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ULTRASONIC MEASUREMENT OF RESIDUAL STRESSES IN WELDED ELEMENTS

Yuri Kudryavtsev(*)
Structural Integrity Technologies Inc., Markham, Ontario, Canada
(*)*Email:* ykudryavtsev@sintec.ca

ABSTRACT

The objective of the study described in this paper is to identify the residual stress distribution and relaxation in large-scale welded panel imitating critical, from the fatigue point of view, zones of welded structure. The residual stresses were measured after welding and in the process of fatigue loading of welded panel by the UltraMARS® system that is based on using ultrasound. The residual stresses were measured in a total of 303 points with 21 residual stress profiles studied.

Keywords: ultrasonic measurements, residual stresses, fatigue strength, welded elements.

INTRODUCTION

The residual stresses (RS) are one of the main factors determining the fatigue strength of materials, parts and welded elements and this factor should be taken into account during the design and manufacturing of different products (Trufyakov, 1995). Although certain progress has been achieved in the development of different experimental techniques, a considerable effort is still required to develop efficient and cost-effective methods of RS analysis (Kudryavtsev, 2008). The application of an ultrasonic non-destructive method for residual stress measurements had shown that, in many cases, this technique is very efficient and allows measuring the RS both in laboratory conditions and in real structures in field for a wide range of materials (Kudryavtsev, 1985).

RESULTS AND CONCLUSIONS

The RS in the large scale welded panel were measured in as-welded condition and during fatigue testing after 1, 2, 10 and 2010 cycles of loading. The welded panel main dimensions were 2000x900x535 mm. The process of RS measurement during fatigue testing by using the UltraMARS® system is presented in Figure 1.

Fig. 1 - The process of residual stress measurement during fatigue testing of welded panel

Figure 2 shows the distribution of RS along the welded stiffener in welded panel in as-welded condition and after 2010 cycles of loading. Stress in direction of longitudinal attachment is denoted as σ_{33}, stress normal to the direction of longitudinal attachment is denoted as σ_{22}.

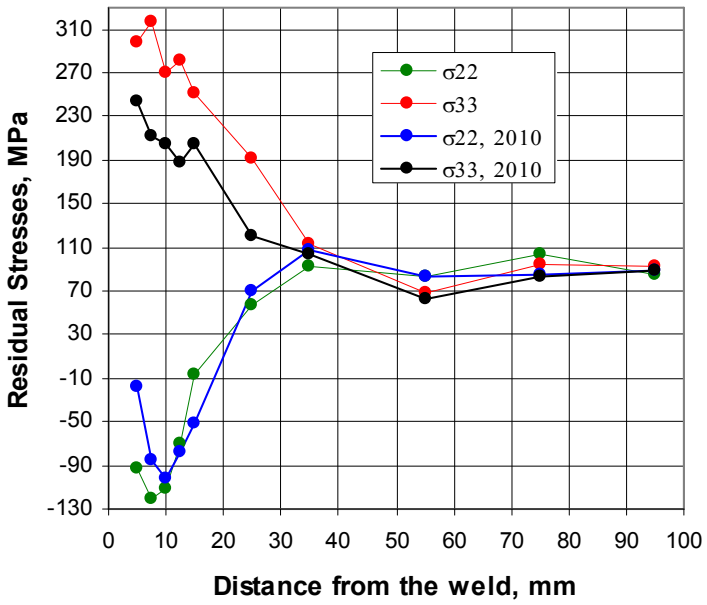

Fig. 2 - The distribution of residual stress along the welded stiffener in welded panel in as-welded condition and after 2010 cycles of loading

Measurements of RS in as-welded condition showed that the maximum residual stress near the welds (4-5 mm away from the weld) acting in the direction of longitudinal attachment and applied load reach levels 300-320 MPa that are close to the yield strength of considered material. The relaxation of tensile residual stress under cyclic loading the was around 25% of initial residual stress for applied hot spot stress range of 200MPa and mean stress of 42 MPa. A comparison of residual stresses determined by measurements using the ultrasonic method and by numerical simulations showed a reasonable agreement both for standard welded specimens and the large welded panel (Kudryavtsev, 2011).

REFERENCES

[1]-Trufyakov V., Mikheev P. and Kudryavtsev Y. Fatigue Strength of Welded Structures. Residual Stresses and Improvement Treatments. London. Harwood Academic Publishers GmbH. 102 p., 1995.

[2]-Kudryavtsev Y. Residual Stress. Springer Handbook on Experimental Solid Mechanics. Springer - SEM. 2008. p. 371-387.

[3]-Kudryavtsev Y. Application of the ultrasonic method for residual stress measurement. Development of fracture toughness requirement for weld joints in steel structures for arctic service. VTT-MET. B-89. Espoo. Finland. 1985. p.62-76.

[4]-Kudryavtsev Y., Kleiman J. and Polezhaeva H. Ultrasonic Measurement of Residual Stresses in Welded Elements of Ship Structure. Proceedings of International Conference on Advances in Experimental Mechanics: Integrating Simulation and Experimentation for Validation (ISEV), 7-9 September, 2011. Edinburgh, UK. p. 625-631.