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MODELLING OF DUCTILE FRACTURE INITIATION IN SHEET METAL STRUCTURES WITH SPATIALLY VARYING MICROSTRUCTURE AND PROPERTIES

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The growing demands for higher occupant safety and lower energy consumption by reduced vehicle weight is a continuous driving force for the development of advanced materials in the automotive industry. Simultaneous forming and heat treatment of sheet metal components, termed press-hardening, has shown a steady increase in use for the manufacturing of automotive body structures. This type of components can be tailored to yield different phase fractions and spatial variation of phases present with slight changes in the process routes.

This study is concerned with plasticity and ductile fracture modelling aspects of press hardened steels, where multiple phases of different yield strength, work hardening and ductility are present. A phenomenological fracture criterion based on the magnitude of the stress vector and the first invariant of the stress tensor, [1], is integrated with a mean field homogenization scheme (MFH) for multi-phase rate-independent plasticity [2]. The fracture criterion is applied to the per-phase averaged stresses, and crack initiation at the macro-scale is assumed to coincide with fracture indication in any of the present phases, such that the weakest link determines the ductility of the composite.

Finite element mesh dependency in the post-localization regime is alleviated using a regularization procedure based on the addition of localized modes to the element formulation for the modelling of the necking process, [3, 4]. Discontinuities in the strain field are introduced into the quadrilateral shell when instability is signalled by a local bifurcation analysis of the homogenized material. The criteria for instability is derived using a simplified deformation theory of plasticity in accordance with [5, 6].

A calibration procedure to obtain regularization parameters and flow curves at high strains based on digital image correlation experiments is proposed [7]. Furthermore, a parametric study on the regularization parameter with respect to different microstructure compositions is performed. The predictions of the integrated MFH and fracture model is compared with experimental results on steel sheets with different thermal histories, in terms of fracture and overall stress-strain curves.

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