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Magnetic Memory Inspection of High Pressure Manifolds

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Abstract

It is significant to assess the stress concentration degree and forecast the service life of high pressure manifolds in advance which were the main stream flow channel of the acid-fracture liquid in petroleum industry, such as straight tube, bent pipe and tee bend etc. The magnetic memory method is a new NDT method that can detect the microscopic damage on the basis of the magnetostriction and magnetoelasticity effect. The objective of this study was to discuss the selection of the applicable probe type, scanning method, scanning times and procedure of magnetic memory method in response to different high pressure manifolds types. And according to the inspection instances, it was certified that the stress concentration degree can be detected and assessed by the magnetic memory method, and thereby the service life of the high pressure manifolds can be forecasted. Furthermore, the common defects of the high pressure manifolds, such as transverse and longitudinal linear defects, etch pits and wall thickness reduction, can also be detected by magnetic memory method. And the inspection results won't be influenced if the stress were released.

Key words：Magnetic memory method; High pressure manifolds; Stress concentration

High pressure manifolds is the general name of all high pressure fluid controllers, which were the main stream flow channel of the acid-fracture liquid in petroleum industry. Because of the high pressure, acid-corrosion and the huge jump-over stress, the stress concentration may be generated on the high pressure manifolds, such as the straight tube, bent pipe and tee bend etc.. The presence of the stress concentration is main predisposing cause of macro-defects, as fatigue crack and stress corrosion etc. and may induce the accident. Therefore, it is significant to assess the stress concentration degree and forecast the service life of high pressure manifolds in advance.

Magnetic memory method is a new nondestructive inspection technology presented by a Russian scholar on the 50th International Welding Meeting. The principle of the magnetic memory method is based on the magnetic memory effect of ferromagnetic components, which can detect the hazard position of the high pressure manifolds with stress concentration. Compared with ordinary NDT methods, the magnetic memory method is characterized by detecting micro-defect, no need to magnetizing and preconditioning, quickly detecting, simply operating , having good repeatability and reliability. The objective of this study was to discuss the selection of the applicable probe type, scanning method, scanning times and procedure of magnetic memory method in response to different high pressure manifolds types.

Inspection instances were taken for example to certify that the stress concentration degree can be detected and assessed by the magnetic memory method, and thereby the service life of the high pressure manifolds can be forecasted.

1. Magnetic memory method

1.1 Principle

Because of the magnetostriction and magnetoelasticity effect, the magnetic domain on the surface of high pressure manifolds with stress and strain concentration will be regularly oriented ,and then area with stress and strain concentration will be self-magnetized when high pressure manifolds were in service and coacted by the high pressure load and terrestrial magnetic field, see fig.1. The surface self-magnetization field on stress and strain area will be reserved even if the load was released, which is so-called magnetic memory. The density of the surface self-magnetization field is correlated to the maximum stress of the stress and strain area. And the tangential component $H_p(x)$ of the surface self-magnetization field is maximizing and the normal component $H_p(y)$ will be zero, as followed from fig. 2. Therefore, the stress and strain area can be indicated by measuring whether the $H_p(y)$ is zero and calculating whether the K value ($K=dH_p(y)/dx$) is maximizing.

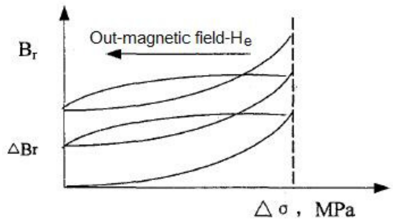

Fig.1 Principle of magnetoelasticity effect
△B_r-The variety of the remaining magnetic induction;
△σ - The variety of periodic load; H_e - Out-magnetic field

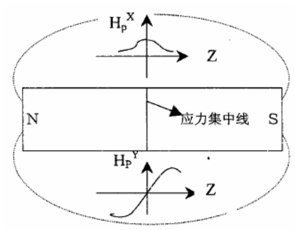

Fig.2 Principle of magnetism memory inspection

1.2 Inspection Equipments

At present, the representative magnetic memory inspection **equipments** is the TSC series produced by Energodiagnostika Co. Ltd of Russian, which is founded by professor Doubov, the presenter of magnetic memory method. The principle of the TSC series inspection devices are similar, indicated from fig. 3, but only the maximum number of the inspection channels are different. Combining to the different types of scanners designed by Energodiagnostika Co. Ltd, all kinds of high pressure manifolds can be inspected.

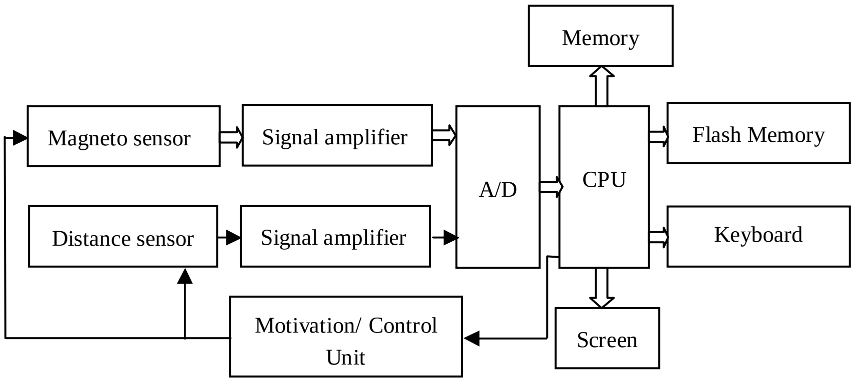

Fig.3 Principle of TSC series magnetism memory test devices

2. Inspection procedure

2.1 Inspection parameter

(1) Inspection device: TSC-1M-4 type magnetism memory test devices produced by Energodiagnostika Co. Ltd.

(2) Scanning sensor: Type 1 and type 3 scanning sensor. Type 1 scanning sensor which is manufactured in form of a 4-wheel trolley with four flux-gate transducers and a length-counting device is designed for quickly longitudinal inspection of straight pipe. Type 3 scanning sonsor which is equipped with two flux-gate transducers and a length-counting device with two wheels is designed for circumferential inspection of bent pipe and tee bend.

(3) Scanning method: the scanning method of different high pressure manifolds see table 1.

Table 1 Scanning method of high pressure manifolds

Pipe type	Longitudinal scanning		Circumferential scanning	
	Scanner type	Scanning times	Scanner type	Scanning times
Straight pipe	Type 1	4 times	Type 3	Number of stress concentration point
Bent pipe	Type 3	4 times	Type 3	Number of stress concentration point
Tee bend	Type 1 or 3	4 to 8 times	Type 3	Number of stress concentration point

2.2 Scanning procedure

(1) Choose the applicable scanning sensor and connect it to the inspection device.

(2) Power on and initialize the inspection device.

(3) Calibration. Including calibrate the flux-gate transducers and length-counting device.

(4) Scanning the high pressure manifolds according to the method mentioned above.

(5) Image explanation. Check the scanning image and find the points of Hp（y）=0 and/or K_{max}.

(6) Image processing. Transmit the scanning image to the computer from the inspection

device and process them using the processing software.

3. Inspection instances

According to the inspection instances in recently years, it is verified that magnetic memory method can detect the stress concentration points quickly and effectively and macrographic defects were detected in some points. Some representative instances are as follows.

3.1 Linear defects

(1) One point of abnormal K value was found on a straight tube which the number is ZGa0002. The magnetic memory inspection image sees fig.4. And it has been verified that there is a longitudinal linear defect of about 5mm in length at the very point by the subsequent ultrasonic inspection. The ultrasonic inspection waveform sees fig.5.

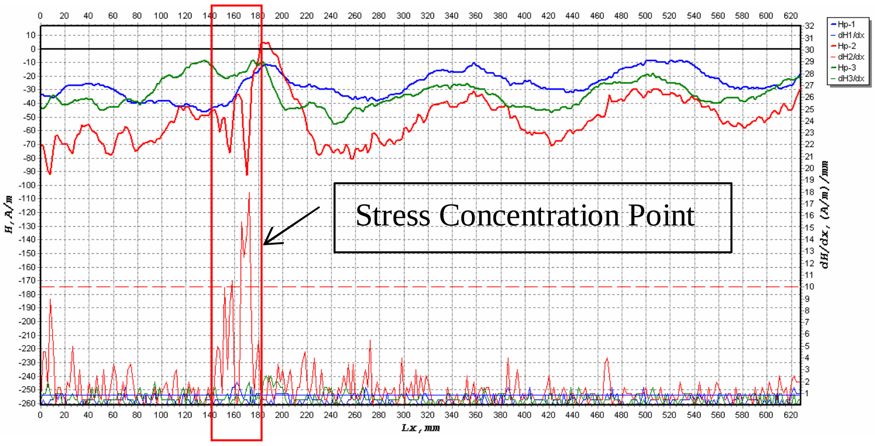

Fig.4 ZGa0002 straight tube magnetic memory inspection image

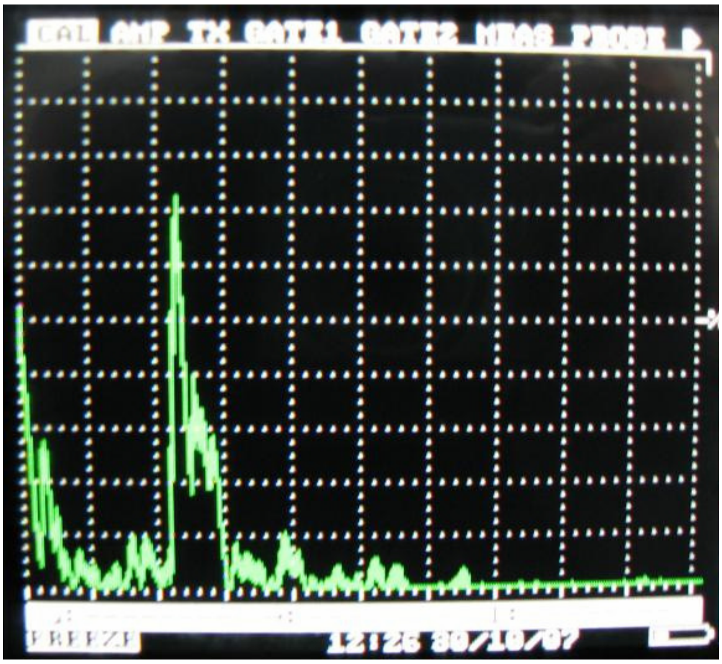

Fig.5 The waveform of ultrasonic inspection

(2) Three points of abnormal K value and Hp (y) =0 were found on a straight tube which the number is ZGa0054. The magnetic memory inspection image sees fig.6. And it has been verified that there is a circumferential linear defect of about 3mm in length at the first point by the subsequent ultrasonic inspection. The ultrasonic inspection waveform sees fig.7. But

no macrographic defects were found at the second and third points by ultrasonic inspection.

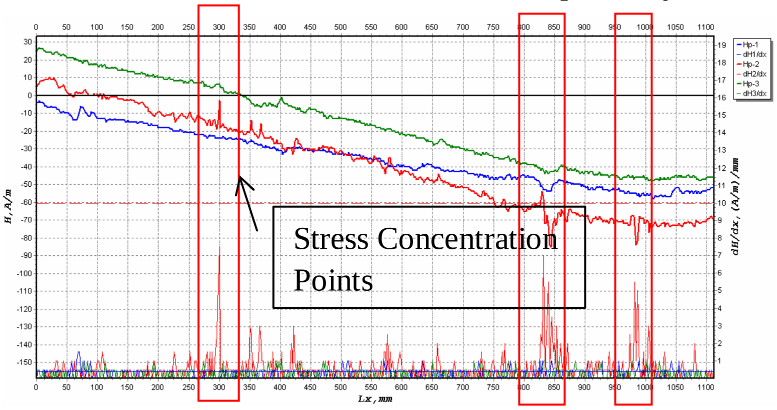

Fig.6 ZGa0054 straight tube magnetic memory inspection image

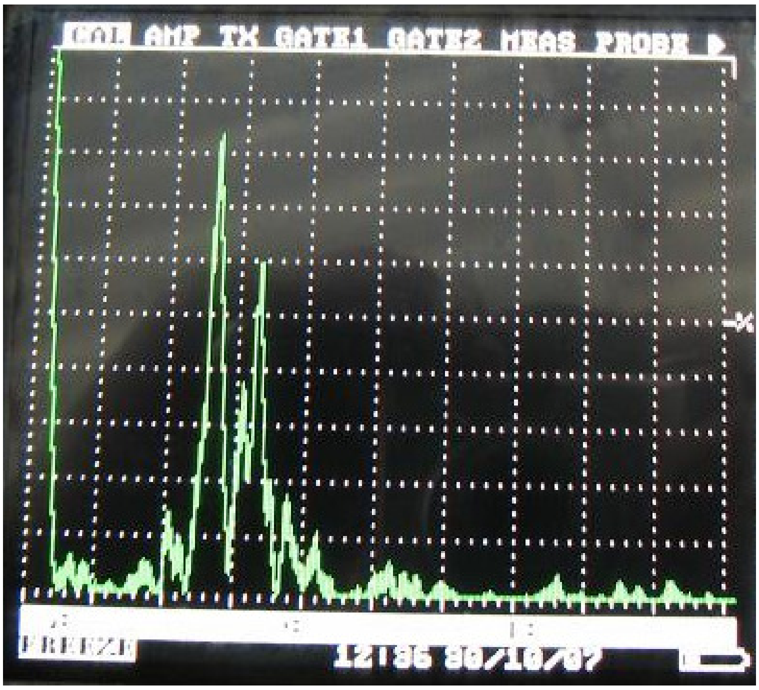

Fig.7 The waveform of ultrasonic inspection

From the two instances above, it is indicated that both of the longitudinal and circumferential linear defects can be detected by magnetic memory method in some sense.

3.2 Inwall corrosion

A large area of abnormal K value was found on a bent pipe which the number is WTa0028. The magnetic memory inspection image sees fig.8. It has been verified that there is a large area of inwall corrosion in that place by the subsequent ultrasonic thickness gauging. And the minimum wall thickness of that place is only 3.88mm, while the limit wall thickness of this kind of bent pipe is 10.67mm. See fig.8. So it can be proved that the inwall corrosion can also be detected by the magnetic memory inspection.

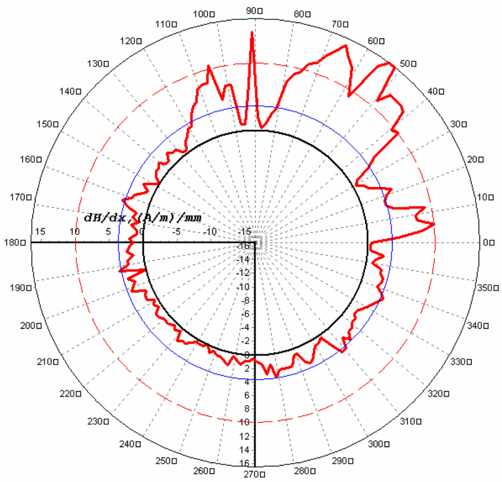

Fig.7 WTa0028 bent pipe magnetic memory inspection results

Fig.8 The minimum wall thickness while ultrasonic thickness gauging

3.3 Magnetic memory test

For verifying whether the magnetic memory inspection will be affected when the stress was released, a bent pipe with a pricker, see fig.9, was magnetic memory inspected. The magnetic memory inspection image sees fig.10. It shows that the point of the pricker is still the maximal K value point, which is up to 240. And it can be proved that the magnetic memory inspection result will not be affected even if the stress was released.

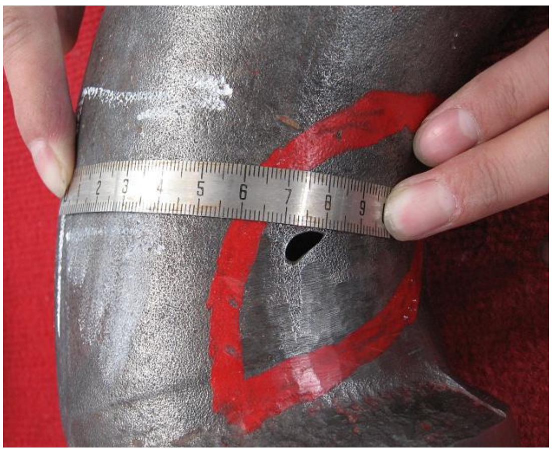

Fig.9 Bent pipe with pricker inspected

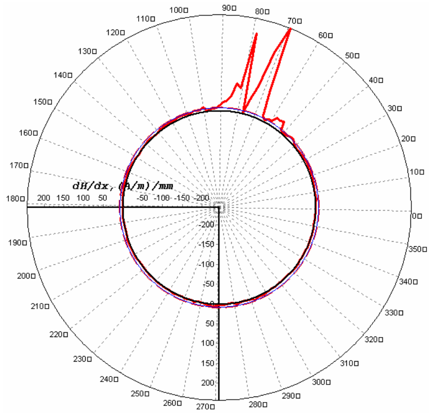

Fig.10 Mmagnetic memory inspection image of the bent pipe with pricker

4. Conclusion

From above, some conclusions were concluded as follows.

(1) The magnetic memory method is new NDT method based on the magnetostriction and magnetoelasticity effect.

(2) The magnetic memory method can be taken as a way of stress concentration detecting and macrographic defects forecasting of the high pressure manifolds.

(3) The common defects, such as longitudinal and circumferential linear defects and inwall corrosion, can be detected by the magnetic memory method.

(4) The magnetic memory inspection result will not be affected even if the stress was released.

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