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Fatigue Influence on the Residual Stress State in Shot Peened Duplex Stainless Steel

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Abstract : Duplex stainless steels (DSS) exhibit a biphasic microstructure consisting of austenite and delta ferrite. Their high resistance to oxidation, and corrosion, even in H2S containing environments, allied to low cost when compared to conventional stainless steel, are some properties which make this material very attractive for several industrial applications. However, several of these industrial applications imposes cyclic loading to the equipments and in consequence fatigue damage needs to be a concern. A well-known way of improving the fatigue life of a component is by introducing compressive residual stress in its surface. Shot peening is an industrial working process which brings the material directly beneath component surface in a high mechanical compressive state, so inhibiting fatigue crack initiation. However, one must take into account the fact that the cyclic loading itself can reduce and even suppress these residual stresses, thus having undesirable consequences in the process of improving fatigue life by the introduction of compressive residual stresses. In the present work, shot peening was used to introduce residual stresses in several DSS samples. These were thereafter submitted to three different fatigue regimes: low, medium and high cycle fatigue. The evolution of the residual stress during loading were then examined on both surface and subsurface of the samples. It was used the DSS UNS S31803, with microstructure composed of 49% austenite and 51% ferrite. The treatment of shot peening was accomplished by the application of blasting in two Almen intensities of 0.25 and 0.39A. The residual stresses were measured by X-ray diffraction using the double exposure method and a portable equipment with CrK radiation and the (211) diffracting plane for the austenite phase and the (220) plane for the ferrite phase. It is known that residual stresses may arise when two regions of the same material experienced different degrees of plastic deformation. When these regions are separated in respect to each other on a scale that is large compared to the material's microstructure they are called macro stresses. In contrast, microstresses can largely vary over distances which are small comparable to the scale of the material's microstructure and must balance zero between the phases present. In the present work, special attention will be paid to the measurement of residual microstresses. Residual stress measurements were carried out in test pieces submitted to low, medium and high-cycle fatigue, in both longitudinal and transverse direction of the test pieces. It was found that after shot peening, the residual microstress is tensile in the austenite and compressive in the ferrite phases. It was hypothesized that the hardening behavior of the austenite after shot peening was probably due to its higher nitrogen content. Fatigue cycling can effectively change this stress state but this effect was found to be dependent of the shot peening intensity was well as the fatigue range.

Keywords : residual stresses, fatigue, duplex steel, shot peening
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