1.3.38. METHOD AND TECHNOLOGY OF DIAGNOSTICS OF PIPELINE SYSTEMS BY GUIDED LOW-FREQUENCY ULTRASONIC WAVES

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The paper is devoted to diagnostics of the technical condition of extended welded pipeline systems for different purposes, which can be generally classified as: main pipelines, technological pipelines of enterprises, pipelines of power units, household and industrial sanitary-technological pipelines. A common feature for all the kinds of pipeline systems is a large number of welded joints, the absolute majority of which are circumferential butt welds.

Continuous monitoring of pipeline technical condition is very important to ensure their performance. However, conducting the monitoring of the pipeline technical condition by regular NDT methods is quite complicated, as the pipelines are covered by insulation and located under the ground, and some pipe sections are raised above the ground, individual sections are immersed into the water, or are laid in troughs under the railway or other flyovers. Therefore, diagnostics of extended pipelines, as regards its main scope, has to be based on the concepts and criteria of defectiveness of metal of both the weld and pipe, so as to have as least some, even though indirect, assessments of the current technical condition of pipelines systems as a whole.

A significant step forward in development of methods for controlling the technical condition of extended pipelines was development of a technology and systems of remote monitoring of extended pipelines, using the method of long-range low-frequency ultrasonic testing (LF UT) by guided waves. Such a technology of monitoring various purpose pipelines was developed to the highest level in mid-1990s in Great Britain [1], USA [2], and then in Japan [3]. Analysis of the features of propagation of low-frequency ultrasonic guided waves, system of diagnostics of various-purpose pipelines using various types of transducers for excitation of guided waves of the longitudinal and torsional modes and reception of echo-signals from the discontinuities is given in Reference [4].

LH NDT method is based on excitation in the examined extended pipeline of low-frequency ultrasonic oscillations from one point of mounting the acoustic array on the pipeline. Low-frequency US waves propagate in the pipeline without attenuation to large distances and while propagating they interact with various discontinuities in the pipe wall. Such pipeline discontinuities are corrosion damage or erosion wear of the pipeline wall changing the pipe cross-sectional area, as well as welded joints, in which the material density and cross-sectional area differ from pipe material density and cross-sectional area. Such an interaction of the guided wave with pipe discontinuities generates echo-signals, the amplitude value of which, exceeding the preset threshold level, is a measure of the presence and size of defects in the pipe wall and pipeline welded joints.

The paper gives analysis of the parameters of extended pipeline medium, which is waveguide in the form of an infinite elastic medium design for transfer of elastic oscillations of the low-frequency guided wave of a certain type from the oscillation source. However, the elastic medium of the extended pipeline will satisfy the “waveguide” definition only in the case, if one certain type of oscillations (wave) prevails in it, while the other types have negligibly small values. Therefore, it is necessary to ensure transfer of elastic oscillations along the extended pipeline, so as to avoid any distortions of the plane guided wave, or the phenomenon of geometric dispersion of oscillation propagation speed. For practical elimination of other types of oscillations, and ensuring an undistorted transmission of the excited elastic oscillations, the nature of wave processes in such a waveguide should correspond to a certain ratio of pipe wall thickness t and working frequency f of the excited low-frequency ultrasonic wave. For pipelines this ratio is selected from the following condition $t \times f \leq 1$ mm. MHz. In this case, it is necessary that the length of the wave propagating in the pipeline …= c / f, where C is the sound velocity in it, was much greater than pipe wall thickness, i.e. ~ >> t.

An essential difference of the method of long-range UT by guided waves from the traditional UT methods is application in the acoustic arrays of the principle of dry acoustic contact of the transducers with the pipe surface, eliminating application of liquid couplants. Depending on the guided wave mode (longitudinal or torsional), the transducer at their application acts on the pipe surface as a concentrated normal or tangential variable force inducing longitudinal or transverse oscillations along the line of acoustic contact.

At a constant value of the exciting signal amplitude on the transducer piezoelectric elements, the echo-signal amplitude at the piezoelectric element output, and the coefficient of transmission of the electroacoustic circuit of the monitoring system will depend on constant force F_0 of piezoelectric element pressing to the pipe surface and degree of surface roughness of the latter. In each specific case of pipeline monitoring by the guided waves, force F_0 of pressing should be specified.

The paper gives the results of R&D conducted at the E.O.Paton Electric Welding Institute of the NAS of Ukraine on development of the technology and technical means of long-range LF UT of extended pipelines by guided waves. In order to study the processes of GW propagation a test welded pipeline 48 m long was built from 6 m long pipes from St.3 steel with the outer diameter of 114 mm and 6 mm wall thickness. The pipeline is mounted on special supports, which isolate it from the environment. During performance of research various acoustic arrays based on piezoelectric transducers for excitation of GW of a longitudinal or torsional mode, were developed and tried out. The arrays provide the required force of piezoelectric transducer pressing to the pipe surface to establish a reliable dry contact. In order to optimize the technology of defect detection in pipes by the reflected echo-signal parameters, a method of physical simulation of the actual defects by mechanically introducing into the pipes the local discontinuity models, was used. The following features were accepted as such models of discontinuities: wall thinning of a pipe of (18 × 10) cm size at 3.2 m distance from one of the pipe ends; a slot around the pipe circumference 2.5 mm wide, 2.5 mm deep and 0.5 mm long, where L is the length of the pipe circumference, at 4.48 m distance from the pipe end; a slot 2.5 mm wide, 2.5 mm deep, 0.3 L long at 14.91 m distance from the pipe end. Working frequency of the excited signals was 19.6 kHz.

References:

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