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DUCTILE FRACTURE CRITERIA IN CUTTING PROCESS SIMULATION

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ABSTRACT

Prediction of ductile fracture formation appears to be an important factor in the engineering design practice. To prevent a structural failure, fracture criteria had to be formulated to fulfill the demands for sufficient reliability with relative simplicity to be used in practical engineering analysis. These criteria were successfully applied to prevent material failure in the simulation of technological processes [1]. Later on, application in the area of material cutting, shearing and machining set new demands for the criteria, as they should now describe the whole process of damage cumulation, fracture initiation and its growth up to the stage of material separation in an effective and realistic way.

In this paper we describe experimental and numerical studies of fracture prediction with Czech steel no.41 2050. Seven ductile fracture criteria were calibrated, applied to simulation of bolt head trimming operation and compared with experimental results of the process, obtained in semi-industrial conditions in cooperation with our industrial partner. The following criteria were analyzed: limit plastic strain, Johnson-Cook [2], ESI-Wilkins-Kamoulakos (EWK) [3], Xue-Wierzbicki [4], Cockcroft–Latham [5], Rice–Tracey [6] and RTCL – combination of the previous two criteria.

Some of the criteria are now implemented in explicit FE codes like LS-Dyna or PAM-Crash, others had to be implemented into the Abaqus-Explicit code as a user subroutine. To cover broad spectrum of stress triaxiality conditions, four tensile specimens (one smooth plus three notched with different radii – Fig.1) and three upsetting specimens with different H:D ratio were used for fracture models calibration. Fig.2 shows behavior of one of the models for different stress triaxiality history: end of each path corresponds to real tensile specimen fracture, whereas the theoretical fracture point corresponds to the unit value of accumulated damage parameter.

Fig.1 *Notched tensile specimen*

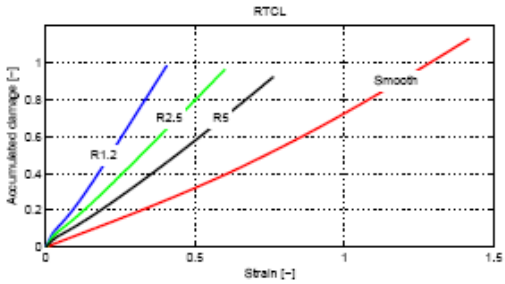

Fig.2 *Damage accumulation in different notch radii specimens*

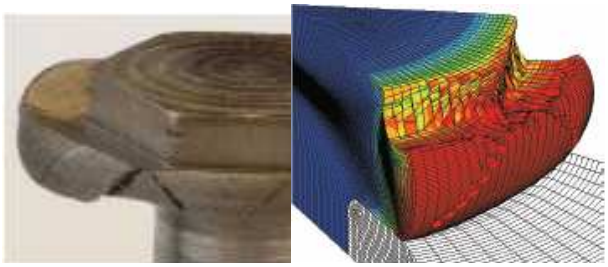

Fig.3 *Bolt head trimming – experiment and simulation*

Successful criteria were later used for bolt head trimming simulation, which helped to improve some details of tool geometry to increase its durability [7]. Some of the criteria together with explicit FE algorithm are able to describe very complex material behavior. In Fig.3, simulation results show that the process of material separation corresponds well to the realized experiments, including the skew fractures running from the corner of the hexagonal bolt head. Although the presented results are promising, looking for a simple, universal fracture criterion applicable to a broad area of industrial processes is still going on.

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