The IMPETUS Afea Solver®

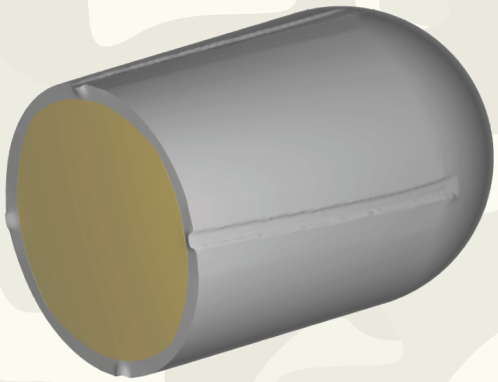
Scoring of a Bullet and Penetration of a Brittle Target

CASE STUDY

CertaSIM, LLC and the US Army ARDEC Picatinny Arsenal collaborated on a project to demonstrate the methodology to accurately model ballistic impact. The project involved a target plate made of brittle aluminum and a copper bullet. The simulation included both engraving of the bullet by the gun barrel "lands" and impact of the target.

The analysis was divided into two steps. The first step involved modeling the bullet as it travels down the gun barrel which cuts grooves into the bullet surface by the barrel "lands". This process is what causes the bullet to spin. The second step was impact of the target plate with the engraved bullet. In order to use the same bullet model for both steps it was necessary to mesh the bullet model with enough resolution to capture the engraving process and to refine the front of the bullet for impact of the target. The target is composed of brittle aluminum and so the classic method of element erosion is not appropriate because it will only create a plug that is pushed through the target. To obtain a realistic and accurate solution it was necessary to use the Node Splitting Algorithm developed by IMPETUS to model material fracture and fragmentation.

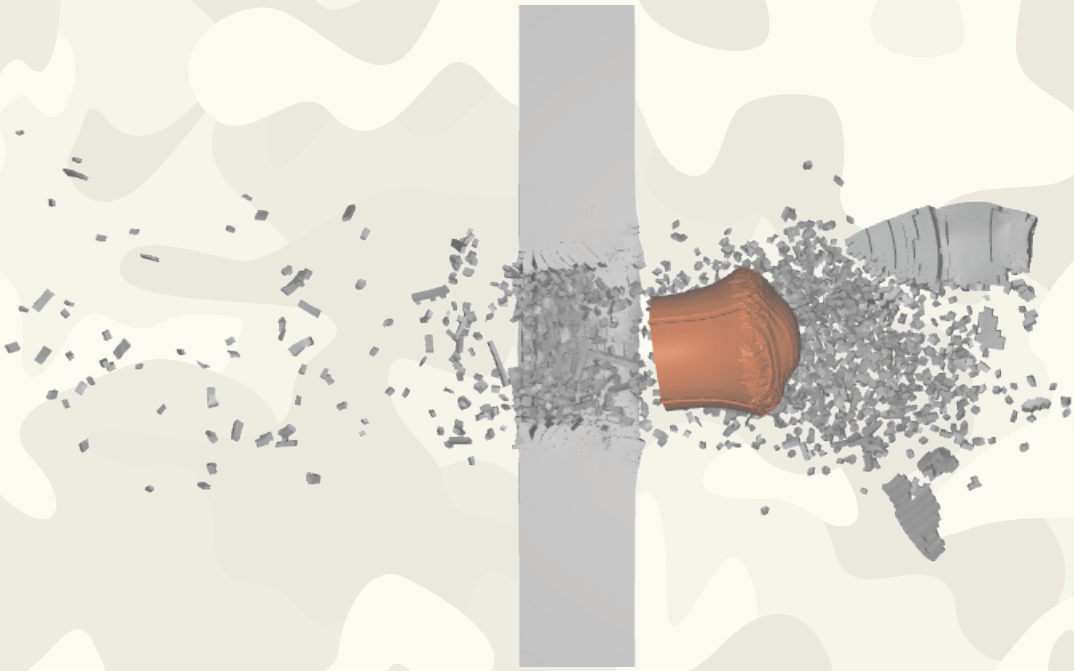
The bullet has a diameter of 0.25 inches and the motion is defined by a pressure history curve applied to backend of the bullet. The bullet travels inside the barrel and makes contact with the lands that have a width of 0.0106 inches. The bullet is modeled with two layers of cubic ASET™ Elements along the surface to capture the deformation and the core is represented by linear elements. The scoring of the bullet is clearly observed and the resulting engraving is very smooth which would not be possible if linear elements had been used for the bullet surface.



The impact with the aluminum target involves highly non-linear behavior both geometrically, materially and in the contact. The fragmentation of the plate is captured with node splitting. IMPETUS separates the damage criteria from the material model which makes modeling of damage very flexible since a damage model can be specified for any relevant material model. It is also very

simple to apply node splitting with the damage command. In this case the Johnson-Cook damage criteria was used for the target.

The node splitting option is one often used for applications where spalling occurs. Fragmentation of the aluminum plate is seen with fragment sizes on the order of 0.0125 inches, so element refinement is used in the impact zone. This is easily done with the "Shadow Refinement" technique where the user defines a geometry to specify the area to be refined by the Solver at runtime. The elements surrounding the impact area that are not affected by the impact are modeled with linear elements.



Key Features and Benefits:

- With the use of the ASET™ Family of Finite Elements, the engraving of the bullet by the barrel "lands" can be accurately modeled.
- Invoking the Node Splitting Algorithm for the target elements increases the accuracy of the penetration model as opposed to using element erosion.
- GPU Technology provides massively parallel processing which is efficient and always load balanced.

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