Dynamic-impact material characterization and advanced modelling strategy of a high hardness steel under complex loading conditions

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Abstract

FEM engineering has become indispensable. Appropriate material characterization, selection and development of suitable material models from the experimental data are the key issues driving high quality simulation in complex loading conditions.
A large number of failure models are available in the literature, which are predominantly phenomenological in nature and mostly focused to special applications. These are usually based on simple assumptions of critical limit values, which lead to failure initiation when exceeded. The problem of failure-controlling stress multiaxiality is only taken into account by very few models. Irrespective of this, the fact remains that the stress state is not only determined by the stress multiaxiality, but also by the Lode parameter, which has a great influence in thin-walled structures but is mostly in application not taken into account.

Experimental access to model parameters is often lacking. This is due to the characteristics of the models themselves, which determine the parameters by multiple non-linear regressions and to the fact that the required material characteristics cannot be determined experimentally from today's point of view under defined loading conditions (i. p. defined stress multiaxiality from the beginning of deformation to failure). Especially under boundary conditions of ballistic and blast threats, data must be available at high deformations, _˜ deformation velocities, _˜ temperatures as well as defined and known stress states in order to be able to meet the goal of precise numerical predictions and analyses of failure processes. This is all the more important today since the prediction of occupant loads and injury probabilities require the most accurate prediction possible of structural behavior under the boundary conditions mentioned.

This presentation shows gaining of experimentally verified knowledge about the relevant protective materials and protective structures in order to improve failure model development and parameter identification and ultimately to achieve progress in the numerical predictive ability of failure processes. Here new test geometries were developed to determine failure strains as a function of the stress triaxiality, Lode parameter, strain rate and temperature. The focus is on the application-oriented highly dynamic characteristic values (tensile _˜, modified notch tensile_˜ compression_˜, compression-shear_˜, shear_˜ tensile-shear _˜). With these experimental data an improvement in FEM simulation predictability for complex loading conditions could be reached.
The advanced material model could be used to increase the lightweight potential of a high loaded structure by decreasing the sheet thickness for a specific thread or increase the protection level with the same sheet thickness.

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