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DIAGNOSTICS AND TECHNIQUE FOR THE ANALYSIS PIPELINES TRANSPORTATION

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У статті обговорюється інноваційна технологія діагностики і техніка виявлення несправностей транспортних трубопроводів. Технологія була заснована на акустичноемісійному методі для діагностики вантажних трубопроводів. Це забезпечить неруйнівний контроль разом зі швидким та точним виявленням, класифікацією, визначенням характеру, геометричних розмірів і місця розташування дефектів.

Акустичний сигнал кристалічних структур дозволяє визначати значення циклічного опору; повторна кореляція вищезгаданих структур з кінематичною діаграмою відмови дозволяє адекватно прогнозувати статичний ресурс трубопроводу.

The article is discussing an innovative technology for diagnostics and technique for fault detection of the pipelines transportation. The technology has been developed on the basis of the acoustic-emission method for forced response, implying diagnostics of freight pipelines. It will ensure pursuing nondestructive control as well as prompt/precise revealing, classification, definition of the nature, geometrical sizes and location of defects.

Acoustic response of both electronics crystalline structures and their phase bonds allows to determine the value of the cyclic crack growth resistance; repeated correlation of the above structures with kinematic diagram of failure make for adequate predicting the remaining life.

Key words: pipeline, diagnostic, spectrogram, acoustic sensors, residual life.

Introduction

We has attack a problem by methods a novel and unique technology for nondestructive testing of metal construction - Compulsorily Induced Acoustic Emission Technique (CIAET).

The proposed inspection method is based on the physical effect of compulsorily induced acoustic emission. CIAET is recording spectral densities of acoustic-emission signals, induced as a response of microstructure of tested object on external excitation by quantum's of acoustic energy - phonons. CIAET analyses the changes of frequency characteristics of induced AE signals in 6 different frequency ranges: 4-434 Hz; 440-1800 Hz; 1800-2700 Hz; 3400-4500 Hz; 4800-5700 Hz; 6200-7100 Hz.

Main Part

Metal tends to progressively degrade during the facilities' operation life, particular transporting metal pipeline, which may lead to formation of micro cracks, segregation, corrosion, surface pits, structural liquefactions etc. Breakdown of metal continuity at different stages of metal degradation is accompanied by specific shift of the resonance frequencies of induced AE signals against the etalon values of frequencies for intact metal. Values of frequencies for different types of intact metals are determined and are used in CIAET as etalon values for identification of deviations related to metal degradation. The shifts of resonance frequencies against etalon values are specific for different types of degradation processes. The shifts of resonance frequencies within each of 6 mentioned frequency ranges, recorded during CIAET testing, carry specific and complementary information about structural changes of the object. The identified functional correlation between the mentioned frequencies and physical-mechanical properties of the metal enables us to determine almost all of the known physical-mechanical parameters of the material, used for description of flaw development. Therefore, the performance capabilities of the CIAET are not limited to the detection of defects and their location, however by using sophisticated algorithm, it enables to assess character and nature of the defect, make prognosis of flaw development and estimate residual life of the object with 95% accuracy.

The testing method comprises a complex algorithm and corresponding software to enable automation of the process of spectral analysis and data interpretation as well as provide in under-friendly format a data on the size and location of defects, intensity and character of degradation, as well as the residual life of the object. Information is provided on display in a form of tables, diagrams and spectrograms [1].

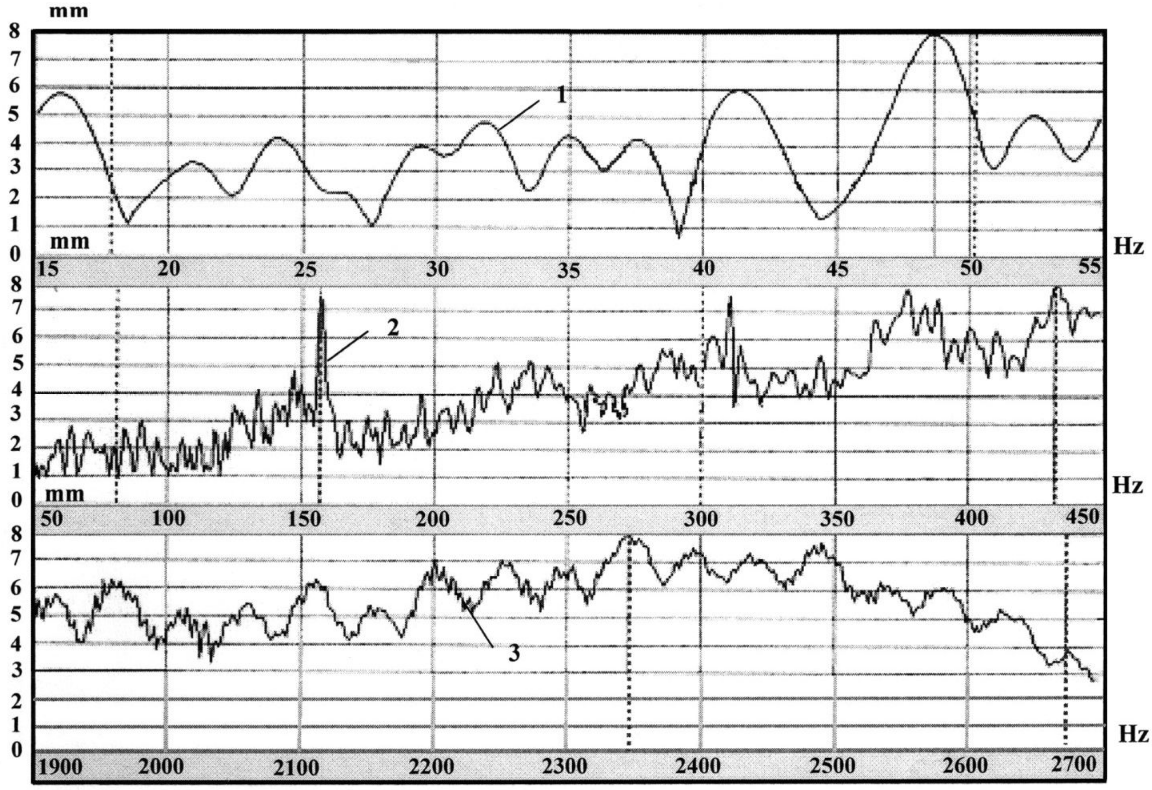

Fig.1 - Spectrograms of information frequency ranges, in which structural forms of metal phase composition are estimated: 1-17,82-50,2 Hz - that characterizes development of screw dislocation, low-cycle fatigue in the type of pitting, pits, speckle segregation, secondary structures along grain boundaries and so on; 2-81,67-433,9 Hz - that characterizes development of edge dislocation, exfoliation in the type of snowflakes, sinterskin and so on; 3-1899,66-2674,25 Hz - that characterizes intensity and coherence of free motion oscillations, crack development in the type of structural segregation, zone segregation of coarse grain, slaty fracture and so on

Shows spectrograms of information frequency ranges in which structural forms of metal phase composition are estimated, which are recorder by means of analysis technique of structural alteration (CIAET)

Inspection procedure implies the attachment of the acoustic sensors (e.g. “KD-43,70” of Danish company “Bruel & Kjaer”) to the surface of the test-object and recording of the AE signals induced as a response on external acoustic excitation. External acoustic impulse is provided by means of a hammer with special focusing system like Fresnel’s zonal screen. It is focused on object’s segment, remote from the attached sensors. Recorded signals characterize cross-section of the strip (sector) of metal between the sensor and point of application of the acoustic impulse. During inspection of metal surface, acoustic impacts are introduced step-by-step, e.g. at an interval of 0.1 m, when the maximum length of tested strip is 450 m. The elements of the object disposed orthogonally to the scanned surface are subject to a separate test.

CIAET Advantages Versus the Convention Methods of Inspection

The main objectives of the NDT control of metal constructions is early and reliable detection of flaws, determination of size and location of defects and estimation of failure-free service period after the testing of the object.

Currently, various NDT methods are used for diagnosis of metal constructions. Each of the methods has its strong and weak points. The most common technologies, used in standard inspection procedures, are:

- X-ray defectoscopy;
- Ultrasonic defectoscopy;
- Magneto-metric methods of flaw detection - set of metal diagnostic methods based on measurement of magnetic parameters, in particular - magnetic field strength and gradient of magnetic field strength. Most promising method from the assemblage of techniques is the "magnetic flux exclusion";
- Traditional method of acoustic emission.

Standard Methods of Defectoscopy

Inspection of metal constructions through application of X-ray, ultrasonic or magnetometric defectoscopy requires scanning of entre surface area of a test-object, a time consuming and expensive exercise when objects under investigation are massive and dimensional (e.g.: above-ground reservoirs, transporting metal pipeline lengthy segments of oil and gas pipelines or railway).

Furthermore, sections of the test-object, which are difficult to access for direct contact, can not be inspected by conventional scanning techniques.

X-ray, Ultrasonic and magnetometric defectoscopy could be successfully applied to inspect current state of metal constructions (identification, location and description of defects) but they are less effective and reliable in terms of estimating the object's residual life and determining its safe operational conditions [2].

Conventional Method of Acoustic Emission (AE)

Conventional AE method, unlike the above-mentioned methodologies. does not require scanning of surface of investigated object; consequently, access to the surface for scanning of large dimensions of investigated object doesn't limit the application of the mentioned methodology. In this respect conventional AE method has certain advantages as well as disadvantages and specific limitations.

Conventional AE testing implies "passive listening" to the object and (unlike Ultras method) does not intend to make active probing of structure by using artificially generated signals. During traditional AE testing, the amplitude characteristics of acoustic waves generated by developing defects are measured. Therefore, conventional AE method can help identify only those defects, that are being developed during the testing process, namely defects caused by active corrosion or micro cracks developing under the conditions of artificial loading of the structure beyond its service load.

Disadvantages of the conventional AE method:

- It can not be used for detecting mechanical defects (delamination, segregation, cracks, pits caused by metal loss, structural liquefaction etc.) unless a special loading tests is applied, when the structure is overstressed.
- It is characterized with "the absence of detectable acoustic emission until previously applied stress levels are exceeded". This is critical for reliable detection of defect-related AE signal for the tanks and pipelines, usually tested before commissioning in overloaded and overstressed conditions.
- It can detect only active corrosion. The method fails to identify corrosion-related defects if the active corrosion is stopped for the moment.
- It cannot be used for determining though-holes in either a tank floor or wall of pipeline unless they are actually leaking. It can't help detect holes plugged by sludge, debris, wax or insulation materials.
- The procedure requires isolation of a test-object from exposure to extraneous noise for the period of testing. For this reason, 6-24 hour prior to investigation, (depending on dimensions of reservoir) it is necessary

to close valves, switch off heating systems and mixer.

- Technology is based on measuring the amplitude characteristics of AE, which easily attenuate in the mass of material and actually present the least noise-resistant parameters.

Conclusion

The most essential advantage of CIAET technology, in comparison with all the above-analyzed NDT methods, is in its unique ability to identify not only the defects and their location but also to estimate with the 95% accuracy their residual life and safe service conditions. Therefore, CIAET enables to cut down expenses, necessary to keep serviceability of equipment.

Unlike ultrasonic, X-ray and magneto-metric defectoscopy, CIAET does not require scanning of entire surface area of the tested object. Correspondingly, an accessibility of the whole surface does not stand out as a limiting factor for application of this methodology, nor do large dimensions of inspected object lead to significant raise of the inspection prices. Consequently, in comparison with the conventional methods, CIAET offers obvious advantages when testing such objects as: floor and bodies of above-ground metal reservoirs and pipelines, metallic casings of aircrafts, submarines, nuclear reactors or spaceships, etc. Application of CAET enables to save expenditures and time and improve the reliability of testing.

CIAET testing is applied without the need of putting the object out of service as well as expensive and time-consuming preliminary preparatory works (e.g. opening and cleaning of tanks).

Principal distinctions of CIAET versus the conventional AE method:

- Unlike traditional AET, which does not imply active probing of the structure, it measures the response to an artificial and repeatable acoustic excitation (2-4 Hz).
- Unlike the traditional technique (AET) focused on amplitude characteristics, which attenuates in material, the CIAET is analyzing changes of the frequency characteristics (most noise-proof parameters) in 6 different frequency ranges.
- Unlike traditional AET mainly dealing with transient signals, CIAET is analyzing frequency characteristics of con tenuous AE signal.

Advantages of CIAET versus the Conventional Acoustic Emission method:

- CIAET is used for flaw detection (corrosion, segregation and delamination, cracking, structural liquefaction. pits, micro cracks of welding joints), without need of putting the object under any additional loading tests.
- The CIAET can defect corrosion-induced defect even if the active corrosion is stopped for the moment of testing.
- CIAET enables to detect pipeline taps and reach-though holes in bodies and floors of reservoirs even when they are isolated by wax, sludge or insulating materials and no actual leakage occurs.
- CIAET enables to inspect sections of underground installation (e.g. reservoirs and pipelines) difficult to perform by conventional AE methods.
- CIAET, versus the conventional AE method, does not require isolation of test-object from extraneous noise exposure for the period of testing. Consequently, there is no need for closure of valves, switching off the heating systems and tank mixers at the beginning of performance.

CIAET enables to determine almost all of the known physical-mechanical parameters of the material, used for description of metal degradation and flaw development, and consequently guides fundamental information regarding detected defects, like:

- Information on character of defects and degradation process (mechanical defect or corrosion, type of corrosion etc.)
- Prognosis of defect development and estimation of residual life (residual life accuracy is improved up to 95%) [3].

The CIAET analysis of positive and negative parameters, elaborated by us, proved that it constitutes the update method and has incontestable advantage with respect to already known prototypes.

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ДИАГНОСТИКА И ТЕХНИКА ДЛЯ АНАЛИЗА ТРУБОПРОВОДНОГО ТРАНСПОРТА

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В статье обсуждается инновационная технология диагностики и техника обнаружения неисправностей транспортных трубопроводов. Технология была развита на основе акустическо-эмиссионного метода, применительно к диагностике грузовых трубопроводов. Это будет гарантировать неразрушающий контроль вместе с быстрым и точным выявлением, классификацией, определением характера, геометрических размеров и местоположения дефектов. Акустический сигнал кристаллических структур позволяет определять значения циклического сопротивления; повторная корреляция вышеупомянутых структур с кинематической диаграммой отказа позволяет адекватно прогнозировать статочный ресурс трубопровода.

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