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Improvement of ultrasonic technology for metal structures inspection

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Abstract. *The paper proposes a new technology for researching structural changes in steel that occur during operation and their impact on mechanical characteristics.*
Keywords: *ultrasonic, metal structures, measurement, acoustic noise.*

Introduction. Most of the equipment of technical systems containing metal structures during operation is exposed to cyclically varying, mechanical, thermal loads and corrosive environments. These influences cause a change in the structural state of the metal, contributing to the accelerated development of defects, which ultimately leads to the destruction of the structure.

Problem statement. Currently existing ultrasonic, electromagnetic and eddy current methods of non-destructive testing are mainly aimed at solving the problems of detecting defects that have already formed. However, it is more important to timely detect the initial stage of the process of damage accumulation in the metal by determining changes in the structural state of the metal.

Results. Experimental studies and analysis of the results obtained, in particular, analysis of images of acoustic structural noise of steels obtained using ultrasonic flaw detectors complete with piezoelectric transducers with ultrasonic phased arrays, showed the presence of the nature and type of dependence between the new informative parameter and the physical and mechanical characteristics of steels.

The propagation speed of ultrasonic waves in metals is functionally related to their elastic moduli, which, in turn, are determined by the force of interaction between neighboring atoms in the crystal lattice. When the structure of the crystal lattice changes, for example, during plastic deformations, the forces of interaction between atoms change, and the elastic moduli change accordingly, which leads to a change in the speed of ultrasound propagation in metals.

To obtain an image of the cross-section of the visualized area of the object, the entire set of received ultrasonic signals reflected from each point of the defect is subjected to coherent spatiotemporal processing, which is the result of summing the responses (echo signals at different angles) from a certain point in space inside the visualized area and assigning the result of the summation of a certain gradient to a certain color. This operation is performed for all points in space located in the plane of the visualized section.

As a result of control using piezoelectric transducers with UZFG with electronic scanning, a sector scan of the scanning area is formed, on which the amplitude of the echo signal from the reflector is color-coded. The color change from dark blue to red corresponds to an increase in the amplitude of the echo pulse of the reflected signal. As a result of refraction and transformation of ultrasonic signals from groups of grains, an increase in the amplitude of the echo pulse of the reflected signal occurs, which in turn allows you to see structural inhomogeneities in the form of light blue spots. In places where the value of the echo pulses is maximum, red spots are formed, symbolizing the presence of a defect.

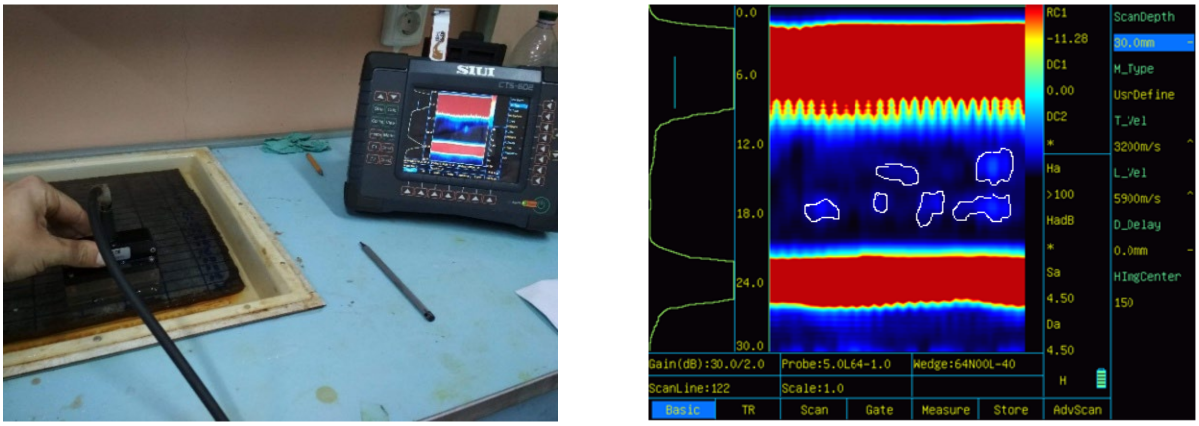
Research on the detection of structural inhomogeneities using ultrasonic flaw detectors complete with piezoelectric transducers with ultrasonic phased arrays was carried out on a sample of steel grade 40G measuring 400x300x18.7 mm. The sample was divided into 200 zones to facilitate identification of the location of the obtained images. (Fig. 1) Ultrasonic studies were carried out using a SIUI CTS-602 flaw detector with a 5.0L-64-1.0-10 transducer and a 64N00L-40 transition prism. Scanning was carried out at a frequency of 5 MHz, the scanning angle was selected as 0˚, the active aperture was 14, and the gain was 30 dB.

Fig. 1. Image of the tested sample of 40 G steel.

The hardware capabilities of the flaw detector allow you to save the acoustic image for further processing. Using the image analyzer program, the obtained images are converted to monochrome mode, arranged in a logical series, and the noise images formed by the prism are cut off.

It is proposed to use the integral density of acoustic images of structural noise as a new informative parameter (Fig. 2).

To determine the integral density of the image, images obtained using a flaw detector from ultrasonic flaw detectors complete with piezoelectric transducers are processed in the MatLab software environment. Each pixel of the image is assigned a number that depends on its color.



a) b)

Fig. 2. Study of structural inhomogeneities in a selected sample of 40G steel (a) and acoustic image of a section of the studied sample with structural inhomogeneities (b).

The integral density of the image characterizes the sum of these numbers and is a dimensionless quantity. In order to determine the presence and nature of the relationship between the informative parameters of the images of acoustic structural noise of steel and its physical and mechanical characteristics, a graphical and correlation analysis was performed. The result of the analysis showed that the value of the correlation coefficient between the yield point and the integral density is quite high and is - 0.9. This indicates that areas with higher values of the integral density reach the yield point at lower stress values.

Conclusions. The use of a new informative parameter, such as the integrated density of the acoustic noise image, will significantly increase the accuracy of determining the FMC of steels, which, in turn, will reduce the accident rate during the operation of gas transportation systems.

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Innovative information technologies in management of educational projects in the era of turbulence

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Abstract. *The study highlights the role of innovative information technologies in managing educational projects under uncertainty and crises. Traditional methods lose efficiency amid turbulence caused by economic shocks, conflicts, and rapid technological change. Tools such as Big Data, AI, blockchain, and cloud systems enhance adaptability, optimize resources, and support collaboration. Special attention is given to hybrid technologies, which integrate diverse solutions for more reliable forecasting and risk management. The paper concludes that these technologies evolve into strategic resources, ensuring resilience and competitiveness of educational projects.*
Keywords: *IT, innovative management, educational projects, uncertainty & crisis.*

Introduction. In modern conditions, innovative project management is the main form of implementing strategic initiatives, effective adaptive solutions and digital transformations [1], [2]. In addition, the modern global environment is characterized by a high degree of uncertainty [3] and instability [4], which is often described by the term “era of turbulence”. Crisis phenomena in the world economy, the cardinal and accelerating pace of technological transformations, geopolitical challenges, environmental disasters and pandemic threats create conditions [5-7] when traditional project management methods cease to be sufficient to ensure their effectiveness and sustainability. In these conditions, innovative technologies come to the fore, which not only expand the project management toolset, but also fundamentally transform the approach to management itself [8]. Innovative total digitalization [9], [10] and intelligent (knowledge-based & data-driven) automation [10], [11], the use of artificial