RESEARCH ON PIPELINE CORROSION AND CRAKING INSPECTION BY BRAOD-BAND ULTRASONIC PIG TECHNOLOGY

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Abstract：

The main reasons of the oil pipeline accidents is wall thinning due to corrosion and cracks. This topic develops a broad-band ultrasonic pig technology to detect pipeline corrosion and cracks。The technique can automatically measure wall thickness、diameter and detect axial crack flaw entirely and it can solve the misjudgments and miss judgment during ultrasonic pipeline corrosion inspection also.

Key words: pipeline, corrosion, axial crack, broad-band ultrasonic inspection,

The pipeline is the most economic and effective means of transferring oil and natural gas over long distance. However, in the long time service the pipelines would weaken the safety performance and even resulted in leakage and pipe explosion accidents because of damages, such as corrosion、scour、outside force. In order to timely discovering the dangerous segment and establishing optimal strategy of instead and maintain pipeline, the in-served pipeline should be periodically online evaluated by using pipeline inspection pigs[1,2] 。

The pipeline intelligent inspection pig must has special performances, such as: it can check out the corrosion flaw of 10×10mm^2 and axial cracks of 1-3mm depth; the measurement precision of wall thickness is +-o.5mm ;it is working on long detecting distance (150-500Km) with speed up to 1m/sec and can storage a great deal of measurement data ; the pigs require integrated electronics and low power consumption etc..

Oil is well ultrasonic coupling, the ultrasonic can precisely measure corrosion thickness and section diameters of steel、S.S 、engineering plastic and composite pipe pipeline wall and can easily realize detection of axial crack and SCC crack. In addition[3,4,5] ;the broad-band ultrasonic

also has the characteristics of narrow pulse and phase information. So we select the broad-band ultrasonic immersion technique to developing the pipeline intelligent inspection Pig[6].

1．Inspection principle of corrosion and distortion with broad-band ultrasonic

The pipeline intelligent pig is a multi-section sealed storehouse structure and consists from multi- transducer array carrier、high integrated broadband ultrasonic electronic and data sampling and storage processing boards、positioning unit and power pile etc..(fig.1)。

In order to reach the pipeline inspection requirements we must select the best structure of probe arrange array. We take ¢426 pipeline for example, 160 broad-band ultrasonic transducers array and a 160ch- multi-channel broad-band ultrasonic electronic must used at least.

The principle of wall thickness and diameter measurement with pipeline Pig show in fig. 1. The ultrasonic probes are vertical to pipe wall。They are launched by barrow pulse and receive the ego pulses （A，B1，B2..） reflected from the inside and outside pipe wall. The time difference from exciting pulse to receive signal A shows the distance between probe and wall (L); the time difference from wave A to wave B shows the thickness of wall (T). The pig system will measure a data series of oil stroke (L), pipe wall (T) and will automatically calculate out all L and T using the time differences and velocity of sound in oil and steel (Vo,Vs):

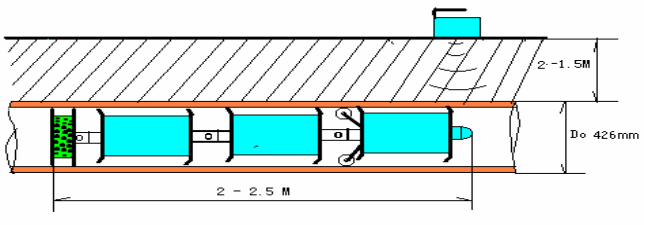
$$L=(ta-to)Vo/2 \qquad \text{…..(1)}$$

$$T=(tb-ta)Vs/2 \qquad \text{…..(2)}$$

During the immersion inspection, the pair of probes on the same diameter would check out not only the thicknesses T1 and T2 of pipe wall, but also the distances L1 and L2 between probe and pipe wall. Because the probe installed on rigid probe ring, and the distance (Lo) between the two probes is fixed, we can calculate the inside diameter and outside diameter (Di, Dout):

$$Di = Lo + (L1+L2 \qquad \text{…….(3)}$$

$$Dout=Di+(T1+T2) \qquad \text{…….(4)}$$



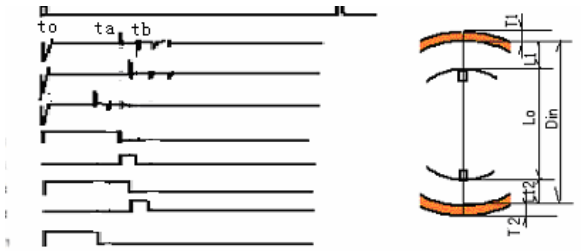


Figure 1 Principle of inspecting pipe thickness and diameter and typical wave forms of broad-band ultrasonic

Over ground station will take out the information from the pig robot and finish digital processing and flaw positioning. By using special image software we can give B-type 、C-type and3D-digital color images of the thickness (T) and Distance (L) (fig2).

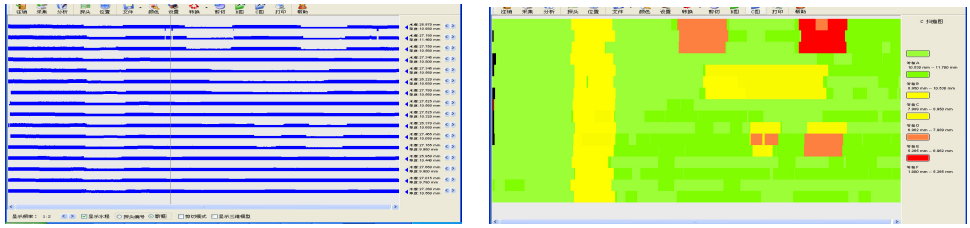


Figure 2 B-type and C-type display of thickness

The B-scan of L will express the changes of the distance between probe and inside wall and B-scan of T will express the changes of wall thickness. When there is flaw in inside surface, the L increased, but when flaw in outside surface, the L is not difference. So we can judge the inside flaw or outside flaw through the B-scan images of T and L (fig.3).

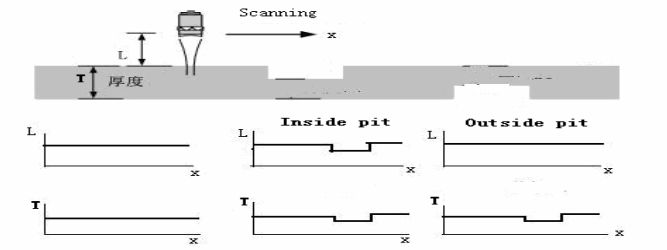
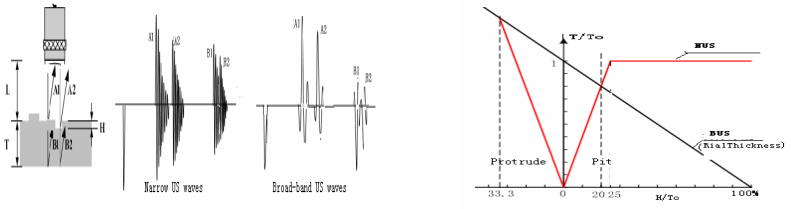


Figure. 3 the sketch map of inside flaw and outside flaw

2． Analysis and solution of the misjudgments and miss judgment during ultrasonic pipeline corrosion inspection.

Besides the large area of general corrosion on pipe wall, there are corrosion smaller pits than the acoustic beam spot. Under the situation of general corrosion, The normal ultrasonic PIG can correctly measure the general corrosion wall thickness ; however, when the inside wall corrosion pit is smaller than the acoustic beam cover area, the measured thickness of remnant wall may be errors. Because the acoustic beam area is larger than pit are, the reflections will form a echo A1

from non-corrosion pipe wall and also form a echo A2 from the bottom of pit (figure 4). In this way, the ultrasonic Pig would mistake the wave A2 for the bottom wave B1. Then get a wrong pipe wall thickness. When the inside corrosion pits are very shallow (< 0.25T), the Pig will think the thinning of pipe wall is serious by mistake; as the same reason, when there are protruding flaws smaller than acoustic beam on inside pipe wall, there would be misjudgments either.



a. Narrow and broad-band ego waves b. theoretical analysis curves

Figure 4 the theoretical misjudgment curve of inside smaller defect

According to the sound impedance of oil < the impedance of steel and the sound impedance of are/ earth < the impedance of steel, the phase difference between waves (A1,A2) and bottom echo (B1 ,B2) will be 180 (fig.4). When using broad-band ultrasonic system, the ultrasonic ego-waves (A1,A2, B1) will have phase information's.. In this way, we can use the broad-band ultrasonic phase identification analysis technique and software to solve the problems of misjudgment and miss judgment during using ultrasonic pipeline corrosion inspection.

3． The study on ultrasonic inspection technology of axial crack

The pipelines are working on high pressure (6-8Mpa). In the long service time, there will be generated not only corrosion, but also cracks. The axial crack is the most dangerous flaw in pressure pipeline. Our new development is studding structure of the multi- transverse wave sensor carrier and date processing technology for on-line inspect the axial cracks in pipeline inside and outside surface.

The special ultrasonic electronic and date processor can digitally measure the amplitude and transfer time of every axial crack ego. And then processor can identify position of every crack and degree of the crack depth. The lengths of cracks can calculated in accordance with the data of the pig going speed and crack ego number.

4． Conclusion

（1）The technique of broad-band ultrasonic pipeline pig has following characteristics: precisionmeasurement of thickness and diameter and can solve the misjudgment and missing judgment problems of smallest inside pits during ultrasonic corrosion inspection;

（2） Using the special ultrasonic transverse wave probe array the pipeline axial cracks can detected.

（3） The special designed sensor-carrier、electronic and software can realize the ultrasonic B-scan, C-scan imaging and the three-dimensional imaging of corrosion and crack flaws

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