CONSTRUCTION FEATURES OF AUTOMATED SYSTEMS FOR ULTRASONIC TESTING OF SHEET AND PROFILED PRODUCTS WITH THE USE OF ELECTROMAGNETIC ACOUSTIC TRANSDUCERS (EMAT)

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Abstract: The report introduces the principles of construction and engineering solutions, which the automated systems for non-contact ultrasonic testing of sheet and profiled products are based on. It also gives the types of EMATs for different purposes and their characteristics. Construction and parameters of basic elements, blocks and units of the electronic-acoustic equipment are considered as well.

Introduction: At present several metallurgical plants of Russia and the Ukraine use more than 30 automated systems for non-contact ultrasonic testing of sheet and profiled products with the use of the EMAT manufactured by the Russian company "Nordinkraft".

These systems provide high-performance ultrasonic testing of metal production in a wide range of temperatures from – 40º C to + 650º C.

The flaw detection part of each installation is a well-organized firmware system that consists of three main parts – a set of EMATs with a magnetization system, receiver-generator equipment of the flaw detection electronics and an industrial computer with digital signal processing units and dedicated software.

The electronic equipment provides the amplitude of probing pulses of EMAT up to 2÷3 kV at a frequency from 500 kHz to 5 MHz. Magnetic field induction in a gap between a test object (TO) and an EMAT can be from 0,1 to 2 T.

Digital signal processing provides for using algorithms of matched filtering, coherent and incoherent accumulation, noise immunity from industrial pulse fields created by electric installations in a work shop.

All this allows one to reach a high signal-to-noise ratio (up to 50 dB) and testing sensitivity, which is enough for performing ultrasonic testing of sheet and profiled products in accordance with most international codes and standards.

Results: Let us consider some features of constructing of UT systems with the EMAT in terms of sheet metal testing.

For detection of laminations and other imperfections of sheet metal (up to 12 mm) the EMA-systems exciting SH-polarized waves proved to be especially good.

The waves mentioned propagate in the body of a metal in the transverse direction of a sheet or a strip at an angle of 90º to the side edges. The signal reflected from the sheet edge is considered as reference signal.

For testing of plates from 6 mm to 60 mm preferable are the EMATs that excite transverse vibrations propagating at the right angle to the surface of a sheet.

Discussion: At that the polarization vector of vibrations can be along or across the direction of rolling.

To test plates with loose scale, a two-line arrangement of EMATs [1] is used, and for providing a 100% coverage a two-line EMAT arrangement in staggered rows.

If a transmitter-receiver EMAT is used for exciting and receiving ultrasonic vibrations, a 2-3 μs dead zone appears after a probing pulse. Therefore, as a rule, testing of sheets is performed in the second interval between the first and second back wall echoes [2].

The first interval can be used when the EMATs are located on two sides and the thickness of a sheet is more than 8 ÷10 mm.

In order to decrease friction in the gap between the EMAT's protector and the surface of a sheet, 4-5 atm compressed air is used. Therefore, the EMAT slides on the air cushion without scratching the surface of a test object.

The EMAT's active zone is from 15 to 20 mm. The number of EMATs in a system depends on the width of a sheet and density of testing. In particular, for a sheet 4800 mm wide the system Sever6-08-5000 operating in the town of Kolpino (Saint Petersburg) uses 272 EMATs.

Results: When testing profiled products, two types of EMATs are usually applied – for detection of surface imperfections and for detection of internal flaws.

The EMAT for detection of surface imperfections is a periodic array of current-operated elements with a pitch equal half of the wave length of radiating vibrations. Such EMAT construction allows one to effectively excite surface (Raleigh) waves and transverse SV-polarized waves propagating at an angle of 30-40°. At that the frequency of excited vibrations comes to 1…1,5 MHz, with the gap between the EMAT's protector and the surface of a test object being up to 1,0 mm.

For detection of internal flaws in profiled iron, we use EMATs that generate transverse waves with the polarization vector directed along the test object. At that the frequency of generated vibrations is chosen depending on the structure noises of a test object and usually comes to 2…3 MHz.

Discussion: To provide a 100% coverage of surface imperfections in bars and billets, it is enough to mount from 2 to 4 EMATs along the perimeter of testing. The TO can move linearly relative to the TO.

To provide a 100% coverage of internal flaws the EMATs are arranged in pairs opposite each other and their quantity depends on the scheme of testing. If a TO moves linearly relative to the TO, then the number of EMATs may come to 80 and more at the diameter of a TO up to 300 mm. If a TO or an EMAT rotate, then the number of EMATs is defined by the speed of testing. Particularly, at the speed of EMAT's rotation of 1500r/sec 32 EMATs will be needed to perform ultrasonic testing at a speed of 2 m/s.

Conclusions: In conclusion it should be said that successful application of EMATs in automated ultrasonic testing systems shows that in many cases the EMA-technique of exciting and receiving ultrasonic vibrations in a TO is preferable comparing with the conventional contact technique which uses PET. However, when designing such systems, it is necessary to take into account the features of physical processes, which underlie the EMA-transformation.

References: 1. Peculiarities of application of electromagnetic acoustic (EMA) transducers to ultrasonic testing of rolled stock. A. Kirikov, A. Zabrodin, NDT World № 1, 2002.

2. Sensitivity of the echo and echo-through methods of ultrasonic testing of sheet metal. A. Kirikov, A. Zabrodin, NDT World № 3, 2001.