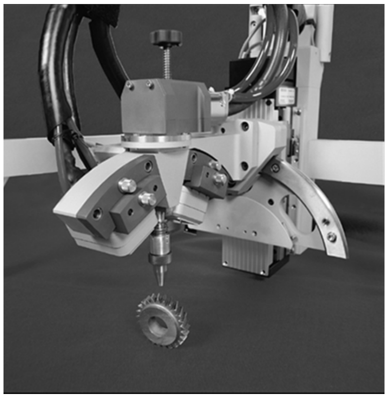
X-Ray Diffraction Using the Sin$^2\Psi$ Technique



The TEC 4000 X-Ray Diffraction System

The sin$^2\Psi$ analysis technique represents the logical evolution of x-ray diffraction stress analysis. X-ray stress analysis, first performed in 1925, employed the single-exposure technique (SET) which was well suited for film detection systems used during this time period. The double-exposure technique (DET) was well suited for step-scanning diffraction systems widely in use prior to the mid-70s. During the mid-70s, position-sensitive detectors were developed making the sin$^2\Psi$, or multiple-exposure technique (MET), a practical way to perform detailed stress analysis.

Both the SET and DET analysis use only two diffraction peaks to determine the stress state of a component. The sin$^2\Psi$ technique uses several diffraction peaks for a more detailed analysis of the mechanical and metallurgical condition of a component. The TEC 4000 X-Ray Diffraction System allows the user to select any number of Ψ angles to accurately measure stresses in less time than conventional systems can measure two peaks. Thus the TEC 4000, in addition to accurately measuring stresses, can also characterize the condition of your parts.

The Importance of Sin$^2\Psi$Analysis
In randomly oriented, fine grained materials having a biaxial stress without shear stresses or stress gradients, there is a linear response expected from x-ray stress analysis. In this very restrictive case, the SET, DET, and sin$^2\Psi$ techniques are equally suited for making stress measurements, since a minimum of two data points are required for defining a line. In all other cases, the sin$^2\Psi$ technique is a superior measurement method.

For example, grinding often results in shear stress at the surface of a component. Shear stresses are immediately recognizable as a sin$^2\Psi$

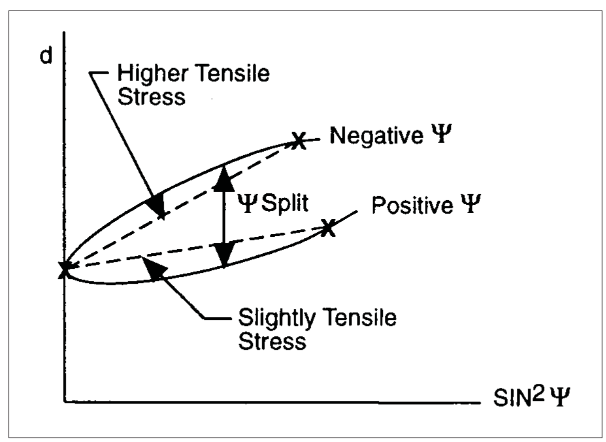


Figure 1: Sin$^2\Psi$ split can be a definitive indicator of sheer stresses.

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split (Figure 1). With the SET or DET method, the stress reported for the sample represented in Figure 1 would be dependent on the direction the sample was mounted in the diffractometer and would range from slightly to highly tensile.

Preferred grain orientation, a very common phenomenon, and large grain size are both represented by nonlinear responses. These conditions can be distinguished with the $\sin^2\Psi$ technique by analyzing the nonlinearity and the diffraction peak intensities. All this information is readily available with the TEC 4000 X-Ray Diffraction System. In the case of preferred orientation or large grain size, the stress measured by the SET or DET methods could range from compressive to tensile depending upon which two angles (diffraction peaks) were used in the analysis.

In conclusion, the $\sin^2\Psi$ technique is a superior method to the SET or DET because shear stresses, preferred orientation, and large grain size are readily discernable. More importantly, erroneous stress measurements may result from the SET and DET when these common mechanical and metallurgical conditions are present.

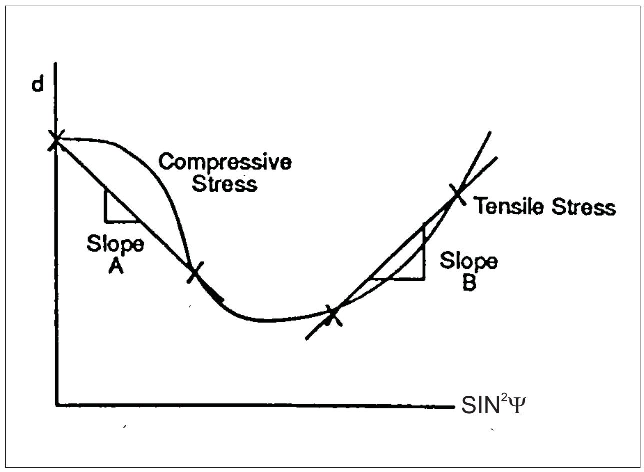

Figure 2: Typical response indicating preferred orientation or large grain size.