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Editorial for Special Issue on Residual Stress in Fatigue & Fracture

This issue began from presentations at the 2005 North American Residual Stress Summit, which was organized by Gary Schajer, Michael Steinzig, and myself. The Summit attempts to bring together practitioners and researchers in applied residual stress technology with industrialists that have issues and problems to solve. A distinctly non-conference event, the Summit strives to achieve an open and frank exchange of practical ideas rather than presentations of isolated research topics. This special issue collects several contributions from the second Summit, held in Vancouver, British Columbia, Canada in 2005, and includes some additional regular contributions to FFEMS that fit the topic. Keeping with the nature of the Summit, several of these papers are more practically oriented then might be typical.

In one sense, the relationship between residual stresses and fracture and fatigue is quite clear. The crack driving force, e.g., the stress intensity factor, is equally affected by applied stresses and residual stresses. In fact, residual stresses can be particularly insidious because they offer no external evidence of their existence and yet often have magnitudes on the order of the material's yield stress. In another sense, however, the importance of residual stresses was not always so clear. For fatigue, conventional wisdom indicated that mean stresses had little effect on fatigue lifetimes, and residual stresses act as mean stresses. For fracture, residual stresses were also routinely ignored. Further fatigue studies have proven that residual stresses play a large role in fatigue crack propagation and the all important threshold stress intensity factor, at least for many materials. Likewise, residual stresses play an increasingly important role in fracture of higher strength materials, especially those that have limited plasticity before failure. A related and increasingly important issue in both fatigue and fracture is the "contamination" of material property measurements with unaccounted for residual stress effects. With such contamination of the measured properties, the prediction of structural failures can be quite inaccurate. Also, inaccurate property measurements can make it difficult to develop new alloys and compare which are stronger.

This special issue begins with an excellent literature survey by McClung on not only residual stress effects in fatigue but also on the stability of the initial residual stresses over the part lifetime.

The next three papers share a common basis. Cheng and Finnie described the crack compliance method for measuring residual stress, also called cut compliance or slitting, in 1985 [1]. Because the method involves incrementally extending a crack-like thin slit and measuring deformations, it is especially well suited to measuring the effect of residual stresses on cracks. In this issue, Schindler et al. use the slitting method to measure residual stress contribution to the stress intensity factor, KI_{rs}, which he then combines with fundamental understanding of the fatigue process to develop a simple procedure to estimate fatigue of welded joints without needing measured fatigue properties or an initial

crack size. Next, Ghidini and Dalle Donne demonstrate the use of crack-compliance measured KI_{rs} combined with analytical models to predict fatigue crack growth rates in overloaded specimens and friction stir welded specimens. Then Donald and Lados use the same basic concept as crack compliance, but use load-displacement measurements taken in situ during fatigue testing to measure residual stress and closure effects during the actual fatigue testing.

The next two papers look at some details of crack growth using numerical simulations. Gardin et al. present some promising results from an ambitious prediction of crack growth under the influence of residual stress using a 3D finite element model with incremental crack growth. Sherry et al. also use a 3D finite element model but then compare it with carefully measured crack opening displacements in specimens to evaluate methods of assessing defects. Finally, Akiniwa et al. present a study on the interactions of residual stress and crack bridging on crack growth and branching in a heterogeneous material, a metal matrix composite.

The 2007 Residual Stress Summit, which will be held in Oak Ridge, Tennessee in October. It will focus on Engineered Stresses, the growing field of purposely induced residual stresses tailored to improve fatigue and fracture performance of structures.

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1. Cheng W, Finnie I (1985). A method for measurement of axisymmetric axial residual stresses in circumferentially welded thin-walled cylinders. *Journal of Engineering Materials and Technology*, **107**, 181-185.