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ULTRASONIC DETECTION OF DEFECTS IN STEEL WELDS

ULTRAZVOČNO ODKRIVANJE NAPAK V JEKLENIH ZVARIH

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Abstract

High-strength micro-steels(VTML) are often used in the modern steel construction of multi-bead welds. Given the effectiveness and efficiency, welding is one of the main technological processes in the production of metal parts to manufacture complex forms.

In this paper, the ultrasonic detection of defects in steel welds is presented. The first part of the paper deals with the problem of the occurrence of defects in steel welds and how to determine them. The next part describes the ultrasonic detection of defects with a *Krautkrämer* device.

Povzetek

Visokotrdna mikrolegirana (VTML) jekla so pogosto uporabljena kot moderna jekla za gradnjo večvarkovnih zvarnih spojev. Glede učinkovitosti in ekonomičnosti je varjenje eden od glavnih tehnoloških postopkov pri proizvodnji kovinskih delov, ki nam omogoča izdelavo kompliciranih oblik.

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V članku je predstavljena detekcija napak v jeklenih zvarih z ultrazvokom. V prvem delu raziskave je opisana problematika pojava napak v jeklenih zvarih in kvalifikacija nastalih napak. V nadaljevanju je opisana detekcija napak v zvarih z ultrazvočno napravo *Krautkrämer*.

1 INTRODUCTION

Welding is the joining of two or more parts of a base material into an indivisible whole *[1]*. Regarding effectiveness and efficiency, welding is one of the main technological processes in the production of metal parts to manufacture complex forms. For effective welding, the knowledge of welding structure design, metallurgical welding, the weldability of materials, and the different technological processes of welding are necessary.

Chemical reactions are not desirable; they enter the weld melt from the atmosphere and base material. The best properties of welded joints are achieved by a very expensive welding process the takes place in a vacuum, for the military and aerospace industries. Structural stresses occur in metal when the crystal structure is modified and as a result of warming or cooling. In the case of Y-α in the iron, the consequence is a change in volume. Furthermore, the rate of change in the material causes elasticity or plasticity of the tested material, *[2-4]*.

Therefore, it is necessary to search and classify the defects in welds. This study presents the most commonly used non-destructive method of finding defects: the ultrasonic method.

2 EXPERIMENT AND RESULTS

The sound field of ultrasonic probes can be divided into the near and far fields. The focusing of the sound is called the *Frasne* zone or a near field. Due to the overlapping and aggregating of individual wavefronts, the impact of the scope is robust and rapid, preventing a reliable assessment of echo heights. In the *Fraunhofer* zone or far field, the sound path increases due to the divergence of the ultrasonic beam split into a rising curve. The impact of the loss of divergence means that the distance of the sound pressure decreases (Figure 1).

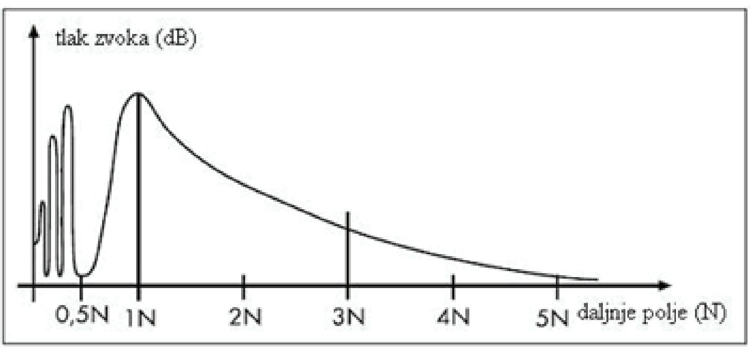

Figure 1: *Sound field (Faculty of Energy Technology archive)*

We assumed that the validity of ultrasound is treated as a deduction of acoustically ideal substances. So, the sound pressure decreases due to spreading of the sound beam travelling through a specimen. Other materials have additional sonic insulation, which can be divided into absorption and scattering.

Absorption represents the conversion of sound energy into heat, *[5-8]*. Such throttling reduces the intensity of waves, but it does not increase the noise in the received signal. The echo height is reduced and can be levelled by increasing the transmission power and the repeater. In *damping* or *scattering*, this cannot be performed because it would lead to an increase in the base noise and would not improve the signal/noise ratio. Scattering represents the parts of the sonic waves that bounce in straight lines and spread when deducted against the inverter. They can be seen on the screen as noise. Due to this phenomenon, the suitability of the materials is reduced in two different ways:

- The intensity of the sound field is decreased, thereby reducing the height of the indications being the result of searching for defects in the material.
- Background jamming occurs because of which the indication of interruption is covered.

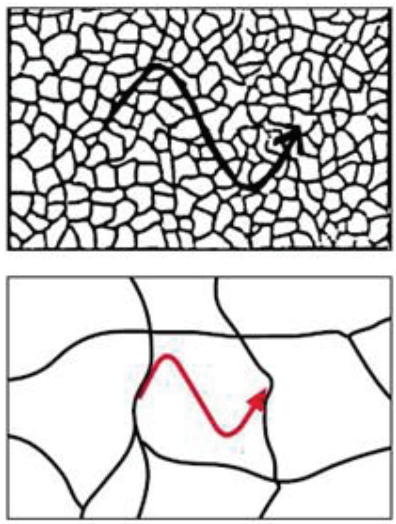

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Figure 2: *Fr Damping of ultrasound (Faculty of Energy Technology archive)*

Very fine grains do not cause scattering since the wavelength is relatively large in comparison to the grain size. If the grain size reaches that of the wavelength, a part of the sound wave is declined from its direction (Figure 2).

Damping of the ultrasound depends on the type of material, the size of specimen grains, and the size of the wavelength. The ultrasonic *Krautkrämer* USM 36 is a device for the non-destructive debugging of steel welds. (Figure 3).

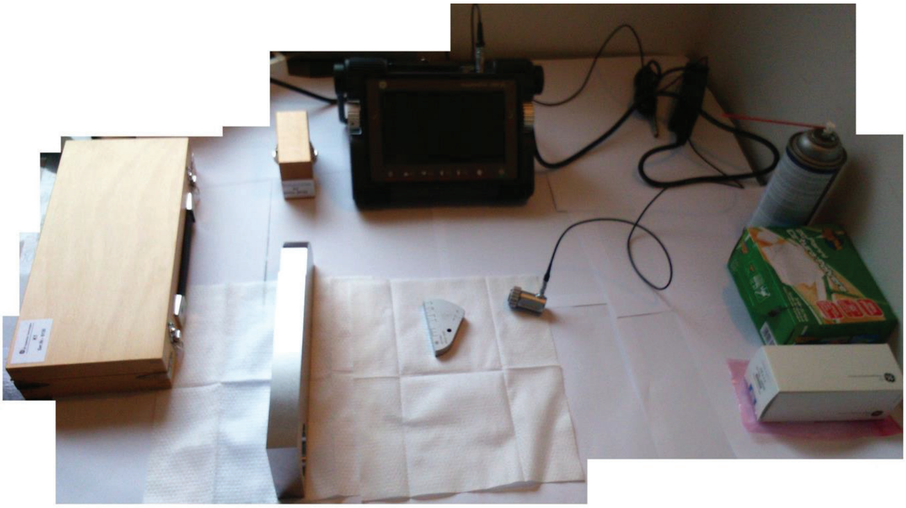

***Figure 3:** Preparations before testing with an ultrasonic method (Faculty of Energy Technology archive)*

The flat head probe sends the sound into the object. The device automatically detects defects on the basis of the data, height, thickness and length of the transmitted signal (Figure 4).

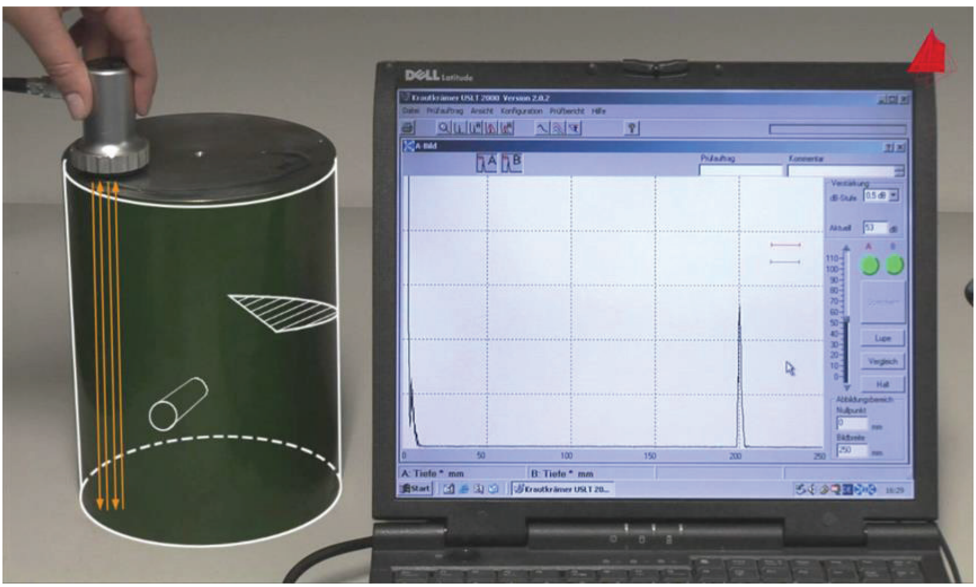

Figure 4: Operation of a flat head probe and the readings on the computer monitor, *[3]*

The device is activated by pressing the start button. Then it has to be connected to the straight probe. To start the measurement, the probe is lubricated with a water-based gel, in a portion the size of a bean. Then the calibrations for each standard or material are made separately.

The ultrasound examination has a tendency in which the natural reflectivity of reflectors is compared with the reflectance of artificial reflectors; the comparisons may be direct or indirect. In the direct mode, a comparator block, which is in accordance with the regulations for comparative reflectors, has to be available, *[9-11]*.

In the indirect comparison, the comparative reflectivity of the reflector is determined. The direct comparison, to be a valid method of the comparative block, the AVG indirect method or the ultrasonic device, called DGS, is used.

The advantage of the DGS method is that it does not require comparative blocks to reduce costs when changing the tasks, while other advantages include the testing of small batches and maintenance. According to the geometry and damping properties of the experimental equipment, the DGS method is more limited than that of the comparative block (Figure 5).

The use of the comparative block requires such blocks with similar acoustic properties of a specimen. Regarding finances, this method is useful for testing large batches.

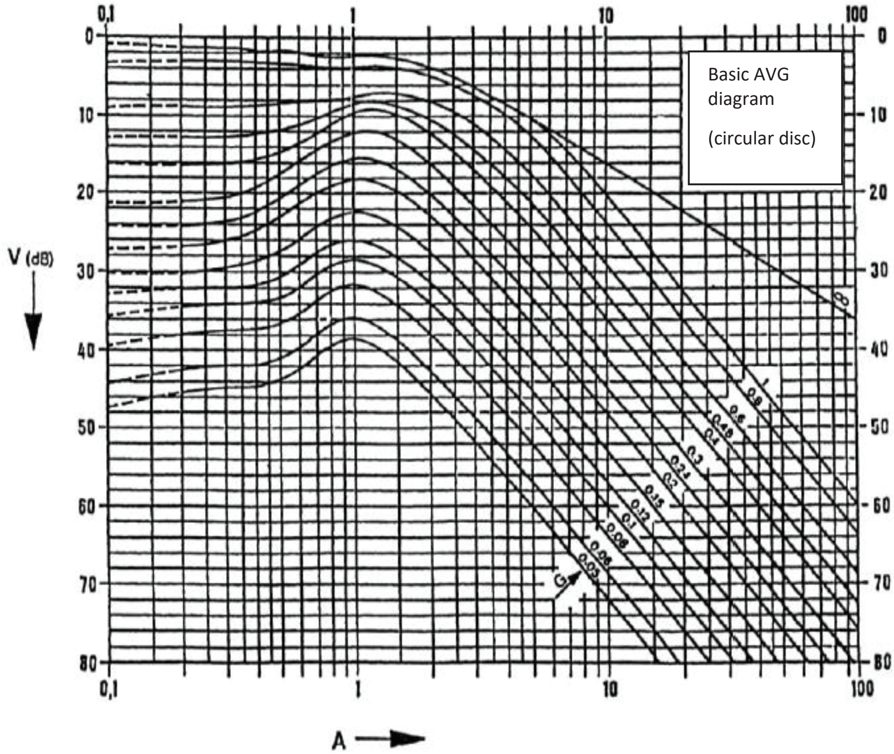

Figure 5: *General AVG or DGS diagram*

The code ˝AVG˝ is an abbreviation of the German words *Abstand*, *Verstärkung*, and *Groß* (distance, amplification, size). The method uses a relative difference attenuator for perfectly circular reflectors of different diameters to increase the distances away from the vibrator. In the diagram of the differential attenuator, the difference in the attenuation setting on the machine is provided due to the need to achieve a signal, both compared with the same reflectors arranged at the height of the screen.

The horizontal axis represents the distance from the reflector vibrator, while the decreasing and increasing of the vertical axis needs amplification. The diagram reflector with different diameters belongs to one of the curves to obtain a group of curves. If the associated reflectors are smaller, more lines run low, and more of them are highly amplified.

The KSR curve of the rear wall is seen just for a limited period, having a lower slope of decline in dependence with the distance. The size and distance are given as quantity norms so that the general DGS diagram can be used for all normal and angle probes.

The protective boxes of probes have ready-made special diagrams valid only for the types of probes. The AVG diagram does not apply to the SE-focused and highly damped probe (Figure 6).

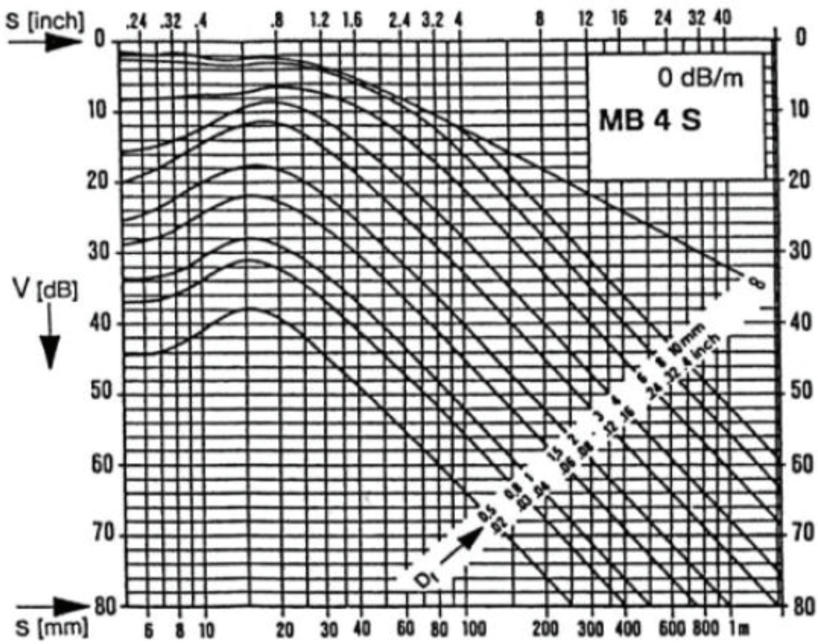

Figure 6: *Diagram only applies to the flat probe MB 4 S*

3 CONCLUSION

Steel welds are an integral part of steel structures. Welded joints are typically characterized by the heterogeneity of chemical and mechanical properties. The welds develop different defects that detrimentally affect the carrying capacity of welded structures. In some cases, a sudden collapse of the structures may occur.

Therefore, it is crucial that the presence of errors is detected in due time. One of the most effective methods of testing is the ultrasonic method. When handling the USM ultrasonic device 36, it is important to properly calibrate it to measurement standards K1 and K2 and to select the corresponding measurement probe with which the defects will be sought.

The defects are classified according to the standard classification, while the size is read through the AVG rocks. This makes it vital to detect defects in due time. One of the most effective methods of testing is the ultrasonic method.

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