Martensitic transformation in a shot peened TRIP steel: influence of shot peening conditions on residual stresses and their relaxation

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Shot peening process is commonly used in mechanical industries to increase life duration of mechanical and structural parts, as automotive gears for instance, by introducing residual stresses (RS). However, RS are likely to be relaxed during the material life [1]. In the case of TRIP-effect steels, the metastable austenite can transform into martensite during shot peening and fatigue life. The final stress state is complex as it results from mechanical strain due to the process and the martensitic transformation that leads to stress redistribution between austenite and martensite. The aim of this work is to study the behaviour of TRIP-effect steels submitted to shot peening by taking into account martensitic transformation, and its evolution during subsequent cycling bending tests. The studied material is TRIP780 steel which exhibits a multiphased microstructure with bainite, ferrite and retained austenite.
First, samples were shot peened, using cut wire shots of two different diameters. Then plane bending cyclic test were performed at different numbers of cycles and loading ratios. At each processing step, retained austenite and RS were determined using X-ray diffraction in the depth of shot-peened specimens. Due to the complex microstructure, RS were analyzed in austenite and in ferritic phases (ferrite + bainite + martensite). Cyclic tests were also performed up to failure to determine the Wölher curves for the different shot peening conditions.

In parallel, finite element simulations were performed taking into account residual stresses, plastic strains and hardening parameters for each phase due to shot peening. It is based on the shot peening model with stress and microstructure gradients developed previously; a semi-phenomenological transformation behaviour law for unstable austenite has been implemented to consider microstructure phase evolution. A similar approach was developed to predict also relaxation in each phase, as well as the evolution of the retained austenite fraction.

[1] Schulze, V., Modern mechanical surface treatment: states, stability, effects, John Wiley & Sons, (2006)