**USE OF LASERS FOR SHOT PEENING**

M.S. Qureshi, M. M. Malik, R. N. Dubey  
Department of Physics  
Maulana Azad College of Technology  
Bhopal, India

**ABSTRACT**

High energy photons in laser pulses may be considered as ideal shot peening media, with advantage of high velocity together with deep penetrating power. Laser induced shock waves develop compressive residual stresses relatively deep within the material. It has been reported that laser shot peening produce compressive layers which are four times deeper compared with those produced by standard shot peening [1]. In the present work it is proposed that metal sheets of various materials, like copper, aluminium, zinc, brass, tin and other alloys will be subjected to a beam of lasers, which will graze the surface in zigzag fashion to cover a relatively large area. Back reflection X-ray diffraction technique will be used to study the variation of residual stress with depth of penetration inside the material.

**INTRODUCTION**

Deep residual compressive stress prevents debris damage from penetrating beneath the compressive layer. Foreign object debris picked up by rotating turbine or jet engine blades can penetrate thin compressive layers resulting into initiation points for fatigue cracks. Concentrated shock waves produced by short pulses of lasers effectively produce tamped (confined) plasmas and produce satisfactory peening. It is expected that laser energy of 200J/cm² with pulse duration of 30 ns which is equivalent to an intensity of 6x10^{-13} Watts/m² subjected on the surface for /ms can generate shock pressures of 10^9 to 10^{10}, when absorbed by a metal surface and confined with a surface layer (tamp) of water. A layer of black paint (Fig.1) on the surface of the metal is used as an
absorber to initiate the plasma. Reported comparative results of shot peening produced by laser and that produced by conventional method are shown in Fig.2. Depth of penetration expressed in micrometer is plotted against residual stress expressed in pascals. As is expected, laser generated shock wave penetrates deeper and creates a larger magnitude of residual stress. It is also reported that successive application of laser to the same sample drives the stress even deeper. (I)

Fig.1 Experimental setup for shot peening with Lasers

Fig.2 Residual stress induced by laser peening
Using X-ray generator PW-1010 (Philips) and camera PW. Lattice spacing can be calculated using Bragg's law \([cullity]\)\(^2\) \([Bapat, Abhyankar]\)\(^3\). One plane surface should be painted with black paint to serve as an absorber of X-rays. The shock waves have to be further confined or tamped by spreading a thin layer of water. Compact laser unit OSW 1303 is fitted in place of a travelling microscope having a base plate to which movement given in X and Y direction. That produces lasers of intensity 2mW, wavelength 632.8 nm confined to a circular beam of diameter 0.63mm. Working current and potential are 5± 0.5 mA and 1500 ± 100 volt respectively. Grazing the laser beam with the X-Y frame helps in covering a large area of the metal surface.

**MEASUREMENT OF RESIDUAL STRESS**

\[ \text{Fig.3 Diffraction strain gauge.} \]

A He-Ne laser can also be used to measure the residual stress using a diffraction strain gauge. The two jaws of a vertical slit are fixed with the sample as shown in Fig.3. The distance between the fixed points on each jaw of the slit on the test member is the gauge length denoted by \(L\). When Fraunhoffer diffraction pattern of the slit is observed, the positions of irradiance minima is given by

\[ x_m = \frac{m\lambda f}{2b} \quad m = 0, \pm 1, \pm 2... \]

The separation between two consecutive minima is given by

\[ \bar{x} = \frac{\lambda f}{2b} \]
This separation is inversely proportional to the slit width. Therefore, if the slit width changes due to residual stress, the value of \( \bar{x} \) will change. If slit width changes to \( 2b' \) then
\[
2b' = 2b + e L
\]
where \( e \) is the strain.
The separation between the consecutive minima is now given by
\[
x' = \frac{\lambda f}{2b + e L}
\]
The value of the strain is given by,
\[
e = \frac{2b}{L} \left( \frac{\bar{x}}{\bar{x}'} - 1 \right)
\]
The residual stress will then be \( S = Ye \),
\[
S = \frac{2b}{L} \frac{Y}{\bar{x} - \bar{x}'}
\]
Where \( Y \) is the Young's modulus of the material of the metal sample.

The jaws of the vertical slit are fixed the metal sample as shown in Fig.3 and aligned in such a way that they run parallel to each other. The beam from the laser impinges on the slit and the diffracted beam is collected by a long focus lens. The observation screen or photographic film located at the focal plane. The separation \( \bar{x} \) is measured before laser shot peening for a number of minima positions and an average value of \( \bar{x} \) is obtained. The sample is subjected to laser beam, producing shot-peening. The slit is again used to produce diffraction pattern and average \( \bar{x} \) calculated. Equation (1) is used to calculate the value of residual stress.

REFERENCES: