DESCRIPTION OF DYNAMIC SHEAR LOCALIZATION-CONTROLLED FAILURE IN STRUCTURAL MATERIALS

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Aircraft and other structures employ lightweight materials such as titanium alloys. The latter, while possessing high strength, are susceptible to a dynamic instability phenomenon called adiabatic shear banding which leads to a premature structural failure. Adiabatic shear bands (ASBs) are narrow shear localized regions resulting from thermomechanical instability and occur under high strain rate loading (involving quasi adiabatic conditions) as a consequence of the competition between hardening and softening mechanisms.

To determine the shear localization onset, the linear perturbation method is applied in the context of dynamic plasticity. Different softening mechanisms (e.g. thermal softening vs. dynamic recrystallization) triggering the adiabatic shear banding are studied (see [1]).

A constitutive model is developed within a large scale postulate wherein the size of the representative volume element (or equivalently the size of the finite element in numerical simulation) exceeds the shear band width, i.e. the shear localization band is embedded within the representative volume element, whereas many existing works consider a length scale lower than the bandwidth. This facilitates numerical implementation of the model on large structures without the need for mesh refinement in the critical zones. The model describes the anisotropic material deterioration induced by the ASB and further micro-voiding in the band wake until the ultimate fracture (see [2]).

The model is implemented as user material subroutine in the engineering finite element computation code LS-DYNA and its performances are evaluated considering some initial boundary value problems such as dynamic shearing of hat shaped structure and ASB assisted chip serration in high speed machining.

REFERENCES

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