclusion is highly reliable. Disadvantages: The testing cost is about 80,000 yuan/km, and it is only applicable to pipe diameters of Φ219mm and above, which requires high pipeline construction conditions.

4.2. Magnetic Tomography Pipeline Corrosion Detection Technology

Technical principle: According to the principle of metal magnetic memory, the instrument receives the distortion of the magnetic line of force acting on the pipeline and the terrestrial magnetic field, and through database analysis, the amount of corrosion loss of the pipeline is finally determined. Advantages: It is not necessary to stop production and excavate the pipeline,

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and the pipeline can be inspected and evaluated more accurately. It is suitable for various pipeline inspections, and the accuracy is more than 85%. Disadvantages: The detection cost is 25,000 yuan/km, the cost performance is low, and the comprehensive detection cost is high.

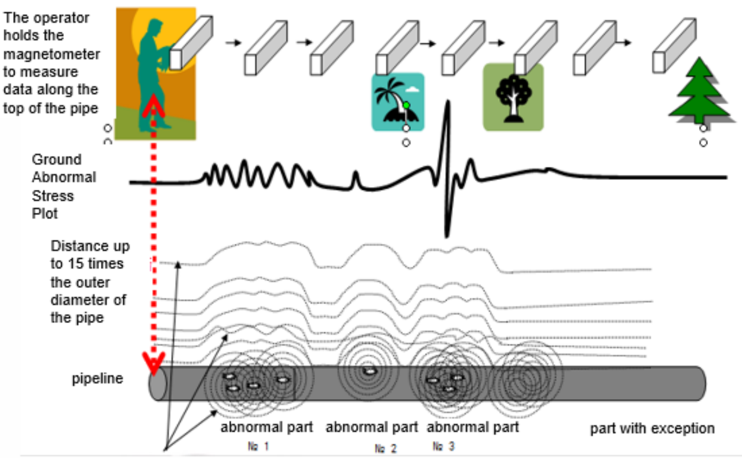

Figure 4. Schematic diagram of magnetic tomography detection technology

4.3. Evaluation Technology of Tube Body Corrosion Based on Comprehensive Parameters

Technical principle: The alternating current signal is applied to the pipeline, the current is transmitted to the distance along the pipeline, and an electromagnetic field is formed around the pipeline. The strength of the magnetic field is positively correlated with the signal current in the pipeline. The equivalent current value in the pipeline can be directly obtained through the receiver. The analysis of the signal finds that the pipe body is abnormal, determines the weak point of the pipe body corrosion, and cooperates with the ultrasonic thickness gauge to detect the remaining wall thickness of the pipe body. Advantages: It is suitable for various types of pipelines, can be stopped production, the inspection cost is 4100 yuan/km, the cost performance is relatively high, and the inspection conclusion has a certain reference value. Disadvantages: Ultrasonic testing equipment only accurately measures local corrosion points, and the overall pipeline evaluation accuracy is relatively low.

Table 2. Principles of selecting points for ultrasonic inspection of pipelines

Analysis of factors	Action performance,	Location of points
Crude oil Flow rate	At high flow rate, the additional shear force on the surface of the pipe body increases, and the liquid-solid two-phase flow scours the surface of the pipe body and uses the passivation film to peel off, aggravating the corrosion of the inner wall of the pipe.	Near the exit of the station, the pipe section at the bottom of the downhill slope, etc.
Liquid Flow	When the fluid medium forms turbulent flow, the contact between the pipe body and the fluid medium is more frequent, which increases the shear stress with the pipe wall, so that the corrosion products are pulled, torn and washed away from the pipe wall.	Inflection point, elbow, V-groove bottom, etc.
Scour Angle	The force of the liquid-solid two-phase flow acting on the scour surface can be divided into horizontal and vertical components, and their damage effects are different: the horizontal component produces a cutting effect on the scour surface; the vertical component produces impact. There will be a certain scour angle, and the combined action of micro-cutting and scour impact will cause the greatest damage.	Feature points such as uphill and downhill
Broken operation history	According to the artificially designated special pipe section selection, this factor takes Changqing Oilfield as an example to select points	Historical leak points, lock spans, close to water sources, risk sources

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In order to effectively understand the current status of pipeline corrosion and operation, reverse the passive control situation of pipelines, and promote the detection and evaluation of pipeline corrosion, in the selection of detection technology, comprehensive factors such as the status quo of the pipeline network, cost performance, and efficiency are comprehensively considered, and the use of comprehensive parameters for pipe body corrosion is finally determined. Evaluation techniques.

Depending on the comprehensive parameters, the inspection process of the tube body corrosion evaluation technology is divided into four: the first step is to organize the pipeline data, and divide the inspection pipe sections according to the landform characteristics, the pipe material and the operating years; the second step is the overall evaluation of the pipeline corrosion, erecting the main engine, and adding the pipeline. Current in different frequency bands; the third step is direct detection, excavation detection of abnormal pipeline frequency and corrosion points, and accurate detection of wall thickness and other data; fourth step: data analysis, to clarify the pipeline corrosion rate, wall thickness loss rate, etc., Form a test report.

5. FIELD APPLICATION OF DETECTION TECHNOLOGY

A total of 279 inspection pipelines have been completed in the 410 area of the WQ reservoir, with a total of 847km pipeline corrosion inspection work. The coverage rate of gathering and transportation pipelines is 89.4%, the coverage rate of water injection pipe network is 13%, and the overall pipe network inspection coverage rate is 51.1%. According to the analysis and test report, the corrosion rate of the pipe network is 0.21mm/a, and the average wall thickness loss rate is 26.6%. 161 hidden pipelines were found, involving 417km, including: 25 pipelines (69km) to be replaced immediately, 46 pipelines (98km) to be replaced within one year, 66 pipelines (160km) to be replaced within two years, and 24 pipelines (90km) to be replaced immediately.

5.1. Indoor Verification

Verification method: Take 2 pipeline samples of the same specification Φ89mm×4.5mm, the length is 1.0m, the interior of the pipeline is corroded to the same degree, the surface of the sample pipeline is painted with blue paint, the appearance is the same, and the labels are 1# and 2#. Verification conclusion: 1# sample is seriously corroded, it is recommended to replace it immediately, 2# sample is slightly corroded, and it is recommended to continue to use.

Figure 5. 1# sample is severely corroded

Figure 6. 2# sample is slightly corroded

5.2. On-site Verification

The on-site evaluation method is the comparison between the detection conclusion and the pipeline operation status. A total of 6 comparisons and verifications were conducted, 5 of which were more accurate, accounting for 83%, and 1 time did not conform to the actual situation. The corrosion detection conclusion has certain reference value.

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Table 3. Pipeline field verification pipeline

Serial number	Pipe name	Test conclusions and recommendations			Verification situation
		Corrosion rate (mm/a)	Wall thickness loss	Suggestion	
1	Q2 station oil gathering pipeline	0.81	41%	It is recommended to replace the entire line immediately	The pipeline was damaged three times successively, and it was damaged once after the inspection conclusion was completed.
2	Q4 station oil gathering pipeline	0.71	33%	Partial replacement is recommended immediately, others within 1 year	The pipeline was repaired by hcc internal coating, and the corrosion photos of the pipeline were taken. The inner wall of the pipeline was all corroded with distributed pitting.
3	Station q83-106	0.38	36%	Some parts are recommended to be replaced immediately, others are recommended to be replaced within 2 years	The pipeline was leaked and damaged during the purging preparation for shutdown.
4	Station x2 to station w3	0.21	38%	It is recommended to replace immediately	Partial replacement was carried out for the severely corroded pipe section in the conclusion, and photos were taken, and the internal corrosion was serious.
5	Station q91-94	0.27	31%	It is recommended to complete the replacement within 1 year	The entire pipeline was replaced, and the internal pictures of the pipeline were intercepted, and the pipeline was corroded seriously.
6	L4 station oil gathering pipeline	0.26	33%	Partial replacement within two years	Partial replacement of the pipeline is carried out, and the corrosion of the pipeline is relatively slight.

6. EVALUATION OF DETECTION EFFECT

6.1. Save Management Costs

Referring to the conclusions of the corrosion detection and formulating treatment measures according to reasonable classification, it can not only detect and control the leakage of hidden pipelines as soon as possible, but also greatly save 42% (9.84 million yuan) of production and operation costs, which has good economic benefits.

Table 4. Comparison of the effect of pipeline hidden danger management

Project	Found damaged and replaced	Governance according to the plan after detection
Workload	Replace 128km	Governance according to the plan after detection
Cost	23.04 million yuan	13.2 million yuan
Construction difficulty	The construction is difficult and the construction period is long	Low construction difficulty and short construction period
Extend your life	10 years	5-8 years

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6.2. Guide the Management of Hidden Dangers in Pipelines

Referring to the conclusions of corrosion inspection and evaluation, and according to the severity of pipeline corrosion, various technologies such as pipeline replacement, HCC internal coating repair, carbon fiber reinforcement, and polymer corrosion-resistant pipes are used to strengthen the management of hidden pipeline leakage. A total of 41 pipelines have been rehabilitated, with a total of 128km, and pipeline corrosion and leakage have been effectively controlled. At the same time, referring to the inspection conclusions, the key workload of the pipeline management plan in the 410 area of the WQ reservoir is preliminarily determined, which will promote the improvement of the controllable operation ability of the pipeline.

7. CONCLUSION AND UNDERSTANDING

1. With the extension of oilfield development time and the intensification of pipeline aging and corrosion, pipeline treatment workload and treatment cost will increase year by year. Pipeline corrosion detection technology is an indispensable technical means. The application of pipeline corrosion detection technology can effectively avoid the occurrence of pipelines. If the pipeline is wasted by blind replacement after damage, the average cost is saved by 76,900 yuan/km, and it can also provide a reliable basis for the management of pipeline hidden dangers.

2. Establish a pipeline corrosion detection and evaluation system, conduct inspections according to the operating years and damage of the pipelines, and use the test results to classify and grade the management. First, it can reduce the safety risk of pipeline operation, and second, it can reduce the cost pressure of pipeline hidden danger management.

3. There should be differences in the selection of detection technology. For special pipelines such as environmentally sensitive areas and purification oil pipelines with a long service life, more advanced technologies such as magnetic flux leakage can be considered. Evaluation method and other conventional testing technologies, testing technologies should be cross-tested and verified with each other during on-site use to improve the accuracy and reliability of testing conclusions.

4. There is no mature internal corrosion detection technology for non-metallic pipelines such as plastic alloys and flexible composite pipes, and it is impossible to effectively evaluate the integrity. How to evaluate the operational safety of such pipelines provides direction for the next detection.

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