EFFECT OF HYDROGENATION ON RESIDUAL STRESSES OF API 5L X-65 STEEL WELDED JOINTS

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ABSTRACT

This study presents a study of the effect of hydrogenation on the residual stresses, of an API 5L X65 steel pipe, manufactured by the electrical resistance welding (ERW) process. Residual stresses were analyzed by X-ray diffraction by the method \( \sin^2 \Psi \). Hydrogenation of samples was performed by electrochemical tests in a simulated soil solution. The results showed that the hydrogenation resulted in significant changes in residual stresses configuration. Microstructural characterization by optical microscopy and scanning electron microscopy (SEM) complemented this study.

Keywords: Hydrogen, residual stresses, X-ray diffraction, API 5L X-65 steel.

INTRODUCTION

The hydrogen embrittlement is a phenomenon that affects the performance of steel used for oil and gas pipelines. Adsorbed hydrogen is generated during electrochemical reactions between the inner wall of steel pipes and the hydrogen sulfide present in the crude petroleum oil. Initially, the hydrogen is adsorbed, and subsequently absorbed by the surface of the steel. During the diffusion process, the monatomic hydrogen can be trapped in crystal lattice defects, such as inclusions, dislocations or grain boundaries [1; 2]. Presence hydrogen gas of these defects can create regions of high pressure and, consequently, localized plastic deformation. The residual stresses generated during the mechanical forming process of the steel can increase the diffusion flux and hydrogen concentration in the crystalline structure of the steel [3]. The increase of the hydrogen concentration may change the state of residual stress and contribute to the embrittlement process [4]. Tensile residual stresses when added to external loads promote the nucleation and propagation of cracks, which can lead to premature failure of the steel, even with operating stresses under the admissible levels.

RESULTS AND CONCLUSIONS

The results of the residual stress analysis conducted on Charpy test samples (before the Charpy test) of the base metal and fusion zone after hydrogenation show significant changes in the magnitude and nature of residual stresses in both the longitudinal and tangential direction. In some samples, stresses that were tensile became compressive or vice versa, in both directions, as shown in Fig. 1, due only to the effect of the hydrogenation process.
Hydrogenation caused significant changes in the magnitude and nature of pre-existing residual stresses in the samples for all tested conditions.

![Fig. 1 - Residual stresses analysis in Charpy test samples.](image)

**ACKNOWLEDGMENTS**

The authors would like to thank the Brazilian research agencies CNPq, CAPES and FAPERJ for the financial support.

**REFERENCES**


