SOME REMARKS ON ULTRASONIC TESTING FOR CAST IRON PARTS

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Abstract: *The following sample article provides some remarks on the ultrasonic evaluation of cast iron samples. The experimental testing was performed at SIDEM factory, Suceava, on 100 samples consisting of steering arm beads for Fiat Bravo.*

Keywords: *keywords list (nondestructive testing, ultrasonic, flaw)*

1. Introduction

The ultrasonic testing of materials is a non-destructive method, which is more than 40 years old, [Berke, 1990]. From the first examinations, using ultrasonic oscillations to the detection of defects in different materials, it has become a classical measurement-based test method, with all the important factors which influence it., Supported in the field of instrument technology, ultrasound testing, is expected to yield test results that can be reproduced with narrow tolerances. This requires an exact knowledge of the factors that influence and the ability to apply in testing technology.

Defectoscopy is a set of procedures for examining materials as well as parts and joints in order to reveal their defects (cracks, gaps, recesses, inclusions) by non-destructive methods.

Appeared and developed with the first damage, nondestructive defectoscopy, finds innumerable applications in the industrial technology. This activity is indispensable for the lifetime of an industrial plant, irrespective of its nature. Defectoscopy cannot be neglected even in the operation of the plant, but it becomes essential when its intended lifetime finishes, when it is intended to prolong its safe use.

The purpose of non-destructive defectoscopy is to promptly detect defects, determine their nature and parameters: position, orientation and size, and issue acceptance decisions , remediation or refusal decisions, in accordance with the admissibility criteria or admissibility limits prescribed in the execution, norms and standards. Determining the nature of the defect is particularly useful in identifying the causes and fixing measures to correct the execution or technology. Finding out what are the other defect parameters is required to accurately indicate the location and extent of the remedy.

Due to the manufacturing technology of the steering arm for the Fiat Bravo, which is made of gray cast iron made of globular graphite, developed in blast furnaces, then poured into the mold, there is the possibility of defects such as cracks and chinks, and for this reason the ultrasound testing was decided to be done.

The ultrasonic testing of materials is a non-destructive method where ultrasound oscillations are used to detect defects from different materials. This has become a classical measurement test-based method, observing all the important factors that influence it. Supported in the field of instrument technology, ultrasound testing is expected to yield test results that can be reproduced with narrow tolerances. This requires an exact knowledge of the factors that influence and the ability to apply in testing technology.

The ultrasound principle is based on the fact that solid materials represent good conductive waves. Waves are not only reflected at interfaces, but also from internal defects (material separations, inclusions, etc.).

The wavelength depends on frequency of the wave, [Krautkrämer, 1990]:

$$\lambda = \frac{c}{f} \qquad [1]$$

c – the speed of sound
f –frequency
λ – wavelength

2. Ultrasonic test equipment

The equipment called USM 36 has been designed and tested according to DIN EN 61010-1: 2011-07. The safety requirements for the measurement electrical equipment, control and laboratory use have been technically safe for use and without defects when leaving the production workshop.

USM 36 Ultrasonic Control Equipment is a test tool for materials. The use for medical purposes or any other application is strictly forbidden! The tool can only be used in industrial environments.

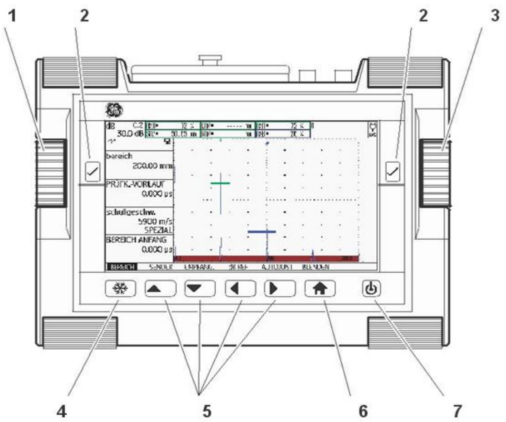

Figure 1: *Keypad functions, [USM,2013]*

1-Left rotary knob for direct gain adjustments

2-Selection keys, for selecting and confirming, for Zoom (long key press)

3-Right rotary knob, for selection of function group or function, changing settings

4-A-Scan freeze direct access key

5-Programmable function keys F1 … F4, alternatively navigation keys, (second operation level, function group CONFIG3)

6-Home key for exit from function group or function, or alternate between the two operation levels (long key press)

7-On/Off key to switch the instrument on or off.

USM 36 calibration is done on the piece of the studied material. The flaw is attempted, then gate A is positioned at 80% of the hole signal and Gate B is positioned on the bottom signal of the track. This is how we view a hole type defect in the studied material. There is also a need for reference standards in ultrasound tests,.

This calibration is required because most of the ultrasound equipment can be reconfigured for use in a wide variety of applications. The user must calibrate the system, including machine settings, transducer, and test configuration to validate that the desired accuracy and accuracy level are achieved.

3. Method of testing

Figure 2 illstruates the principle of testing with Ultrasonic test equipment.

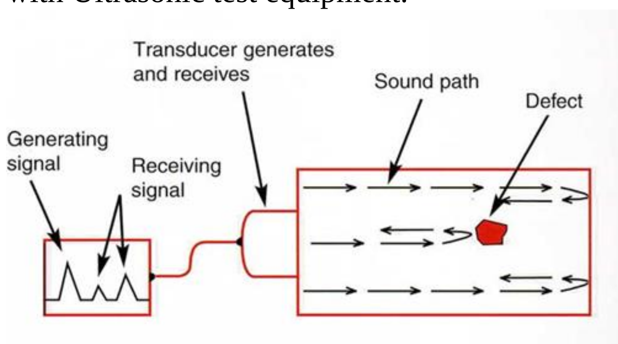

Figure 2: *Principle of ultrasonic testing*

While high frequency sound waves are sent into a material with the help of a transducer, the sound waves are the ones that travel through the material. Thus they are received by the same transducer or a second transducer. The transmitted or received amount of energy together with the time the energy is received are being analyzed to determine the presence of flaws. In this way, changes in material thickness as well as changes in material properties can be measured.

Ultrasonic inspection is known to be used to locate surface together with subsurface defects in various materials such as metals, plastics, and wood. In the same way it is used to measure the thickness of materials as well as to characterize the properties of the material based on sound velocity or attenuation measurement.

Standard testing is done as follows:

a coupler (gel) is placed on the cylindrical side to test with the ultrasound.

In this way the sound pulse at the probe crystal is triggered by the electrical transmission pulse. Simultaneously this voltage pulse is feed to the input of the amplifier. Because of this the high voltage causes a vertical deflection of the display sweep. This is what call the initial pulse. Together with this initial pulse, the sweep is started in the lower left corner of the display at the same time with the start of the sound pulse in the test object and it begins to move along the base line at a constant speed to the right. [Edmonds,1981].

Being transmitted through the couplant and into the probe, the sound pulse part generates a small electrical reception signal at the crystal which, via the amplifier, leads to a vertical deflection of the beam spot, known as the backwall echo or back surface echo .

On the left side of the screen we have the generating signal or initial pulse, and on the right the back surface echo. The high initial pulse starts on the left in front of the scale zero point.At the moment the positioning of the transducer shows that everything is fine on the graph.

Still moving the transducer on the cylindrical surface a defect is found. In this case, the wave does not reach the back because it is interrupted by finding that fault and there is a a new flaw echo.

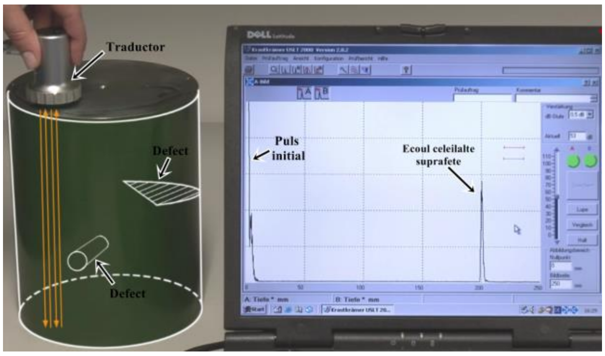

Figure 3: *Conforming probe*

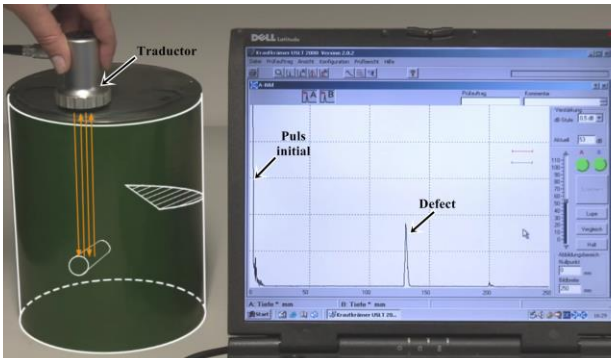

Figure 4: *Nonconforming probe*

3. Testing results

The ultrasonic steering gear made from cast iron, shown in the figure below, was tested.

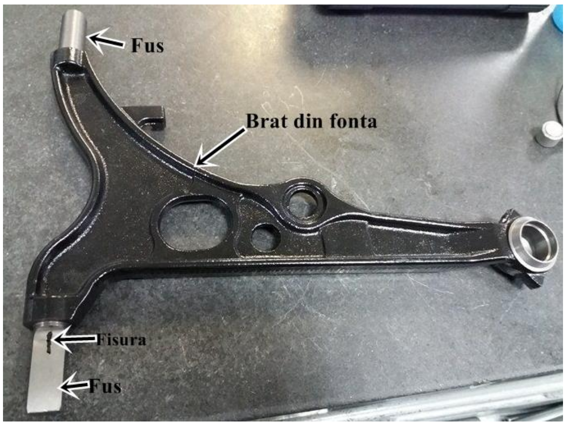

Figure 5: *Nonconforming probe*

The control of the spindles is done after the cutting of the front surface, that comes in contact with the transducer, the defects being retracted and the crack.

The *casting defects* illustrates gaps formed by a non-uniform solidification process and local volume changes. The restraints can be opened or closed, usually placed at the corner of the parts. The scattered retail or microstrip forms so-called porous structures, which frequently occur in aluminum alloys.

Figure 6: *Ultrasonic test*

The *crack* is considered to be the most dangerous defect due to its high propagation capacity, either in time through a fatigue process or abruptly as a result of fragility. The crack occurs during solidification (cold cracking) or cooling (cold cracking) due to the local loss of plasticity or due to material fragility, especially by hydrogenation during cooling or heat treatment. However, the crack can also be generated as a result of the high level of internal tensile stresses as well as the formation of unstable, tough constituents with expansion coefficients different from those of the basic structural matrix.

3.1 Experiment 1

After the starting the ultrasonic equipment, it is calibrated, the frequency and length of the cast iron arm are set. As can be seen in Figure5 on the display of the equipment, we have a frequency of 59.6 dB, and the total length is 75 mm (gate B, blue). After making these settings, we take the sensor and place it on the left end of the spindle, moving it across the entire front cylindrical portion of the arm to see if it has material retrievals inside. On the graph, we can clearly see the ultrasonic signal of gate B, and there is no ultrasonic signal on the spindle length. The conclusion on this graph is that it has no defect inside the spindle.

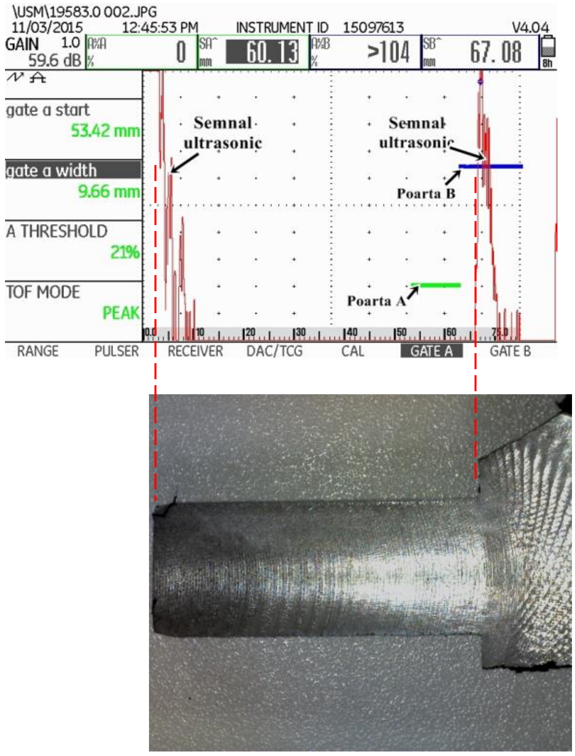

Figure 7: *Experiment 1*

In order to convince us that the test results are good, the steering arm spindle has been mated. The result is presented in the above image and it can be seen that it has no cracks or material gaps.

3.2 Experiment 2

In figure 8 it can be seen that after the initial pulse we have a very strong ultrasonic signal, and further on the graph we see several signals but not as strong as the ones in front, Figure 4.

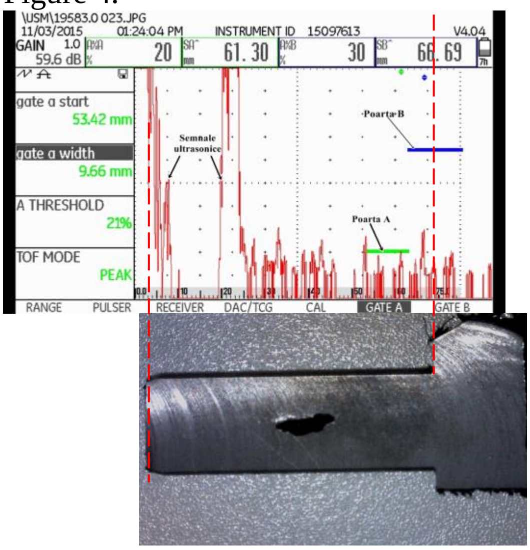

Figure 8: *Experiment 2*

In the above picture we have the result after milling the arm where one can see its defect.

3.3 Experiment 3

On this graph we have a very strong signal at the front and the biggest problem is that we do not see the signal of the gate B. Normally, the defect signal should not be greater than that of the gate B. When we encounter such cases, that arm has a defect. Further ultrasound signals that show defects of this arm are still visible along the length of the spindle.

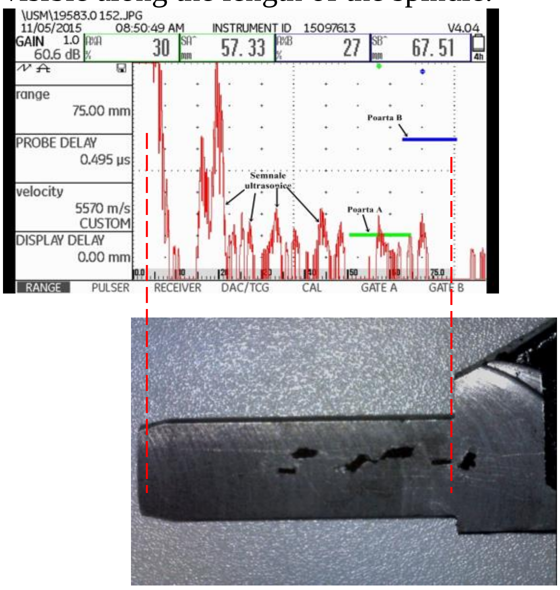

Figure 9: *Experiment 3*

After milling, we notice that the spindle has multiple voids inside.

Figure 10 shows other types of defects encountered in the tests.

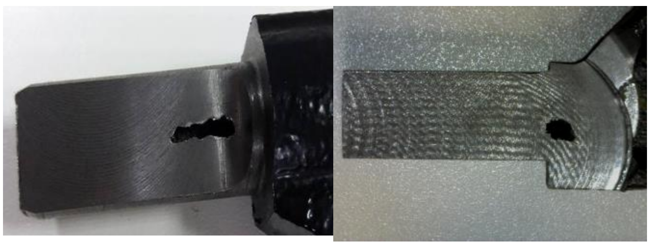

Figure 10: *Material flaws*

4. Conclusions

A batch of 100 pieces PA 1322501 steering arm beads for Fiat Bravo were tested. The ultrasonic test equipment was used to detect defects in the material.

The working mode was the following one:

-the processing the spindles to get the best possible contact between the transducer and the piece;

-the control of the pieces is done after the machining process. This is detrimental to the economic unit because if there are non-compliant parts they are rejected in the processed phase, but it was decided to use this route because the manual polishing does not provide a uniform contact on the surface and due to the beginning " noise" which appears at the ultrasonic control errors can be made and they can lead to test failure and incorrect evaluations.

-calibration was conducted on a piece of material in the studied because deviations may occur in the material structure from one batch to another, requiring a further adjustment of the apparatus;

- the defectoscopic control must be carried out 100% on the spindles using the calibrated apparatus; random control can cause undetectability of large gaps that constrain a safety feature in operating the final piece;

- the selection of non-compliant parts must be performed immediately and the status of the parts will be indicated by marking with the green marker, the yellow marker for the pieces at the limit, which must then be tested in the transverse direction, and with red the non-conforming pieces.

-Following the analyses, it has been shown that the defect with the highest probability of occurrence in this piece is not the crack, but the .

-With a total of 100 arms, the percentage of those with casting defects is about 3%.

5 References

1. [Berke,1990] M. Berke, M,. Hoppenkamps, U., *Testing materials ultrasonically*, Krautkrämer Training System, 3rd edition, 1990.

2. [Krautkrämer,1990] Krautkrämer., J. and H., *Ultrasonic testing of materials,* 4th edition Springer-Verlag, 1990.

3. [Hellier,2003] Charles Hellier, *Handbook of Nondestructive Evaluation*., McGraw-Hill, 2003.

4. [USM,2013] USM_36 Technical Reference and Operating Manual, 2013.
5. [Edmonds,1981] Edmonds, P.D., *Materials of Experimental Physics, Volume 19, Ultrasonics*, Academic Press Ltd., New York, London, 1981.
6. [Baldev,1990] Baldev, R., Jayakumar, T., *Practical non-destructive testing*, 1990.