L.6: Suppression of inter-granular corrosion of 304 SS through laser peening

Inter-granular corrosion is responsible for many industrial failures of austenitic stainless steel components operating in corrosive environment. The phenomenon has a major implication in welding of austenitic stainless steel components. Intergranular corrosion of austenitic stainless steel arises due to intergranular precipitation of chromium-rich carbides in the temperature range of 773-1073 K. Intergranular chromium carbide precipitation is accompanied by the development of chromium-depleted zone adjacent to grain boundaries. This state is referred as "sensitization". Chromium-depleted zones, being anodic with respect to grain interior, are preferentially attacked in susceptible environments, leading to intergranular corrosion. In a recent in-house research study considerable suppression in intergranular corrosion susceptibility of sensitized 304 stainless steel was achieved through a multiple laser shock peening treatment using an indigenously developed 2.5 J/7 ns solid state Nd:YAG laser.

The study was performed on 5 mm thick type 304 stainless steel specimens which were heat treated at 923 K for 10 minutes to obtain "ditch" microstructure as per ASTM A262 practice A. These heat treated specimens, when subjected to IGC test as per ASTM A262 practice E, developed severe cracking on the convex surface of U-bent specimens. Figure L.6.1 presents magnified view of the convex surface of ASTM A 262 practice E tested (involves 15-hour exposure to boiling $CuSO_4/H_2SO_4$) heat treated 304 stainless steel specimen and its cross-section.

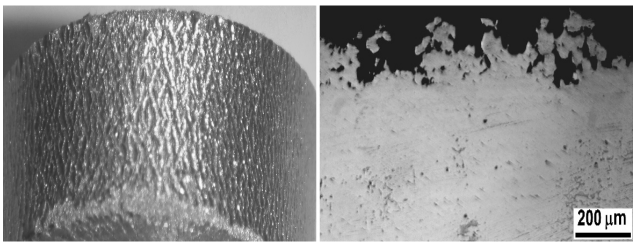

Fig. L.6.1: Magnified view of (left) convex surface and (right) cross-section of ASTM A262 practice E tested 304 stainless steel specimen in heat treated condition.

Laser shock peening experiments were performed on heat treated 304 stainless steel specimens. The results of IGC tests demonstrated progressive reduction in IGC susceptibility of heat treated 304 stainless steel specimen with an increase in the number of laser shock peening treatments. Triple LSP treatment of heat treated 304 stainless steel brought about significant suppression in its susceptibility against IGC in ASTM A262 practice E test. Figure L.6.2 presents a magnified view of heat treated and triple laser peened stainless steel specimen and its cross-section after specimen's exposure to ASTM A262 practice E test.

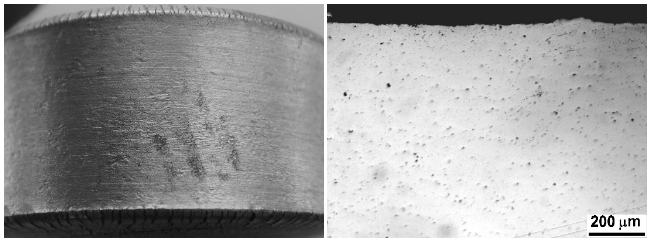

Fig. L.6.2: Magnified view of (left) convex surface and (right) cross-section of ASTM A262 practice E tested heat treated + triple laser peened 304 stainless steel specimen.

Triple laser peened surface of heat treated 304 stainless steel specimen exhibited nano grains of austenite and strain-induced martensite, produced as a result of grain fragmentation under high stain rate plastic deformation imposed by laser shock peening treatment. Laser shock peening induced plastic deformation of sensitized 304 stainless steel also brought about dispersion of inter-granular network of chromium-depleted region, as revealed by double loop electro-chemical potentio-kinetic reactivation (DL-EPR) test, (Fig. L.6.3). Disrupted network of chromium-depleted regions in triple laser peened specimen was responsible for its improved IGC behaviour with respect to that of as heat treated specimen.

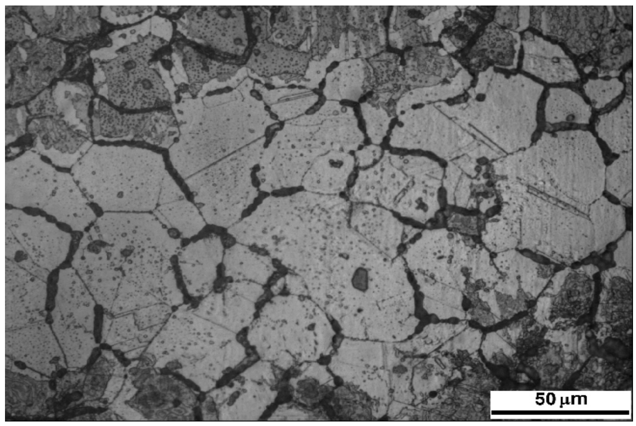

Fig. L.6.3: DL-EPR tested surfaces of heat treated and triple laser peened 304 stainless steel specimen showing discontinuous network of grain boundary attack.

The results are particularly important for enhancing intergranular corrosion resistance of austenitic stainless steel weldments without resorting to solution annealing treatment which may otherwise introduce unwanted distortion in the component.

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