A MODIFIED JOHNSON-COOK FAILURE MODEL FOR TUNGSTEN CARBIDE

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ABSTRACT

The analysis of brittle materials subjected to large strains, high strain rates and high pressure is of significant interest due to their extensive use in projectiles and armor applications. One material of particular interest is tungsten carbide, which is very special since it exhibits both ductile and brittle properties. The particular tungsten carbide studied in this paper consists of approximately 10% cobalt and is significantly more ductile than ceramics, while still being very hard.

Tungsten carbide cores are often used for armor piercing projectiles due to their excellent penetration capabilities in armor steel. However, at high impact velocities, the penetrator can fracture early in the penetration process, thus strongly reducing the penetration depth. On the other hand, break up of the penetrator during exit of the target is necessary to achieve a significant fragmentation pattern. Thus, there is a conflict between the required penetration and fragmentation properties. Determining an optimal balance between these properties is a very challenging problem. One important aspect is to understand and develop a material model for tungsten carbide, in particular the fragmentation behaviour.

In this paper we examine the fragmentation of a 7.62 mm tungsten carbide AP projectile on perforation of steel plates. Experiments are performed varying the yaw and impact angle to study the break-up of the tungsten carbide core as a function of these parameters. Using a combination of flash x-ray and high speed video, details of the projectile behaviour are experimentally determined.

The Johnson-Cook failure model is a candidate for describing the fracture properties of tungsten carbide. From uniaxial static tests, experimental data are obtained. Numerical simulations of the perforation experiments using ANSYS AUTODYN are performed using the Johnson-Cook model and seen to give poor agreement with experiments as long as only static material data are used. The influence of the two dynamic terms in the Johnson-Cook failure model on the numerical results are studied systematically, leading to the conclusion that agreement with experiment is unlikely for any combination of parameter values. A Modified Johnson-Cook failure model with a new dynamic dependency is proposed and seen to agree better with experiments.