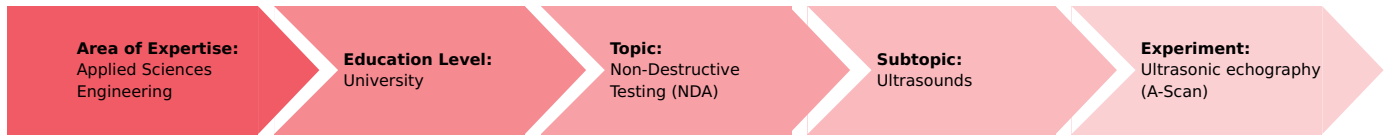


Ultrasonic echography (A-Scan) (Item No.: P5160200)

Curricular Relevance



Difficulty



Difficult

Preparation Time



10 Minutes

Execution Time



2 Hours

Recommended Group Size



2 Students

Additional Requirements:

- PC (Windows)

Experiment Variations:

Keywords:

Propagation of ultrasonic waves, Time of flight, Echo amplitude, Reflection coefficient, A-scan, Crack detection, Non-destructive testing, NDT, Ultrasonic transceiver

Overview

Principle

An ultrasonic wave transmitted in a sample is reflected at discontinuities (defects, cracks). From the relationship between the time of flight of this ultra-sonic echoes and the velocity of sound, the distance between ultrasonic transducer and defect (reflector) for different kind of defects can be calculated. Position and size of these defects can be determined by measuring from different directions.

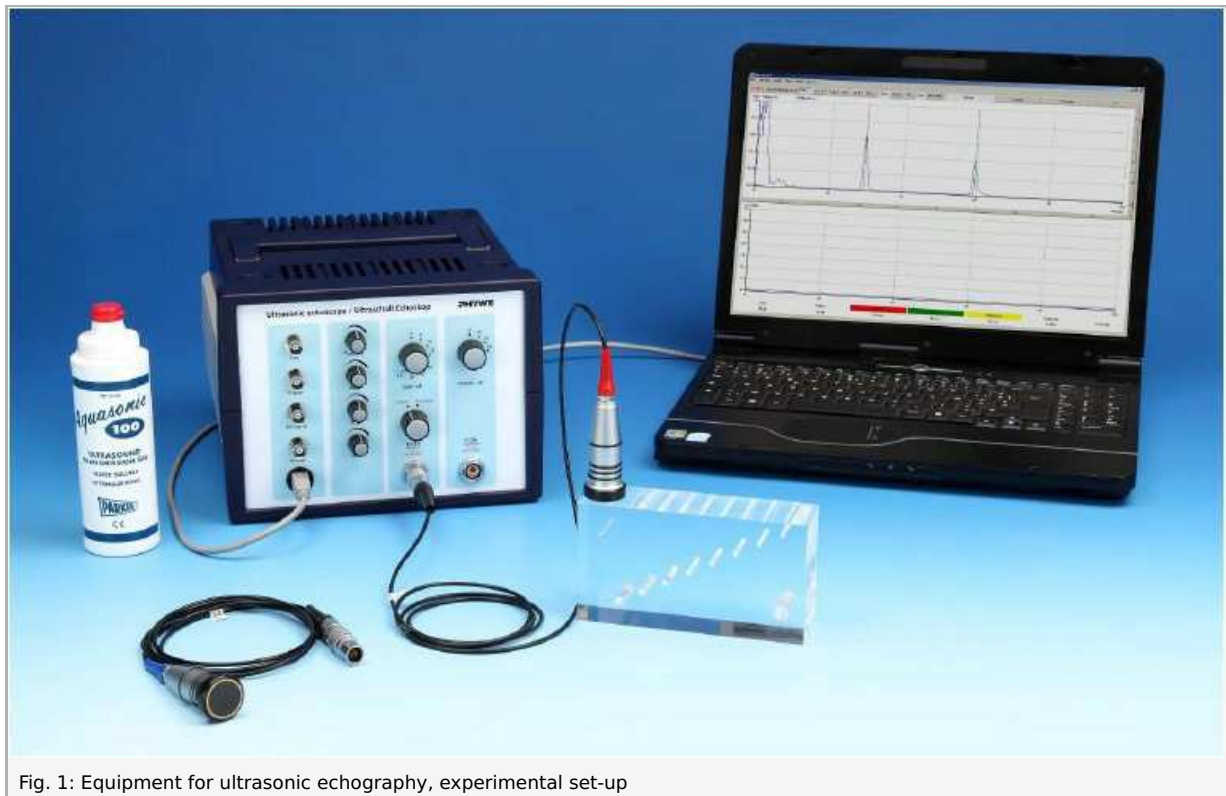


Fig. 1: Equipment for ultrasonic echography, experimental set-up

Equipment

Position No.	Material	Order No.	Quantity
1	Basic Set Ultrasonic echoscope II	13924-99	1
2	Vernier calliper stainless steel 0-160 mm, 1/20	03010-00	1

Tasks

1. Measure the block with the calliper and the time of flight with the measure ultraecho software.
2. Calculate the sound velocity.
3. Measure the position of the discontinuity with the measure ultraecho software from different angles. Calculate the size of the defects of the test block.
4. Measure the locations and size of the discontinuities with the calliper and compare it with the results of task 4.
5. Discontinuity 10 is also circular. Measure the position and extension in a proper way.

Note

Pay attention to the special operation and safety instructions in the manual of the ultrasonic echoscope.

Set-up and procedure

The system Basic Set "Basic Set Ultrasonic echoscope II " consists of an ultrasonic echoscope controller which connects to a computer via USB interface, ultrasonic probes (1 MHz and 2 MHz), an ultrasonic test block, an ultrasonic cylinder set, ultrasonic text plates, ultrasonic gel and echoscopy software for Windows. Proceed as follows:

To perform task 1, to derive the sound velocity, pursue the following steps:

- Measure the size of the test block (BS) with the calliper. While measuring, apply only gentle pressure to avoid scratches on the acrylic block.
- Prepare the echoscope i.e. read manual echoscope entirely and the section on the A-scan (section 5.5.1) and the accessories (section 8) in particular. Switch it on.
- Connect the echoscope to the PC.
- Connect the 2 MHz probe to the "Probe (Reflexion)" plug.
- Switch the selection knob to "Reflexion".
- Set in the measure ultraecho software, menu "Options"- "Parameter"- "Time shift" values of probe delay determined in P5160100 and set "Time shift enabled".
- Couple a probe to the test block (on the short side to measure the long side length) using a gel or a water film. Search the back wall echo.
- When using water as a couplant make sure it does not run under the cylinder. It could produce misreadings.
- Switch the measuring range (in the "measure ultraecho software") from "Half" to "Full" because the time of flight of the reflex is longer than 100 micro seconds.
- The "measure ultraecho software" program shows the reflected wave as a peak. Adjust the transmitter and receiver amplifier settings until the peak height maximum covers at least 75% of the window height. The amplifier settings are displayed in figure 8.
- Measure the time of flight at the bottom of the rising echo peak edge (same procedure as in P5160100). There are a red and a green cursor on the display to illustrate that. Their values and the difference of the two are shown under the red and green bar under the lower diagram. The difference between the two is displayed under the yellow bar.
- The time of flight can be read out directly using the software cursors.

To perform task 2, to calculate the velocity, follow these steps:

- Calculate ultrasound velocity and adjust the value in measure ultraecho software. Switch the display to "Depth". Now, the distance to the defect can be measured directly.

To perform task 3:

- Measure the defects, put the block on its long side and determine the block size (BS), the distances S1, S2 and S3 or S4 (Fig. 2) for each hole.

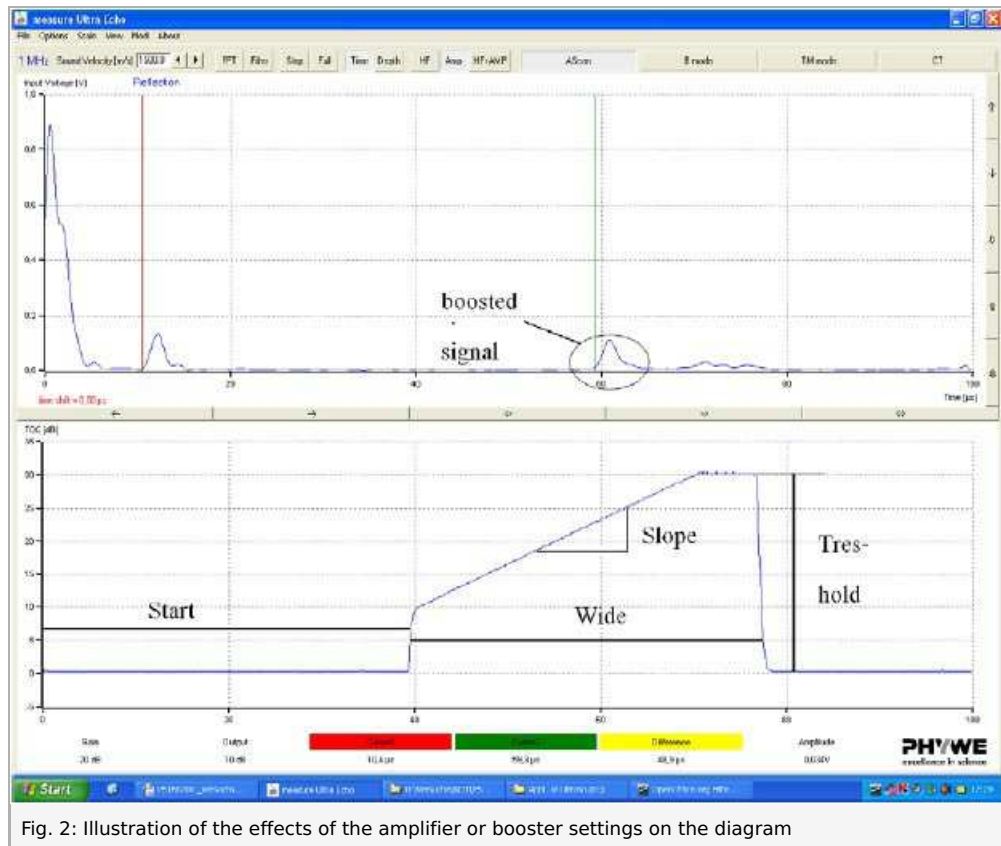


Fig. 2: Illustration of the effects of the amplifier or booster settings on the diagram

- Defects in deeper areas of the block do not yield a signal of the same strength. Hence, the echoscope is equipped with an amplifier. The strength of the signal can be adjusted with the knobs threshold, wide, slope and start.
- The parameters at the echoscope should be chosen that the peaks are big enough to be measured but the amplification is low enough to avoid a high background noise. All defects of the sample are measured either relative to both long sides (so the extension of the defect can be determined) or are measured from two sides perpendicular to each other in order to find the precise position of the defect. The determined hole sizes can be compared with the values measured with the calliper.
- Repeat the same procedure with the 1 MHz probe

Software

- The measure ultraecho software records, displays and evaluates the data transferred from the echoscope. After starting the program the measure mode is active and the main screen "A-Scan mode" is open. All actions and evaluations can be selected and started in this window.
- The main screen shows in the upper part the A-scan signal, the frequency of the connected transducer and the mode (reflection/ transmission). Actual positions of cursors (red and green vertical line) are displayed at the bottom of the window. The cursors can be positioned by mouse click. The time of flight is displayed under the cursor buttons.

Note: Maintenance

- The ultrasonic cylinders and the probes should be cleaned immediately after use with water or a normal detergent. Dry residues of ultrasonic gel are hard to remove. If necessary use a soft brush. Never use alcohol or liquids with solvents to clean the cylinders or the probes. Deep surface scratches influence the coupling and can induce measurement errors.

Theory and evaluation

The ultrasound echography (also sonography) developed to be one of the most important investigation methods among others in medicine and NDT (non destructive testing). There are unreviewable multitudes of ultrasonic devices for different applications. They all work on the same basic principles of emitting a mechanical wave, whose reflection will be and recorded in an echogram.

Using the ultrasonic echoscope an ultrasonic probe coupled to the medium under investigation is excited by a short pulse. The emitted ultrasonic wave is reflected at inhomogeneities of the sound impedance and this reflection is detected by the same transducer. The time of flight (t) between the start of pulse at the transmitter and the appearance of the echo is related to the velocity of sound (c) of the medium with the distance (s) of the defect from the ultrasonic probe in the following way:

For measurements in reflection mode

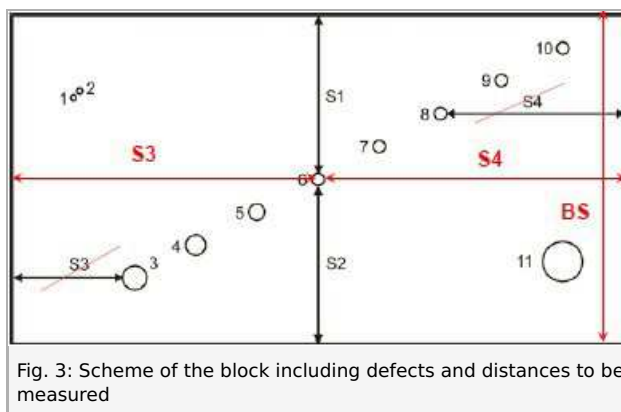
$$(1) c = \frac{2s}{t}$$

Note: The measured values are corrected with probe delay.

Fig. 3: Scheme of the block including defects and distances to be measured

By knowing the velocity of sound of the material under investigation, the distance of a defect can be determined directly from the time of flight. The amplitude of the ultrasonic echo depends on the damping of the material between probe and defect, on the difference of the impedance of the material and defect as well as on the geometric form and orientation of the defect.

From the measured distances (Fig. 3), the hole size is calculated after (2):



$$(2) ds \text{ Echo} = BS - S1 - S2$$

BS is the size of the block as shown in Fig. 3. Alternatively, it is the height of the block in Fig. 1

Results

Determination of sound velocity of the acrylic block

Measured distance: 148.2 +/- 0.1 mm

Time of flight: 108.0 +/- 0.2 μs

Calculated velocity of sound acryl: 2744 +/- 7 m/s after (1)

Literature value: longitudinal sound velocity of acrylics = 2600-2800 m/s.

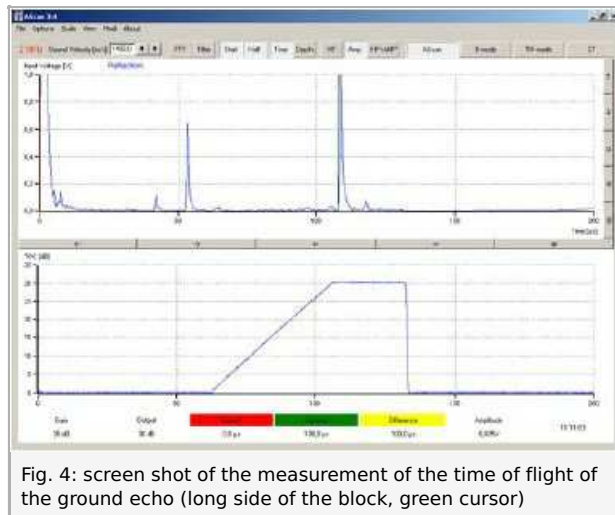


Fig. 4: screen shot of the measurement of the time of flight of the ground echo (long side of the block, green cursor)

Hole 10 can be measured only from one side (acoustic shadow of hole 11, see Fig. 5 and 6).

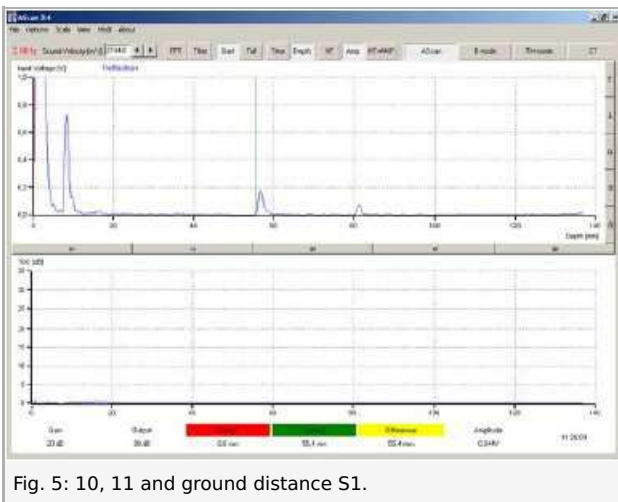


Fig. 5: 10, 11 and ground distance S1.

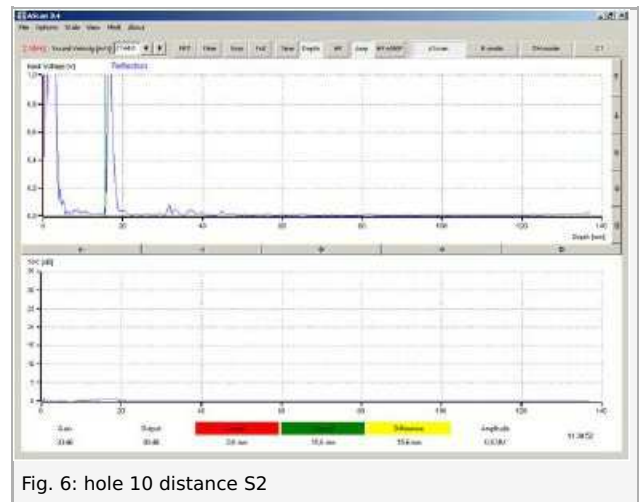


Fig. 6: hole 10 distance S2

Hole 1 and 2 can be nearly separated by the 2 MHz probe (Fig. 7). The exact determination of the time of flight of the second hole is not possible though.

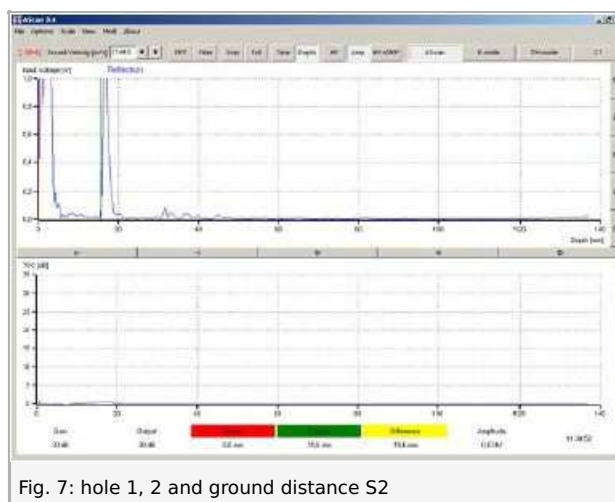


Fig. 7: hole 1, 2 and ground distance S2

Hole 1 and 2 cannot be separated by the 1 MHz probe.

The hole size determined by ultrasound is too small since the ultrasonic field cannot detect precisely the upper rim of the hole because of its extension (about 1 cm).

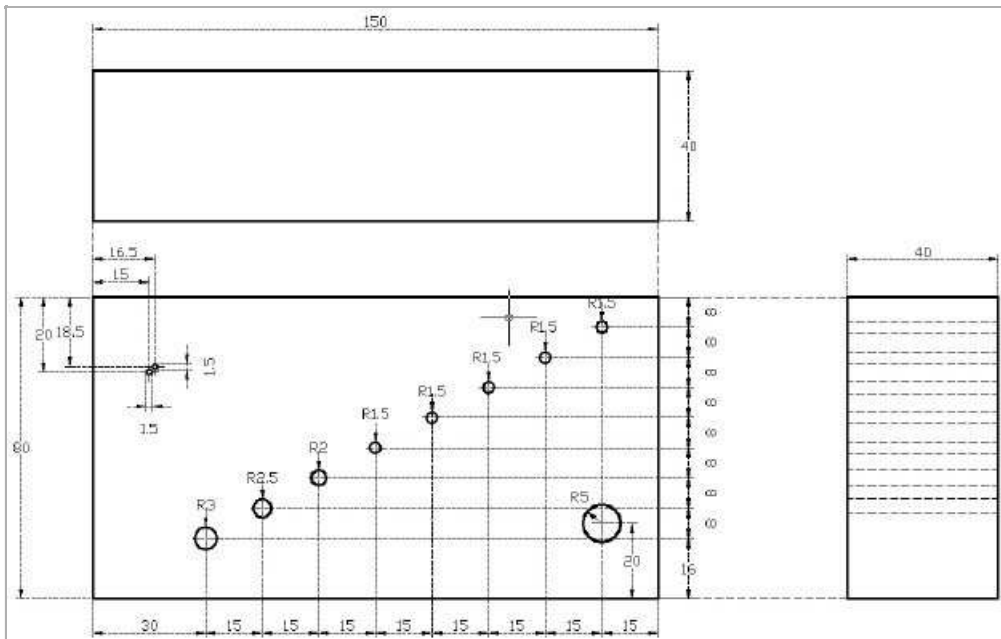


Fig. 8: Engineering drawing of the test block

Table 1: measured distances and calculated values of the holes

Hole	BS	1	2	3	4	5	6	7	8	9	10	11
S1 in mm	80.1	20.1	18.1	61.1	53.6	46.1	38.9	30.8	23.1	15.1	55.4	7.2
S2 in mm		59.3	61.5	13.8	22.2	30.7	39.1	47.2	55.0	63.0	15.6	x
dS Echo	80.1	0.7	0.5	5.2	4.3	3.3	2.1	2.1	2.0	2.0	9.1	x
dS Calliper		1.2	1.2	5.9	4.9	3.9	2.9	2.9	2.9	2.9	10.0	2.9
S3 in mm		15.0	16.5	25.9	41.5	56.6	72.2					
S4 in mm								59.0	44.0	29.0	10.5	14.1