Prediction of Dynamic Material Failure – Part II: Application with GISSMO in LS-DYNA

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As alluded in the first part of the present contribution, strain rate effects are quite relevant during a high speed crash event. If one intends to accurately predict failure under such conditions, it is important to properly understand and depict the underlying phenomena involved in such a scenario. For instance, the adiabatic heating that takes place during the plastic deformation process at high strain rates softens the material in such manner that the local plastic strain increases in critical zones. Also, localization is more pronounced in such critical zones due to the softening caused by adiabatic heating. On the other hand, the failure of metallic materials depends on innumerous factors such as stress state, strain path, non-proportionality of loading but also on the plastic strain. Therefore, it is quite important to properly model the plastic straining under the different strain rates if one aims to predict failure in full car crash simulations. In this respect, the first part of this contribution has proposed a methodology to deal with the description of viscoplasticity by using effective yield curves with *MAT_024. As a consequence, the local plastic strain at critical zones is more accurate, which means that the definition of a failure criterion for ductile fracture can be done properly. In this work, we use the so-called GISSMO damage/failure model available in LS-DYNA through the keyword *MAT_ADD_EROSION. GISSMO allows the definition of a fracture curve which is used for the nonlinear accumulation of scalar damage. This kind of accumulation inherently takes into account the effects of strain path change during plastic deformation, a very important effect in crash simulation. Furthermore, strain localization is predicted by accumulating an instability measure, which activates element fading by affecting the stress tensor with the damage variable. GISSMO also has a simple regularization tool which scales the fracture curve in order to take spurious mesh dependence into account. These features of GISSMO have been tested when adopting the dynamic yield curves calibrated for different strains rates with *MAT_024. The associated GISSMO calibration for two modern steel alloys is presented in the present contribution. It is shown that, for these two materials, a single fracture curve can be used with reasonable results, i.e., the simulation of specimens under different stress states and different strain rates could reproduce experimental data with good accuracy. The effects of strain rate dependence on the regularization methodology of GISSMO have also been focus of the present study. Numerical investigation conducted by the authors suggests that the different strain rates require different regularization factors. This effect is more pronounced for coarser (5mm > Le > 10mm) than for finer (1mm > Le > 3mm) mesh refinements. In fact, up to an element size of 3mm the already existing regularization method provides satisfactory results. Therefore, for such mesh refinements, the calibration of a strain rate dependent GISSMO card seems somewhat similar to the quasi-static case. Nevertheless, further investigation is still needed in order to better understand the consequences of such modeling technique.