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MODELLING DUCTILE FAILURE FROM DAMAGE TO FRACTURE

*** Jose M. A. Cesar de Sa[1], F.M. A. Pires[2] and Cai Zheng[1]**

[1] IDMEC- Institute for Mechanical Engineering,
Faculty of Engineering, University of Porto
Rua Dr. Roberto Frias, s/n, 4200-465 Porto, Portugal.
{cesarsa, fpires, cai}@fe.up.pt,
http://www.fe.up.pt

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ABSTRACT

The computer codes used nowadays for large plastic deformations play an important role in the design, optimization and innovation of metal forming processes. In fact with these tools it is possible to determine important information like, for example, the prediction of final shapes, the necessary processing forces, final residual stresses or inelastic strains. The increasing industrial requirement for models capable of simulating the behaviour of materials under conditions in which internal deterioration plays a significant role has determined the increasing interest in the development and application of Continuum Damage Mechanics in the simulation of those processes. Ductile fracture, which may accompany these large deformation processes, is usually associated with the phenomenon of initiation and growth of cavities and micro-cracks. In metal forming processes involving large deformations, their appearance must usually be avoided as they lead, almost always, to defective parts. Nevertheless in certain processes, like sheet blanking or metal cutting, fracture is a part of the process itself and its appearance and evolution are important aspects to be handled.

Continuum Damage Mechanics may describe micro-cracking effects (and their evolution), the degradation of material properties through the deformation process and the prediction of fracture location but not the size of a resulting crack at the macro scale and its evolution. This last aspect, i.e. crack evolution, may be dealt with by resorting to Fracture Mechanics, that describes the decohesion of two parts of a continuum in which an initial macro crack already exists. This work aims to establish a transition from one model to the other in the modelling of forming processes: with Damage Mechanics the location of an expected crack is determined and with Fracture Mechanics its evolution is followed. Based on the work of Mazars and Pijaudier-Cabot [1] a thermodynamics basis is established in order to relate damage and fracture mechanics. A damaged zone may then be substituted by a macro crack by equating the dissipative energy associated to damage, up to a critical value, with the fracture energy associated to the creation of a

crack surface, from which a length of the crack is defined. The orientation of the crack may be obtained from the local stress history.

The ductile damage model used is based on the enhanced Lemaitre model[2] which includes a crack closing parameter to distinguish damage evolution in compressive or tensile stress states. Numerically the inclusion of a crack is made resorting to the XFEM (eXtended Finite Element Method) [3-4]. The Level Set method [5] is used to locate the crack and follow its evolution. Some numerical examples illustrate the solution algorithm.

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