Validation of the Material Removal Correction for Residual Stress Measurement Results Obtained Using X-Ray Diffraction Techniques

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Abstract

X-ray diffraction (XRD) techniques are routinely applied to the measurement of residual stress (RS) for a variety of industries and applications. In most cases where RS is of interest, the component under investigation is subject to a cold working or heat treatment process that imparts a RS gradient with depth. As such, characterization of the resultant RS gradient is normally performed by successive layer removal via electropolishing followed by RS measurement at each subsurface layer. As stressed layers are removed, the component will distort to compensate for this effect so it remains in equilibrium; thus, the layer removal process must be accounted and corrected for. Current best practices call for corrections based on an analytical approach first proposed by M.G. Moore & W.P. Evans ("Mathematical Correction for Stress in Removed Layers in X-Ray Diffraction Residual Stress Analysis", SAE Transactions, Vol. 66, 1958) however some of the assumptions in this approach, such as the requirement that the component be a perfectly flat plate or a perfect cylinder, and that the entire layer be removed are unrealistic in practice for RS measurements in real components. With no formal indication as to the sensitivity of the correction to deviations from the assumptions made, an experimental approach to validate the Moore & Evans correction was executed. The effect and accuracy of the corrections were evaluated for various layer removal spot sizes through a given thickness of coupons with a known RS gradient. This paper will demonstrate how effective the Moore & Evans material removal correction is for a variety of scenarios so as to determine its applicability and suitability to RS measurement and subsequently improve current best practices in terms of a practical approach to subsurface RS measurement via XRD.