A Computational Study of the Ballistic Performance of Composite Materials

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In this study we assess the difference of ballistic projectile penetration between the traditional armor steel and a composite material. These simulations were carried out using CARTABLANCA [1], an object oriented, Java-based capability. CARTABLANCA is an Eulerian-Lagrangian code that uses the Material Point Method (MPM) along with a multipressure-based multiphase flow capability. Here, we use an Eulerian mesh with Lagrangian particles to handle multimaterial interactions as shown in Fig. 1.

Since this is an exploratory study, we assume that the projectile is a cylindrical-shaped tungsten bullet traveling at a speed of 2 km/s before impact on a stationary target. The projectile is 2 cm long and ~0.5 cm in diameter. To study the different deformation dynamics we consider two choices of the target. The first is a steel plate of 2-cm thickness and 5-cm long in each transverse direction. The second target is also chosen to be of the same dimensions, but is constructed as equal part of steel and composite layered on top of each other. In this comparison, we assume that the steel and composite are perfectly bonded. The dynamic interaction between the projectile and the target block is shown in Figs. 2 and 3 for the steel and steel-composite target respectively. In these figures the red particles represent the projectile (tungsten) while the blue (composite) and green (steel) particles represent the target block.

The constitutive relation for both the steel and tungsten projectile are described using the Johnson-Cook model [2], in which the yield stresses of the metals are functions of the effective plastic strain and the temperature. The model parameters are the same as used by Zhang et al. [3]. For the composite we use an anisotropic linear elastic stress model along with the appropriate failure and damage criteria.

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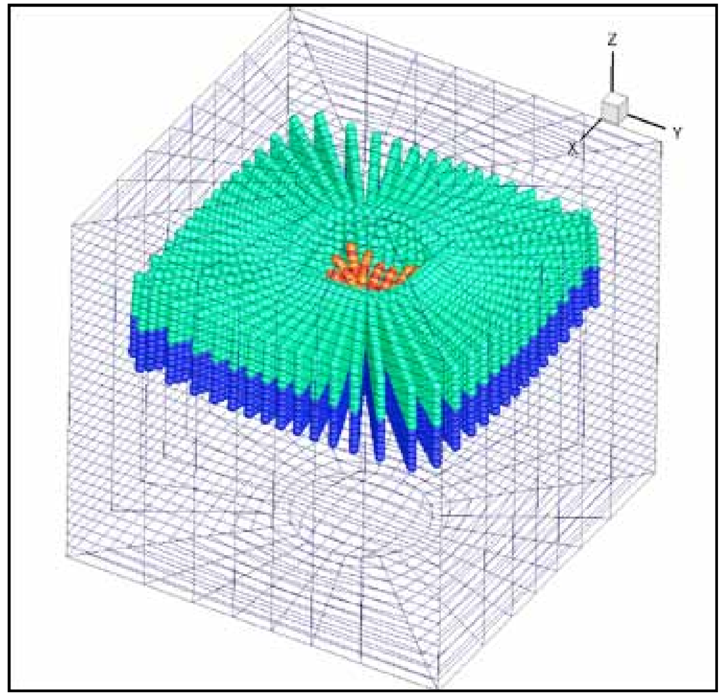

Fig. 1. Problem computational setup shows the background Eulerian mesh with the Lagrangian material points. Red particles depict the projectile while the light blue/green and dark blue particles represent the steel target and the composite material respectively.

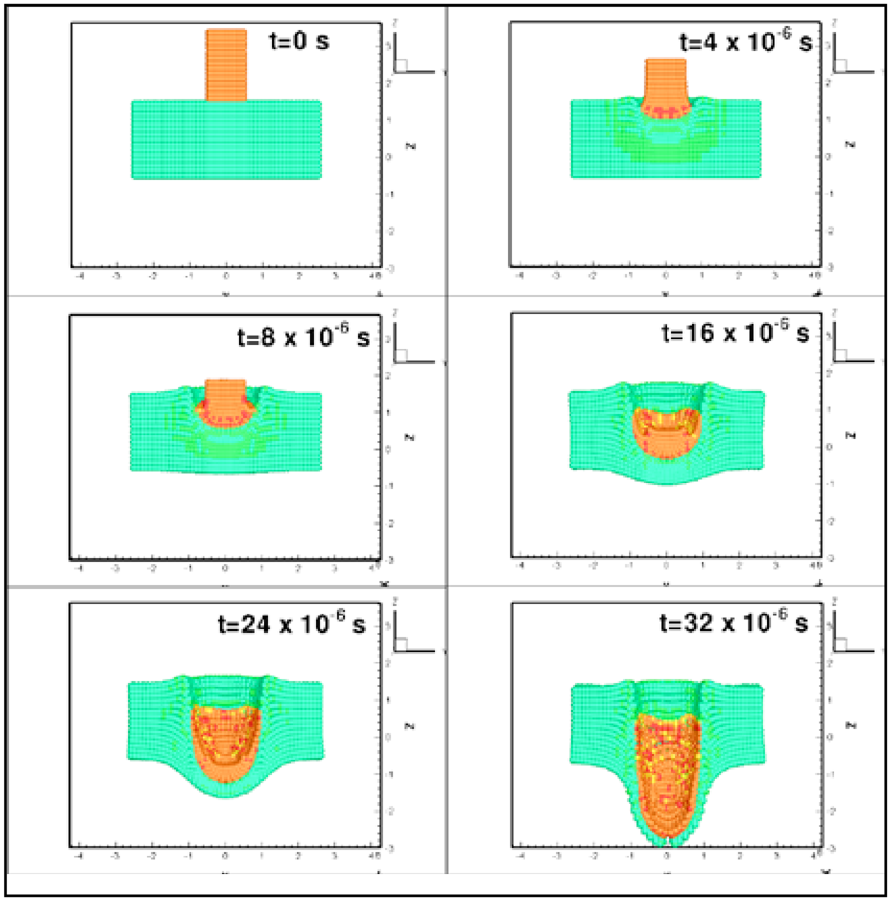

Fig. 2. Time evolution snapshots of a tungsten projectile penetration on a steel target block. The snapshots show a cross section at the center of the block.

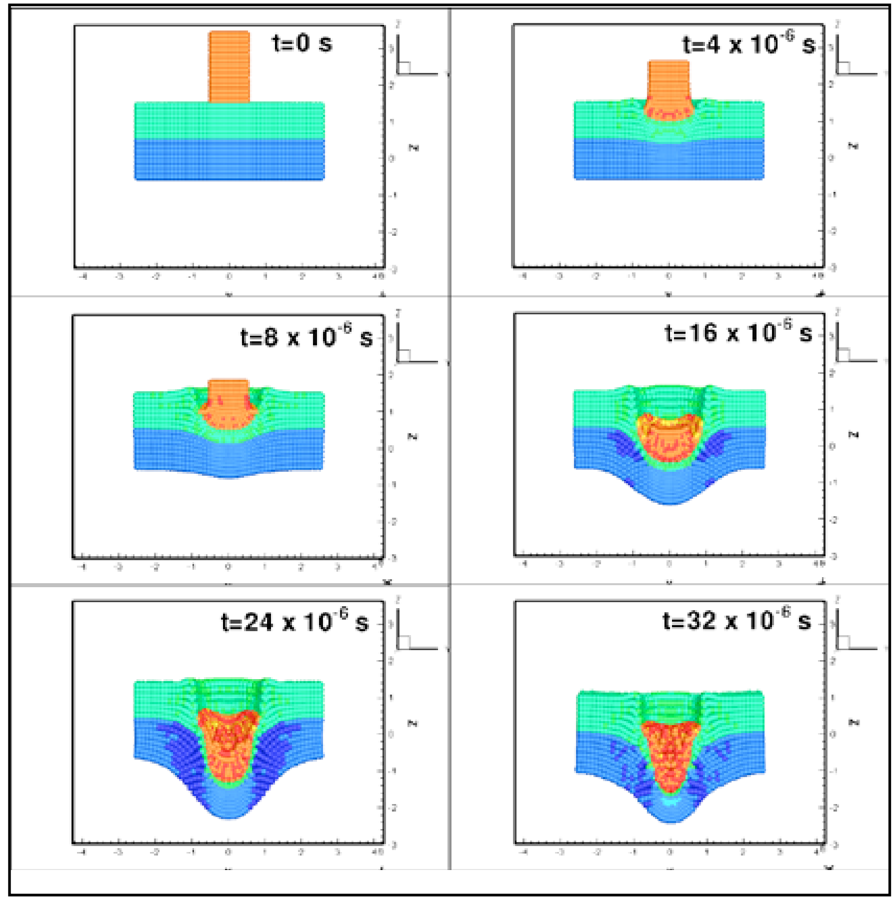

Fig. 3. Time evolution snapshots of a tungsten projectile penetration on a steel-composite material target block. The snapshots show a cross section at the center of the block.

[1] CARTABLANCA, http://www.lanl.gov/projects/CartaBlanca/
[2] G.R. Johnson, W.H. Cook, *Eng. Fract. Mech.* **21**, 31 (1985)
[3] D.Z. Zhang et al., *J. Comp. Phys.* **227**, 3159 (2008).

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