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MICRO-MECHANICAL MODELING OF DUCTILE DAMAGE AND FAILURE TAKING INTO ACCOUNT VARIOUS STRESS-STATES

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The presentation discusses the effect of stress-state on plastic deformations, damage mechanisms and fracture of ductile materials e. g. aluminum. To be able to model these effects a continuum damage approach is introduced taking into account the dependence on stress-state of the constitutive model. It is based on the introduction of damaged and fictitious undamaged configurations [2]. The plastic behavior of the material is characterized by a yield criterion and a flow rule which are formulated in the undamaged configurations. In a similar way, the damage mechanisms are described by a damage condition and a damage rule. They are written in terms of the damaged configurations. Furthermore a coalescence criterion and a fracture condition are proposed to simulate the failure process of ductile metals. Different branches of the criteria are considered to be able to take into account different damage mechanisms on the micro-level depending on stress intensity, stress triaxiality and the Lode parameter [1, 3].

It has been shown that it is nearly impossible to identify all constitutive parameters only by experiments [4]. Therefore, to get more insight in the complex damage mechanisms micro-mechanical numerical simulations have been performed. The three-dimensional simulations are based on unit cells containing voids [5, 6]. The calculations on the micro-scale are performed under various loading conditions covering a wide range of stress triaxialities and Lode parameters in the macroscopic tension, shear and compression domains. The results from these numerical simulations are used to show general trends as well as to understand the fundamental physical mechanisms of damage in ductile metals. Furthermore, based on these numerical results it is possible to propose the damage equations e. g. the damage condition and the damage rule, and to introduce a coalescence condition and a fracture criterion formulated in terms of damage strain tensors. Additionally, they are used to identify the stress-state parameters of the continuum damage model.

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