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ESTIMATION OF THE MEASUREMENT ERROR OF ULTRASONIC FLAW DETECTORS WHEN DETERMINING THE DISTANCE OF EXISTING DEFECTS IN METALS

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ABSTRACT

This article considers the assessment of the absolute error of ultrasonic flaw detectors, which is used in the ultrasonic method of non-destructive testing, using ultrasonic standard measurement blocks when determining the distance of defects in metal products.

Keywords: Non-destructive testing, ultrasonic method, flaw detector, ultrasonic standard measurement blocks, accuracy, ultrasound examination, measurement, nominal value

INTRODUCTION

Based on historical and current data, it was shown that ultrasonic testing is one of the most important testing method in Non-destructive testing field. Ultrasonic testing (UT) has been practiced for many decades. Initial rapid developments in
instrumentation spurred by the technological advances from the 1950's continue today. Through the 1980's and continuing through the present, computers have provided technicians with smaller and more rugged instruments with greater capabilities. We can include ultrasonic flaw detectors to these measuring devices. Many ultrasonic flaw detectors have a trigonometric function that allows for fast and accurate location determination of flaws when performing shear wave inspections. Cathode ray tubes, for the most part, have been replaced with LED or LCD screens. These screens, in most cases, are extremely easy to view in a wide range of ambient lighting. Bright or low light working conditions encountered by technicians have little effect on the technician's ability to view the screen. Screens can be adjusted for brightness, contrast, and on some instruments even the color of the screen and signal can be selected. Transducers can be programmed with predetermined instrument settings. The operator only has to connect the transducer and the instrument will set variables such as frequency and transducer drive.
Various ultrasonic flaw detectors are used for determining the distance of existing defects in metals in the industries of Uzbekistan. The reliability of these estimates is determined by metrological control of ultrasonic flaw detectors. The metrological control of ultrasonic flaw detectors is carried out by the single laboratory of non-destructive testing of Uzbek National institute of metrology in Uzbekistan.

In this paper, the thickness measurement error of ultrasonic flaw detector is evaluated based on the experimental results. Ultrasonic reference block type CO-2 is used as reference measuring instrument in this evaluation process.

Technical specification of the ultrasonic reference block type CO-2 is given in Table 1.

Table 1.

№	Technical parameter	Value
1	Nominal value and permissible height deviation measures, mm	59,00±0,3
2	Nominal value and permissible deviation of the distance from working surface to the center of artificial defect, mm	44,0±0,3
3	The speed of propagation of a longitudinal wave and its permissible deviation in the block material at a temperature of 20±5 °C, m/s	5900 ±59
4	Beam angle	0 – 80°; Δα ±10

Ultrasonic flaw detector type A1212 MASTER is used as a device under test in the measurements. In the first stage of the measurement the direct transducer is connected to the electronic block of the flaw detector and set in the flaw detector several settings.

- type of connected transducer (separate-combined or combined);
- nominal frequency of the transducer;
- delay 0 μs;
- input angle 0 degrees;
- excitation pulse 100 V;
- 1 period;
- disable thickness;
- Temporary sensitivity control (TSC);
- scale – μs;
- resolution 0.01;
- maximum measurement mode.

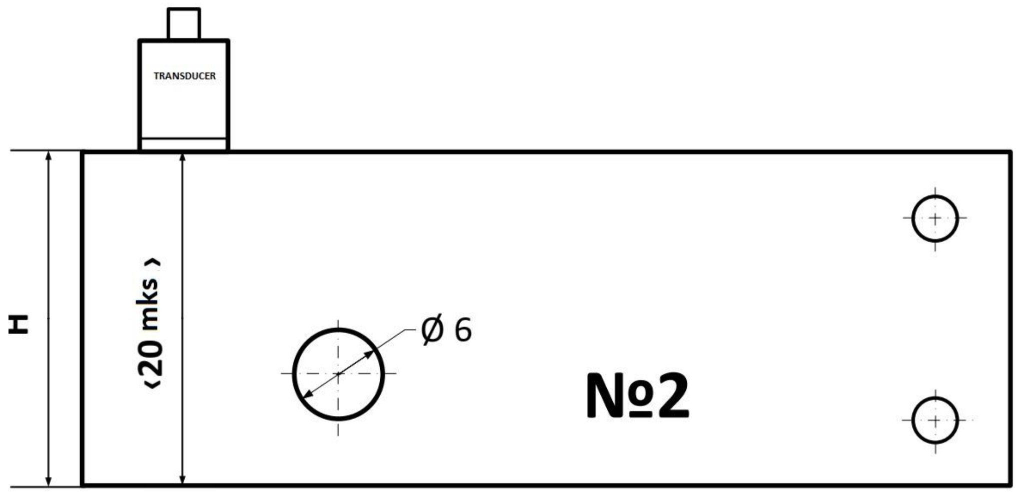

Figure 1. Ultrasonic reference block CO-

After all settings, the strobe is set to 50% of the screen. The transducer is placed on a surface moistened with contact fluid of reference block CO-2 to a defect-free area(figure 1).

By changing the time base, obtain signals on the flaw detector screen, reflected from the bottom surface of the block and the level of the first reflected signal above 50% of the screen height is set by changing the flaw detector gain. The time position of the first reflected signal t_{meas1} is measured after pointing the strobe at the first reflected signal(Figure 2).

From Figure 2 we can know that the time position of the first reflected signal t_{meas1}=20.935μs.

The next step is to increase the gain so that the level of the second reflected signal exceeds 50% screen height and move the strobe to this area. After that the time the position of the second reflected signal t_{meas2} is measured same as the first reflected signal t_{meas1} is measured

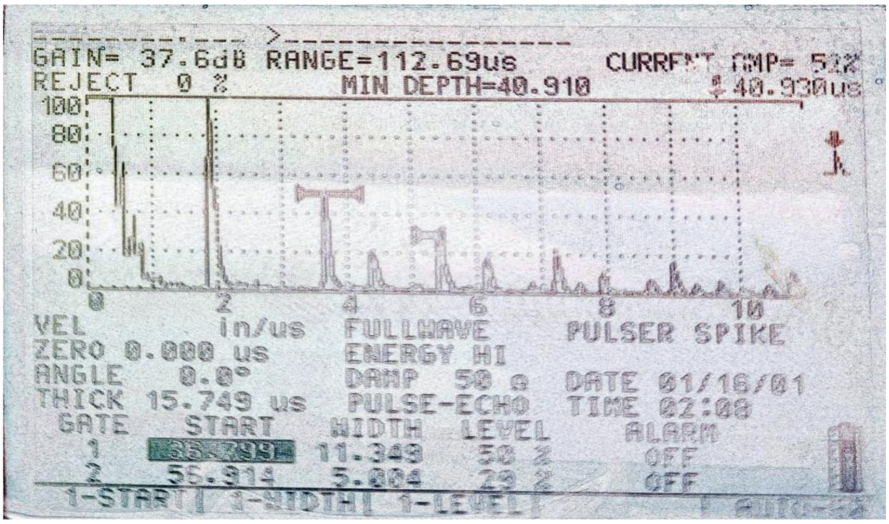

Figure 2. Measuring of the time position of the first reflected signal

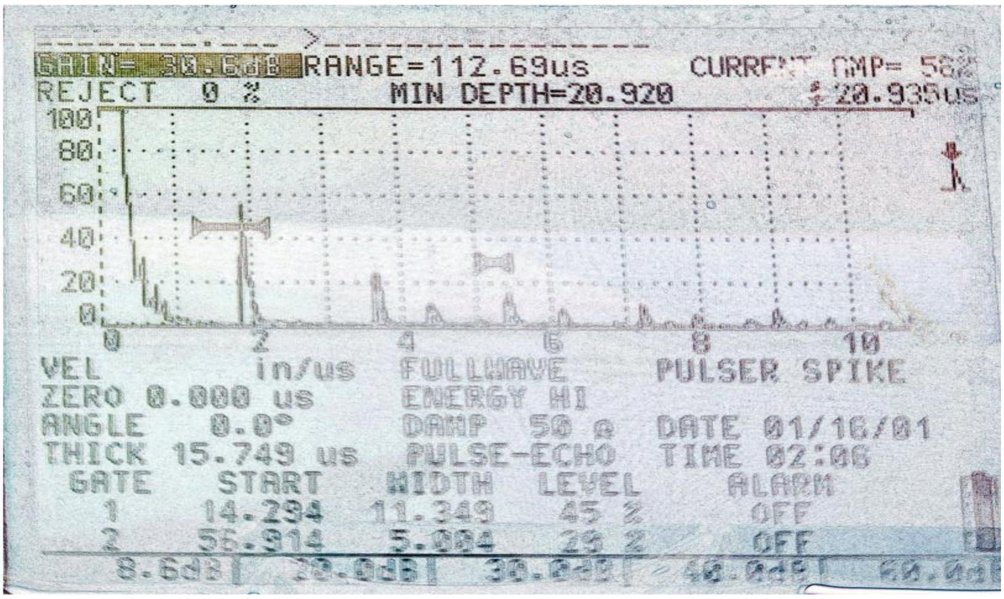

Figure 3. Measuring of the time position of the second reflected

Figure 3 shows us that the time position of the second reflected signal t_{meas1}=40.930 μs.

On base of receiving information, the delay time in the transducer prism t_{dt} , μs, is calculated using the formula (1).

$$t_{dt} = 2t_{meas1} - t_{meas2} \quad (1)$$

According to the formula (1) the calculating value is given in Table 2.

Table 2

№	t_{meas1}, µs	t_{meas2}, µs	the delay time, t_{dt}, µs
1	20.935	40,930	2*20.935-40.930=41.87-40.930=0.94

In the next stage of the procedure, the delay calculated in formula (1), the speed of longitudinal ultrasonic waves according to the CO-2 passport and the scale – mm depth are set in the flaw detector settings. The transducer of ultrasonic flaw detector should be placed on the surface of the reference CO-2 block moistened with the contact liquid. Because the ultrasonic waves can pass easily through a object with the help of the contact liquid.

By successively installing the probe on the surface of the sample according to Figure 4, the maximum amplitudes of echo signals are found from a reflector located at different depths. If necessary, the time base and gain of the flaw detector are changed.

The depth of a defect is measured using a strobe aimed at the signal from the reflector. Measurements are performed three times and the arithmetic mean value of the depth of the defect H_{meas} is calculated. After that, the absolute measurement error of the defect depth ΔH, mm, is calculated using the formula (2).

$$\Delta H = H_{meas} - H_{nom} \quad (2)$$

where H_{nom} is the nominal value of the defect depth, mm

According to the formula (2) the calculating value is given in Table 2.

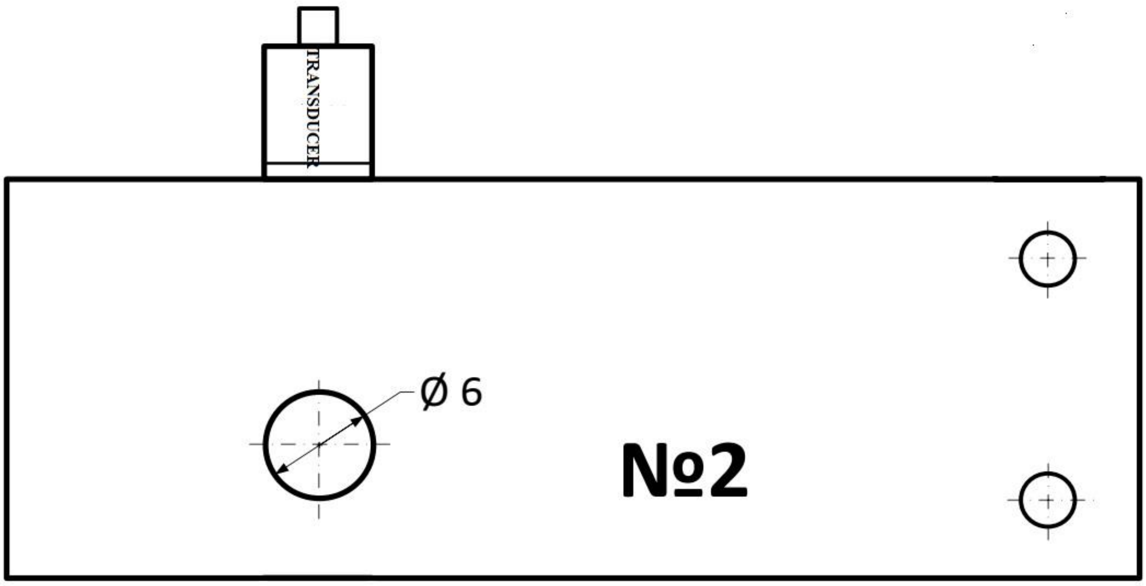

Figure 4. Installing the transducer in reference block CO-2

Table 2

№	H_{measi}, mm	H_{mean}, mm	H_{nom}, mm	ΔH, mm	Hp.er., mm
1	43.73	43,696	44	-0,304	±1,88
2	43.65				
3	43.71				

The ultrasonic flaw detector is considered to have passed metrological control with a positive result if the absolute error in measuring the depth of the defect (on steel) with straight probes does not exceed ±(0.02·H+1.00) mm, where H is the measured depth of the defect in mm.

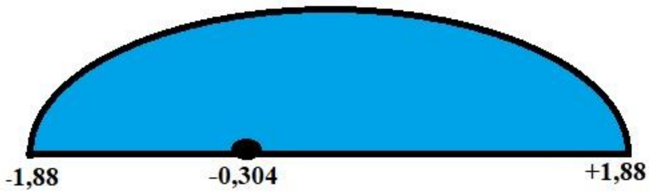

Figure 5. The interval of measurement results

In reference block CO-2 the depth of the defect is 44 mm according to technical specification of CO-2. The permissible error is ±(0.02·44+1.00)= ±1,88 mm at the base of the depth value. The value of ΔH is equal to -0,304. The absolute error ΔH is lied in the interval of the permissible error(Fig. 5). It is concluded that The ultrasonic flaw detector is passed metrological control with a positive result for determining the distance of existing defects in metals. This parameter is one of the most important point for ultrasonic flaw detectors. The main aim of ultrasonic flaw detectors is to find the existing defects in the controlling object and determine in which distance they are located. The right estimation of the parameter help us to complete successfully this mission. But it will not give us total permission to use with the ultrasonic flaw detector. There are another technical specifications that must be estimated. Linearity Accuracy, Gain and also Material Velocity are such kind of specifications of ultrasonic flaw detectors.

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