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RESIDUAL STRESS MEASUREMENT IN AN ULTRASONIC PEENED SPECIMEN

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ABSTRACT

Plastic deformation from peening induces a compressive residual stress on the treated surface which provides resistance to metal fatigue. Hence, peening is often used to extend the fatigue lives of welded components by reducing the effective tensile residual stress. This paper describes the influence of ultrasonic peening on the residual stress. For this study a four point plastically bent beam specimen, similar to the reeling process, was used. The specimen was made from 50D steel a material often used in offshore structural components. The residual stresses in the specimen were measured before ultrasonic peening with 5 different measurement techniques. After the ultrasonic peening treatment the residual stress was measured using the Incremental centre hole drilling and the ring core techniques. Measurements were carried within the homogeneously bent section location as well as outside. In order to see the variation of the results influenced by the gauge volume, strain gauges of three different sizes were used to provide results within 0.5mm, 1mm and 2mm depth. The measurements show that the ultrasonic peening surface treatment carried out induced high compressive residual stresses up to 2mm deep inside the specimen. Finally a compendium of residual stress profiles using different peening processes and materials is presented and discussed.

INTRODUCTION

During the last couple of years significant research has been done on the subject of ultrasonic peening [1]. This research has increased the awareness and understanding of the improved fatigue life ultrasonic peening can achieve when applied on welded components. Ultrasonic Peening (USP) has been widely used in the offshore industry to increase the fatigue life of welded components [2]. Previous research has shown that USP can induce compressive residual stresses into material [2] and has therefore been used on the weld-face of fatigue hot-spots. Compressive residual stresses improve resistance to metal fatigue and to some type of corrosion, since cracks will not grow in a compressive environment. USP treatment of the weld face is especially applied on multi-pass welded components.

Until now the change in residual stresses at the surface of the component was not accurately documented. To gain a better understanding of the USP effect on residual stresses a program was initiated using a four point plastically bent beam type specimen. The resulting through thickness residual stress distribution has a typical "Z" shape with tension in one side and compression in the other side [3]. Measurements were made in the homogeneously bent section with zero shear force and a constant bending moment area using five different Residual Stress Measurement (RSM) techniques prior to the USP treatment to evaluate the stress field. After USP treatment measurements were carried out using the Incremental Centre Hole Drilling (ICHD) technique with different gauge sizes and the Ring Core (RC) technique. The measurements carried out after USP treatment showed high compressive residual stress at the surface of the bent beam. As the compressive residual stress exceeded the 80% of the yield strength the ICHD measurement have to be considered as indicative as they tend to overestimate the residual stress as suggested by the ASTM E837-13a [4]. In order to evaluate the incertitude of the presented ICHD measurement an estimation of the new yield strength after work hardening has been done using the hardness data.

Finally, a comparison using the residual stress database has been done using various peening techniques as well as different material types from previous research.