

Interaction between Short Surface Cracks and Residual Stress Field in Shot Peened Titanium Samples

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Abstract: To enhance the fatigue life of metal components, frequently compressive stress is introduced to the surface layer. Although procedures such as shot peening have been practiced for many decades in other industries, an improved understanding of the fundamental mechanics that leads to the improved performance is desired. From a continuum mechanical point of view, the interaction between the crack and the stress intensity field is the factor determining whether the crack will propagate. Of special interest for fatigue performance is the propagation behavior of microstructurally short cracks, where the energy release rate, ΔG , is smaller than the threshold value, ΔG^{th} . For this presentation Abaqus/Standard has been used to calculate J-integral values for different ratios of crack length and compressive residual stress depth, as well as different residual stress magnitudes.

1. Introduction

Implantable medical devices are in general exposed to cyclic loading originating from physiological processes and patient activities. For example, in cardio-vascular applications dilatation of blood vessels due to the change from systolic to diastolic pressure or the motion of the heart due to its beating results in 10^8 to 10^9 cycles over the life time of a device. In addition, patient activities, such as arm motion or walking, lead to 10^4 to 10^5 cycles at higher load levels. In many cases both loading conditions are superimposed which makes accurate longevity predictions difficult. On one hand, activity levels vary from patient to patient, and the very specific implant location and orientation, and patient anatomy define the resulting stress and strain levels. On the other hand, variations in material properties and residual stresses from manufacturing determine the resistance of a component against fatigue failure. Finally the resistance of a material against corrosion and other forms of material degradation plays an important role in the prediction of the longevity of a medical device, but is not considered in this paper.