PERFORMANCE OF STEEL FAILURE MODELS AT PREDICTING PENETRATION OF A HIGH SPEED PROJECTILE (HSP) INTO A PROTECTIVE PANEL

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Impact of a high speed projectile (HSP) on a structural steel target can cause strain rates sufficiently high for adiabatic shear bands (ASB) to develop. An ASB is a region of metal softening caused by localized heating from plastic flow of the metal. ASBs influence how a metal fractures, and the failure model used for predicting HSP penetration into a structural steel target should include this phenomenon.

Two models were examined for characterizing steel failure in a protective panel from HSP impact: the Johnson-Cook failure model and the generalized incremental stress-state dependent failure model (GISSMO) failure model. These failure models are implemented in the commercial finite-element solver LS-DYNA®.

The Johnson-Cook failure model has the advantage of explicitly including a temperature term that adjusts the fracture strain of a metal as a function of temperature. However, the Johnson-Cook treatment of stress state is more primitive than the GISSMO model, and its failure constants are based on limited data sets.

By contrast, the GISSMO failure model is a general treatment of failure and fracture in metals. The main feature is a fracture locus (or surface) defined as equivalent plastic strain to failure (ε_f) as a function of triaxiality (η) and load angle parameter (ξ). The GISSMO failure model does not explicitly include the effect of temperature on plastic strain at failure. For the penetration calculation, it was accordingly combined with the Johnson-Cook constitutive model, which does calculate material softening as a function of temperature increase. Combining the Johnson-Cook constitutive model with the GISSMO failure model resulted in accurate prediction of penetration into the panel and observed steel failure patterns.

In this paper, the Johnson-Cook and GISSMO failure models are described and contrasted. Their performances for an HSP penetration into a protective panel are assessed. Finally, possible explanations are offered for the accurate performance of the GISSMO failure model despite the model's lacking an explicit temperature dependence.