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Modeling of Damage Deactivation under Complex Cyclic Loadings

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ABSTRACT

Motivated by a new model dealing with the concept of the damage induced anisotropy in low-cyclic fatigue (LCF) proposed recently by Abdul-Latif and Mounounga (2007), qualitative and quantitative studies are performed emphasizing the damage deactivation effect. In this model, the plastic strain and local damage variables are examined at the crystallographic slip system scale for fcc metallic polycrystals. The elastic behavior is initially assumed to be compressible and isotropic and determined at the macroscopic scale, in which the anisotropic damaged (activation and deactivation) behavior concept is adopted. With a fourth order damage tensor, the deactivation damage effect is modeled describing the related phenomenon of the inducted-oriented anisotropy. Accordingly, the non-linear damaged behavior, particularly the deactivation phase due to the microcracks closure under complex cyclic loading paths, is of particular interest in the study. The numerical solution of highly non-linear model responses represents an important topic since it needs relatively an important computational time-integration. Hence, one of the principal goals of this study is based on the formulation and the numerical integration of such a micromechanical model. To enhance the computing time and its precision, four well-known algorithms are thus applied to the model, namely the algorithms of Runge-Kutta of order 2, 4 and 5 with an adaptive step (noted respectively by RK2, RK4 and RK5). The algorithm of Burlisch-Stöer (MDP) is also presented. According to the obtained results, it appears that the algorithm RK5, contrary to several studies showing for other application that the algorithm MDP being the best one, demonstrates an appropriate compromise between the computational time and its precision.

After determining the appropriate algorithm, a host of plastic damaged behavior of metallic polycrystals is predicted under multiaxial cyclic loading paths underlining the unilateral damage and loading path effects on the multiaxial LCF behavior. Quantitatively, the model can successfully describe the LCF behavior of the Waspaloy at room temperature.