A Cyclic Plasticity Model with Damage-Induced Stiffness and Yield Capacity Reduction

Steen Krenk* and Lasse Tidemann*†

* Department of Mechanical Engineering
Technical University of Denmark
Building 403, Nils Koppel's Alle, DK-2800 Kongens Lyngby, Denmark
E-mail: sk@mek.dtu.dk, lastid@mek.dtu.dk - Web page: http://www.mek.dtu.dk

† Structures and Pipelines, Mærsk Oil
Britanniavej 10, DK-6700 Esbjerg, Denmark
E-mail: Lasse.Tidemann@Maerskoil.com - Web page: http://www.maerskoil.com

ABSTRACT

Elasto-plastic materials exposed to reversed stress levels beyond the yield level will develop cyclic yielding, and for elasto-plastic structures this effect may lead to redistribution of the stresses and may lead to accumulated damage effects and eventually failure.

A simple cyclic plasticity model with damage effects is presented. The model is based on an internal energy with observable elastic stresses as well as internal parameters. It combines the classic von Mises yield function with a flow potential in which the centre of the yield surface is represented as an internal stress tensor, and the cyclic features are controlled by an additive term containing the internal stress tensor describing the centre [1]. A particularly simple and robust format is obtained when representing the additional term in the form of a power of the internal equivalent stress. When the exponent is larger than unity the internal stress term dominates the yield surface term in the flow potential, leading to a balance defining an ultimate stress level. In its simplest isotropic form such a cyclic plasticity model only needs five parameters: two elastic parameters, the initial yield level, the ultimate stress level, and a parameter describing the stress range between the yield and the ultimate stress. It is notable that the parameters of the model represent physically observable features of the response rather directly.

The model is extended to include possible deterioration of the yield stress, the ultimate stress and the elastic stiffness. These effects are represented by including the corresponding parameters as internal variables in the energy function, and by including their conjugate variables in the flow potential.

In spite of its simplicity, even when including damage effects, the model gives a rather good representation of observed cyclic behaviour of steel [2] and of ratcheting effects [3,4,5], both with respect to the maximum points and the general shape of the stress-strain curves.

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