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X-RAY DIFFRACTION ANALYSIS AT ULTRASONIC WELDING

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ABSTRACT

In the article [2] the author present experimental investigations regarding of residual stress distribution in weld bead vicinity of submerged arc welded naval plates. In this way, residual stresses from vicinity of weld bead acts like compressive stress. The ultrasonic welding is acting in order to compress the weld bead and the heat affected zone. In this paper is presented X-ray analysis to obtain information about mosaic block dimensions, micro stresses fields and density of dislocations.

KEYWORDS: density of dislocations, residual stresses, X-ray analysis

1. Introduction

The welding process of polycrystalline carbon steel produces essential structure changes in heat affected zone (HAZ). The HAZ grains structure differs from the other zones and this is a subject of thermal stress action.

After welding, these strains will result in the retention of elastic stresses in the welded joint referred to as residual stresses.

If the strain is different from point to point within the crystallites it is the micro stress (second order stress), whereas stress existing over large distances is macro stress (first order stress) [1].

The effect of strain can be seen in the diffraction peaks. Uniform strain will make the peak shift to one side or the other of ideal Bragg peak, while non uniform stress will broaden the peak as some parts of aggregate will shift the peak to one side and other parts will shift it to the other side.

In figure 1 the shift of position X-ray diffraction line appeared at big diffraction angle is shown.

The amount of first order stress σ_I that leads to a normal deformation on the superficial layer can be calculated with relation:

$$\sigma_I = -\frac{E}{\upsilon}(ctg\,\theta)\cdot \Delta\theta \qquad (1)$$

where $\Delta\theta$ is the shift o diffraction line, $E=2.1\cdot10^5$ [MPa]-Young Module, υ=0,3-Poisson Coefficient.

This all happens because the strain changes the distances between diffracting planes.

In figure 2 a schema concerning unstressed and stressed crystalline lattice that implied the existence of second order stress is shown.

In figure 3 the influence of second order stress on the shape of the diffraction line appeared at big diffraction angle is displayed.

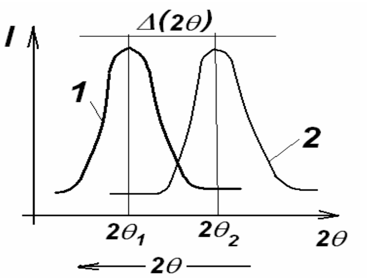

Fig. 1. *Shift of (nh nk nl) diffraction line due to σ_I [3]*

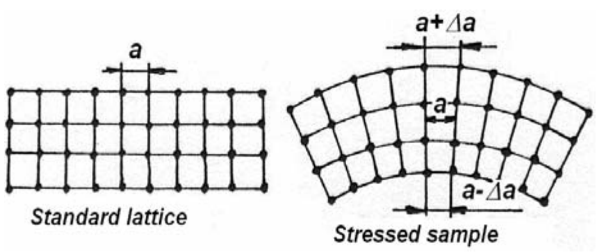

***Fig. 2**. Mosaic Block. Unstressed and stressed crystalline lattice [4]*

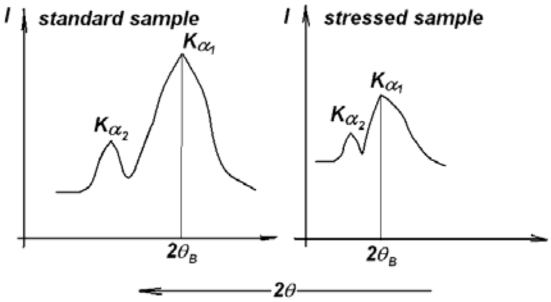

***Fig. 3**. Influence of σ_{II} on shape of diffraction line [3]*

The amount of second order stress σ_{II} was evaluated using the physical width of the diffraction line (220), β_{220}, knowing that:

$$\sigma_{II} = \frac{E}{\upsilon} \cdot \eta_{220} \qquad (2)$$

where η_{220} is a measure of the interplanar distance non-homogeneity given by relation [4]:

$$\eta_{220} = \left(\frac{\Delta a}{a}\right)_{220} = \frac{\beta_{220}}{4tg\,\theta_{220}} \qquad (3)$$

with

$$\beta_{220} = \sqrt{(\beta_{220})_S^2 - (\beta_{220})_{ST}^2} \qquad (4)$$

where $(\beta_{220})_S$ is a width of diffraction line (220) from stressed sample, while $(\beta_{220})_{ST}$ is the same parameter from standard sample.

The level of dislocation density, ρ, in the crystalline lattice was estimated with:

$$\rho \approx \left(\frac{I_{\min}}{I_{\max}}\right)_{220} \qquad (5)$$

where I_{min} is the intensity of the background diffraction line (220), I_{max} is the maximum intensity of the same line.

2. X-ray diffractograms. Experimental research

For determining the diffractograms were used CoK_α radiation with wave length of $K\alpha_1$ $K\alpha_2$ components:

$\lambda_{K\alpha} = 1{,}79019\,\mathring{A}$; $\lambda_{K\alpha 1} = 1{,}78897\,\mathring{A}$; $\lambda_{K\alpha 2} = 1{,}79279\,\mathring{A}$

The (110) diffraction line is $2\theta = 52^\circ$ and for (220) diffraction line is $2\theta = 123{,}8^\circ$.

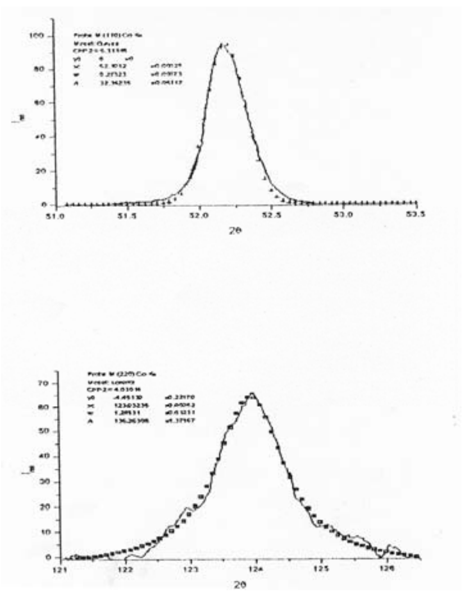

***Fig. 4**. Aspects of diffraction line (110) and (220) for normal welded plates-NWP[1]*

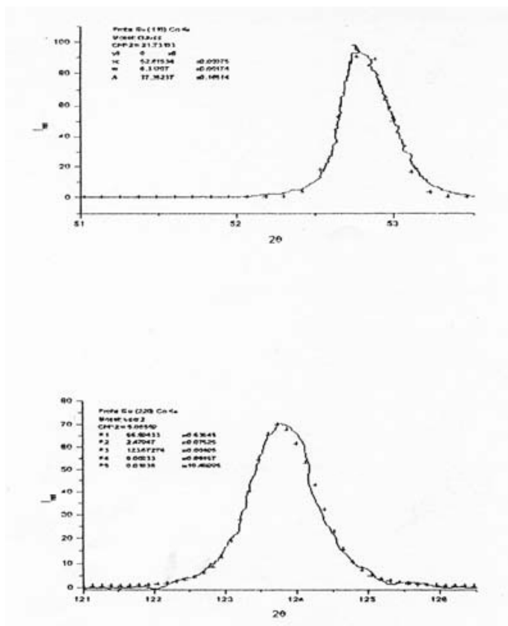

***Fig. 5.** Aspects of diffraction line (110) and (220) for ultrasonic welded plates-UWP [1]*

Table 1. *Dimensions of mosaic blocks, interplanar distance, density of dislocations*

Samples	The average dimensions of mosaic blocks D(μm)	Interplanar distance non-homogeneity η_{220}	Density of dislocations ρ
NWP	>2 μm	2.154×10^{-3}	2.65×10^{-3}
UWP	>2 μm	1.41×10^{-3}	1.13×10^{-3}

Table 2. *Normal and parallel strain*

Samples	$\varepsilon_{\perp}=\sigma_{\perp}/E$	$\varepsilon_{\phi}=((1+\nu)/E)\,\sigma_{\Phi}$
NWP	1.53×10^{-3}	-0.060
UWP	2.22×10^{-5}	0.00816

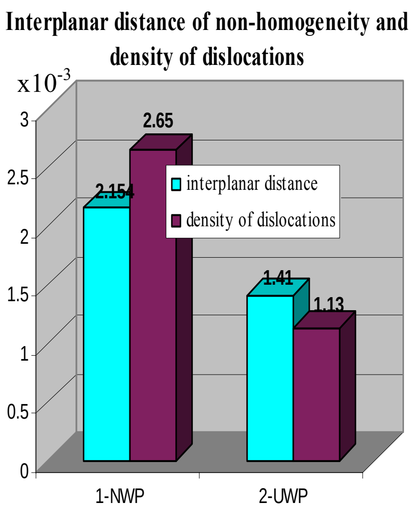

Fig. 6. *Interplanar distance η_{220} and density ρ [1]*

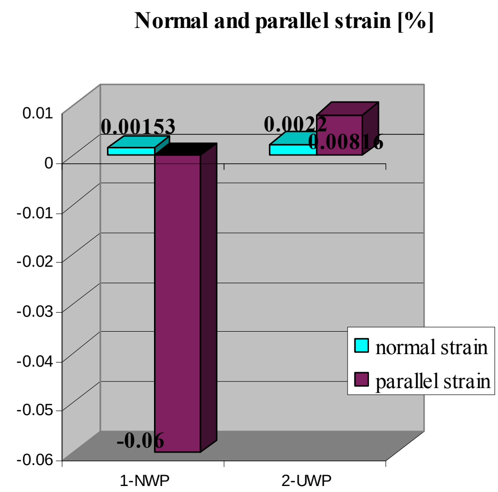

Fig. 7. *The normal strain $\varepsilon_{\perp}=\sigma_{\perp}/E$ and parallel strain $\varepsilon_{\phi}=((1+\nu)/E)\,\sigma_{\Phi}$ at surface layer(220) [1]*

Welding it was performed under both normal conditions (classical welding-NW) and ultrasonic activation of electrode wire (UW) with amplitude in welding zone $A=10\times10^{-6}$m.

During ultrasonic welding, both micro and macro residual stresses are reduced, but the strength and hardness of welded joint remain high.

All experimental data were performed on the submerged welded plates in the proximity of welded beads which corresponding with heat affected zones (HAZ).

4. Conclusions

Ultrasonic welding in condition of submerged arc improves mechanical resistance characteristics because it is supposed that ultrasonic energy transmitted by an electrode wire into metal liquid bath at resonance, breaks primary crystals forming into the weld and reduces grains' size.

The interplanar distance non-homogeneity η, and density of dislocations ρ, depends of ultrasonic welding process and decrease with 34 (η) and 57 (ρ) percents. This reduction depends with amplitude of electrode wire.

First order strains (normal and parallel) give information about the signs of residual stresses in surface layers.

The normal strain is increasing in UWP plates with 31 percents because of ultrasonic field influence in surface layers. Normally, at the thin welded plates with low stiffness, parallel strain at the right angle on weld bead determine the compressive stress which is changing rapidly in tensile stress during ultrasonic welding.

References

[1]. Dumitrache C. - *Cercetări privind influenţa ultrasunetelor asupra elementelor de substructură şi tensiuni ale construcţiilor sudate*, Teză de doctorat, Iaşi, 2000;

[2]. Dumitrache C., Comandar C., Barsanescu P. - *Residual Stresses Measurements in Welded Naval Steel using the Hole-Drilling Strain-Gage Method*, pg. 145-151, 21-24 may 2000, Third International Congress in Materials Science and Enginneering, Iasi, ISSN 1453-1690;

[3]. Gheorghieş C. - ***Analysis of the surface layer by X-rays diffraction method*** National Tribology Conference **ROTRIB '03**, 24-26 sept. 2003, Galaţi, The Annals of University "Dunărea de jos", Fascicle VIII, pag. 302-311, Tribology, ISSN 1221-4590;

[4]. Gheorghieş C - *Controlul structurii fine a metalelor cu radiaţii X,* Ed. Tehnică, Bucureşti, 1990.