DUCTILE FRACTURE AND ITS APPLICATION IN METAL CUTTINMG MODELING

Yalla Abushawashi[1], Viktor Astakhov[2], Xinran Xiao[1*]
1- Michigan State University, Lansing, MI, USA
2-Production Service Management Inc. (PSMi), Saline, MI, USA

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ABSTRACT

In ductile metals, the final fracture is preceded by plastic deformation and progressive damage evolution. To model the ductile fracture behavior, the material constitutive model must represent the material behavior from plastic flow, damage initiation and evolution to final fracture.

This talk presents a ductile fracture model and its application in metal cutting simulations. The materials model incorporates the Johnson-Cook strain rate dependent plasticity law with the stress state dependence of damage initiation and evolution, and a strain energy density based failure criterion. To obtain model parameters at low and negative stress triaxiality regions typical for metal cutting, a novel double-notched specimen has been developed. This new specimen can cover a wide range of stress trixiality from -0.25 to 0.6. For steel AISI1045, the plastic strain at damage initiation decreased from 0.81 to 0.17 in this range.

The developed model was implemented in FEM package ABAQUS as a user material model and used in the investigation of orthogonal metal cutting. A number of practical machining cases were investigated, including the effect of the cutting tool rake angle, cutting feed, tool-chip interface friction, and chip breaking tool features. The model predictions for these cases agreed well with the trends known in metal cutting.

The stress trixiality state in the primary deformation zone was examined. It showed that the influence of above machining parameters on the stress trixiality correlated to the cutting force. A parameter change that resulted in an increase in the stress triaxiality reduced the cutting force, i.e. reducing the strain energy to fracture, and vice versa. This work demonstrates that fracture is important in metal cutting

simulations. A machining process can be optimized by minimizing the energy of plastic deformation of the work material in its transformation into the chip.

*presenter, 2727 Alliance Dr, Lansing, MI 48910, Tel: (517) 884-1606, E-mail: xinran@msu.edu