

# Residual Stress Measurement using the Slitting Method

MANCHESTER  
1824

The University of Manchester

STRESS DAMAGE CHARACTERISATION UNIT



With the slitting method, incremental cuts are made into the component causing the residual stresses to relax. The cutting action releases residual stress which deforms the component, and allows us to measure the strains after each incremental cut by means of strain gauges glued to the surface of the component. These measurements are then used to determine the residual stresses normal to the face of the slot as a function of slot depth. This technique, of determining residual stress by the extension of a slot, is also known by several other names, such as the slotting, successive cracking, rectilinear groove, or crack compliance method.

## METHOD

A cut is made into the component containing the residual stress. Residual stress normal to the face of the cut is released and the resulting strain is measured by surface mounted strain gauges. Further incremental cuts and associated strain measurements are made through the workpiece to a predetermined depth (Figure 1). The strain measurements are then used to determine the residual stress in the component as a function of depth. For shallow cuts a top gauge will provide good

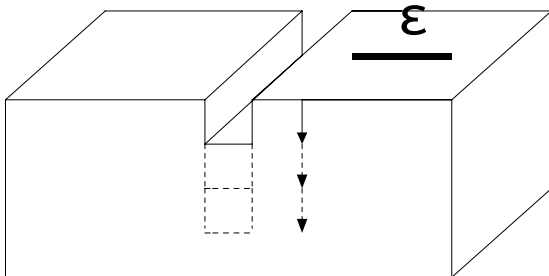


Figure 1—Incremental slot cutting and strain measurement

measurement sensitivity. But for deeper slots, as the cut progresses, the leading face of the cut becomes further away from the gauge, and the strain readings will

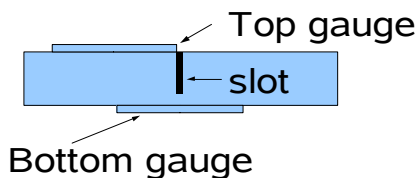


Figure 2—Strain gauges fitted on the top (just off-centre) and bottom (centred on the slot) of the component

eventually plateau and become meaningless. However, this problem can be overcome by fitting an additional gauge on the bottom of the sample. With both top and

bottom gauges (Figure 2), as the sensitivity at the front gauge decreases the bottom gauge sensitivity increases. When using both top and bottom gauges, the top gauge will improve the results for the first 5-10% of the cut depth, whereas a bottom gauge will provide good results between 5% and 95%.

When data analysis is carried out, any data recorded from the top gauge, after sensitivity is lost, is removed before fitting.

## CUTTING

A number of cutting techniques can be used with the slitting method, but measurement inaccuracies due to cutting induced stresses need to be considered. For example, a bottom gauge is relatively insensitive to cutting stresses introduced on the top face of a component, and therefore cutting techniques such as sawing and milling, if carried out with care can prove adequate. However, a top gauge located immediately adjacent to the cut is much more sensitive to cutting induced stresses, and therefore cutting methods which introduce minimal stresses, such as electro discharge machining (EDM), are required.

## WIRE ELECTRIC DISCHARGE MACHINING

Wire electric discharge machining (EDM), utilises a small diameter wire, that is electrically charged relative to the workpiece, to make a cut by spark erosion (Figure 3). The wire, which is continuously fed through

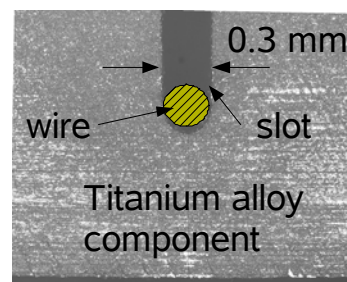


Figure 3—A wire EDM slot cut into a titanium aerospace alloy

the cutting area, does not come into physical contact with the workpiece. The electrical potential difference between workpiece and wire causes a spark to jump the gap and erode material away from the slot. Although other slot cutting methods can be used, there are several advantages of cutting by wire EDM. It introduces very little stress when used with appropriate cutting parameters, due to the very fine slot which can be produced. Because the cutting area is either completely submerged, or covered by flowing de-ionised water, temperature fluctuations are minimised giving stable strain readings.

### CASE STUDY

A comparison study of the residual stresses in laser peened and shot peened samples of a titanium aerospace alloy (Ti-6A-4V) was made. The cutting method used was wire EDM, with continuously flowing water (Figure 5).

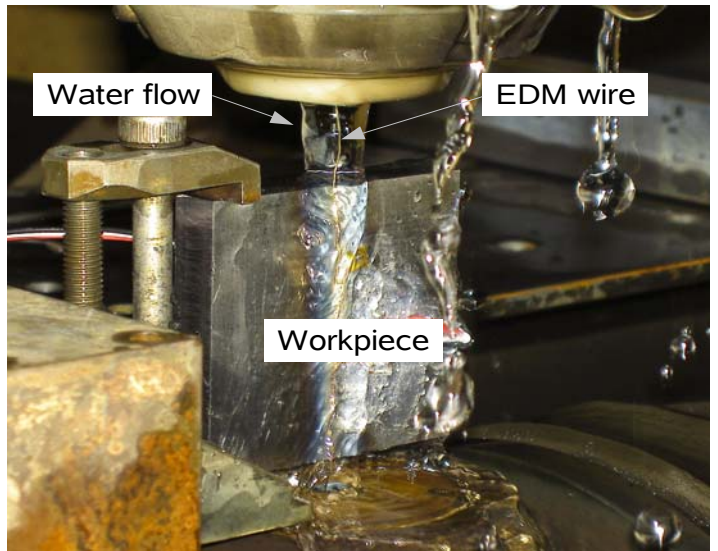


Figure 5—Slitting the workpiece by wire EDM

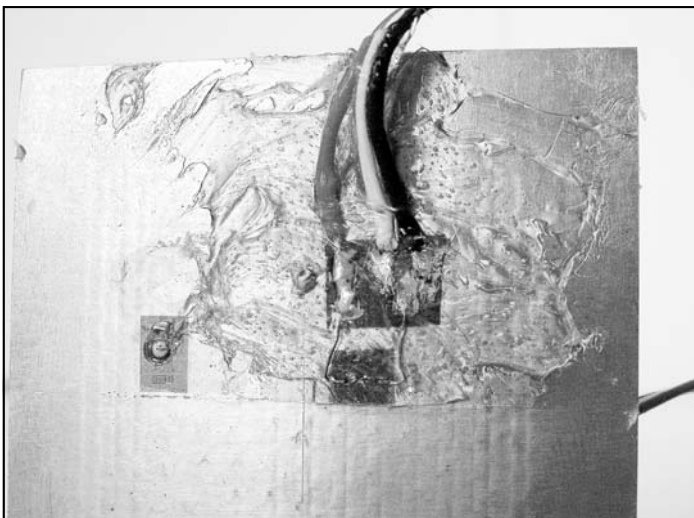


Figure 4—Strain gauges fitted to the laser peened Ti-6A-4V sample (laser peening pattern just visible)

Top and bottom strain gauges were fitted to the sample and covered with water proof sealant (Figure 4). Figure 6 shows the fitted microstrain curves, and figure 7 the curves of the residual stresses calculated from the microstrains.

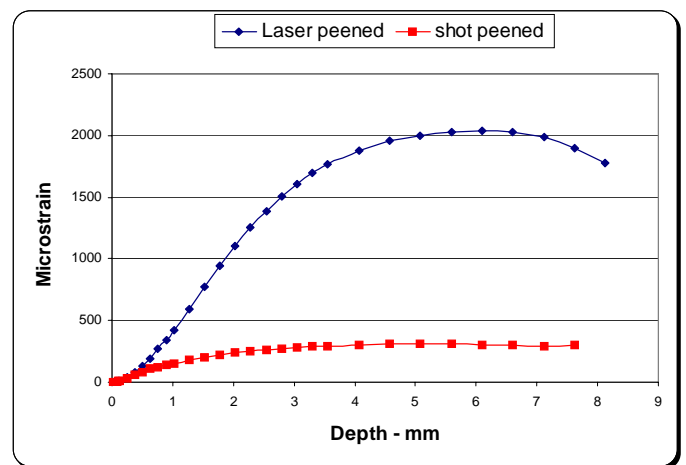


Figure 6—Measured microstrains in laser peened and shot peened Ti-6A-4V samples

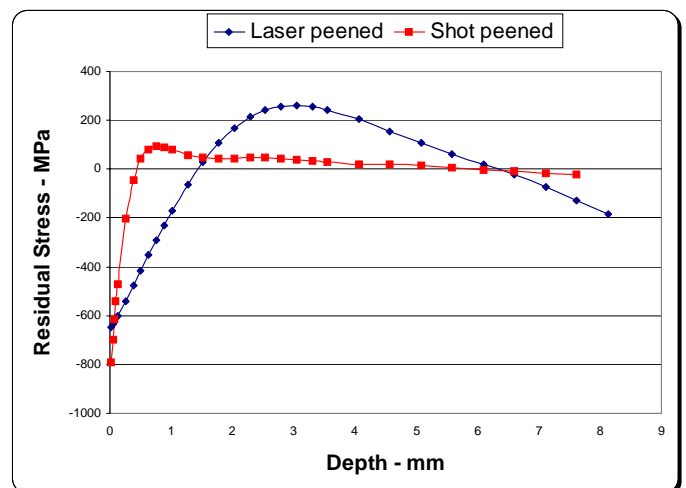


Figure 7—Residual stresses in laser peened and shot peened Ti-6A-4V samples

For more information on the slitting method contact:  
 Peter.Worth@manchester.ac.uk Tel: 0161 306 5940  
 Andrew.Winn@manchester.ac.uk Tel: 0161 306 5948