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Modelling multiaxial fatigue with a new combination of critical plane definition and energy-based criterion

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Abstract

A new multiaxial fatigue criterion is proposed that takes into account the influence of material properties and loading conditions on the direction of the critical fatigue plane. Poisson's effect, normal and shear strain energies, both elastic and plastic, and material hardening can be taken into account in this criterion. Ten different materials subjected to various loading paths with different test-sample geometries are used to validate the capabilities of the proposed approach. The comparison with other commonly used energy-based criteria is also presented. The results show that the proposed criterion provides very good predictions for all the analysed materials and loading conditions (within a factor of two) used in this work. The error in life prediction with the present approach also compares favourably with respect to other criteria available in the literature.

Keywords

Critical plane; energy-based fatigue parameter; multiaxial fatigue; normal and shear strain energies; loading path.

1. Introduction

Life prediction in multiaxial fatigue is one of the very important fields in engineering research. A better understanding of the multiaxial fatigue damage can help to improve not only the economic efficiency but also the security of components and structures. Compared with uniaxial fatigue a number of variables appear under multiaxial fatigue conditions, i.e., the changing of the loading direction, the amplitude, the stress ratio and the loading path. All of them can lead to a more complex material response, which make the prediction of the multiaxial fatigue life much more challenging than that in uniaxial fatigue. Even though there are some physical interpretations, based on failure mechanisms, trying to explain multiaxial fatigue damage [1,2], further research into the multiaxial fatigue failure mechanisms is still urgently needed in order to gain a real predictive capability in engineering design, as there is not a well-accepted multiaxial fatigue criterion which can be used universally [2].

There are several important issues in the analysis of multiaxial fatigue, for example, the prediction of the fatigue plane direction, the selection of an adequate fatigue parameter to predict the fatigue damage, the accurate description of the stress-strain response and the choice of an appropriate cycling counting method. Many criteria have been proposed in an attempt to predict multiaxial fatigue damage. In a very wide classification, these methods can be divided into stress/strain and energy-based methods. Very recently, reported research suggests that fatigue failure can be well correlated with

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