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APPLICATION OF THE VIDEO-EXTENSOMETRY FOR THE COMPARISON OF THE PLASTIC DEFORMATION WELDED SHEETS

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This paper presents the results obtained from the experimental study conducted in relation with the research focused to the plastic deformation development and its localisation during the static tensile test and test of the notch toughness on the welded steel sheets. The aim of experiments was to determine the possibilities of obtaining the data for the estimation of the welds toughness applying the video-extensometry scanning of the deformation distribution, to estimate deformations within the individual sections of the weld and to compare them with the notch toughness. Based of the results obtained it can qunatitied the relation between the strain and toughness of thich sheets.

Key words: mechanical properties, longitudinal deformation, transverse deformation, video-extensometry, strain distribution

Primjena video-extezometrije za usporedbe plastične deforamcije zavarenih traka. Članak daje rezultate experimentalnog istraživanja razvitka plastične dformacije i njezin lokalizacije u epruvetama zavarenih čeličnih traka za vrijeme vlačnog i ispitivanja žilavosti. Cilj experimenta je određivanje mogućnosti dobivanja relacija o žilavosti zavara vide-extenziometrijskim očevidom deformacijskog polja, utvrditi deformaciju pojedinih dijelova zavara i to uspoređivati sa žilavosti. Na temelju dobivenih rezultata može se kvantificirati odnos deformacijskog polja i žilavosti po debljini trake.

Ključne riječi: mehanička svojstva, uzdužna deformacija, poprečna deformacija, video-extenziometrija, deformacijsko polje

INTRODUCTION

The onset of the plastic strain localisation, strain distribution (planar or special), strain gradient, size and pattern of the area in which localisation is formed as well as the values of the critical (fracture) strains are the main features for characterisation of the strain kinetics [1]. Recently, there are several methods of the contact-less measurement of the strains based on the scanning of the suitably adjusted surface of the loaded piece.

Optical extensometry is the method of the strains measurement, utilizing the computer aided and scanning technologies as well as the support of the new software applications. The development of this measurement method is affected by the development of the image analysis, or by the development of the software methodology of the scanned image analysis, however mainly by the application requirements placed by the industry [2,3]. Video-extensometry method is a contact-less method of the strains scanning. Experimental facility consists of CCD camera and computer, which serves for the processing of the signal from the camera, and corresponding software. Signal from camera is processed in the computer by frame grabber and software. Suitable contrast marks are dashed on the scanned surface (dots). The specimen is illuminated by non-spot source of light and in such manner obtained can be the best contrasts between the specimen surface and dashed dots during the measurement. In course of the test the software records the co-ordinates of the centre of the individual dots and concurrently allows the storing of the image sequence of the scanned specimen surface. To acquire the information from the multiplied number of dots, the stored images are evaluated applying software appropriate after the scanning completion. In this case, it is possible to work with the greater number of dots [4,5].

EXPERIMENTAL WORK

Experiments were carried out with the hot rolled micro-alloyed steel sheets determined for the pipes production, with the thickness of 10 – 12 mm. The flat specimens with the square of 5 x 25 mm were used for the static tensile test. The specimens were taken from the longitudinal direction of the weld. A smaller thickness of the specimens (5 mm) in comparison to the sheet

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thickness (10-12 mm) will assume better homogeneity for these thinner specimens. The grid 12 x 17 with the step of 2 mm was applied on the specimens for the strain scanning. Tensile test was performed statically, applying the loading rate of 1 mm/min.

CCD camera was used to scan the surface of the tested specimens during the tensile test. The longitudinal strains ε_L (parallel with the direction of loading) and the transverse strains ε_T (perpendicular to the direction of loading) in the area of fracture were evaluated.

Processing of the results obtained from the test under uniaxial tension. The results from the measurement were evaluated using the software Dot Measuring to the video-extensometer ME-46.

Determining parameter is the contrast of the individual dots. The evaluated co-ordinates of the centres are further processed applying the table processor Microsoft Excel. The relative strain between two dots was evaluated according to formulas (1) and (2):

$$\varepsilon_T = \left[\frac{X_2(t_2) - X_1(t_2)}{X_2(t_1) - X_1(t_1)} - 1 \right] \times 100\% \qquad (1)$$

$$\varepsilon_T = \left[\frac{Y_2(t_2) - Y_1(t_2)}{Y_2(t_1) - Y_1(t_1)} - 1 \right] \times 100\% \qquad (2)$$

Where: ε_T – transverse strain
ε_L – longitudinal strain

The samples for the notch toughness test ware taken from the welded joints in the area of the welded joint, perpendicularly to the weld axis. The aim was to measure the values of the toughness in the individual areas of the weld. Values of in such way obtained notch toughness were then compared with the local strains measured video-extensometrically for the weld individual areas of the same material when subjected to uniaxial tension.

Figure1 shows longitudinal strain and Figure 2 shows transverse strain. Figure 3 shows graphs of the toughness values measured at 20°C for the selected distance from the notch axis.

Toughness represents the work in course of the plastic deformation of the specimen volume up to its fracture. Due to the practical reasons, the toughness obtained from the notch toughness test is expressed as the ration of the work and the initial cross section area of the specimen. Strain is without physical dimension. To be able to compare it with the toughness, used was the parameter of the similar dimension, which is proportional to the strain and its value is [J.mm^{-3}]. The equation (3) gives its representation.

$$w = \varepsilon_{lom} \times \sigma_p \, /\mathrm{J.mm}^{-3} \qquad (3)$$

Where: ε_{lom} – critical local strain just before fracture, σ_p – average value of the stress between the yield strength ultimate tensile strength.

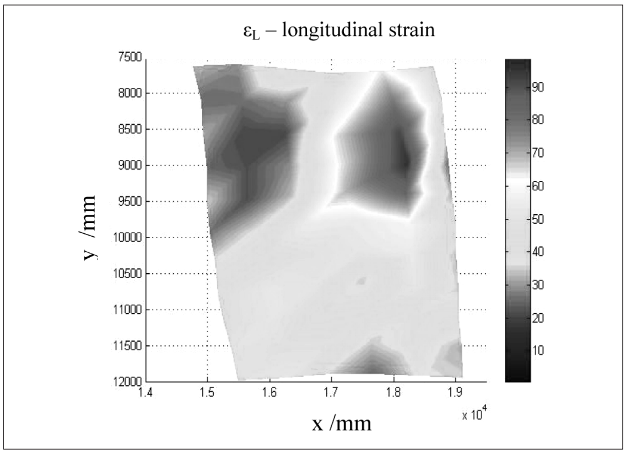

Figure1. Longitudinal strain

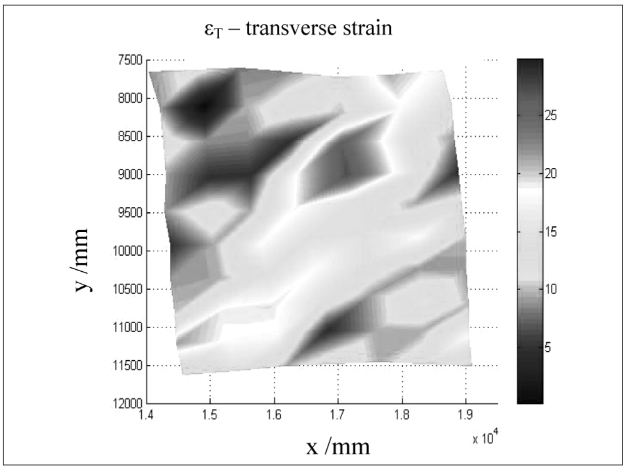

Figure 2. Transverse strain

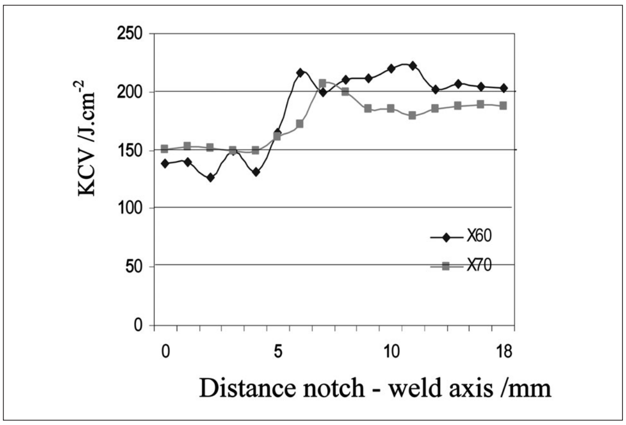

Figure 3. Dependence of notch toughness KCV on the distance: notch - weld axis

CONCLUSIONS

Proposed and tested was the strain measurement methodology conducted on the welded sheets applying the video-extensometry system ME-46 of the strain contact-less measurement. Obtained data, after their processing, provided the detailed information on the strain kinetics of the welded joints. The method is suitable for the estimation of the welds mechanical properties.

– Applying the system ME-46 estimated was the planar distribution and the size of the strains within the individual areas of the welded joint.

The longitudinal strains arisen in the observed sheets, gained the highest values within the area of the weld metal however the transverse strains had the highest level in the base metal.

- The strain gradients were determined applying the video-extensometry method. From the analysis of the strain distribution in the longitudinal and transverse direction follows for welds with similar thickness that a strain gradient exists already at the point of ultimate tensile strength only on this place where later the crack initiates. Outside this place no strain gradient was observed at UTS.
- Estimated was the relation between the notch toughness and the plasticity of the certain area of the welded joint. Based on this relation, quantified was the relation between the strain and toughness of the thick sheets.

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