INTERNATIONAL SCIENTIFIC CONFERENCE ON
ADVANCES IN MECHANICAL ENGINEERING
PROCEEDINGS

EXPERIMENTAL *J*-INTEGRAL DETERMINATION OF DIFFERENT WELDMENTS REGION AT LOW TEMPERATURE

[1]MILOVIĆ Ljubica, [2]ALEKSIĆ Vujadin, [3]MARINKOVIĆ Aleksandar,
[4]LAZOVIĆ Tatjana, [5]STANKOVIĆ Miloš

[1]Associate professor
[1]University of Belgrade, Faculty of Technology and Metallurgy
acibulj@tmf.bg.ac.rs

[2]Researcher
[2]Institute for testing of materials-IMS Institute
vujadin.aleksic@institutims.rs

[3,4]Associate professor
[3,4]University of Belgrade, Faculty of Mechanical Engineering
[3]amarinkovic@mas.bg.ac.rs, [4]tlazovic@mas.bg.ac.rs

[5]Researcher
[5]University of Belgrade, Faculty of Mechanical Engineering, Innovation Center
shomyguca@yahoo.com

Abstract
Behavior of welded joint regions (parent material, weld metal and heat-affected zone) in the presence of crack is presented. Specimens were made of high-strength low-alloy steel and were tested at -40°C. Diagrams load versus crack opening displacement, resistance curves and J versus crack extension are analyzed.

Keywords: *fracture mechanics, crack, high-strength low-alloy steel, J integral.*

1. INTRODUCTION

Classical approach to metallic welded structures calculation based on the assumption that the material is homogeneous and isotropic is represented by allowable stress design and safety factor. Such design approach turned out to be not sufficiently reliable because structure failures during their exploitations may occur under stresses that are less than allowable ones. Main reason for that are material defects existing in real structures. Cracks are the most dangerous among those defects.

The majority of metallic structures are manufactured by welding. No matter how good a welded joint is carried out, it represents a defect of material because it disrupts its homogeneity. That is why a welded joint is potential location where cracks can initiate and represents stress concentrators.

In order to have a complete metallic structure characterization, it is necessary to understand material behaviour in the presence of cracks, i.e. the estimation of material resistance to crack initiation and propagation. As the result of such approach we get structures of lower mass with significantly reduced fracture risk.

operating conditions. In WM, Figure 3, pop-in can be seen meaning that, when crack entered in local brittle zone, it propagated fast, after that crack entered in zone of higher toughness where had continued to grow stably. Crack propagated until the end of experiment when clip-gage linear capacity was exhausted, at *CMOD* value of 3.103 mm. In Figure 4 it can be observed that fatigue crack was positioned in locally softened zone of HAZ with higher toughness, so the growth of crack was stable. HAZ behaviour is similar to PM only that maximal load in HAZ (13.872 kN) was reached at lower load values than in PM but also at higher *CMOD* values (0.944 mm) than in PM, indicating good toughness in HAZ.

Resistance curves given in Figure 5 show the energy amount needed for crack propagation. Relatively high values are needed for crack propagation in PM, for 1 mm of propagation J was approximately 720 N/mm. J value in WM were drastically lower comparing to PM (for crack propagation of 1 mm J was approximately 235 N/mm). J value in HAZ are lower than for appropriate ones for PM but much higher than for WM (for crack propagation of 1 mm J was almost 520 N/mm) which can be explained by the fact that crack was positioned in local softened zone with surprisingly high toughness. After stable crack growth through HAZ, crack reached PM where continued to grow stably.

Values of J_{IC} parameter are used for characterization of material resistance to crack growth. Experimentally obtained values for J_{IC} at -40°C of PM show relatively high value of 528 N/mm, Figure 6, and J_{IC} value for WM was 102 N/mm showing that, in pressure vessels, the weakest part will be WM, Figure 7. High J_{IC} value in HAZ of 257 N/mm, Figure 8, confirms the suitability of investigated welded material for pressure vessel fabrication.

4. CONCLUSION

Impact testing ant fracture mechanics testing show that NIONIKRAL 70 steel is suitable for manufacturing of pressure vessels for applications up to -40°C.

5. ACKNOWLEDGEMENTS

Authors acknowledge the financial support of the Serbian Ministry of Science, project TR 35011. The authors are thankful to Peter Rozsahegyi, Bay-Logi Institute for Logistics and Production Systems, Miskolc, Hungary, for valuable help in experiments. The authors also express their appreciation to Professor Blagoj Petrovski from the University of Belgrade, for invaluable help and suggestions in writing this paper.

6. REFERENCES

[1] **ANDERSON, T. L.:** *Fracture mechanics*, Taylor &Francis, USA, 2005, 636 p.

[2] **RICE, J. R.:** *A Path Independent Integral And Approximate Analysis Of Strain Concentration By Notches And Cracks*, Journal of Applied Mechanics, 1968, 35: pp. 379-386.

[3] **SEDMAK, S., PETROVSKI, B., SEDMAK, A.:** *The Resistance to Crack Growth of Different Regions of Weldments in a Real Structure*. International Journal of Pressure Vessels & Piping, 1992, 52: pp. 313-335.

[4] **MILOVIĆ, LJ., VUHERER, T., ZRILIĆ, M., MOMČILOVIĆ, D., JAKOVIĆ, D.:** *Structural Integrity Assessment Of Welded Pressure Vessel Produced Of HSLA Steel*, Journal of Iron and Steel Research International, 2011, 18(1-2): pp. 888-892.

[5] *ASTM International E 1820* (2008) *Standard test method for measurement of fracture toughness*, 48 p.