L.8: Oblique laser peening - A new approach to peen internal surface of cylinders

Laser shock peening (LSP) is a surface modification process extensively applied to increase fatigue life of the components. The process of LSP exploits high energy short laser pulse to generate high pressure shock wave which rapidly propagates into the substrate and introduces high magnitude of residual surface compressive stress. Compressive surface residual stress, introduced by LSP, enhances resistance of material against fatigue and stress corrosion cracking (SCC). LSP is known not only to inhibit crack nucleation but also to retard its propagation.

Laser shock peening at normal incidence is an established technology, however, application of this technique to the interior surface of cylindrical components remains highly challenging due to very high intensity (of the order of GW/cm^2) of the laser beam which can damage the beam delivering optics. Further, accommodating mechanical fixtures holding optics in constrained space is a difficult task.

To circumvent such problems, a new approach of oblique laser peening (O-LSP) has been evaluated to treat internal surface of tubular components. Fig.L.8.1 shows the schematic of angular peening for 100 mm diameter tube. Angle of incidence (AOI) on inner diameter of the tube for laser peening is decided by the focal length of the lens used for peening, the diameter of the tube and the length of the tube to be peened. For large diameter tube, angle of incidence will be smaller.

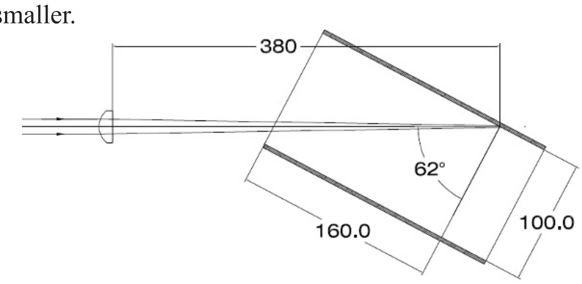

Fig. L.8.1: Schematic diagram O-LSP on the interior of 100 mm dia tube where peening can be done for 160 mm length for an angle of incidence of 62^o

O-LSP experiments were performed with an in-house developed 3 J, 7 ns flash lamp pumped electro-optically Q-switched Nd:YAG laser on type 304 SS and Zr-2.5%Nb tubes with 100 mm internal diameter kept at AOI of 62^o. With these parameters peening length of 160 mm could be achieved. In order to facilitate residual stress measurements the 304 SS tube was wire cut into 6 segments along tube's longitudinal axis. Such segments were subsequently re-constructed to form tube using jig. Specimen was mounted on a computer controlled translation and rotation stage. Parameter optimization was done by varying laser energy, repetition rate and movement speed of linear and rotational stages. Pre and post peening residual stresses were measured using hole drilling technique & X-ray diffraction technique. Results are shown in Figs. L.8.2 & L.8.3. Zr-2.5%Nb tube displayed residual compressive stress more than -350MPa near the surface and a case depth of ~800 microns at -50 MPa level. For 304L SS tube residual compressive stress was -300 MPa in the longitudinal direction and a case depth of ~400 microns at -50MPa level was recorded.

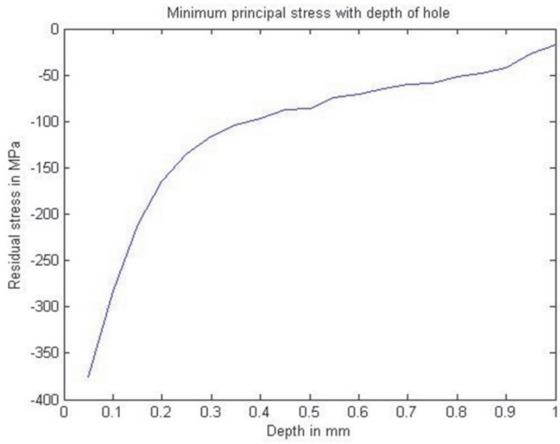

Fig. L.8.2: Residual compressive stress depth profile for Zr-2.5%Nb tube of internal dia 104mm peened at 62 angle

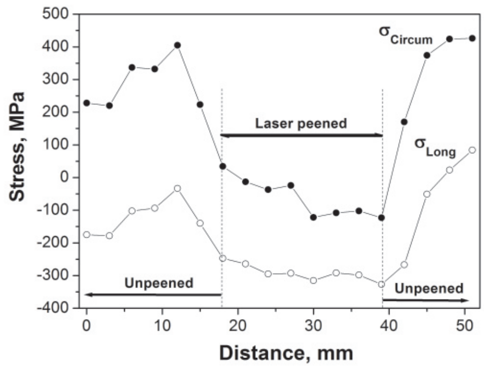

Fig. L.8.3: Residual compressive stress surface profile on SS304L Alloy tube of internal dia 104mm peened at 62^o angle

The technique of O-LSP, in spite of its inherent limitations on length of peened region being limited by tube diameter and the need for access from both the sides, presents a simplified approach for peening internal surface of small tubular components. Large compressive stress has been induced in internal surface of the tubular components using O-LSP technique

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