QUALITY CONTROL OF MULTI-PASS WELD BY MEANS OF ACOUSTIC EMISSION

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Abstract: *The article proposes a method of assessing the quality of multi-pass weld by acoustic emission. The AE method involves the identification of developing defects at the stage of stress changes in the material, as well as in the statically loaded state. In the process of control two independent data collection systems were used, which worked in the process of testing synchronously. The selected method of control of the object has a number of advantages over other methods of NDT.*
KEYWORDS: *ACOUSTIC EMISSION, WELDING JOINTS, PROPAGATING DEFECTS, DATA ACQUISITION SYSTEM.*

Introduction

Currently, it is more and more popular the NDT method of welding structures elements technical condition assessing by the physical principles of acoustic emission. The main advantage of this method is its integrality without binding at the first stage to a specific place and fixing the health as "there **is** a DEFECT-**no** DEFECT" in a certain zone. After that, the decision is made quickly, for example, in the control of multi-pass welds in thick-walled structures, to eliminate defects with a minimum amount of metal sampling. However, this method requires real-time analysis and multy information that is coming in with high intensity, which is not always feasible. So there is the risk of losing some data on the further study of the defect, its nature, root cause and level of danger (maintainability)[1].

Research technology

The object of the research is multi-pass welding seals as butt straight joints of the bridge support pylon section (Fig. 1). The object of study is made by welding cylindrical cones of steel grade S355NL - analogues (USA A656, Russia 17Г1С, 17ГС). After welding, the quality is usually controlled by traditional non-destructive testing: visual, magnetic, ultrasonic, and radiographic.

Fig.1 *Test Object*

To compare the effectiveness of the NDT methods, we will additionally check the object by the acoustic emission method. [1]

AE data acquisition system

With the aim of obtaining acoustic emission data during the checking, there are used two independent from each other data acquisition systems, which operated simultaneously in the testing process (see figure 2, 3):

1. AE data acquisition system Lel / A-Line 32D (DDM) / - DIGITAL A-Line 32D. This is multi-channel AE data acquisition modular system

Fig 2. *Portable AE data acquisition system A-Line32D*

2. Mobile data acquisition system Physical Acoustics Pocket AE with outer preamplifiers 40dB

Fig 3. *Portable AE-Station Pocket AE-2*

The Pocket AE has only one recording line. The pickup gauge has been installed on outer surface of test object. (Fig. 4/1, left).
The A-Line System has two AE signals recording lines: the first pickup gauge has been installed on the outer surface of test object (Fig. 4/2), and the second - on the inner surface (Fig. 4/3), nearby the welding seal. [3]

Fig 4. *The pickup gauges disposition on the test object.*

Each AE pickup gauge has its own channel line and has been mounted on he surface by magnetic holder.
The test program included three stages
1.Lifting the object from the support with a crane
2.Keeping the object for 10-12 minutes
3. The descent of an object on a support
The AE method assumes the identification of propagated defects at the stage of stress changes in the material, as well as in the statically loaded state.[2]
Changing the load is occurred during the change in the direction of deformation of the object. The test object has round in section, mass near 2 tons. Under its dead weight the pressed and bending loads are originated along the vertical axle.

(Fig 5.)

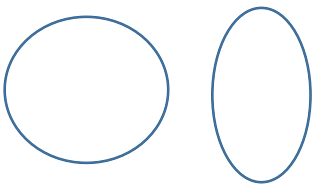

Fig. 5. *The test object section deformation mode, then it sits on surface (left) and hangs (right) .*

Then hang position the mode of load is changed. Under dead weight the pressed and bending loads are originated in horizontal axle of test object. Under the load changing any defects in existence generate the AE signals. Inspecting the AE characteristics, such as dynamics, amplitude etc., it is possible to reveal, identify and, if necessary, to locate the defect in test object.
After the lifting stage (12 sec), there is the static holding stage during 600 sec. All the time AE signals have been recorded. Some detected AE signals have proved the existence of probably AE origins.
During final checking stage the test object is moved down on supports in horizontal state. The load changing occurs in opposite order, than in the first stage. The unbend and spread stresses changes the compressed and bending ones. Also the AE signals are recorded.

Results of AE NDT

The picture of AE impulses during the experiment #1 (until the section of test object was rotated to 90^0), recorded by Mistras Pocket AE-2, channel #1.
The Test Results (the data line of Pocket AE)

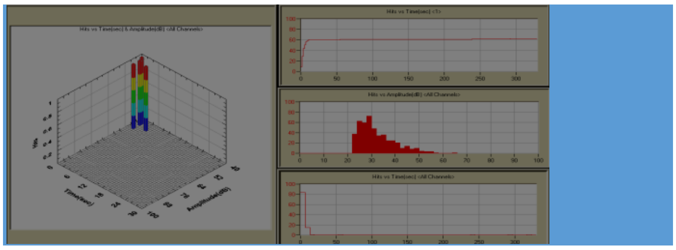

Fig.6*. Left: the AE intensity and amplitude versus time*

Right-upper: AE-summing versus time;
- center: AE impulses amplitudes frequency;
- down: AE intensity versus time

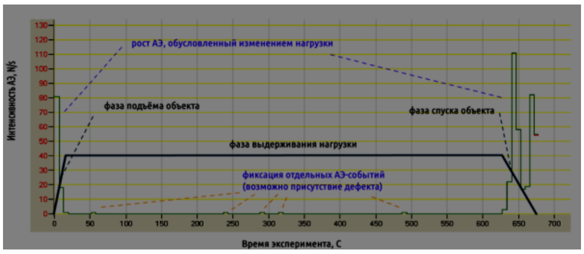

Fig. 7*. The Test object loading and AE intensity. Experiment #1*

The test program included three stages
1. Lifting the object from the support with a crane
2. Keeping the object
3. The descent of an object on a support

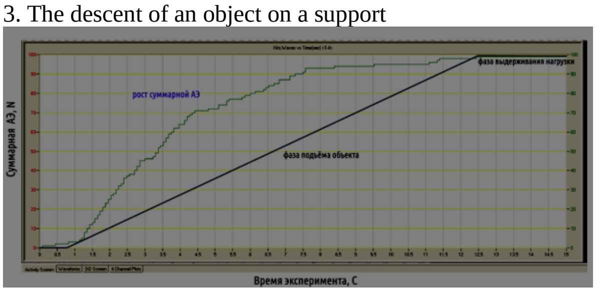

Fig. 8*. The Test Object loading and AE intensity during Test Object lifting (experiment #1)*

From the first second the acceleration of the AE-intensity growth is observed (α-criteria) [5]. From the second 13 of the beginning of test object holding-off two step-up stages of AE-intensity (Pocket AE) are observed (secc. #640 and #670).

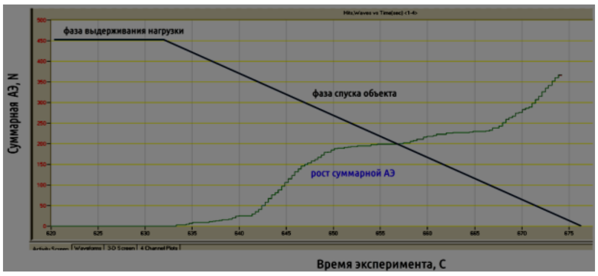

Fig. 9*. The test object loading and AE-intensity during its descending (experiment 1, Pocket AE).*

After the first experiment, the test object was rotated by 90 grad around the longitudinal axis and the tests were repeated. It is necessary in order to identify possible defects that did not revealed due to a possible difference of the mutual direction of the proposed crack contour and the vector of the applied load.

The test object checking results (A-Line System).

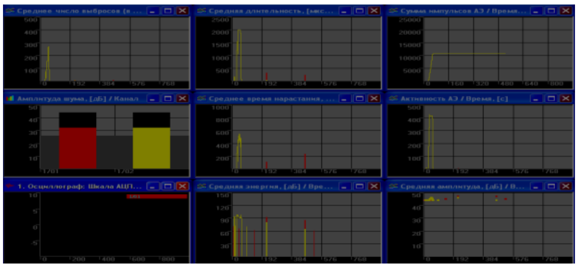

Fig. 10*. Diagrams of AE data plots (A-line system, first experiment, till test object rotation.).*

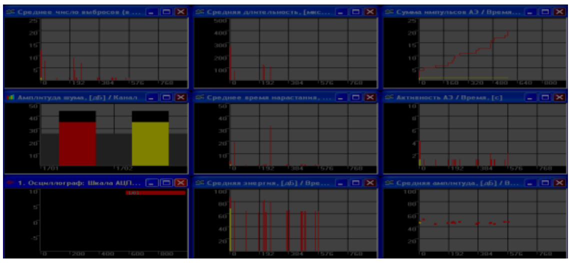

Fig. 11*. Diagrams of AE data plots (A-line system, second experiment, after test object rotation.).*

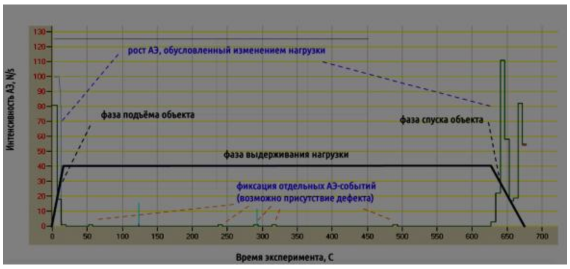

Fig 12*. The Test object loading and AE intensity. Experiment #1 (A-Line).*

Comparing the A-Line and Pocket AE sistems pickup data their agreement is observed.
During experiment following AE-signals data are registered.
- amplitude,
- intensity,
- AE impulses summing

At the stages of test object lifting and descending on the support AE average (dozens of impulses per second) intensity was observed. The nature of the total AE-summing is different. At the stage of lifting, the total AE diagram has only one characteristic pronounced break-point, while at the stage of descent — two

stages. This may indicate the presence of fine heterogeneity in the material of the object.
At the stage of test object holding no intense emission was observed. Single events that occur within 600 seconds of the experiment do not carry information about the presence of dangerous heterogeneity that propagated over time. This emission is normal for a homogeneous material.
Additionally the welded sample was checked by visual and ultrasonic method

Results of visual and ultrasonic NDT checking
Under visual-measuring check of welded joint defects have been not identified. Ultrasonic scanning was carried out along the entire length of the weld, after the closing of welding within up 40 hours [4]. The results were obtained by using USM 35 XS ultrasonic flaw detector. Angle beam transducers of transverse waves are used to scan, the dimensions of the piezo-element 14x14 mm, frequency 2 MHz, with input angles of 45º, 60º and 70º, and also the direct transducers of longitudinal waves were used. The dimension of the piezo-element 6x20мм, a frequency of 4 MHz and a piezo-element with a diameter of 24 mm 2 MHz, the tuning was performed on the lateral drilling with a diameter of 3 mm. In the zone specified by of acoustic emission checking, the indication at a depth of 12 mm with a signal amplitude +3 dB conditional length of 10 mm in the analysis of the characteristics of the signal was revealed, it was determined as the indication of the defect spherical shape

See Fig. 13.

***Fig. 13.** The pickup data of ultrasonic NDT*

Summary
The proposed method of the object checking has some advantages over methods of NDT. The time of preliminary assessment of the technical state of the object practically coincides with the time of the experiment. Taking into account the preparation and tuning of the equipment, it took about 30 minutes to check the object. The method does not require the use of dyes, powders, ionizing radiation. The inspection process does not involve the use of consumables or cleaning of the object after the experiment. At the same time, short-term use of lifting or loading equipment (crane, Jack, etc.) is required.
Tests have shown the presence of heterogeneity of the material, manifested under dynamic loads, but not detected in a static state. To localize this heterogeneity a re-AE-experiment with the number of sensors not less than 4 is required. Such experiment is possible with the use of the A-Line 32D system and does not require additional AE equipment. For classification of heterogeneity to the class of hazardous or non-hazardous, other NDT methods are required, which is confirmed by the data obtained as a result of ultrasonic scanning.

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