NORDINKRAFT
The quality guard

EQUIPMENT FOR AUTOMATED ULTRASONIC TESTING OF PIPES OF BIG DIAMETERS

EMATEST-PIPE

INTRODUCTION

Unlimited penetration of scientific and technological progress into different spheres of human life, its increasing rate require permanent development of means and methods, scientific and application achievements that give an impetus to quantitative and especially quantitative growth of production, which is realized on the basis of universal information technologies.

Modern quality and life protection standards define the specific of building and modernizing gas and oil pipelines, developing new mines, and make high demands on the quality of tubes and pipes in the 21st century.

Today production of pipes and tubes is inconceivable without advanced methods, inspection and quality control facilities. To the most important and reliable non-destructive methods of testing of tubes and pipes we can refer ultrasonic inspection. Wide use of ultrasonic inspection equipment is one of the latest and most effective means of improving their quality.

ULTRASONIC TESTING EQUIPMENT OF EMATEST-PIPE AS A MEANS OF REALIZATION OF THE LATEST AND MOST EFFECTIVE ULTRASONIC INSPECTION TECHNOLOGIES

NORDINKRAFT has a wide practical experience in development, design and implementation of complex equipment for automated ultrasonic testing of big-diameter pipes. Such systems are produced under the name of EMATEST-PIPE.

- The EMATEST-PIPE equipment can be used in the production line of any modern pipe plant and perform effective ultrasonic inspection of both longitudinal and spiral welded pipes made from carbon and alloy steel grades.

- The EMATEST-PIPE equipment meets the strictest contemporary norms and standards such as DNV-OS-F-101, EN 10208, API 5L, ISO 3183-3:1999(E), GOST R 52079.

- The objects to be tested are the weld, the heat-affected zone, pipe ends and the pipe body if necessary.

- Such equipment performs inspection of longitudinal and spiral welded pipes from 500 to 1420 mm in diameter with the wall thickness from 5 to 25 mm. These are the most typical pipe dimensions although they are not the limit.

CONFIGURATION OF A EMATEST-PIPE

FLAW DETECTION

A EMATEST-PIPE can be equipped with 3 relatively independent flaw detection units:

- Inspection of the weld and the heat-affected zone.

- Inspection of pipe ends.

- Inspection of pipe body.

The configuration containing the first two units is the most common.

ULTRASONIC TRANSDUCERS

Ultrasonic transducers are located on measuring modules. Each measuring module (unit) is functionally independent and can carry a set of 40 ultrasonic transducers. Besides a set of transducers, the module carries the elements and sensors of a weld tracking system, pneumatic equipment, executive devices and mechanisms. If inspection of the pipe body is required, it is not enough to have only one measuring module. Moreover, two measuring modules can be used during simultaneous inspection, when pipes are transported in two parallel independent flows.

Ultrasonic testing system can use 3 types of transducers:

- Conventional piezoelectric probes (PEP).
- Phased array probes (PA).
- Electromagnetic acoustic transducers (EMAT).

The type of transducers to be used depends mainly on the production conditions and the choice of the customer.

Fig.1. Piezoelectric probe for weld inspection.

Fig.2. Electromagnetic acoustic transducer for weld (1,0 MHz) and ends inspection (5,0 MHz).

Fig.3. Piezoelectric phased array for weld inspection.

Piezoelectric discrete probes are more simple, understandable, available and inexpensive devices.

It should be noted that for weld inspection one needs quite a big number of these probes (16 and more PEP). Adjustment of such a system is not an easy task and requires high qualification of the personnel, experience and skills of team work.

Electromagnetic acoustic transducers are non-contact devices. No couplant is needed for their operation. The interaction with a test object is more stable due to electromagnetic forces. The EMAT is able to operate in a wide range of temperatures, for example, from – 30 to + 300 and higher. The speed of testing in the case of EMAT is several times higher than in the case of PEP. The sensitivity of EMATEST-PIPE is comparable with the equipment that uses conventional technology (PEP).

The EMAT though has its weak points in the detection of longitudinal defects, which are a relatively low reflection power that limits the range of wall thicknesses and a relatively narrow working range of excitation angles. This, however, does not influence the detection of transversal defects. As for the detection of laminations, the EMAT has superb characteristics.

Phased arrays – are state-of-the art probes with software-controlled ultrasound excitation angles. Their use for weld inspection is highly effective. A single PA allows one to replace a theoretically unlimited number of discrete PEP. The overall dimensions of a PEP and a PA are the same!

Adjustment of a PA-based system for another pipe diameter takes less than one minute. No repositioning or alignment of probes is required.

WELD INSPECTION SCHEMES WITH THE USE OF DIFFERENT TYPES OF TRANSDUCERS (BY THE EXAMPLE OF LONGITUDINAL DEFECTS DETECTION)

From the practical and economical standpoint, it is interesting and worthwhile to combine different types of transducers.

One measuring module as well as the whole system can use the following transducer combinations PEP + PA or PA + EMAT.

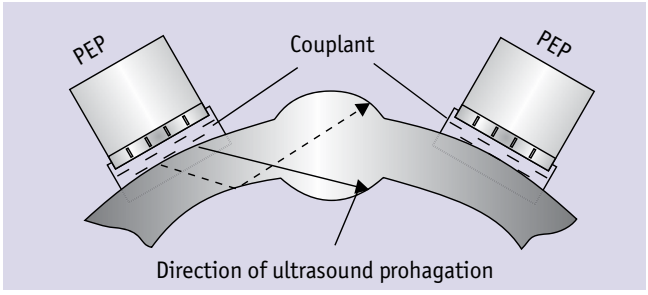

Fig.4. Weld inspection with the use of piezoeletric probes.

Detection of artificial longitudinal defects in a weld with the use of a PA that performs automatic electronic scanning within a specified angle is shown in Fig.9.

The measurements were taken on a test piece with a weld sample cut out of a longitudinal welded pipe 1020mm in diameter, wall thickness being 23,5mm. The minimum length between the neighboring defects along the weld axis is 40 mm.

The length between the weld axis and the PA was kept constant for all the measurements.

Parameters of a piezoelectric phased array:

- central frequency in the probing pulse spectrum – 4 MHz;
- nominal excitation angle at zero phase shift (in-phase excitation) – 65 degrees;
- ultrasonic beam swinging range - 35÷75 degrees.

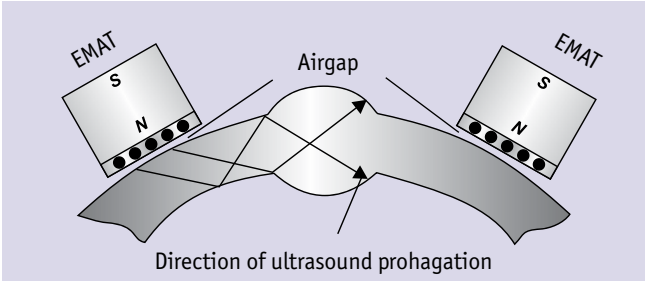

Fig.5. Weld inspection with the use of an eletromagetic acoustic transducer.

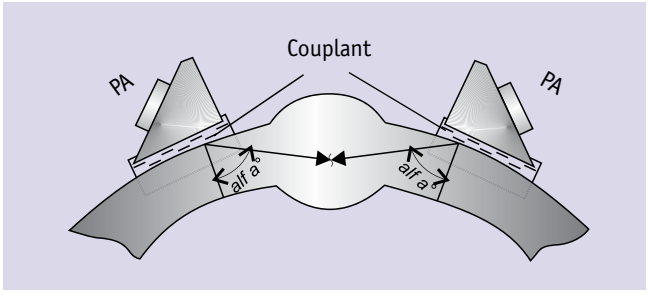

Fig.6. Weld inspection with the use of phased array probes.

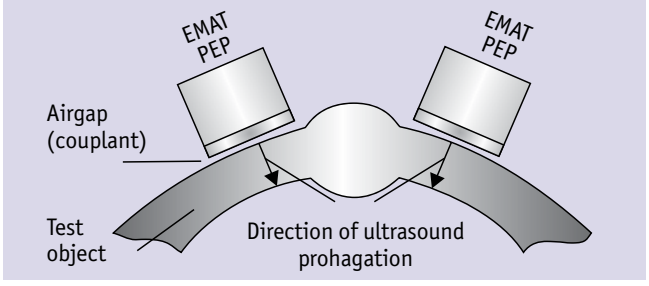

Fig.7. Inspection of heat-affected zone.

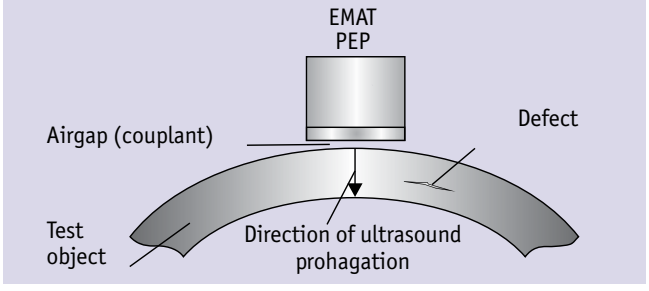

Fig.8,a. Ends inspection. Detection of laminations.

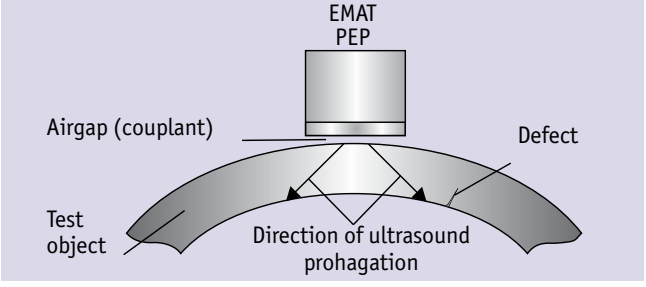

Fig. 8,b. Ends inspection. Detection of longitudinal cracks.

Longitudinal groove along weld axis 1mm deep on external surface of reinforcing bead	Through vertical hole 1.6mm in diameter on weld axis (detected twice)	Longitudinal groove along weld axis 1mm deep on internal surface of reinforcing bead (detected twice)	Axial hole 2mm in diameter in central part of weld (detected twice)

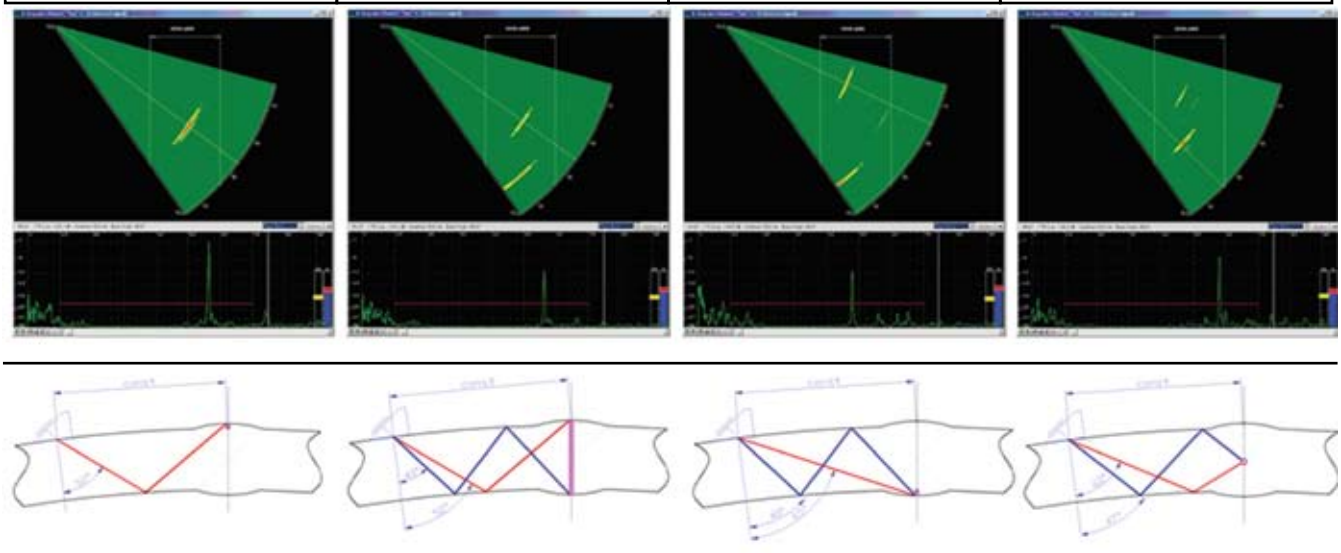

Fig.9. Example of detection of defects in a weld with the use of a PA.

TRACKING SYSTEM

The test speed that EMATEST-PIPE systems are able to reach when inspecting the weld, the heat-affected zone and the ends comes to 25 m/min! The quality of automatic tracking is perfect! A special system follows the weld and the pipe ends with high accuracy.

Due to a special construction of sensors and a patented algorithm, the equipment can provide the highest accuracy of scanning parameters maintenance. Position of a measuring unit is influenced neither by the weld shape nor by its geometry.

Besides physical weld tracking, the system uses a so-called «Method of virtual correction» of positional relationship of each transducer towards the weld axis. The method is patented. It makes the system more stable to occasional changes in position and geometry of the structural components of the weld joint.

All mentioned above determines high reliability of ultrasonic testing and a splendid repeatability of its results! The situation, when each third pipe is rejected for no reason, which is quite typical for many similar systems, practically never happens if one uses the EMATEST-PIPE-equipment!

AUTOMATICS AND CONTROL COMPUTING SYSTEM

All operations prior and during the inspection process are fully automated. The pipe is transferred automatically; «smart» manipulators define its borders and set the weld in «zenith» position. The operator does not even need to leave the operator's cabin in order to adjust the equipment for another diameter or wall thickness. The beams created by phased array probes are controlled by an intelligent electronic system.

All subsystems of the UT-complex are connected through a single control computing system that unites, coordinates and synchronizes their work. The control computing system controls information flows, organizes the testing process, collects, processes, presents and stores data.

AUTOMATED ULTRASONIC TESTING SYSTEMS OF EMATEST-PIPE IN OPERATION

For the last 10 years NORDINKRAFT has manufactured and put into industrial operation seven sets of equipment for automated and automatic ultrasonic testing of big diameter pipes.

Five systems for automated ultrasonic testing of longitudinal welded pipes are in operation at JSC «Chelyabinsk Tube-Rolling Plant».

Two systems for spiral welded pipes inspection are operated at JSC «Volzhsky Pipe Plant». In 2006 JSC «Volzhsky Pipe Plant» implemented a new modernized system EMATEST-PIPE. For the first time one system uses two types of ultrasonic transducers: electromagnetic acoustic transducers and piezoelectric phased arrays.

Fig.10. EMATEST-PIPE for spiral pipes inspection - Volzhsky Pipe Plant, Volzhsky (Russia).

Fig.11. EMATEST-PIPE for ultrasonic inspection of spiral welded pipes - Volzhsky Pipe Plant, Volzhsky (Russia).

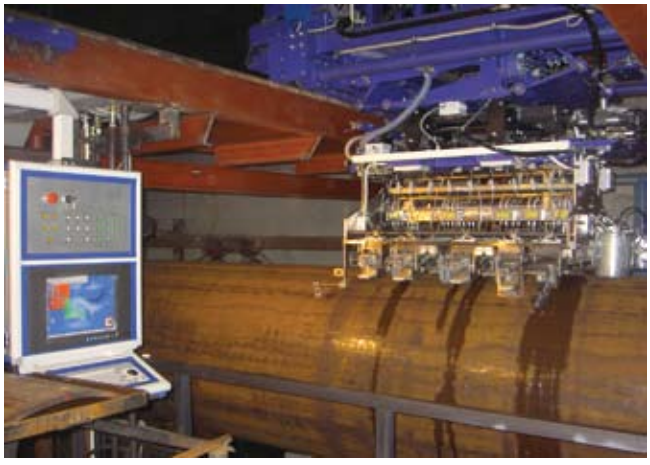

Fig.12. EMATEST-PIPE for longitudinal welded pipes. Two systems for acceptance testing EMATEST-PIPE are located in parallel with each other in the production line «1220» - Chelyabinsk Tube Rolling Plant, Chelyabinsk (Russia).

Fig.13. Control desk of the system EMATEST-PIPE - Chelyabinsk Tube Rolling Plant, Chelyabinsk (Russia).

Fig.14. EMATEST-PIPE for ultrasonic inspection of spiral welded pipes - Volzhsky Pipe Plant, Volzhsky (Russia).

Fig.15. EMATEST-PIPE for ultrasonic inspection of spiral welded pipes - Volzhsky Pipe Plant, Volzhsky (Russia).

Fig.16. EMATEST-PIPE for longitudinal pipes inspection. Two systems for acceptance testing EMATEST-PIPE are located in parallel with each other in the production line «820» - Chelyabinsk Tube Rolling Plant, Chelyabinsk (Russia).

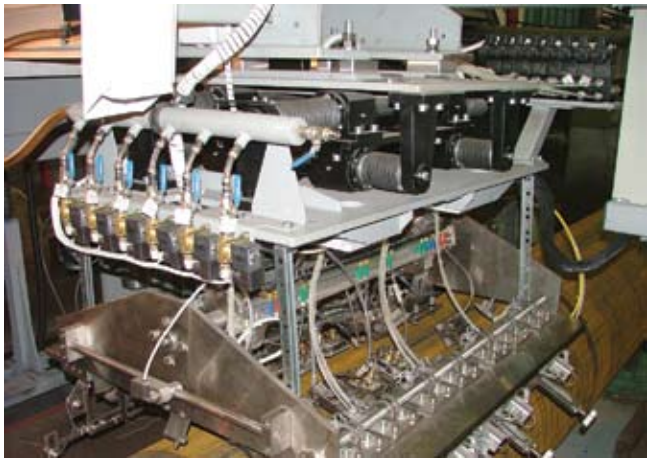

Fig.17. Measuring unit with phased arrays.

Fig.18. Measuring unit with electromagnetic acoustic transducers (noncontact).

Fig.19. Automatic system control panel EMATEST-PIPE.

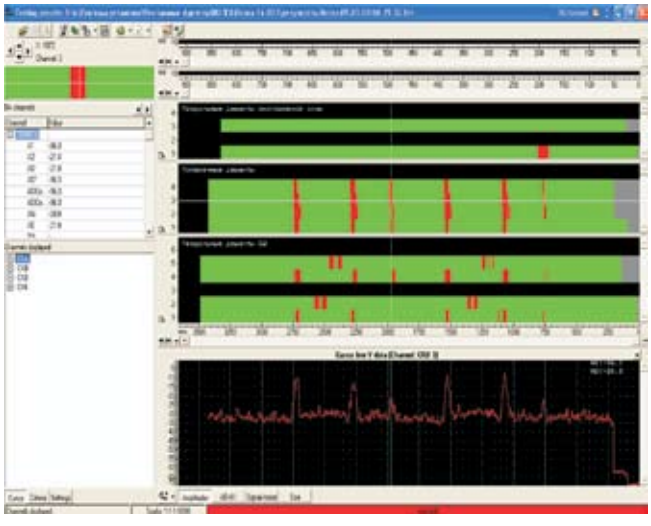

Fig.20. C-scan of pipe weld (test piece).

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