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# USE OF A CONTINUUM DAMAGE MODEL BASED ON ENERGY EQUIVALENCE

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## ABSTRACT

Generally, continuum damage models (for a definition see Lemaitre [1] and Chaboche [2]) use the assumption that the unknown response functions for the real damaged material may be established from that ones for an undamaged fictitious material. The response functions for the latter are expressed in terms of effective stress and effective strain variables and are supposed to be known. Cordebois and Sidoroff [3] discussed the energy equivalence principle for the case of pure elastic mechanical behavior. Interesting extensions to elastic-plastic materials were then proposed by Chow and Lu [4] as well as Saanouni, Forster and Hatira [5]. Only isotropic hardening is considered in Chow and Lu [4] and an equivalence for the incremental plastic work is postulated. According to the assumptions made, the yield function for the real material is known and the effective accumulated plastic strain is gained by the principle. The latter is used to formulate the isotropic hardening rule for the real material. Both, isotropic and kinematic hardening are assumed to be present in the theory of Saanouni, Forster and Hatira [5]. Equivalence is defined for the free energy functions responsible for elasticity and for the energy stored in the material due to hardening, as well as for the dissipation potentials. This way, the evolution equations governing the hardening response are obtained by making use of the generalized normality rule. Again the yield function for the real material is supposed to be known.

An energy equivalence principle for modelling damage effects in material response is proposed in Grammenoudis, Reckwerth and Tsakmakis [6,7]. In contrast to other works, we assume the yield function for the real material to be unknown and postulate an equivalence for the material functions governing the plastic and the hardening powers. As a result, we obtain for the real material a family of yield functions, as well as the evolution equations for the hardening variables. Moreover, the theory is extended to anisotropic elasto-plasticity coupled with anisotropic damage. This model is implemented into the finite element code ABAQUS and is employed to determine stress distributions for a single-crystal superalloy under complex loading histories. The obtained results are compared with experimental measurements in order to examine the capabilities of the proposed theory.

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