Ultrasonic Inspection of DP Steel Joints Made by EBW

Hodúlová Erika, Kovaříková Ingrid, Šimeková Beáta

Abstract – As an electron beam welding of duplex stainless steels offers a variety of advantages over traditional welding processes. Problems that are typically occurring due to the cooling is the ratio of ferrite and austenite, such as solidification cracking and formation of porosity. Ultrasonic non-destructive testing can be used for quality assessment of EBW duplex steel joints. In this paper, a novel approach for the detection of defect is proposed using a suitable ultrasonic testing method without the scattering and refraction in austenite.

Keywords – Non-destructive Inspection, Duplex Steel, Ultrasound Inspection, Austenite.

I. INTRODUCTION

Duplex steels are nowadays the very often used construction materials in different industries. DP is a dual phase steel, the structure is formed of ferrite and austenite. The ratio of austenite and ferrite 50/50% provides good mechanical properties and good corrosion resistance in particular [1-3]. The joining of these steels are currently often provide by using the concentrated energy beam welding (LW and EBW). These processes allow to create a deep and narrow welds with a very narrow HAZ, to form a minimum deformation of welded materials [4-7]. The EBW method is not required the using of filler material for joining, weld gap is very small and it creates the narrow weld. The problem is the rapid cooling of the weld after welding, thereby the structure of the weld is forming by ferrite, which amount may be up to 60-90%. This is already provided by the application of weld heating after welding process, to achieve ferrite ratio of 40-50% (8-10). By using the incorrect welding parameters it indicates a lack of root filling with molten metal, which often causes the formation of cavities in the weld root. However the non-destructive inspection of duplex and superduplex steels is a big challenge as those steels, being composed of ferrite and austenite, have some particularities. When using ultrasound, for instance, its waves propagate well in ferrite, but suffer strong attenuation, scattering and refraction in austenite. This paper describes the ultrasound testing of weld joints made by EBW. The aim is to propose the concrete ultrasound method for DP steel welds testing [10-12].

II. EXPERIMENTS

Prepared samples were welded by EWB method with the following parameters: welding voltage - 55kV, welding current - 45 mA, welding speed - 10mm.s⁻¹, focusing current - 585 mA and the welding position - PA. Dimensions of the sample was 200 x 200 x 5 mm.

The detection of internal indications in weld joints was performed by ultrasound reflection method. It was used the ultrasound equipment Olympus Epoch LTC with 4MHz probe and angle of 70°.

As the second method was used Phased Array ultrasound testing method. The measurement was performed by Olympus OmniScan MX2 with 10 MHz probe PA10L16-A00 (Table I).

Table I Parameters of ultrasound scanning

<table>
<thead>
<tr>
<th></th>
<th>Classic UT method</th>
<th>PA</th>
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<tbody>
<tr>
<td>Probe frequency</td>
<td>4 MHz</td>
<td>10 MHz</td>
</tr>
<tr>
<td>Probe /Wedge angle</td>
<td>70°</td>
<td>39°</td>
</tr>
<tr>
<td>Gain</td>
<td>66 dB</td>
<td>66 dB</td>
</tr>
<tr>
<td>Sound Velocity</td>
<td>5960 m/s</td>
<td>3100 m/s</td>
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Calculation minimum defect dimension, which can be measured by Phased Array probe with a frequency of 10 MHz in homogeneous material with fine-grained structure:

$$\lambda/2 = \frac{\lambda}{2f} = \frac{3100 \text{ m/s}}{10 \cdot 10^6 \text{ Hz}} = 0.31/2 = 0.155 \text{ mm}$$ (1)

III. RESULTS AND DISCUSSION

Testing of samples by using the Olympus UT Epoch LTC equipment with the probe of 70° despite a various changes of parameters, it was difficult to obtain the useful results.

![Fig. 1. Olympus EPOCH LTC scan report](image)

The problem is in the dimension of austenite grains, and when using the classical probe the ultrasound beam is breaking at the grain boundaries, to obtain a noise results due to the structure of the material (Fig. 1).

Based on this knowledge was used the Phased Array ultrasound testing method.

The sample was testing by using the angle PA probe at a frequency of 10 MHz. In the weld the internal defects are not presence, also the testing by using the greater
The ultrasound testing was performed on samples from duplex stainless steel joined by electron beam welding. The test was performed by ultrasound testing equipment Olympus Epoch LTC using an angular probe 4 MHz with an angle of 70°. This method of ultrasound testing does not provide useful results due to the ferrite-austenite structure of duplex steel, which indicates the false defect causes by the refraction of the ultrasound beam at the austenite grain borders. The high noise was noted and also with changing parameters of the device cannot be distinguished initial, defect and end echo from noise. The results show, that the classical ultrasonic testing with fixed angle probe of 70° cannot be used for testing of this type of material. The grain size of the structure is very difficult for the ultrasound scanning by classic angular probe with a fixed angle from the view of probe sensitivity, therefore it was choose based the Phased Array method, which achieves better S/N ratio. The Phased Array ultrasound testing method was carried out by Olympus OmniScan MX2 device with angular probe with a frequency of 10 MHz. The sample were tested with a probe of 10 MHz frequency, with no internal defects in the weld was found, the probe experienced external defect the not fully melted weld root, and at a probe frequency of 10 MHz can be seen considerable amounts of noise from the austenitic grains of the material structure. The Phased Array testing method is suitable for the weld joints defects detection in case of the shorter length of defects as the probe aperture. If the length of the defect aperture is shorter than the probe, it may be from a linearscan (no motion sensor) to detect a possible increase of the defect dimensions earlier and more accurately than manually by measuring the height and length of the defect from the probe move on the surface. The sectorial B-scan can be relatively easily on the basis of local color differences to identify even small defects and diffraction echoes that are in A-scan difficult to distinguish from noise.

**APPENDIX**

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**REFERENCES**


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