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POSSIBILITIES OF TECHNICAL PROCEDURE CREATION FOR TESTING THE WELD JOINT BY A NON-DESTRUCTIVE METHOD

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ABSTRACT

The continuous increasing of requirements for product quality leads to increased flaw control and evaluation. One of the inspected parts of the product is a welded joint. The flaws should be eliminated as far as possible to avoid the failure or destruction of the product. In the field of weld inspection, there is the most used the non-destructive testing, whose main advantage is that the product remains unchanged for further use after testing. The presented article is focused on the possibilities of technical procedure creation of weld inspection by use of non-destructive testing. The introduction part of this article describes a theoretical approach to non-destructive testing, concretely the ultrasonic testing with the consequent description of materials and methods which were used to create the technical procedure. The main part of the article describes the possibilities of creating the technical procedure for a concrete practical example and it provides a general evaluation of the proposed solution at the end.

Key words: technical procedure, welding, non-destructive testing.

INTRODUCTION

Non-destructive testing is a set of methods for testing materials without breaking or altering their properties, testing components and structures so that they can perform their function after the test. The role of non-destructive testing is to detect flaws, its visibility by physical indication or characteristic deviation of the electrical signal and subsequent evaluation of the findings together with their interpretation. (Zajac et al., 2016; Stančeková et al., 2013) The basic methods of non-destructive testing are presented in the following table.

Table1. Methods of non-destructive testing

Technique	Limitations	Capabilities
Radiography	Smallest defect detectable is 2% of the thickness; radiation protection	Subsurface flaws
Visual inspection	Small flaws are difficult to detect; no subsurface flaws	Macroscopic surface flaws
Ultrasonic	Evaluated material has to be a good conductor of sound	Subsurface flaws
Eddy current	Difficult to interpret in some application, only metals	Surface and near-surface flaws
Acoustic emission	Expensive equipment	Entire structure

One of the basic methods of non-destructive testing is ultrasonic testing. This method allows detection of internal material flaws, even at a great depth below the surface. The principle of ultrasonic testing exploits the fact that the solid materials (metal and non-metal) are good conductors of sound waves. The ultrasonic waves transmitted to the material are reflected from each interface and thus from internal flaws (inhomogeneity). The higher the frequency of the waves, the smaller the defects can be detected. (Mičko et al., 2016; Mohyla et al., 2014)

Ultrasonic testing is used to measure thickness, to detect hidden defects in material, or to determine some material properties in metals, plastics, composites, ceramics, rubber and glass. These are precisely directed acoustic waves with high frequencies transmitted to the material. Ultrasonic devices generate short ultrasonic pulses; this acoustic energy is transmitted by acoustic coupling to the material. The instrument monitors and analyses the reflected or transmitted waves and then generate the relevant values. Probes in conjunction with ultrasonic detectors are used to transmit and receive ultrasonic waves. (Hijazi, 2019)

The ultrasonic test is performed after the visual testing, magnetic particle testing or penetrant testing. The tested welds have to be visibly marked by:

- identification number,
- the code on the label.

The test is carried out over a 100% cross-section of the weld over its entire length, from both sides and one surface, by angle and straight probes. The base material (contiguous to the weld joint) is tested by angle probes for the presence of lamellar imperfections that may affect the angle probe testing before being tested by angle probes in the band corresponding to the test surface.

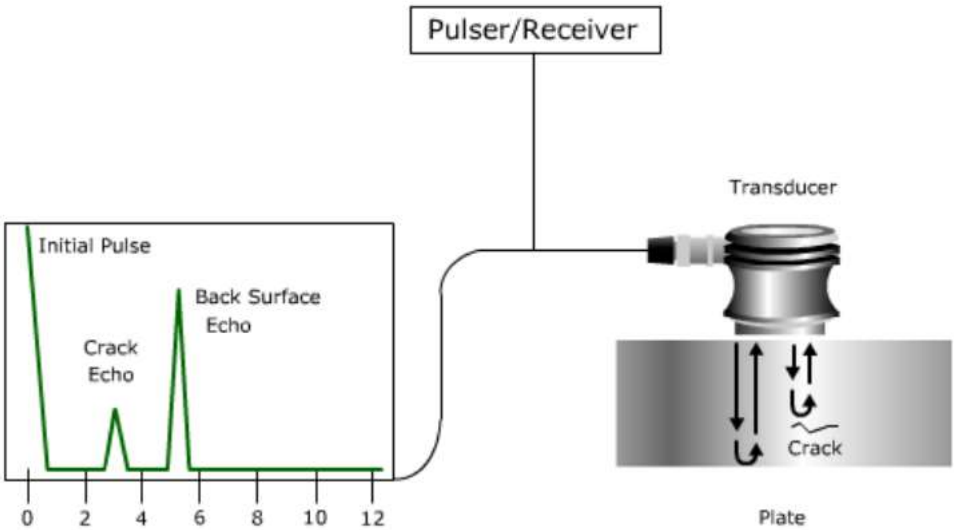

Figure 1 The basic principle of ultrasonic testing (Stanoev et al., 2016)

MATERIAL AND METHODS

The research used material S355J2 + N, fine-grained weldable steel. This steel is used to manufacture components and constructions for the automotive industry. The minimum yield strength is 355 MPa, which decreases with the thickness of the material. The following table shows the basic specification of the used material.

Table 2. Determination of used material

Chemical composition [%]				
C	Mn	Si	S	P
0.22	1.60	0.55	0.035	0.035
Mechanical properties				
Yield Strength [MPa]	315 - 355			
Tensile Strength [MPa]	490 – 630			

Elongation A5 [%]	max. 22

Technical procedure was created for weld by use of arc welding melting electrode in the protective atmosphere. Arc welding with a melting electrode in the protective atmosphere is currently one of the most spread types of construction steel welding. Like in the case of arc welding with coated electrode the heat created by the combustion of an electric arc is used for heating and partial smelting of weld and additional material. The arc burns between the base material and the end of melting iron electrode that is continually pushed to the fusion by feeding mechanism. The electrode is at the same time the source of additional material.

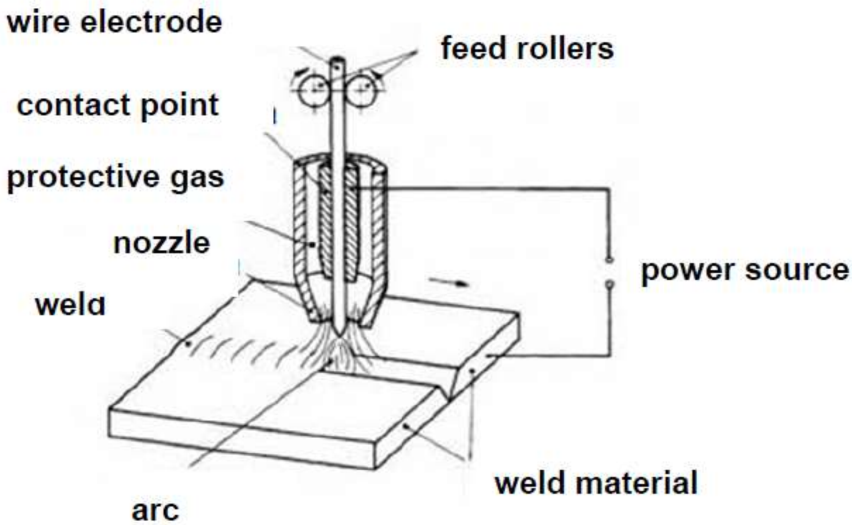

Figure 2 Schematic presentation of the used welding technology (Krivošík, 2006)

In the case of this type of welding, the way of metal transfer through the arc is an important factor. It is separation and movement of drops of liquid metal between partially smelted end of the electrode and their merging with welding bath. Each type of transfer has its specific significance within welding practice. Metal transfer depends on parameters of welding, mainly on the current density, the voltage on the arc, the polarity of welding current, electrode diameter and type of protective gas. Basic types of transfer are presented in the following figure.

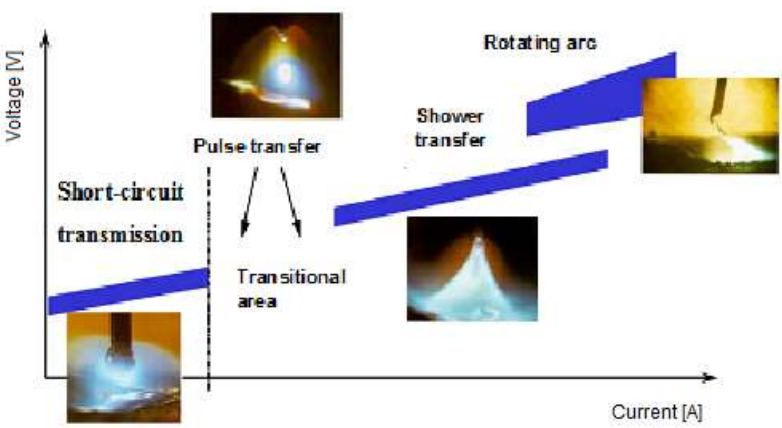

Figure 3 Basic types of arc transfer (Roubíček et al., 2016)

From the above-mentioned material, it was produced weldment whose mechanical assembly drawing is shown in the following figure.

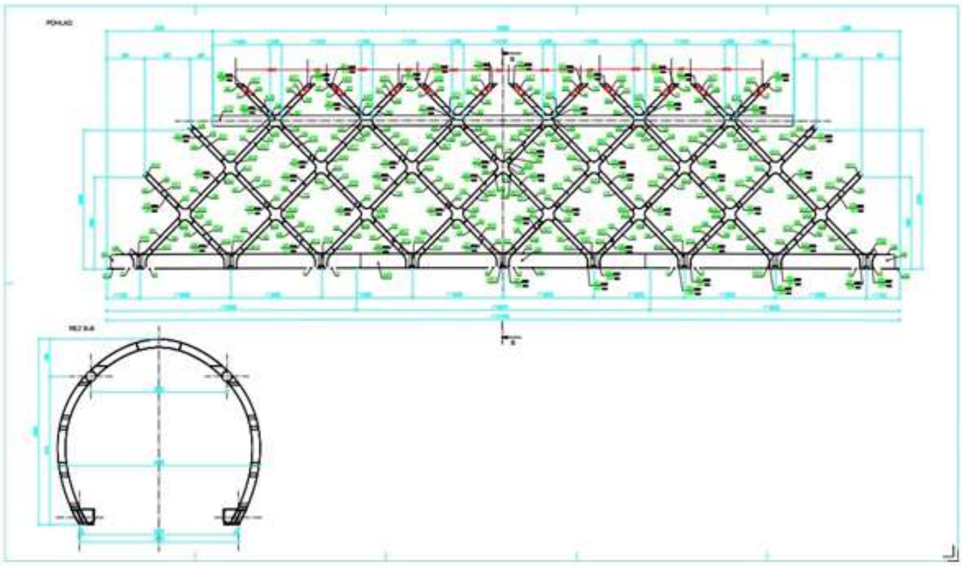

Figure 4 Mechanical drawing of the weldment

On the basis of the first mechanical drawing, it was created the second mechanical drawing, showing the geometry of check points (Figure 5).

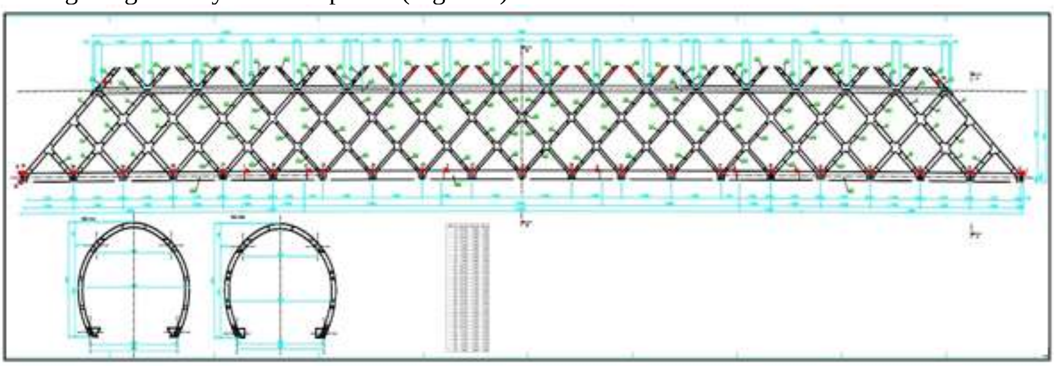

Figure 5 Mechanical drawing – the geometry of check points

TECHNICAL PROCEDURE OF WELD INSPECTION

Ultrasonic testing of welded joints and adjacent material shall be carried out in accordance with the STN EN ISO 17640 standard and shall be evaluated in accordance with the STN EN ISO 11666 standard. The test shall be carried out at the manufacturer's premises. The test is carried out by personnel who must be qualified and certified in accordance with the Centre's qualification regulations and must comply with all OHS requirements applicable at the place of the test.

When preparing the surface of the test piece, it is necessary to ensure smooth and straight surfaces, which should not contain flaws, rust, recesses, etc. In the gap between the probe and the test surface, the roughness of the test surface shall not create a gap greater than 0.5 mm.

Various testing gauges, aids and devices such as K1 and K2 gauges, a 70° angle probe, binding medium and the like are used for testing, using only universal ultrasonic detectors with valid calibration. The basic types of ultrasonic detectors are "K1 and K2 Calibration Blocks", which are designed to assess depth resolution, adjust the range and assess the linearity of the time base. The K1 calibration gauge provides a wider range of correct settings for ultrasonic testing than K2. A reference scale with side cylindrical bores ø 3 mm made of the same material as the component under test shall be used to adjust the sensitivity.

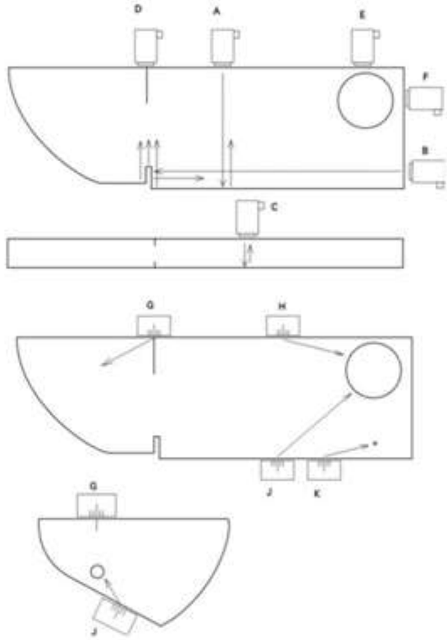

Figure 6 K1 and K2 Calibration Blocks

Timebase setting of probe:

- Selection of the required instrument range according to the material thickness (straight probe)
- Selection of the required instrument range according to the required path (angle probe)
- The setting of the propagation speed at the half-thickness of the selected range or known smaller thickness (straight probe)
- Finding the maximum height of successive echoes (angle probe)
- Sensitivity setting on the reference block (straight and angle probe) - construction of the evaluation curve

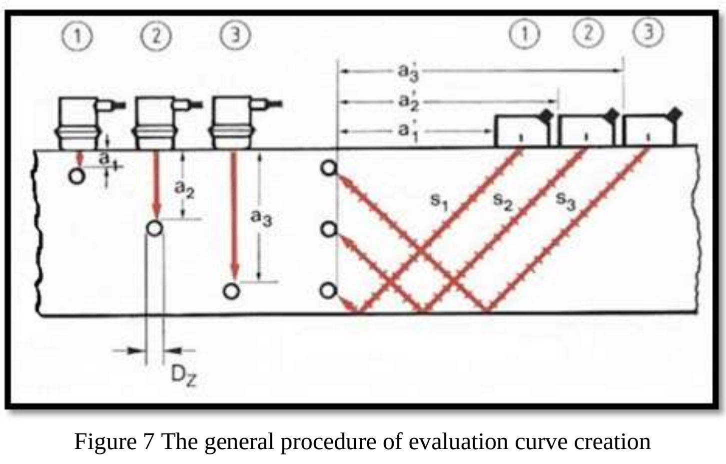

Figure 7 The general procedure of evaluation curve creation

Sensitivity and range settings shall be made prior to each test in accordance with the non-destructive ultrasonic testing procedure. Inspection must be carried out every 4 hours and after testing to verify these settings. Inspections are performed when system parameters are changed or equivalent settings are assumed.

After determining the basic settings, the weld joint and the adjacent base material are tested, the procedure being as follows:

- Inspection of the cleanness of the weld joint surface and adjacent material surfaces (min. 60 mm wide on each side)
- Verification of probe parameters and functionality of the test system
- Testing of the base material (straight probe) to determine surface flaws parallel to the surface
- The setting of the sensitivity reference level of the straight and angle probe
- Inspection of welded joint - detection of internal flaws parallel to the tested surface (straight probe, detection of internal flaws perpendicular to the tested surface (angle probe), detection of longitudinal and transverse flaws
- Marking of the direction of the weld and adjacent material testing
- Recording and evaluation of test results in a report and plot founded flaws
- Correction of detected flaws and re-implementation of ultrasonic testing

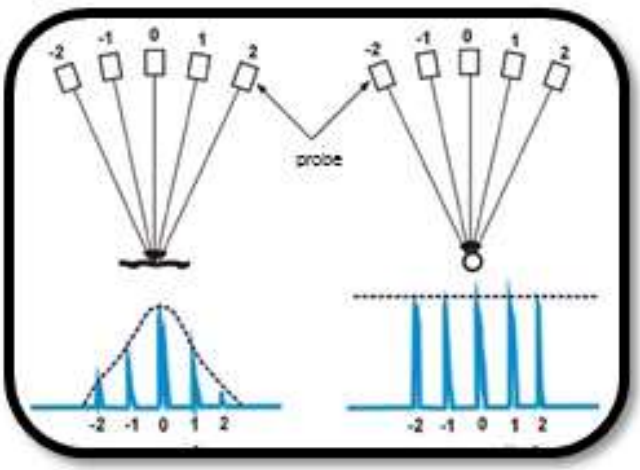

Figure 8 Output echo – area flaw (left) and volume flaw (right)

CONCLUSIONS

Non-destructive testing is based on the knowledge that the weld is satisfactory as long as there are no defects or only the defects are serious. Inspections ensure early detection of external and internal defects in the product or semi-finished product. Methods of non-destructive testing for individual products and semi-finished products are prescribed in the relevant standards and regulations. It is precisely in this respect that the customer's requirement, which determines according to which regulations or standards the product is to be evaluated, is a key element. (Schmidova, et al., 2016; Masláková, et al., 2012) The present article was focused on the description of the creation of the technological procedure for testing the weld joint by a non-destructive method. The created proposal of the technical procedure brings a practical methodology for the implementation of non-destructive tests using ultrasonic testing. In general, in most cases, it is necessary to select a combination of several methods to comprehensively detect the flaws found in the weld formed. Development of technological procedures for combined applications of non-destructive methods is the subject of further research.

ACKNOWLEDGEMENTS

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