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Ultrasonic Examination of „Difficult" Welds

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Abstract

In this article the through-transmission method of ultrasonic weld examination is described. This method, rarely used, enables the examination of some type of welds that can not be examined by traditional pulse–echo method and, because of this, they are not mostly examined by ultrasonic techniques – "difficult" welds. Many examples of weld examinations with usage of this method are presented. The article contains also methodology and procedure of ultrasonic examination of some type of welds with the through-transmission method. This method can be automated by application of special mechanical system that makes easy the movement of probes and enable the use of scanner for automatic registration of examination results.

Keywords: Ultrasonic, Through-transmission, Pulse-echo

1. Introduction

Advantages of ultrasonic examinations like: low testing costs, mobility, availability of equipment, basic standardization, makes this method as elementary testing method. It means that **this method is used most often and in the widest range** of applications. Beside mentioned advantages of ultrasonic examinations of welds there is a fault. The fault is the division of welds that can be tested with ultrasonic and that can not be tested with ultrasonic. This division is leveled very slowly.

Based on assumption that sentence "welds can not be tested" is wrong we will introduce the division of "easy welds" and "difficult welds". "Easy welds" is the welds that examination has: systematic and reliable system of standards or procedures, complete technical equipment (flaw detectors, probes), etc. The others welds are the "difficult welds".

The most common example of "difficult welds" are thin welds. These welds became "easy welds" after introduction of IBUS-TD method that concern ultrasonic examination of thin welds 2-8 mm [1].

Potential range of occurrence of "difficult welds" seems much larger than tested set of "easy welds". For example T-joints without full fusion that very often are base of steal constructions. Beside the range of occurrence more important is the danger appear from lack of testing which is unfortunately confirmed by winter 2005/2006 (many hall disasters in Europe). The most horrible disaster in Poland was the hall crash in Chorzow. One of causes pointed by specialists was "lack of fusion and incomplete fusion in welds" [2].

2. Pulse-echo method and through-transmission method

It is well known that two ultrasonic methods are used: pulse-echo method (P-E) and through-transmission method (T-T). In the history of ultrasonic examinations the T-T method was used earlier than P-E method. The T-T method was used in early thirtieth of previous age thanks to J. S. Sokolow works. Even J. and H. Krautkramer made reference to that works in their fundamental work *Werkstoffprufung mit Ultraschall* [3] that formed basic ultrasonic testing methods.

However the P-E method dominated the T-T method thanks to its advantages means possibility to more precise description of flaw position and size. It is hard do say why in years of evolution this domination increased. We wonder why the obvious advantage of the T-T method wasn't noticed. This advantage is that the T-T method is void of possibility of occurrence “false echoes”. The main reason of non testing “difficult welds” are “false echoes”. The confirmation of our observation is European Standard for the T-T method [4] which gives the title “Techniques of through-transmission” and basically doesn't say anything about possible method's applications.

3. Exemplary set of tested “difficult welds”

In two years time of the T-T method application for “difficult welds” testing, set of exemplary usage is collected. Below is the set os tested “difficult welds”:

3.1 Very thin welds of car seats, 1mm, T-joints and lap joints. Examinations were performed after optimization of different probes construction. Chosen probes had: 4MHz, transverse wave, angle 67 degrees, 7mm transducer diameter (4T67 7).

3.2 T-joints and butt angle joints of steal constructions with carrying cut 6-15 mm. Examinations were performed after optimization of different probes construction. Chosen probes had: 4MHz, transverse wave, angle 45 degrees, 9x10 mm transducer size (4T45 9x10). (Figure 1, Figure 2)

3.3 Lap joints of steal constructions with carrying cut ~10 mm. Examinations were performed after optimization of different probes construction. Chosen probes had: 4MHz, transverse wave, angle 45 degrees, 9x10 mm transducer size (4T45 9x10).

3.4 Butt joints of steal constructions – special reinforcement of spar, with carrying cut ~12mm. Examinations were performed after optimization of different probes construction. Chosen probes had: 4MHz, transverse wave, angle 45 degrees, 9x10 mm transducer size (4T45 9x10).

Figure 1. Readings on 3 mm reference hole

Figure 2. Readings on acceptable place

4. Examination techniques

4.1 Basis of ultrasonic examinations with usage of through-transmission method

Graphic basis of examinations was made with usage of “Symul” made by Ultra. Transmitter probe sends ultrasonic beam to receiver probe. Signal strength gives us amplitude level. Amplitude decrease means that something (bad probe geometry, flaw, smaller weld cut, etc.) stopped part of ultrasonic beam. Basis of the T-T method is shown on Figure 3 and Figure 4.

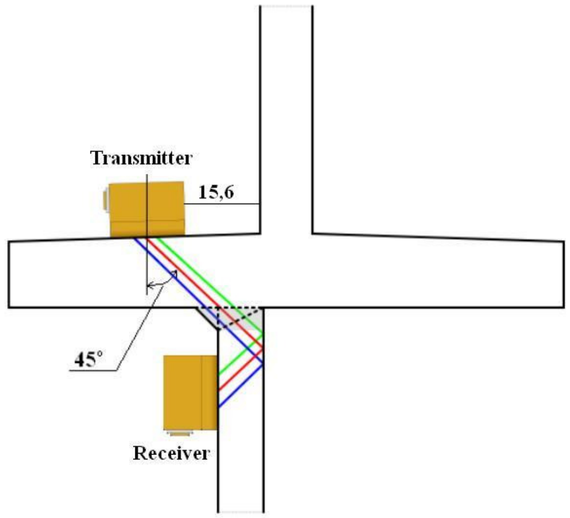

Figure 3. Transmission of ultrasonic beam in optimal probes geometry.

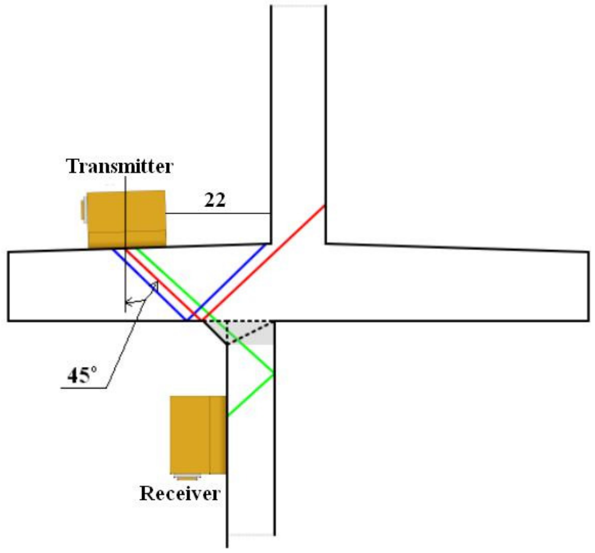

Figure 4. Transmission of ultrasonic beam in non optimal probes geometry.

As we can see beam goes trough triangle weld. Lack of fusion or inclusions in weld area reduce the strength of ultrasonic beam. Eventually crack in weld area will cause limitation or reflection of ultrasonic beam. Reduction of ultrasonic beam makes amplitude level smaller which tells us that something is wrong.

4.2 Geometrical model of through-transmission method

Figure 3 presents beam transmission in real geometry with full compatibility of dimensions, angles, cuts. Probes position is optimal and it gives us maximum amplitude. Figure 4 presents one of many situations other than optimal probes position. It is obvious that in non optimal probes position amplitude level will be smaller or it will disappear.

Amplitudes in mentioned methods (P-E and T-T) are not the same thing. Interpretation of amplitude in these cases is different. In the P-E method maximum amplitude allows evaluate flaw size. In the T-T method maximum amplitude (for example on Figure 2) means:

a. if we get minimum once amplitude higher than acceptation level than it means lack of flaw bigger than acceptation criterion

b. if we don't get amplitude higher than acceptation level than it can mean:

- flaw bigger than acceptation criterion
- probes position isn't optimal (Figure 4)

Distinction of two causes of the same readings is simple and unique.

4.3 Examination stages

Preparation procedure and examination performing is the same for each weld joint:

a. surface preparation for both probes movement

b. geometrical measurements of joined elements, outer weld shape that will allow making of sketch like on Figure 3

c. making of sketch of optimal state with real dimensions (Figure 3) with usage os tool like "Symul", weld drawings simplify making of sketch

d. for choosing the place for making reference hole:

- initial examination at least 1 meter of weld with optimal probes geometry
- pointing at least 15cm of weld that has maximum amplitude in range of ± 2dB
- marking on flat piece of joined element comparative amplitude on distance similar to initial examination
- if both amplitudes (from a. and c.) differ no more than 10dB than chosen piece of weld is good for making a reference hole

e. making a 3mm reference hole on chosen piece of weld

f. setting the flaw detectors gain and setting gate at acceptation level

g. performing examination

h. **examination results are evaluated according to acceptation criterion from point 5.**

4.4 The method of performing examination

Examination is performed cut by cut and it has two purposes:

a. unique qualification one of three possible conditions:

- lack of flaw – good cut
- non optimal probes geometry – further searching
- bad weld (cut)

b. examination of full weld witch is tested point by point

5. Mechanization

Examination performed cut by cut means that in each cut we are looking for optimal probes geometry is quite time-consuming, however operator quickly learns how to do it. Significant improvement (even in compare to traditional P-E method) was archived by simple mechanization shown on Figure 5.

This Figure presents "Riksza" that moves along angle weld. It is equipped with set of three probes with magnetic holders and water-coupling system which provide very good ultrasonic contact. Probes can be set in different optimal geometries for different types of welds. Two probes are used for the T-T method. Third probe on surface wave is a part of ultrasonic scanner that allows result registration (Figure 6) and gives us result of examination of full weld.

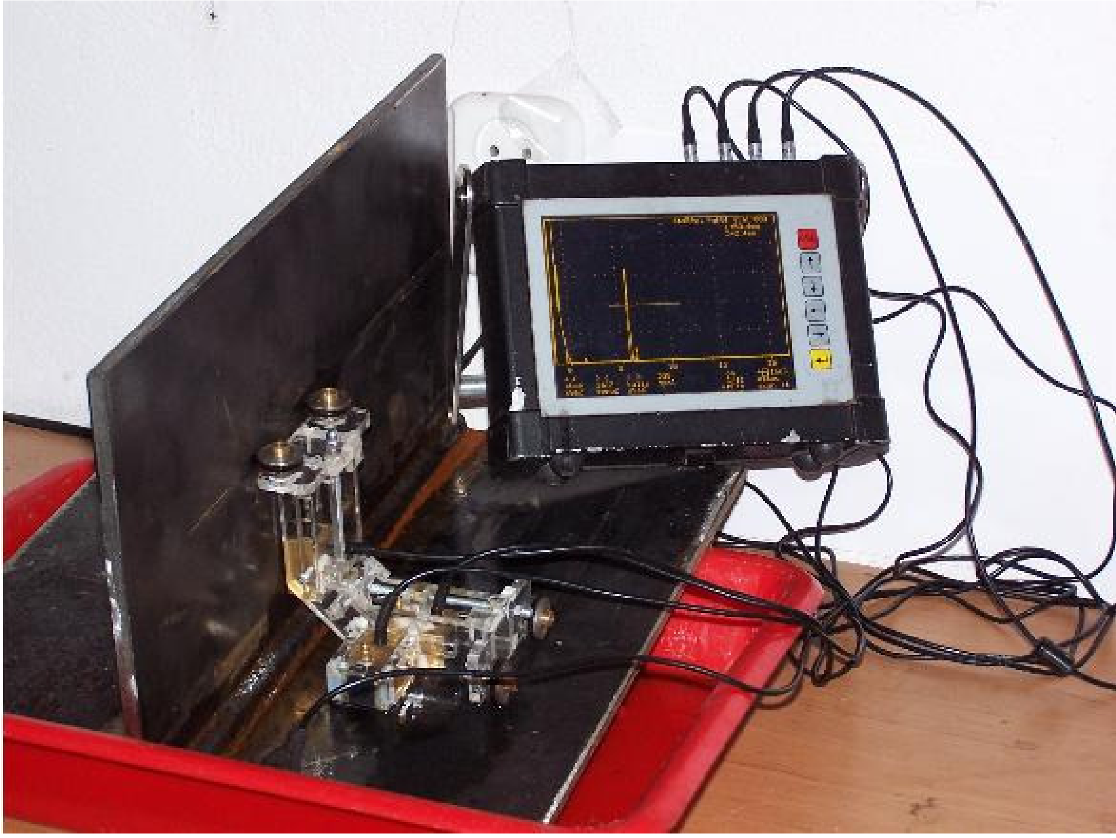

Figure 5. Angle weld tested by "Riksza", acceptable reading is shown on flaw detector's

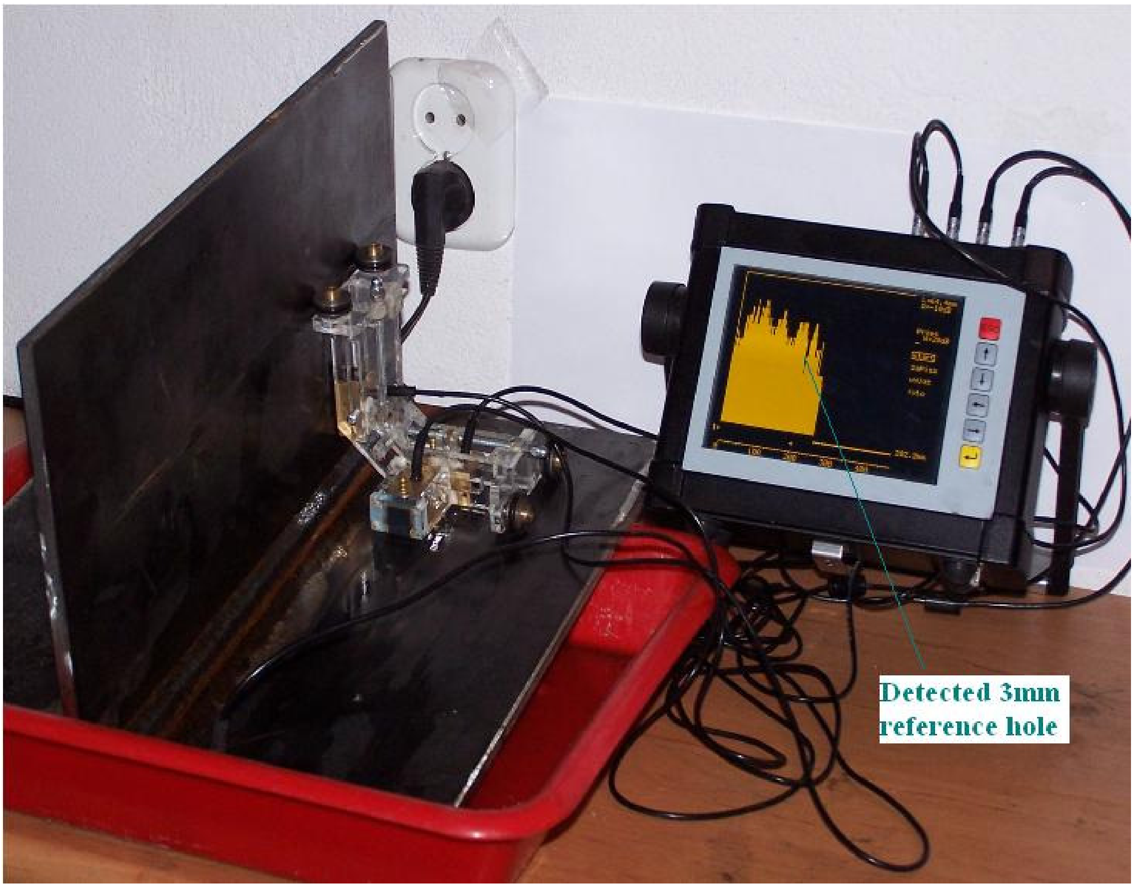

Figure 6. Angle weld tested by "Riksza", whole weld testing result is shown on flaw

6. References

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