Fast, flexible stress measurements

SmartLab® X-ray diffraction system

Leading With Innovation

APPLICATION NOTE

Many mechanically processed components face residual stress problems, which makes them susceptible to fatigue or mechanical failure in their operational environment. Stress measurement techniques have been developed to evaluate quantitatively the magnitude of the residual stress. X-ray diffraction, a non-destructive technique, has been used for decades, largely because it does not alter the original state of the sample. The automated Rigaku SmartLab diffractometer makes stress analysis much easier and faster, requiring minimal user input and experience.

Measurement system description

The Rigaku SmartLab diffractometer, with a built-in Eulerian-cradle, is designed for multi-purpose applications. No additional attachments are needed to perform stress measurements using either the side-inclination or the iso-inclination technique. Using an X-ray mirror contained in the Cross-Beam Optics (CBO) module, the X-ray radiation is conditioned into a parallel beam (PB) to minimize the peak position error caused by sample morphology. The combination of PB optics and the motorized three-way translation sample stage allows samples of various dimensions, even irregularly shaped, to be mounted and aligned automatically. Mapping of the stress distribution in an area up to 6" x 6" can be achieved.

Data acquisition software

The SmartLab Guidance™ data acquisition software provides a package for automatic residual stress measurement, including optics alignment, sample alignment, and sample measurement as shown in Figure 1. The software configures the Ψ-tilt range available for iso- or side-inclination method. In addition, SmartLab Guidance's macro measurement capability allows the combination of stress measurements and XY mapping so that stress mapping can be achieved automatically.

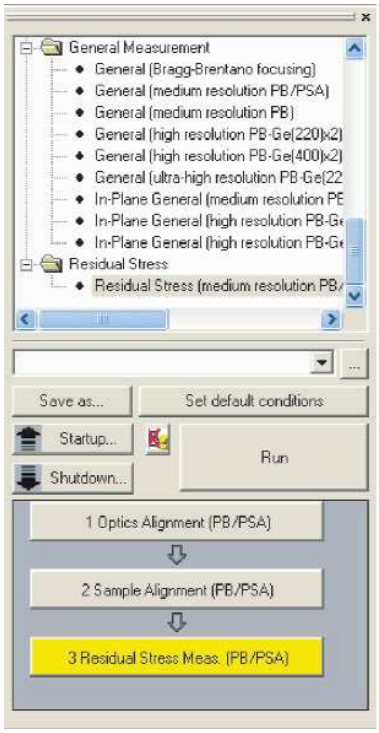

Figure 1. SmartLab Guidance's measurement menu

SmartLab X-ray diffractometer

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APPLICATION NOTE

Data analysis software

Rigaku's residual stress analysis software allows users to process raw X-ray diffraction data into a $\sin^2\Psi$ plot with just a few mouse clicks. Analyte material information can easily be entered into the software so that residual stress and measurement error range can be calculated. Figure 3 below shows a typical data processing window, in which the experimental data taken at the middle of an Al seed embedded in steel is shown. The linear variation in peak position (2θ) as a function of $\sin^2\Psi$ is indicative of a uniform compressive stress state at this position. Stress distribution across the Al seed along the short side is also displayed in Figure 3, showing variation of stress from tensile at one end to compressive at another end.

Conclusion

Our measurement results indicate that the stress in the embedded Al seed varies from point to point, both in magnitude and sign (compressive or tensile). Multi-purpose design and automated measurement software make SmartLab a powerful tool for stress analysis that requires minimal user knowledge and input, while the stress analysis software package yields the desired analytical results with little effort on the user's part.

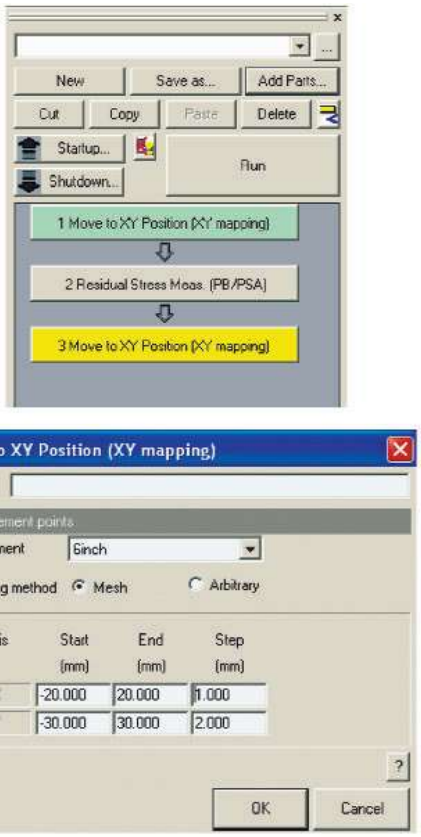

Figure 2. SmartLab's XY mapping dialogue windows

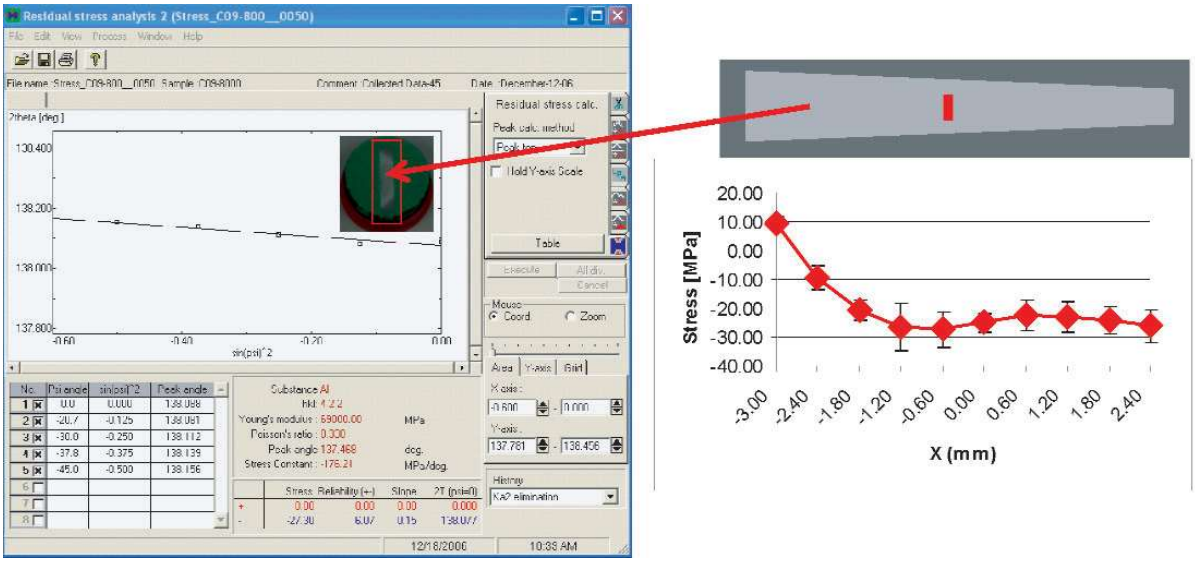

Figure 3. Rigaku residual stress analysis software (left) and stress distribution across the embedded Al seed (the sample diagram is stretched to match the stress plot; the red spot indicates the X-ray spot size)

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