NORDINKRAFT

The quality guard

EQUIPMENT FOR AUTOMATED ULTRASONIC TESTING OF PLATES

EMATEST-PL

MODERN TENDENCIES IN THE FIELD OF ULTRASONIC INSPECTION OF PLATES

Plates are the most commonly used and mass manufactured kinds of metallurgical products. The use of steel plates for making pipes of big diameters in the most important sectors of industry is the key factor that stimulates the development of world metallurgy.

An annual increase in the need for high-quality plates makes it necessary to intensify production, look for and rapidly implement new metallurgical technologies.

«Every plate that is going to have an important use must undergo 100% ultrasonic inspection» - this actual thesis reflects demands of the times and society. Prevention of man-caused disasters and a natural desire to live in harmony with the environment are the main reasons of rapid development of science and technology in the field of physical methods of product inspection.

An increase in the rate of plate production and stricter quality requirements involve the development of an appropriate complex of modern methods and means of efficient ultrasonic inspection.

A new generation of standards, norms and specific consumer requirements, rapid development of science and technology make the characteristics of ultrasonic testing equipment that were acceptable several years ago unacceptable now.

The table below shows modern tendencies and requirements for ultrasonic testing systems. Such systems are understood as means and methods (equipment) for ultrasonic testing of plates.

Characteristics of ultrasonic testing systems acceptable until recently (before 2003)	**Modern requirements for the technology and ultrasonic equipment for plate testing**	**Comment**
1. Random inspection: only part of plates from a lot had to be tested.	All plates for sale must be inspected.	This requirement became obligatory when automated ultrasonic testing systems technically capable of performing inspection on an industrial scale had appeared.
2. Strip inspection of plate body when only part of the surface is covered.	100% ultrasonic inspection of plate body is required.	In the future partial overlap of scanning (testing) lines is likely to be required.
3. Inspection of longitudinal edges only.	Inspection of both longitudinal and transversal edges.	See comment to item 1.
4. Inspection at final stages of plate production. Surface temperatures are below 100 °C. It is too late to make any influence on the technological parameters.	Inspection at the earliest possible production stages when one can influence the technological parameters. Surface temperatures are up to +650 °C.	Technical capability of performing ultrasonic inspection of hot materials allows one not only to simplify the rolling technology but to increase economic indexes of an enterprise on the whole.

5. Only internal defects could to be detected.	Internal, surface and subsurface defects can be detected.	This requirement makes UT methodology and the configuration of test equipment more complicated but at the same time increases the reliability of testing.
6. Range of surface temperatures from +1 °C to +99 °C.	Wider range of temperatures from – 30 °C to +650 °C.	The necessity is dictated by the requirements of stability and intensification of metallurgical and pipe production in continental climate
7. Manual inspection was acceptable to the final consumers of plates. The operator was allowed to make a final decision on the quality of the material.	Ultrasonic inspection is fully automated. Human factor is minimized or excluded.	The tendency is based on the necessity to exclude human factor. Physiological aspects of man sufficiently limit the efficiency and quality of ultrasonic inspection.
8. Only defects equivalent to FBH 5 were to be detected.	Defects equivalent to FBH 3 must be detected. Reflection factor is used more often for evaluation of defects.	Due to modern views on industrial safety, quality requirements for plates have become stricter. The reflection factor more precisely characterizes the danger of flat defects, which are most typical for plates.
9. Double inspection was required neither at the producer nor at the customer's. Ultrasonic testing on the producer's site of plates was considered sufficient.	Double inspection is becoming obligatory. Moreover, the inspection must be automated, with human factor minimized or excluded.	Double inspection allows one to exclude the risk of missing quite rare but unfavourably progressive defects, which might not exist when the «first» testing was being performed.
10. Producers rarely used the information obtained during the ultrasonic testing as a means of improving the quality of their products.	Information obtained during the ultrasonic testing is used as a means of improving the quality of products.	Manufacturers of final products more often require giving them access to the data on the quality of materials and component parts. And this tendency is yet to grow.

AUTOMATED AND AUTOMATIC ULTRASONIC TESTING SYSTEMS OF EMATEST-PL. CLASSIFICATION

The equipment for automated and automatic ultrasonic inspection of plates and strips produced by NORDINKRAFT is called EMATEST-PL.

Depending on the type of transducers, the systems for plate inspection are divided into:

- ***Conventional systems*** that use piezoelectric acoustic transducers (PET) and water as a coupling medium.
- ***Non-contact systems*** that use electromagnetic acoustic transducers (EMAT) and no water.

Practically all «wet» systems manufactured by Nordinkraft can have a «non-contact» design.

The systems based on piezoelectric transducers are constructively simpler and usually 10-20% cheaper than similar non-contact equipment.
Fig. 1 and 2 show EMAT units used for plate inspection.

Depending on their location, the systems are divided into:

- In-line (installed in the production line).
- Off-line (off the production line).

In the first case plates move under a stationary test unit. In the second case plates go to a special area, where a moving test unit performs their inspection. In both cases human factor is minimized.

When testing is finished, the system will print out a test report with the test results and a decision whether the tested plate is acceptable or not.

Depending on temperature conditions, the systems can be divided into:

- conventional (from +1° to +99 °C);
- with an extended range of test object's temperatures (from about – 15° to +250 °C);
- high-temperature (up to + 650 °C).

Only EMAT is possible in cases 1 and 2.

Depending on types of EMATs, the systems can be divided into:

- with one (common) magnet;
- with individual magnets.

Fig. 3 and Fig. 4 show the one (common) magnet solution. In this case a special electromagnet creates the magnetic field for all EMA-transducers. An EMAT line with magnetic circuits is part of the common magnetic system.

A system with individual magnets (see Fig. 5) uses powerful permanent magnets, which provide high technical and working characteristics. The system is designed so that the magnetic field switches off mechanically after the working cycle is over. The coverage of each EMAT unit with an individual magnet is a strip of 68 mm wide. Variation in sensitivity within this strip does not exceed ±1,5 dB. In the center zone of a plate 100 mm thick we can detect defects that are not more than 1,2 mm in diameter. This is a perfect result, isn't it?

Ultrasonic testing systems of EMATEST-PL are certified by GOSSTANDART of the Russian Federation and GOSSTANDART of the Ukraine and entered in the appropriate registers of measuring instruments.

Fig. 1. Four-channel EMAT unit.

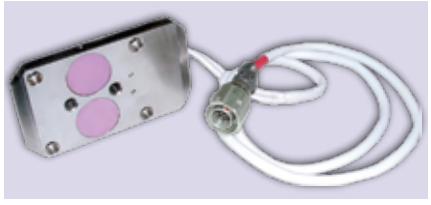

Fig. 2. Two-channel EMAT unit.

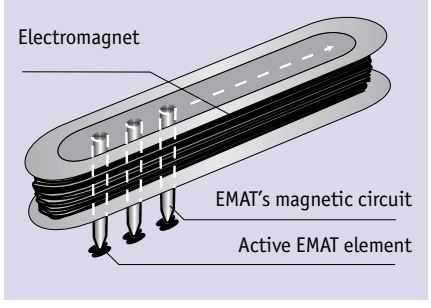

Fig. 3. Design with a common magnet.

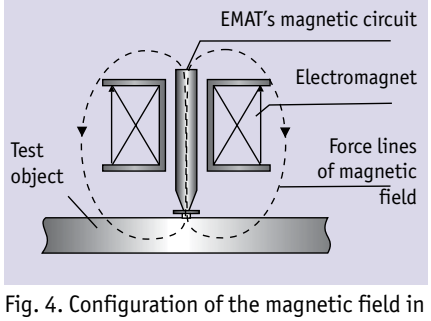

Fig. 4. Configuration of the magnetic field in the working zone.

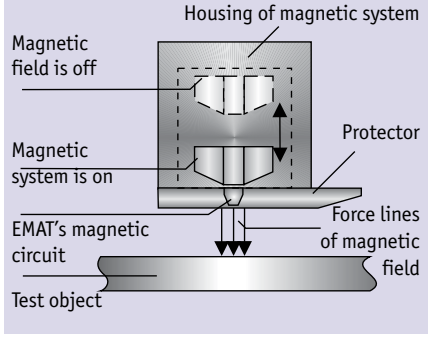

Fig. 5. EMAT design with an individual magnet.

EMATEST-PL. EQUIPMENT OF THE FIFTH GENERATION

The fifth generation of EMATEST-PL obviously has the best technical and working characteristics. This equipment does not only meet the latest norms and standards but also anticipates their changes in the future.

The equipment uses the EMAT with an individual magnetic system. Such a design makes it possible to essentially decrease the weight of a test unit as well as the inertia of the tracking system and increase the level of automation up to «Fully-automated».

The new type of transducers has given us the chance to raise sensitivity of flaw detection equipment.

The following example illustrates the highest noise-immunity of the new system.

A piezoelectric (or electromagnetic acoustic transducer) connected to an outside impulse flaw detector is put on a piece of plate in front of the transducer EMATEST-PL as shown in Fig. 6. Acoustical axes of transducers coincide that is why when both devices are activated, we can expect strong noise.

In fact, the screen of the flaw detector displays this noise as parasitic impulses with big amplitudes; these impulses make a defect signaling system of the flaw detector response continuously, which is proved by a flashing red light.

It seems incredible but the presence of another emitter makes absolutely no influence on the operation of the system EMATEST-PL. Its defect signaling system does not even «notice» the noise!

The new generation of EMATs show a great mechanical strength. Like for other ultrasonic systems for plate testing, air cushion protects transducers from wearing down. For the first time applied for this purpose compressed air (patents № 2258218, № 2247978 and № 2247979) perfectly protects transducers from high temperature.

The following example demonstrates the effectiveness of the air cushion. When air is not supplied, the EMAT presses to the plate surface so tightly that one can move it only by applying more than 500 H. When the pressure of 4 atmospheres is created at the input of a supply collector, it makes the EMAT slide over the plate surface. If the material had a perfectly flat surface, the protector could be considered «eternal».

NORDINKRAFT has manufactured and sold three systems of type EMATEST-PL. One of them is now in operation at «URAL STEEL» and «AMURMETALL», the other one was delivered to a foreign customer.

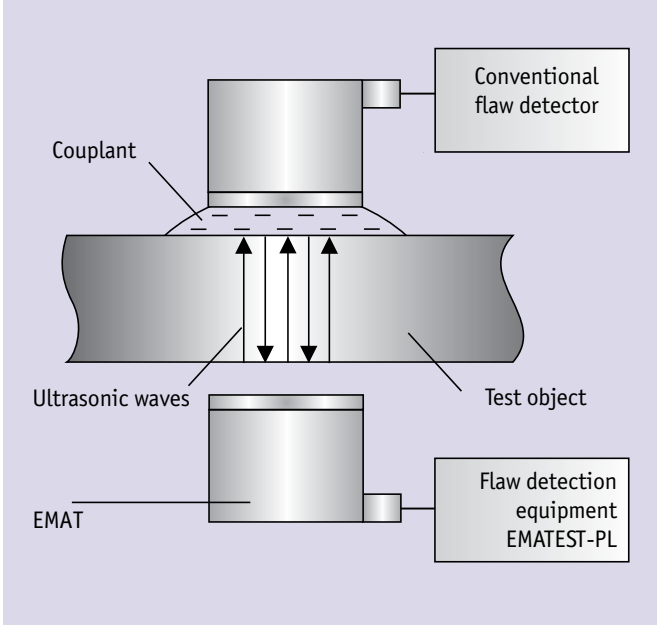

Fig. 6. Scheme of experiment.

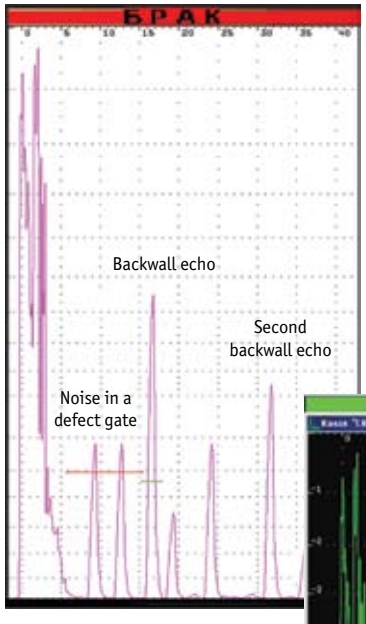

Fig. 7. Noise registered by a conventional flaw detector. No inspection is possible under such conditions.

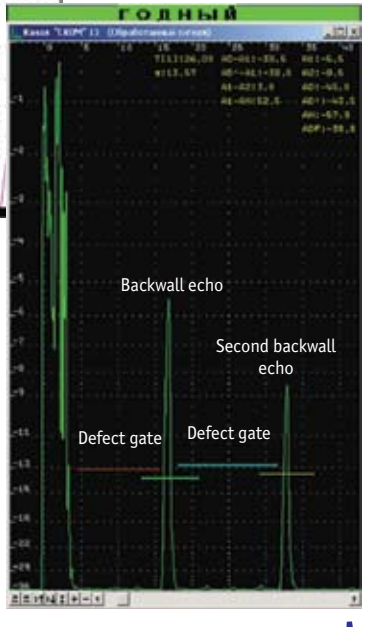

Fig. 8. EMATEST-PL screen when there is an influence of a conventional flaw detector. The noise suppression system.

OPERATING SYSTEMS FOR AUTOMATED ULTRASONIC INSPECTION OF PLATES AND TRIPS EMATEST-PL

A standard system for plate inspection consists of the following units:

- Multi-channel test unit with a set of EMATs (PETs) installed on a pull-out or scanning platform;
- Test electronics;
- Control Computing System to be located in an operator's cabin;
- Automatics and power supply;
- Auxiliary equipment (plate positioning and geometry measuring devices, pyrometers, television system, defect markers etc).

In each case the optimal configuration of equipment, type and number of ultrasonic probes are defined and agreed with the customer.

THE GEOGRAPHY OF EMATEST-PL

NORDINKRAFT has the richest and successful experience in developing, manufacturing, implementing and servicing the equipment of ultrasonic testing of plates and strips.

From 1997 to 2007 the company has designed, produced and put into industrial operation fifteen (!) systems for automated ultrasonic inspection of such products.

These systems are in operation in plate rolling shops of JSC «Severstal», JSC «Volzhsky Pipe Plant», JSC «Magnitogorsk Iron and Steel Works», OJSC «Alchevsky Iron and Steel Works», JSC «Ural Steel», JSC «Amurmetall».

Another system of the latest design EMATEST-PL was produced for a steelmaker in Japan.

Fig. 9. Plate testing system EMATEST-PL – Magnitogorsk Iron and Steel Works (Russia).

Fig. 10. Plate testing system EMATEST-PL – Plate rolling shop-3, Severstal, Kolpino (Russia).

Fig. 11. EMATEST-PL – Plate rolling shop-1, Severstal, Cherepovets (Russia).

Fig. 12. EMATEST-PL. Test assembly in the company's workshop before shipment.

Fig. 13. Test unit of EMATEST-PL. EMATs with individual magnets – Ural Steel, Novotroitsk (Russia).

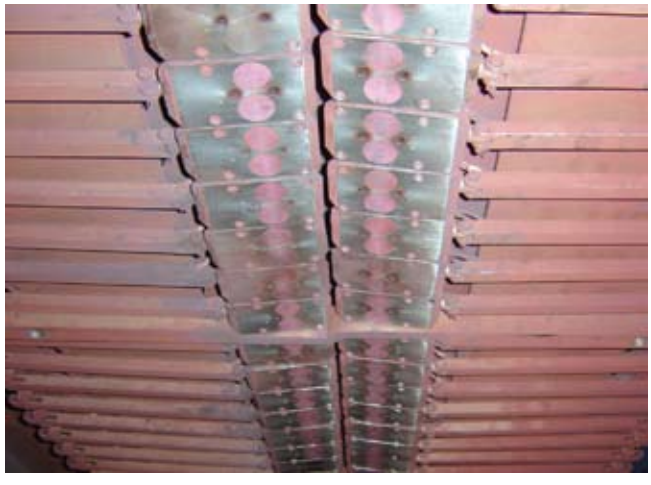

Fig. 14. Test unit of EMATEST-PL. EMATs with a common magnetic system – Alchevsky Iron and Steel Works, Alchevsk (Ukraine).

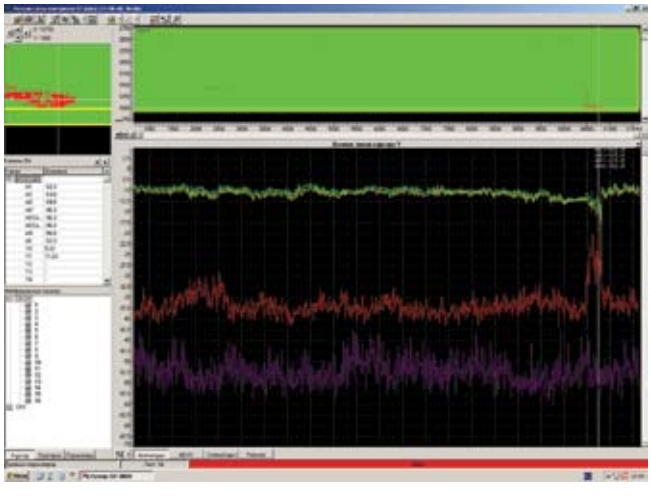

Fig. 15. Test report of a plate and a record of signal amplitudes in a selected channel.

Fig. 16. Signal oscillogram in a lamination area.

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