Research on Application of Pipe Crawling Device

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Abstract: In this paper, the working principle of pipe crawling device in oil and gas pipeline engineering and the choice and control of the primary detection technology's parameters are discussed. By analyzing the detection sensitivity, the feasibility of detecting defect using pipe crawling is demonstrated.

Keywords: Pipe crawling device; Radiographic testing; Technological parameters

With the development of oil and natural gas industry, the pipeline transport as the fifth largest transport mode has been thriving. The Chinese government continued to construct some large petroleum and natural gas pipe engineering, such as Chuan-East Gas Pipeline Project and West-East Gas Pipeline Project second line and so on. In the mass, the development's trend of pipe specification applied in national project is that the radius of pipe becomes bigger and bigger; the wall thickness becomes thicker and thicker; the degree of materials becomes more and more excellent. However, in the mass, the pipes specification applied in local project are that：the radius of pipe is relatively small; the wall thickness is relatively thin; they are applied in the branch of large pipe project or pipe network in city. For pipeline whose radius of pipe is big and pipe wall is thick (for example, Φ1016×30 mm), dual wall/single projection transillumination using general ray machine is almost unrealistic. If the pipes whose radius of pipe are small and pipe wall are thin are transilluminated by 100% dual wall/single projection using general ray machine, the workload of transillumination will be heavy, duration of detection will be long, the sensitivity will be low. It doesn't meet the needs of construction quality and days for constructions. Pipe crawling device as a new detection equipment contains many advantages, whose detection speed is quick, positioning accuracy is high, and sensitivity of detection is accurate. It has been the main detection machine which is applied in detecting on pipe welding line. The radius of pipe has direct influence on the detection technology parameters which are focal length, exposure and so on. This paper is focused on the selection and control of detection technology parameters, when the conditions satisfy the standards.

1 Theory of pipe crawling device and domestic detecting equipment

1.1 Theory of pipe crawling device：

Inside centric transillumination method（F=R）in radiographic inspection: Ray source or focus are located in the center of pipe, radiographic film wholly or one by one covers the

whole outer wall of annular gap. A disposable circumferential exposure is completed in weld by ray (Figure1) .This radiation perspective arrangement, transillumination K=1, crack detection angle $\Theta=0^0$, once-through penetration length is the whole length of circumferential seam. X ray pipe crawling device is the equipment which photographs the butt weld of pipe by using omnidirectional X ray photographing in the pipe laying project. Use a trolley towed to take the X-ray detector into the pipe. When ray emission window aligns the welding seam, ray machine exposures the butt weld of pipe at given exposure voltage and exposure time by remote control. Because the circumferential X-ray detector exposure in the center of pipe and focal length is short and projection mode is single-wall projection, the whole exposure of whole weld is disposable. Compared with the method of dual-wall projection out of the pipe, the efficiency is improved dozens of times. The movement of pipe crawling device in the pipe is controlled by the instruction source or radio control box to complete forward action, recession action, stopping action, exposure action and so on.

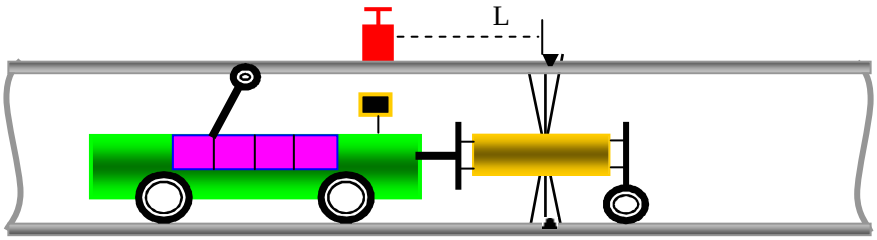

Figure 1 Diagram for Transillumination Methods

1.2 Component of common domestic crawling device：

Pipe crawling device is composed of ray tube, inverter, driving part, power part and control part. Both ray tube and inverter are the core component of crawling device which usually uses head of X ray machine or Se75 γ ray source, it determines the quality of negative detection. The power part is mainly composed of motor, transmission system, differential mechanism and driving mechanism. For fitting the bending radius of the elbow of pipeline, crawling device mechanically use two structural styles: one style is train mode; another style is the steering mechanism of differential mechanism. The power part usually employs battery; the control part is usually controlled by two forms(Cs137 γ ray source or radio control box). The domestic manufacturing companies of pipe crawling device are mainly located in Dandong, Huangshi and Tangshan region and so on. The types are I type, II type and III type. The main covering specification is Φ210-Φ1200mm. Φ159 mm pipeline can be detected by Se75 pipe crawling device.

2 Domestic application standards of radiographic inspection of pressure piping and their application range

2.1 The detection by using pipe crawling device is mainly based on the standard of radiographic testing. Its control and selection or technical parameters of the detection system are determined to the demand of inspection standards. The inspection standards about oil and natural gas in China are JB/T 4730-2005(Nondestructive testing of pressure equipments) and SY/T 4109-2005(Nondestructive testing of oil and gas steel pipeline).

2.2 JB/T4730-2005 Nondestructive testing of pressure equipments:

It is applicable to the butted-joint of radiographic testing during fabrication, installation and inspection in service. The metal materials used as weld joint contain carbon steel, low alloy steel, stainless steel, copper & copper alloy, aluminum & aluminum alloy, titanium & titanium alloy and nickel & nickel alloy.

2.3 SY/T4109-2005 Nondestructive testing of oil and gas steel pipeline.

It is applicable to the inspection and quality classification for the circumferential butt weld at the pipes which are used for long-distance transportation, gathering transportation and oil/gas station transportation. The wall thickness of the pipes is 2-50mm and the materials of the pipes are metallic material like low carbon steel, low alloy steel and so on. ;

3 Control and selection of main technical parameters

3.1 Method for transillumination

Inside centric transillumination method is firstly used. If it can't be put in practice, dual wall/single projection will be selected.

3.2 Ray source

3.2.1 Principle of selection about ray source:

X ray is firstly used. If it can't be put in practice, γ ray will be selected.

3.2.2 The Highest Voltage

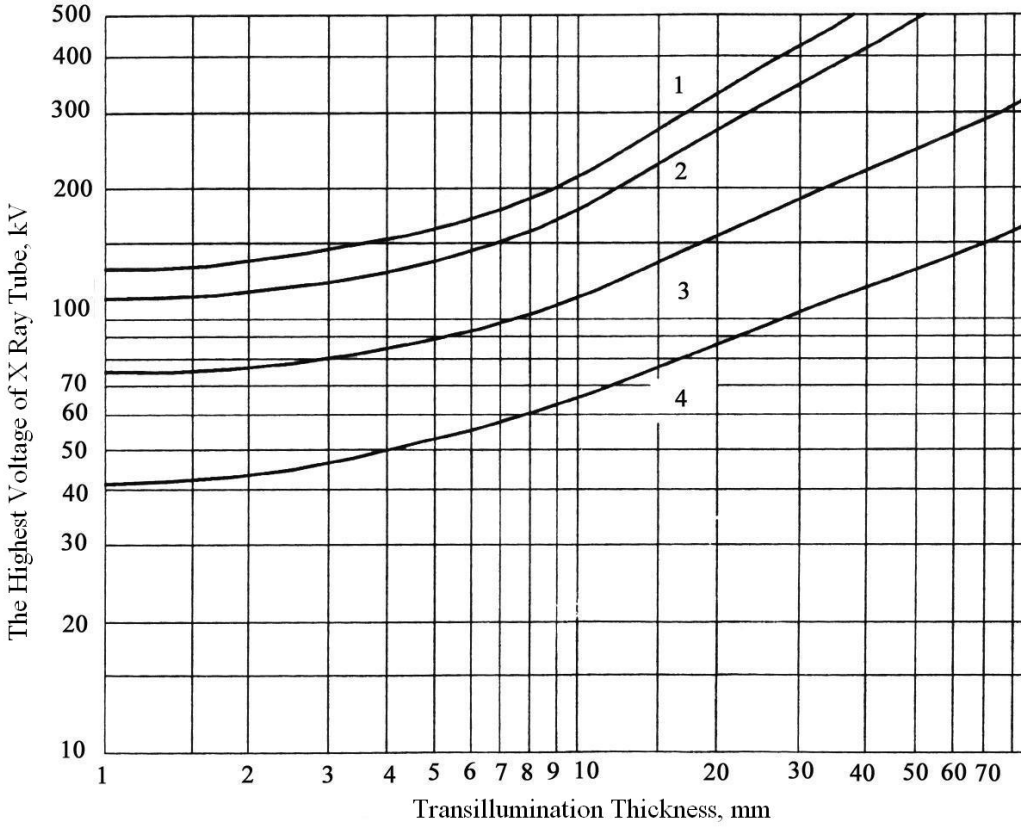

Figure2 The Highest Voltage of X Ray Tube
For Transilluminating Materials of Different Thickness

1-copper&copper alloy; 2-steel ; 3- titanium & titanium alloy;4- aluminum & aluminum alloy

3.2.3 Common ray sources for pipe crawling device(Table 3)：

Table 3　Common Ray Sources

Ray source	Transillumination Thickness　W /mm
	AB level
Se75γ	Standard requirement: ≥10-40
	Relaxed standard requirement： Only when the sensitivity of image quality indicator meets the need of requirement for sensitivity of film, the minimum allowable transillumination thickness is the half of lower limit value in this table by using inside centric transillumination method, can be 5.
160KV X	≤20
200KV X	≤29
250KV X	≤39
300KV X	≤49

3.3 Focus-to-film distance of radiographic

3.3.1 Calculation of the focus-to-film distance of radiographic:

$$L_1 \geq 10 d L_2^{2/3}$$

Where: d —the effective focus dimensions of ray source (mm)

L_2—the distance between work piece and the film (mm)

L_1—the distance between ray source and the surface of work piece (mm)

3.3.2 The distance between ray source and the surface of work piece L_1:

See Fig.3 for L-nomograph.

3.3.3 If the negative quality to obtain by inside centric transillumination method can meet the requirement for film density and sensitivity of image quality indicator, the distance between ray source and the surface of work piece can be decreased, not exceeding 50% of specified value.

3.3.4 The radius of pipe determines the focus-to-film distance of radiographic

The radius of pipe determines the focus-to-film distance of radiographic. To know whether focus meets the requirement for standard, it is necessary to calculate or use

nomograph. Specification of crawling device which belongs to their users is also considered after focus meets the demands. If: the effective focus dimensions of ray source in II type equals to 3mm, the distance between work piece and the film equals to 10mm, the distance between ray source and the surface of work piece equals to 246mm. Solution: $L_1 \geq 10dL_2^{2/3}=10\times3\times10^{2/3}=140$ mm, L_1 is less than 246 mm , allowable If: the effective focus dimensions of Se75 γ ray source equals to 3mm, the distance between work piece and the film equals to 8mm, the distance between ray source and the surface of work piece equals to 73.5mm. Solution: $L_1 \geq 10dL_2^{2/3}=10\times3\times8^{2/3}=120$ mm, f=120/2=60 mm□73.5 mm , allowable.

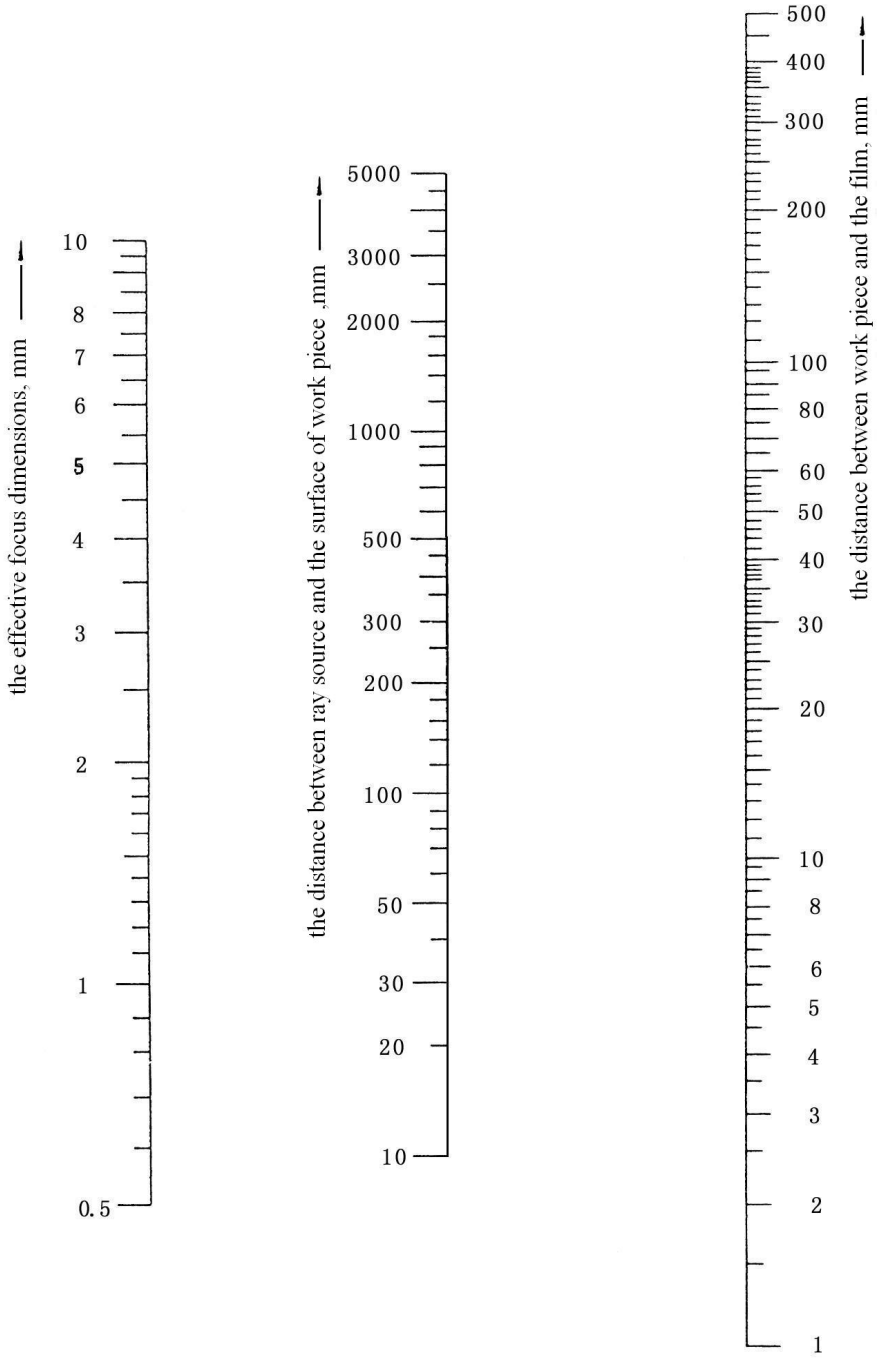

Figure 3 Nomograph for determining distance between focus and work piece at AB level

3.4 Exposure

3.4.1 Using X ray, the recommended exposure about 700mm focus is no more than 15mA•min at AB level. If focus varies, the recommended exposure can be calculated by inverse square law. Using γ ray source, the total exposure time should be no less than 10 times of round trip time about transportation resource.

3.4.2 Calculation:

$$E1/E2=(F1/F2)^2$$

If: F2=254mm。Solution: 15/ $E2=(700/254)^2$, E2=2 mA·min.

3.5 Practical application for pipe crawling device

The power of pipe crawling device is provided by battery. Forward action, recession action, stopping action and exposure action are controlled by instruction source or radio control box.

3.5.1 Before use, adjust the milliampere value and exposure time, train equipment necessarily.

3.5.2 Adjust detector's height to ensure that command is received sensitively and location is accurate.

3.5.3 Charge battery and connect modules correctly.

3.5.4 Turn on the power button and switch as necessary. Put the front wheel at inner wall. Push button to send the pipe crawling device into the pipe. Adjust the balance.

3.5.5 After arranging films, the inspector move the crawling device to the certain place and then stop to exposure.

3.5.6 After inspecting this weld, inspect next weld or draw back. Collect films and dispose in darkroom.

4 Conclusion

In this paper, the working principle of pipe crawling device in oil and gas pipeline engineering and the choice and control of the primary detection technology's parameters are discussed. By analyzing the detection sensitivity, the feasibility of detecting defect using pipe crawling is demonstrated. If the specification and technical parameters are selected suitably, pipe crawling device can meet the requirements for standards. For application of pipe crawl device in practical pipeline engineering, the paper has certain theoretical guidance meaning.

Reference

[1]JB/T4730-2005, Nondestructive testing of pressure equipments.

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