Evaluation of defect parameters in long products with double-sided access

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Traditional ultrasonic testing techniques, which are based on reflection methods, do not allow measurement of real parameters of defects. In the process of testing, the coordinates of reflector and conventional dimensions differ from actual geometric parameters of cracks by several times. Time of Flight Diffraction (TOFD) methods and devices with phased array technology (PAT) are based on an accurate determination of reflecting points' coordinates. However, measurement results of reflector parameters have an unacceptably large error due to specificity of reflecting properties of defect and its orientation. We have proposed a new approach to calculate to cracks' size by through-shadow ultrasonic techniques. The proposed approach is based on drawing the boundaries of the defect with a narrow ultrasonic beam during a two-dimensional scanning of the product from opposing surfaces by several pairs of transducers. The boundaries of the defect in this case are determined by sizes of decrease the amplitude of through signal below threshold. The positions of defect are determined by boundary during the longitudinal scan. As a result, the ultrasound tomogram of the product can be formed by scanning of each layer sequentially. Then it is possible to calculate the following defect parameters: the coordinates of the center within the volume of the product, three linear sizes and the angles of its orientation in space. Using computer simulation, we have tested the results of the proposed method for different values of parameters of cracks (sizes, location and orientation). It was found that the error in determining the parameters of defects does not exceed 10 percent in idealized conditions. The minimal defect size corresponds approximately to the diameter of the ultrasonic beam at a frequency of 2.5 MHz (~ 3...4 mm). Besides, there is the problem in real testing' conditions when the product has non-parallel surfaces and even a possible wear. The problem of providing the alignment of the enter angles of the sending and receiving transducers has been solved successfully: transducers' angles are changed according the shape of the product. The most important task is providing acoustic contact (coupling) on the real surfaces of products during scanning. For this purpose, we have investigated new materials - hydrogels, which can absorb liquid up to 98 percent of its own volume and retain it for a long time. These approaches and solutions were tested during the non-destructive ultrasonic testing of rails and introduced into the portable ultrasonic flaw detector AVICON-17 and the removable trolley AVICON-31. Well known, fatigue cracks arise in rails when railways are in use. Despite this, a significant number of rails are operated with non-hazardous surface damages in the rail head, such as slipping, peeling and chipping of the metal on the rolling surface. Ultrasonic testing of these areas is complicated by the fact that the surface damage partially or completely interrupts the ultrasonic waves and the signals from them are similar to the signals from dangerous cracks. Having said that, dangerous transverse or horizontal cracks often arise in the head under surface defects, which can lead to a break of the rail. Correct recognition of signals is a significant challenge for an operator of a high speed diagnostic train and manual or removable ultrasonic flaw detector. We have developed a special scanner which the operators use in the area of surface damage to the rail head. The sensitivity of ultrasonic channels is adjusted automatically. We are planning to automate the scanning process with minimal human involvement. Many dangerous cracks were detected under surface damage using the scanner. These rails are removed from the track and broken in the press. A comparative analysis of testing results and pictures of broken rail allows us to state that the accuracy of defect parameter estimation under real control conditions does not exceed 15 percent. The indicated approaches and proposed principles are not limited to rail transport. They can also be successfully used for the detection and evaluation of defect sizing in many industrial facilities with two-side access (drill rods, tubes, beams and etc.).