A Summary of the Slitting Method

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The slitting method can be employed to determine a residual stress distribution along one direction and can give good results near the surface or through the thickness. Slitting consists of three main steps: strain gage application (Figures 1 and 2), incremental slitting while monitoring near-slit strain change (Figure 3), and data reduction.

Theoretical development and details of the slitting method can be found in the open literature. Much of the development is due to Finnie and co-workers, and was extensively reviewed by Prime[1]. Some of our own work has been directed to more fully document the method and to illustrate the influences of various choices made in carrying out the method[2]. A standard method for slitting is currently in development within ASTM.

The research work in our laboratory is directed to address the influences of residual stress on the mechanical performance of materials, and slitting has been a valuable tool. We have found slitting to be a stable, adaptable, and reliable method for residual stress determination in a wide variety of materials (metallics, plastics, FGMs, and single crystals) and geometries (plates, disks, cylinders). A few examples from recent studies on residual stress induced by laser peening and other surface treatments (Figures 4 and 5) are included to illustrate the capability of the method. Further details can be provided upon request.

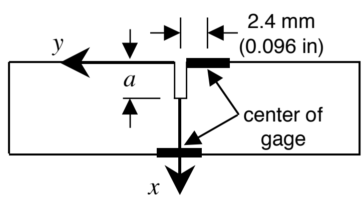
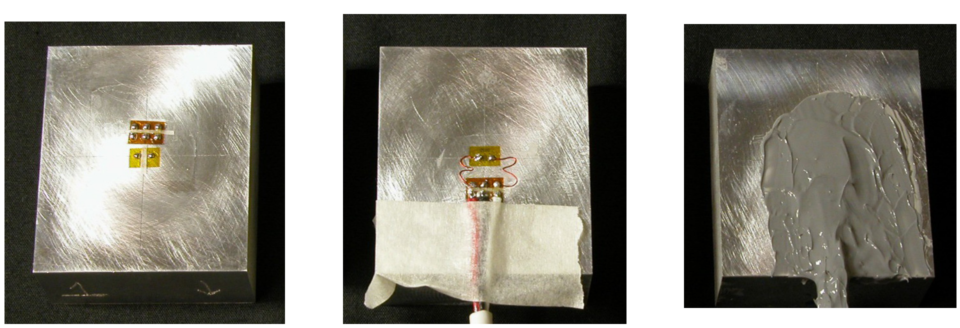


Figure 1: Slitting method schematic where slitting is used to determine the distribution of the axial stress in a beam or a plate as a function of depth from the surface (i.e., $\sigma_{yy}(x)$). One or two strain gages are commonly employed in slitting measurements, one near the start of the slit ("top" gage) and one on the back of the coupon, in line with the slit ("bottom" gage). The top gage gives good sensitivity for shallow cuts, and the bottom gage gives good sensitivity for deep cuts.



(a) (b) (c)

Figure 2: Strain gage application on back face of coupon (bottom gage): (a) strain gage application, (b) lead wire attachment, (c) waterproof coating (3145 RTV). Proper waterproofing is important when cutting with wire EDM.

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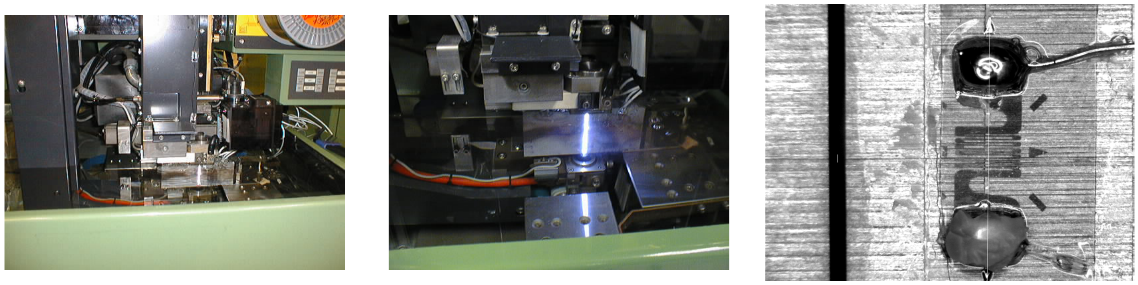
[1] Prime, M. B., 1999, "Residual Stress Measurement by Successive Extension of a Slot: The Crack Compliance Method," Appl. Mech. Rev., **52**(2), pp. 75-96.

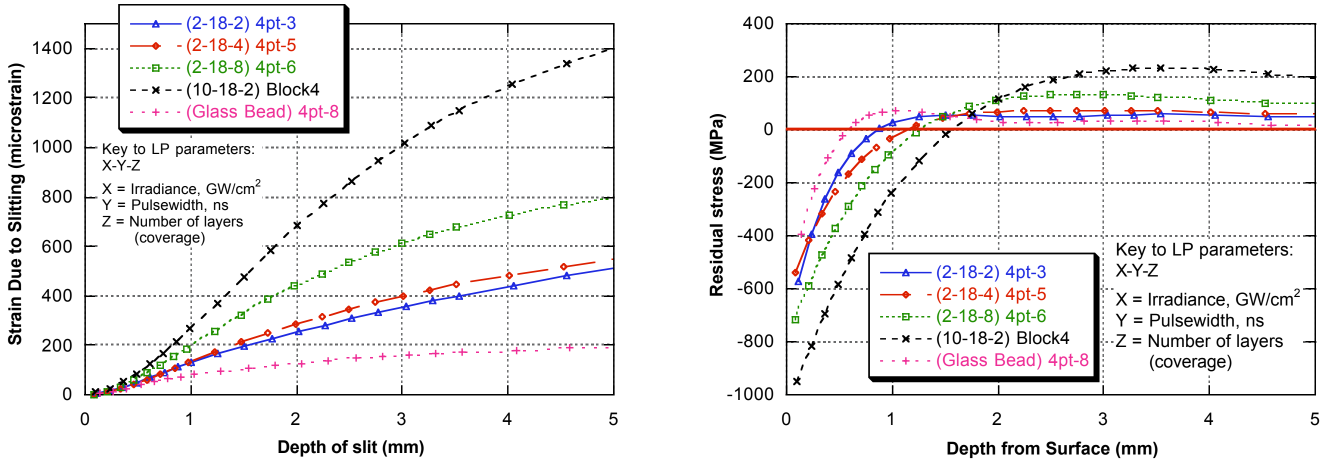
[2] Hill, M. R., and Lin, W., 2002, "Residual Stress Measurement in a Ceramic-Metallic Graded Material," J. Eng. Mater. Technol., **124**(2), pp. 185-191.

Rankin, J. E., Hill, M. R., and Hackel, L. A., 2003, "The Effects of Process Variations on Residual Stress in Laser Peened 7049 T73 Aluminum Alloy," Mater. Sci. and Eng. A, **349**, pp. 279-291.



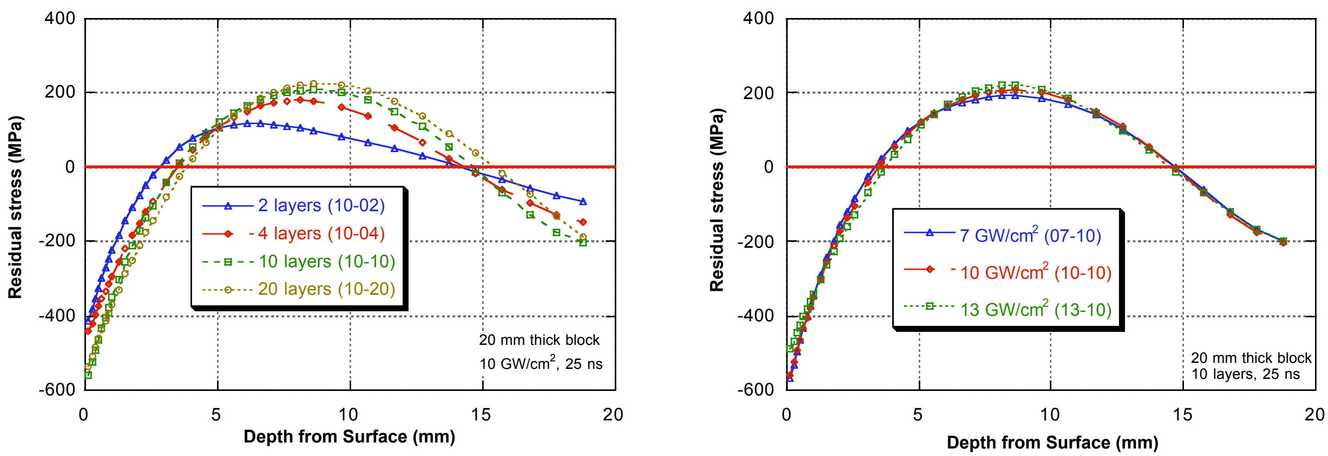
(a) (b) (c)

Figure 3: Slitting experiment underway in submerged wire EDM tool (a and b) and (c) post-experiment microscope image of a top strain gage next to the EDM slit (gage grid length is 0.031 inch (0.79 mm) and slit width is 0.010 inch (0.25 mm)). Wire EDM has little influence on measured residual stress[3], exerting no mechanical force on the part during cutting and providing a very narrow slit with excellent dimensional accuracy.



(a) (b)

Figure 4: Results for a recent set of slitting measurements using only a single bottom strain gage on each coupon: (a) Strain versus depth data, and (b) computed residual stresses. Note the large measured strain values, which are typical of the slitting method. Results compare residual stress from surface treatments applied to 12.7 mm thick Ti6Al4V blocks. In this material, residual stress from laser peening depends significantly on both irradiance (laser pulse power per unit area) and number of peening layers. Published studies have shown that the very deep residual stresses generated by laser peening provide significantly improved resistance to failure by corrosion and fatigue.



(a) (b)

Figure 5: Results for another recent set of slitting measurements illustrating the effects of laser peening parameters on residual stress in 20 mm thick Alloy 22. The number of peening layers was found to influence residual stress depth much more than laser pulse irradiance.

[3] Cheng, W., Finnie, I., Gremaud, M., and Prime, M. B., 1994, “Measurement of Near Surface Residual Stresses Using Electrical Discharge Wire Machining,” J. Eng. Mater. Technol., **116**, pp. 1-7.