Automatic Ultrasonic Pipe Inspection

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1 Introduction

This article presents various concepts about the full-body inspection of tubes. The tubes could be seamless but also with longitudinal weld (mostly ERW) in case they replace seamless tubes in their final application. Most common test task is the detection of longitudinal defects. Secondly, a wall thickness measurement could be carried out. For some applications, also transverse defects have to be found. Some production procedures also induce oblique defects and the ultrasonic test might be even extended accordingly. Welded pipe testing (ERW and SAW) is presented in another paper during this conference.

2 High-Speed Tube Testing without Mechanical Rotation

Tubes in the diameter range from 20 up to 170 mm can be inspected with the HRP.R-ECHOGRAPH system. The biggest advantage of this system is the high through-put rate of up to 2 m/s which is achieved by avoiding any mechanical rotation. The circumference of the pipe is surrounded by stationary probes. The number of probes is sufficient to produce overlapping sound fields for full sound coverage. The type and orientation of the probes allow for the detection of longitudinal and transverse flaws. Longitudinal defects are detected by sound transmission in both circumferential directions. Transverse defects require sound transmission in the tube axis direction. A precise evaluation of the flaw length is much more reliable than with any rotational system since the defect is always detected by the same probe with several ultrasonic shots. Also, the detection of short defects is a strong point of a stationary system. In addition, a wall thickness measurement and lamination test might be carried out.

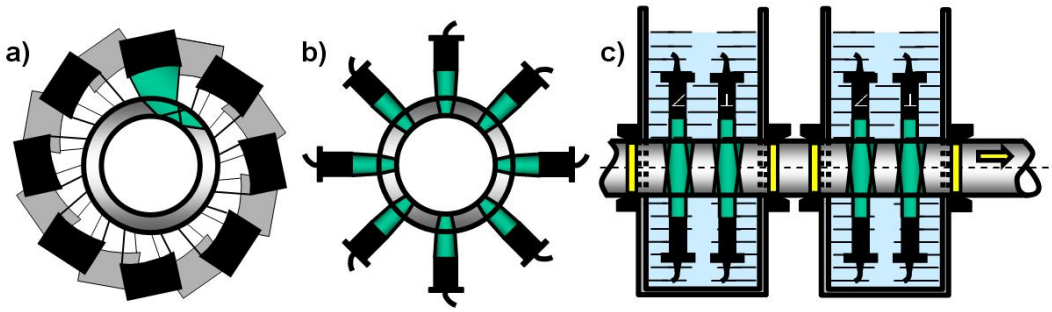

Fig. 1: HRP.R-Echograph high speed tube test a) angle probes for longitudinal defects (only clockwise probes shown), b) probes for wall thickness measurement, and c) test principle with two immersion tanks, each carrying angle and straight-beam probes.

3 Rotational Tube Testing in Partial Immersion

Large tubes with diameters up to 610 mm can be inspected in partial immersion with the RPS.R-ECHOGRAPH testing system. Water-filled test chambers are located underneath the tubes and hold several probe batteries. While the probes remain fixed, the pipes move along the test chambers with a helical motion. Again, various probe orientations lead to the detection of all flaw types and a measurement of the wall thickness. For a rotational inspection, the goal is to produce wide test traces for a high through-put rate. This is achieved by using special-made probe batteries which hold several probe elements in one housing while the gaps between the elements should be kept as narrow as possible.

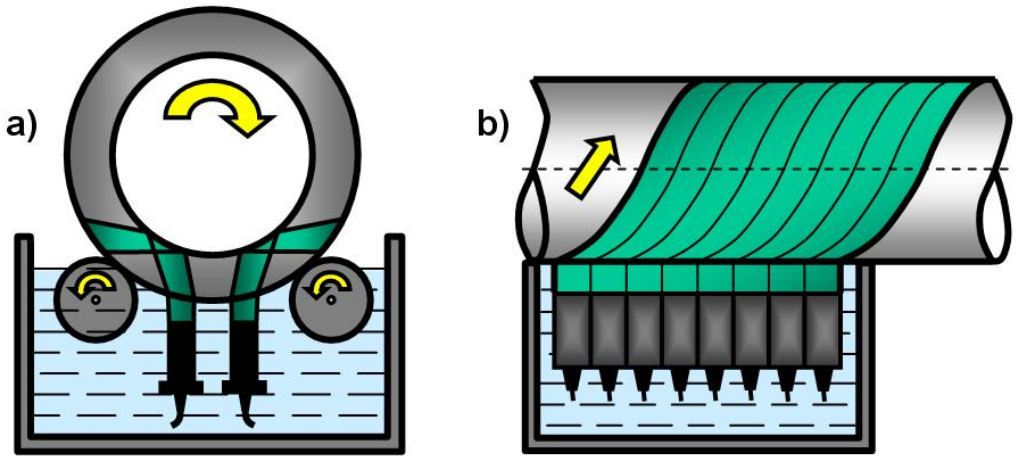

Fig. 2: RPS.R-Echograph rotational tube test in partial immersion
a) longitudinal defect detection with clockwise and anti-clockwise sound transmission,
b) probe battery (example 8 elements) beneath the spirally transported tube.

4 Rotational Tube Testing with Compact Multi-Probe Holders in a Testing Portal

The third considered type of system is the RPT.R-ECHOGRAPH. This system is especially suitable for an off-line inspection. It consists of a testing portal and several multi-probe carriers. The tubes are typically loaded with a transverse conveyor system. Once the tubes are placed in the testing portal, rollers put the tubes into rotation. The number of probe carriers is chosen in accordance with the desired through-put. They are linearly moved along the tube and inspect the tube in the 12 o'clock position. Rotational and translatory movements result in helical test traces. Each compact multi-probe carrier holds up to five probes for the combined inspection for laminations, longitudinal and transverse defects. The coupling is achieved with guided water jets (squirter technique). An extension to also detect oblique flaws with several extra probes in the same probe holder has also been realised.

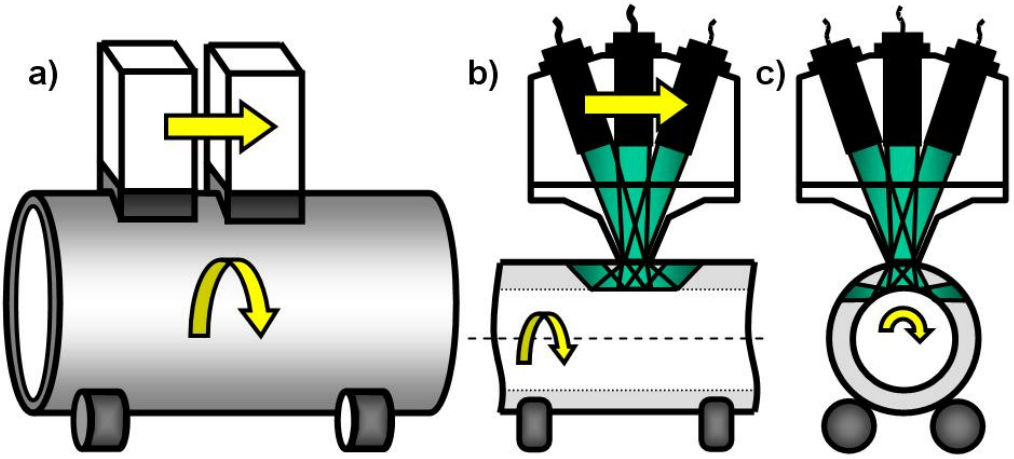

Fig. 3: RPT.R-Echograph rotational tube test with multi-probe holders a) rotation of the tube and linear probe holder movement for helical test traces, b) multi-probe holder in cross sectional view showing transverse defect detection and wall thickness measurement, and c) multi-probe holder showing longitudinal defect detection and wall thickness measurement.

5 ECHOGRAPH Ultrasonic electronics

The evaluation of the ultrasonic signals is carried out with multi-channel electronics. The electronics can be programmed according to all previously mentioned testing tasks. In general, a multitude of channels is necessary and each channel can be individually configured. The robust environment in a pipe mill suggests the use of external pre-amplifiers close to the ultrasonic probes. The probes cables have to be well shielded and the electronic needs a large amplification range with high signal-to-noise ratio.

PC-based electronics have shown difficulties in the pipe mill. The PC is typically using a Windows-operating system. This platform shows problems with real-time applications such as ultrasonic testing. Secondly, external noise sources such as motors and welding equipment close to the ultrasonic system impose serious danger of degrading the ultrasonic results. Therefore, sophisticated test electronics use the PC only as an operating platform and as a user friendly interface. The PC allows for setting the system parameters and collects the test data for visualisation and storage purposes. The data transfer into a higher ranked network is commonly carried out.

Signals from all channels are processed in real-time. Each channel is equipped with four gates and with up to three thresholds. Gates and thresholds can be individually set for each channel. A fast programmable time-corrected gain (TCG) is implemented which compensates the acoustic damping for increasing travel time. The result is a very even testing sensitivity. The TCG can also be programmed differently for each channel.

As a supplement to the electronics, a data management system (DAV software package) is provided. The test data are processed according to the customers needs using an industrial PC. Test protocols are generated. The test parameters are stored for quick retrieval and therefore ensure short change-over times. The Windows-operation system allows for a convenient operation of the entire ultrasonic testing system.

An extra electronic module is responsible to combine the ultrasonic data and the data from the position sensors which record the relative movement between probe(s) and specimen. The specimen is subdivided in so-called test intervals where the spatial resolution can be chosen by the operator. An on-line display of all signal amplitudes with respect to the specimen position is shown on the PC-screen. Exceeding of the pre-set amplitude

thresholds is clearly visible and helps the operating personnel to supervise the current inspection. The system operator decides on the type of documentation and on the amount of data which has to be stored. Graphical documentation, tabulated text and a statistical evaluation of the test data are available. A statistical evaluation contains all collected data, e.g. for an entire batch or a working shift.

6 Summary

This article contains a brief overview on the automated full-body inspection of tubes. The HRP.R-Echograph-system is suitable for the diameter range up to 170 mm. Key property is the unmatched through-put rate and the wear-free mechanics by avoiding any mechanical rotation. A larger diameter range can be inspected making use of a rotational testing concept. With the RPS.R-Echograph-system the tube is inspected with probe batteries in partial immersion and with helical test traces and spirally transported tubes. The RPT.R-Echograph-system is appropriate for an off-line inspection, again in helical test traces. The mechanics consist of a testing portal and compact multi-probe holders using a rotation of the pipe and linear probe movement. Advantageous for both last-mentioned system types is the guidance of the ultrasonic probes along the tube surface. The larger the tube diameter and the larger the ovality tolerances, the more important this feature gets. Also the position uncertainties due to the tube transportation are well compensated.

7 References

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