Numerical simulation of ductile fracture under shear dominated loadings at high strain rate

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ABSTRACT

In metal machining and forming processes, ductile fracture is the basic behaviour for material removal and part forming. The ductile fracture is mainly induced by the localized damage under shear dominated plastic deformation with high strain and high strain rate. To accurately simulate the chip formation and part forming, the strain rate and the shear effect have to be taken into account in the material model.

The present work deals with the prediction of ductile fracture due to the shear dominated large plastic deformation with high strain rate and localized ductile damage by use of a Galerkin type meshfree approximation scheme, the Optimal Transportation Meshfree (OTM) method. The finite plasticity model and the ductile damage model are applied to describe material behaviour in coupled and uncoupled ways.

The lode parameter enhanced Lemaitre damage model, which is derived from a thermodynamic framework and coupled with finite plasticity, is used to capture the shear deformation in this work. The Johnson-Cook fracture model and Johnson-Cook plasticity model, where the influence of strain rate is incorporated, are also applied in an uncoupled way and compared with the coupled model in the simulation. The material-point erosion approach, originally derived from the eigenfracture scheme, is applied to simulate the ductile fracture as well in the present work. The ductile fracture initiation and evolution is predicted and validated by shear test simulations. The mixed tension and shear tests with the butterfly specimen and the metal cutting simulation are conducted to compare the model performance on capturing the effect of shear and high strain rate loadings.

REFERENCES

[1] T.-S. Cao. J.-M. Gachet. P.Montmitonnet and P.-O. Bouchard, "A lode-dependent enhanced Lemaitre model for ductile fracture prediction at low stress triaxiality", *Eng. Frac. Mech*, **124-125**, 80-96 (2014).

[2] B. Li. F. Habbal and M. Ortiz, "Optimal transportation meshfree approximation schemes for fluid and plastic flows", *Int. J. Num. Meth. Engng*, **83**, 1541-1579 (2010).