L.4: Laser shock peening enhances corrosion resistance of type 316L stainless steel

Austenitic stainless steels (SS), due to their excellent corrosion resistance, find wide spread applications in nuclear and process industries. High corrosion resistance of austenitic SS is attributed to passive surface oxide film, which is essentially a duplex film comprising of outer layer of iron and chromium oxy-hydroxide with an inner compact layer of chromium oxide. Aggressive ions such as chloride bring about local breakdown of the protective film formed at steel-solution interface (either passive oxide layers or inhibitor-containing films), causing pitting corrosion which is one of the most dangerous forms of localized corrosion. Laser surface treatment is an effective means of enhancing corrosion resistance of austenitic SSs, without affecting its bulk properties. Most widely adopted approach for enhancing corrosion resistance involves surface melting (with or without addition of alloying elements) which adversely affects its surface finish. This study was taken up with an objective to exploit solid-state laser shock peening treatment as a tool for microstructural modification for enhancing corrosion resistance of 316L SS with minimum change in its surface roughness. It should be noted that laser shock peening has been extensively used for introducing compressive surface stress for enhancing materials' resistance against fatigue and stress corrosion cracking but application of this technique as a microstructural modification tool is not well reported.

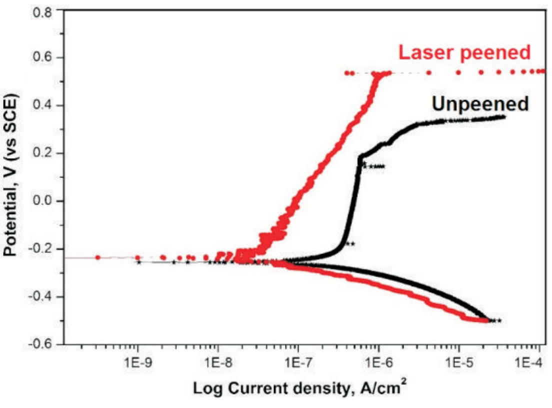

Fig. L.4.1: Polarization plots of laser peened and unpeened 316L SS specimens in 0.5 M NaCl

The study was performed on 5 mm thick sheet specimens of type 316L SS. Laser shock peening experiments were performed with an indigenously developed Nd:YAG laser with a pulse energy of 2.5 J and pulse width of 8 ns. Potentio-dynamic polarization testing of both unpeened and laser peened specimens in 0.5 M NaCl demonstrated absence of active dissolution and spontaneous passivation till the onset of pitting. Laser shock peening brought about considerable increase in pitting potential from 180 to 530 mV$_{SCE}$, along with corresponding reduction in passive current density (I_{pass}) and also cororsion current density (I_{corr}), as shown in Fig. L.4.1. This observation is also supported by significantly reduced pitting sites on polarization tested laser peened specimen (Fig. L.4.2). Laser peened surface of 316L SS specimen exhibited higher polarization resistance (R_p = 14430 Ωcm^2) against its unpeened counterpart (R_p = 7735 Ωcm^2). The results are indicative of more protective nature of passive film formed after laser shock peening and hence higher corrosion resistance.

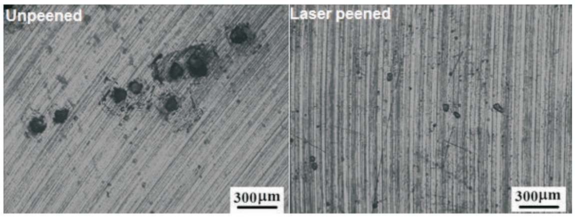

Fig. L.4.2: Magnified views of unpeeend and laser peened surfaces of 316L SS specimen after potentio-dynamic polarisation test in 0.5 M NaCl

Influence of laser shock peening on intergranular corrosion resistance of non-sensitized 316L SS was also evaluated through potentiostatic experiment at 1.3 V$_{SCE}$ for 5 minutes in 48 wt% HNO_3 at room temperature. The test clearly brought out the influence of laser shock peening on material's response in nitric acid medium. In contrast to severe intergranular corrosion attack on unpeened surface, laser peened specimen remained largely unattacked. Figure L.4.3 presents magnified views of unpeened and laser peened specimens after their exposure to 48 wt% HNO_3 at 1.3 V. The results indicated that laser shock peening brings about an increase in threshold voltage for onset of intergranular corrosion of non-sensitized 316L SS specimen in nitric acid medium.

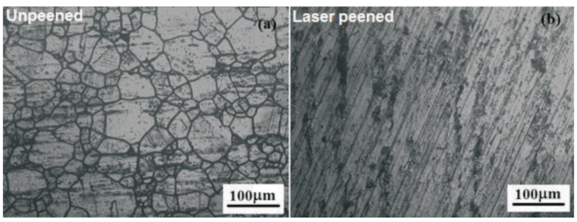

Fig. L.4.3: Magnified views of unpeened and laser peened surfaces of 316L SS specimen after their treatment in 48 wt% HNO_3 at 1.3V for 5 minutes

The results of the study are particularly important towards enhancing service life of austenitic SS components operating in saline and nitric acid media.

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