Damage Criterion for Prediction of Ductile Failure during Severe Plastic Deformation

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ABSTRACT

Severe Plastic Deformation (SPD) processes are known to introduce large plastic deformation into material resulting in extreme grain refinement to nanometer range and significant enhancement of mechanical properties (e.g. strength) [1]. However, the material cannot withstand the unlimited amount of plastic deformation and failure of billet is often observed during SPD.

To design the tooling, to investigate parameters of processing, such as friction, temperature and speed of deformation, Finite Element (FE) simulation is used. FE gives the opportunity to run many simulations with different parameters in a short time and to optimize the deformation process. The typical output fields from FE simulation are strain, stress tensors and temperature distribution within the deformed material.

However, to design the process against ductile failure of the workpiece, a single criterion is needed, which relates all output variables in a single scalar function. For this purpose the damage accumulated during plastic deformation is very useful. The damage model introduced in our earlier works is shown to be robust and accurate [2]. This model is based on Kachanov's hypothesis that damage is non-linearly proportional to the accumulated equivalent plastic strain and intensity of damage accumulation depends on specific stress parameters.

The ability of material to deform without fracture at different stress paths is defined by the Low Bound Ductility (LBD) function. LBD is a critical strain at fracture shown to be a function of stress parameters and temperature. It is highly sensitive to the initial microstructure, pre-processing history and composition. Therefore, it is not feasible to use the published data on material, in anticipation of similar failure behaviour, and LBD function has to be defined for accurate prediction of defects formation. The methodic of testing of material and building the reliable LBD function for this damage model is discussed.

REFERENCES

[1] R.Z Valiev and T. Langdon, The art and science of tailoring materials by nanostructuring for advanced properties using SPD techniques, *Advance Engineering Materials*, **12** (8), 677-691 (2010)

[2] R. Lapovok, *Damage evolution under severe plastic deformation*, *Int. J. of Fracture*, **115** (2), 159-172(2002).