Automated system for non-destructive examination of tube plates

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Keywords

NDT, Eddy currents, tube pates, pipes, automated system

1. Introduction

Pipes from heat installations or heat exchangers from the component of energetic and chemical equipments are subjected to mechanical, thermal and chemical stress [1]. At the same time the pipes are subjected to continuous or long working conditions, thus, making it important to apply fast and safe methods to evaluate the technical state, simultaneous with periodic revisions, in order to highlight defects, degradation time evolutions, as well as the remaining work-life of the pipes [2-4].

The pipes round shape, characteristic for pipe fascicle equipments mounted in tubular rods, limits the access needed to investigate, in most non-destructive testing, NDT, thus, the main analysis method for mounted pipes, applied only in the case of non ferromagnetic materials is the electromagnetic method with Eddy currents [5].

Analysis performed using the electromagnetic method with Eddy currents is accomplished by a probe guided, successively, in the pipes interior, centered on their diameter [6-7]. The probe is equipped with one or more coils powered by alternative currents, with a frequency in the x10 ... x100 kHz range, which generates an electromagnetic field that inserts Eddy currents in the pipe materials. The different local discontinuities of the pipes change the Eddy current range in a characteristic manner, thus variations of the magnetic field resulted allow identifying defects by type and surface (length) [8]. The transmitter ca be the generating coil, the measuring coil, or, with both generating and measuring coils that work in an emission-receiver system. [9-10] The signal received is amplified, filtered and viewed on the cathode/digital oscilloscope by a phase-tension diagram, which is at the basis of the assessments, figure 1.

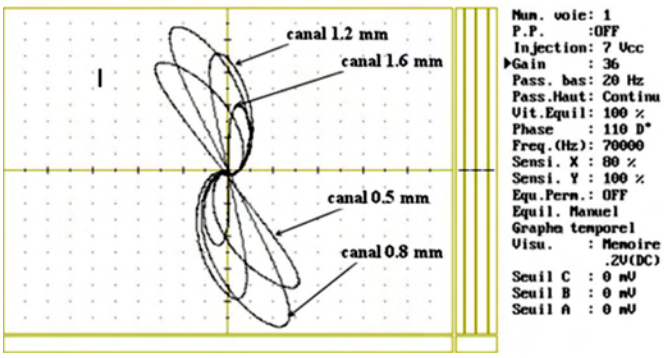
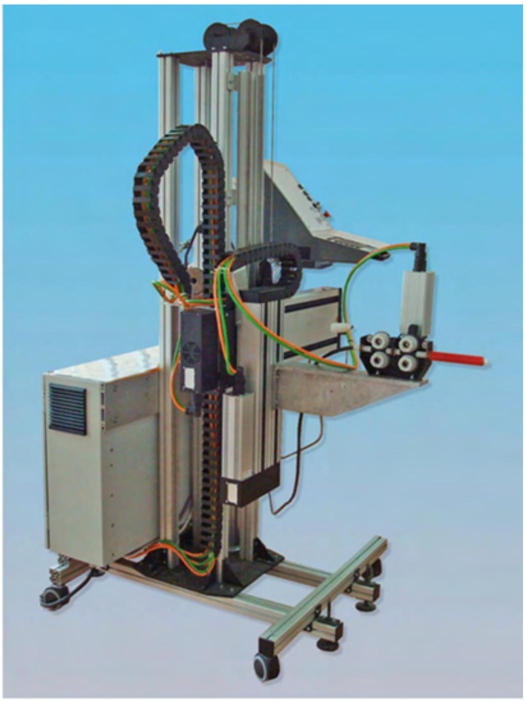


Figure 1. Oscilloscope phase-tension diagram for 4 circular channels

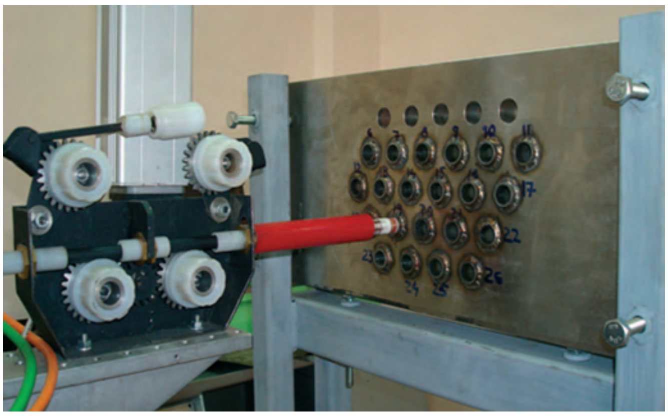
The NDT method allows the identification of surface defects (corrosion, mechanical wear, cracks, voids), separate for both interior and exterior of the pipes, being less sensitive to depth defects due to the surface effect id the introduced currents.

2. Equipment

In order to implement this type of testing, in the frame of a research program CEEX, a team of researchers from ISIM Timisoara (general assembly and the mechanical part), IFT Iasi (sensors, data acquisition and data processing) and ICPE–CA Bucharest (command center and the data mangement and processing center) developed the experimental model of an automated system that examines non-destructively pipes made from tubular plates, (figure 2).



a)



b)

Figure 2. Testing equipment.
a – general view, b – sensor and moving assembly

From a constructive point of view, the automat pipe analysis system is made up of three principle modules:

- Electromagnetic transmitter
- Transmitter positioning gear
- Command and control unit that has at is basis specific hardware and software for NDT analysis

Figure 3 presents the block scheme of the automated NDT analysis command system, which controls and monitors the entire process parameters and data control, interpretation and reception.

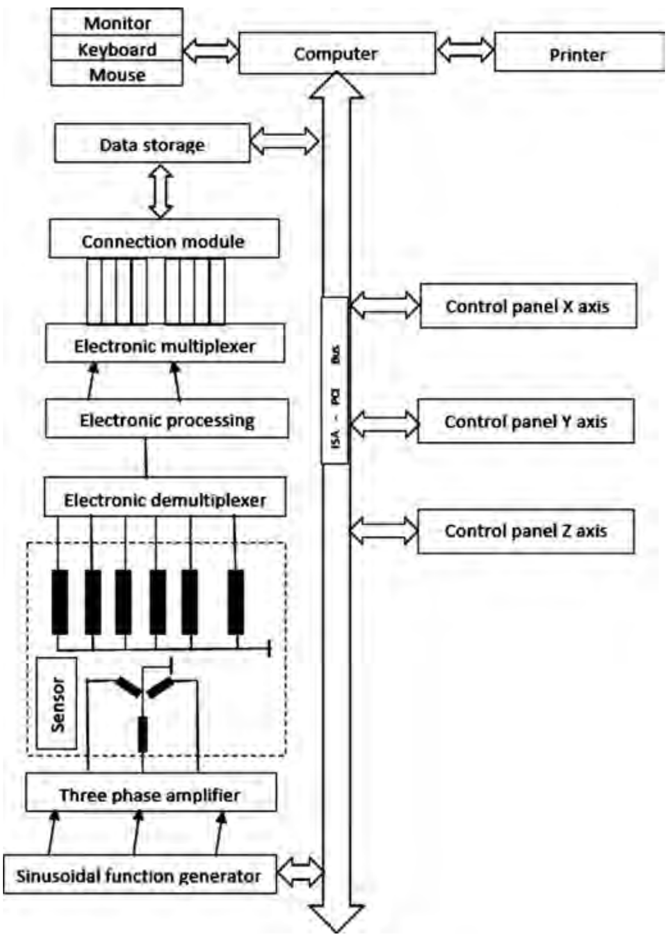


Figure 3. Block scheme of the NDT electrical command system

Examining pipes made from tubular sheets of the investigated installations is done within the pipes, the electromagnetic transmitter is successively inserted into the equipment pipes with the help of a guiding system at a constant speed; function to the systems performance the transmitter generates the correct sound. Between analysis sequences, the transmitter is stored in a support box. The exterior transmitted diameter must be choose function to the interior diameters of the examined pipes, thus the radial slack is minimal. In order to obtain a useful signal for the correct evaluation of the entire pipes section (the magnetic field depth reach), the magnetic current is shaped into frequency, covering a range of frequency through the multiplexer. The frequency range adopted in the development of the NDT pipe examination system is comprised between 1kHz…..2.5mHz. Signals are received and converted in digital signal with a 12 bits precision in order to process them through a ISA extension card. The transmitter has a semi-flexible electrical cord that contains both the power conductors and the signals delivered by the measuring coils.

3. Experiments

During 2018, whithin ISIM Timisoara, the research was continued, regarding the equipments ability as well as training qualified personel in NDT, on austenitic steel samples, made from pipe Ø 25x2,5 W-Nr 1.4301, according to EN 10.216-5, without weld, with the length of 1000 mm. Samples were designed with special adjustments in order to simmulate real defects (circular interior/exterior channels in V and U shape, longitudinal channels, flat exterior blades, holes and so on), presented in the figure below.

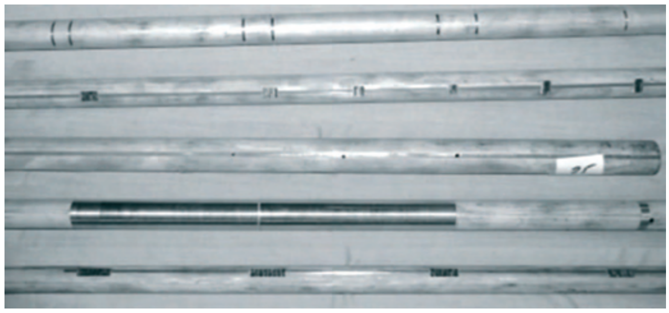


Figure 4. Samples with artificial defects.

The tests and work procedures applied were according to ASME section V, Chapter 8 and Annex I and II, that refer to the examination of non-ferromagnetic pipes from heat exchangers. The probe ussed was developed at IFT Iasi, type emmision-receptor, equipped three magnetic coils, set at 1200 and powerd by a source that has a three-phase current in order to create a spinning magnetic field. The reception coils, three of them, were equipped with nano-structured core. Powering the probe and collecting inducted tensions was done through a flexible cable that servet to move along the length of the pipe.

4. Results and conclusions

Analysis results revealed the equipments capacity to detect and characterize simmulated defects, for a usefull signal-backround noise of 5:1, found in the case of holes unde Ø1,0 mm, or superficial scratches, of cca. 0,5 mm. We would like to mention that the backround noise is not only due to the sensor analysis, or the electronic equipment that processes signals, but also due to the examined pipes (dimmension and form deviation, metalographis structure variation, magnetic proprieties, etc), thus, it is important that the calibration samples, used to examin the equipment, to be strictly manufactured from the same blanks as the examined equipment, even the samples taken from its structure.

The equipments is the main subject in the patent no 125632/30.04.2014, «Automate system for non-destructive examination of tube plates», authors Institutul Național de Cercetare-Dezvoltare în Sudură şi Încercări de Materiale - ISIM Timişoara şi Institutul Național de Cercetare-Dezvoltare pentru Fizică Tehnică - IFT Iaşi, inventors Farbaş Nicolae, Grimberg Raimond, Popovici Iuliu.

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