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Effect of Pulsating Water Jet Peening on 316L Stainless Steel

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Abstract: High-speed pulsating water jet was applied on polished surface of 316L stainless steel. Surface slip bands appeared after this treatment. In the most severe conditions, microcracks were formed. Hardness measurement showed that the affected layer is thinner than 60 μm. Application of the pulsating water jet has beneficial effect on the fatigue life of the material.

Introduction

Hardening of surface of ductile alloys by cold-working processes is often used in order to increase surface hardness, prolongate fatigue life by creating near-surface compressive stresses, remove nonhomogeneous residual stresses from the machining or even reduce corrosion. The most used surface cold-working process is the shot peening; other reported methods are e.g. deep rolling, laser shock peening or surface mechanical rolling [1-2]. This paper refers about recently developed method of surface treatment using high-speed pulsating water jet (PWJ). Theory of generating the pulsating water jet is described in [3] and the effect of its application on Al surface in [4].

Experiment

Material. Austenitic stainless steel 316L was supplied in a form of rods with 22 mm in diameter. The rods were cold worked which results in relatively high yield stress for this steel of 417 MPa.
Pulsating water jet. Specimens with carefully polished surface were subjected to PWJ generated at various water pressures from 20 to 30 MPa and moving on the specimen surface with various velocities. In these conditions, every place on the specimen is hit by 10^4-10^5 water droplets.
Characterization. Surface of specimens after the application of PWJ was observed by SEM-FEG Tescan Lyra. Microhardness was measured using head ZHU0.2. Fatigue experiments were performed using MTS servohydraulic testing machine and specimens with cylindrical gauge length.

Results & Discussion

The surface of flat polished specimens after the PWJ treatment was observed by the SEM. Slip bands were formed during the process. The surface density of bands and their height varied according the conditions of the PWJ process. In the most severe treatment (20 MPa), the bands are very pronounced and even microcracks appeared within such bands (Fig. 1a). The bands are different from those formed in standard fatigue test; they consist of sharp steps (Fig. 1b).

Microhardness was measured on specimen´s cross-section. No effect of the PWJ is observed (Fig. 2a), however, the indents were made 60 μm from the surface or farther. The surface layer affected by the PWJ is thus thinner than 60 μm. Effect of the PWJ (20 MPa) on fatigue life is shown in Fig. 2b. It is visible that for high stress amplitudes σ_a there is no difference in lifetime but for low σ_a the beneficial effect of the PWJ appears.

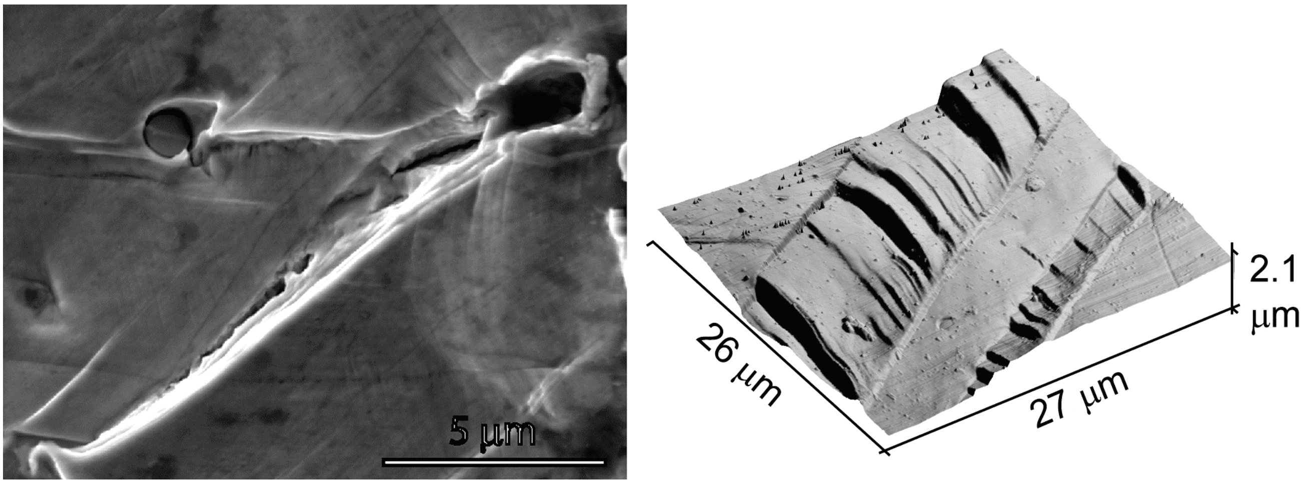

Fig. 1: a) Detail of surface bands and small cracks, b) AFM 3D imaging of the surface bands.

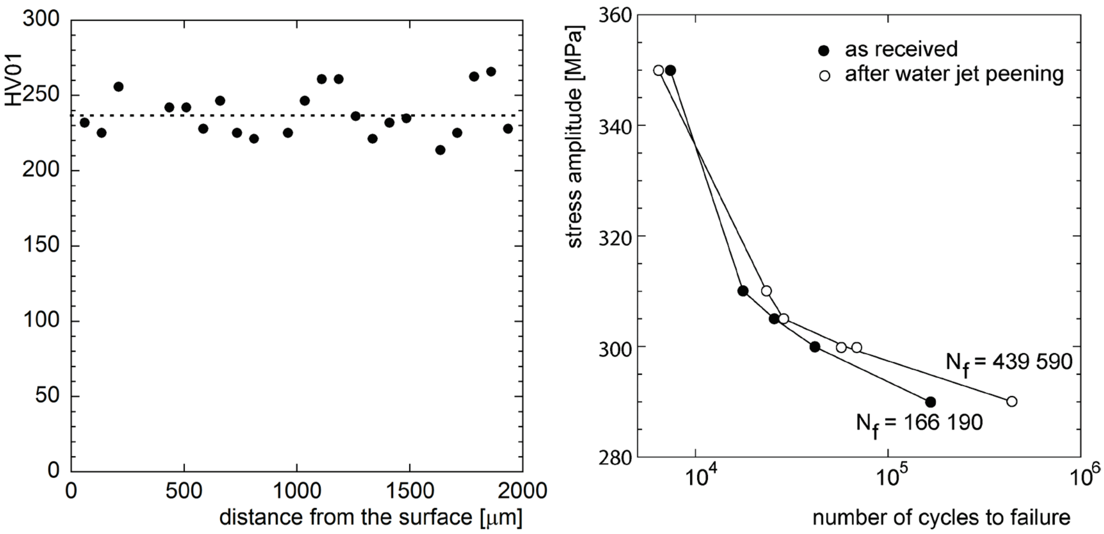

Fig. 2: a) Microhardness as a function of the distance from the surface. b) S-N curves of the as-received material and specimens with the surface treated by the pulsating water jet.

Summary

The PWJ process is a new possibility for surface cold-working treatment. The hardened surface layer is thinner than in the case of shot peening, but the beneficial effect on fatigue life is comparable.

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