Improvement of the pitting corrosion resistance of AISI 316L stainless steel by laser shock waves:

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This study aims to correlate the microstructural and mechanical modifications induced by laser-induced shock waves on a AISI 316L stainless steel, with pitting corrosion properties in saline environment.

Laser shock peening (LSP) is a novel surface treatment that allows to generate plastic deformation and it turns compressive residual stresses on the surface with the use of short pulsed lasers. For this study, LSP experiments have been carried out with 2 different laser pulse durations (3 ns and 10 ns) on an AISI 316L. The microstructure of the alloy consists of single austenitic phase with 50 µm equiaxed grain, and inclusions in the form of Mn, Ti, Al, Si, Ca, Mg aggregates.

Among all the modifications affecting the surface properties of metals, one can mention as main factors roughness R_a and chemical content and as possible factors of influence: microstructure, hardness, and residual stresses.). First, chemical and microstructural analysis (GDOS, SIMS, SEM, EDX and EPMA) indicate that LSP preserves the chemical composition and the density of inclusions of base materials. Second, LSP generates a roughness increase depending on pulse durations: R_a value is more important at 10 ns (0.8 µm) than at 3 ns (0.15 µm) because long pulses tend to induce higher plastification levels. Also, the density of slip bands and the number of persistent sliding bands (PSB's) are more important at 10 ns (2 to 3 sliding systems activated per γ grain) than 3 ns (1-2 systems activated). The microstructural modifications are associated with a surface hardening (+ 10% at 20 GW/cm^2 and + 50% at 5 GW/cm^2). Lastly, the compressive residual stresses, determinated by the X-ray diffraction technique, increase with short pulse durations (at 3 ns σ=-620 MPa and at 10 ns σ=-400 MPa), and with the number of impacts (because of a cyclic hardening behaviour).

The aim of our electrochemical investigations was to obtain information to state how these surface modifications may influence the pitting corrosion behaviour of 316L steel in a NaCl 3g/l environment. Three kinds of electrochemical tests were displayed on 316L samples in 0.05M NaCl solution. The rest potential recording (E°=f (t)) gives information on the passive film formation and growth. These results indicate that E° tend to increase with time without reaching a constant value. Moreover no anodic shifts could be demonstrated after LSP. Therefore, it is suggested that the surface modifications do not influence the passive film behavior. Pitting potentials increases have also been demonstrated during potentiodynamic testing (I=f(E)): + 100 mV versus only + 30mV for the protection potential E_{pp} after LSP. Moreover, fluctuations of the anodic current attributed to anticipated dissolution of inclusions before pitting are less present after LSP.

As a conclusion, this study demonstrates an improvement of the pitting corrosion resistance of AISI 316L with LSP, although all surface parameters (PSB's, σ_r, R_a) are expected to depreciate the electrochemical behaviour. All these observations suggest that the increase of the residual compressive stresses and the surface work-hardening play important roles on the pitting resistance, by modifying the inclusion-matrix interface due to local plastifications, thus reducing their harmfulness.

On coming, investigation (XPS, wettability tests) will tend to characterize the properties of passive film growing on a prestressed layer and to measure the liquid/metal surface energy.