USING XRD ELASTIC AND PLASTIC STRAIN DATA TO EVALUATE THE EFFECTIVENESS OF DIFFERENT COLD-WORKING TECHNIQUES IN AEROSPACE MATERIALS

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Studying stresses in aerospace materials is important for aircraft sustainment and for developing new materials and designs for next generation air and spacecraft. Due to natural vibrations and mechanical mechanisms, fatigue failures are a primary concern in aerospace structures. For this reason, residual compressive stresses are generally desired. The effectiveness of compressive stresses in protecting an aerospace structure depends on not only the magnitude of the stresses but also on the depth or range to which they extend.

X-ray diffraction (XRD) is a direct method for measuring the elastic strains (residual stresses) in crystalline materials. Additionally, the diffraction peak width is a measure of the plastic strain in a part. The elastic and plastic strains can be used to better assess the true condition of a sample compared to just using residual stress data.

This paper deals with two studies on aerospace materials. In the first case, compressive stresses were introduced into samples by shot peening. Several shot peening conditions were evaluated. Residual stresses were measured and profiled. Fatigue tests were also performed to determine optimum life relative to the peening conditions and correlated to the residual stresses. The peak widths were compared to the stress profiles and showed that coupling elastic and plastic strain information from the surface could indicate which samples had the deeper layer of compressive stresses.

The second study involved cold-worked holes in aluminum alloys. The split-mandrel technique was used to impart compressive residual stresses at and around holes simulating rivet holes in aircraft structures. Some holes were not cold worked. The residual stresses and diffraction peak widths were then used to determine if the samples had been cold worked and to rank the samples according to the amount of cold working.

These two studies show the importance of using elastic and plastic strain data to evaluate the true condition of materials used in the aerospace industry. It also shows the possibility of using the plastic strain information from the surface to predict subsurface behavior.