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Comparison of Johnson-Cook and Linear Elastic-Perfectly Plastic Material Models for Ballistic Impact Case

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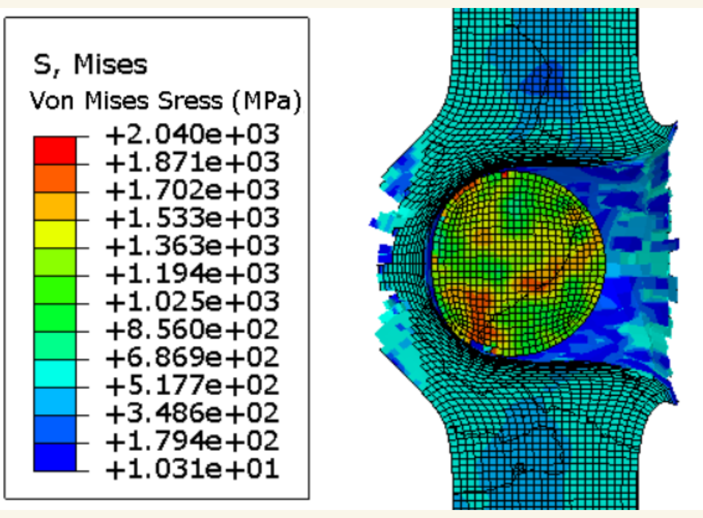
DETERMINATION OF MATERIAL MODELING FIDELITY LIMITS FOR BALLISTIC IMPACT CASES

By Logan Callahan, Marella Failla, and Harrison Williams

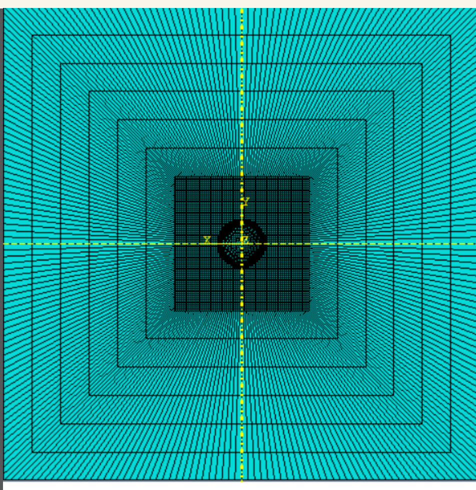


PROBLEM STATEMENT

This project uses Finite Element Analysis (FEA) in an effort to characterize different material models in ballistic impact cases. It will focus on linear elastic-perfectly plastic (J2) and Johnson-Cook Strengthening and Damage, and Johnson-Cook Plasticity (JC) material models.

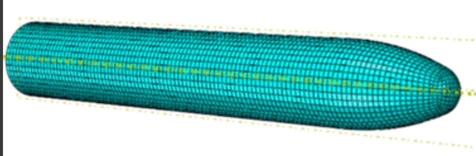
MESH DETAILS

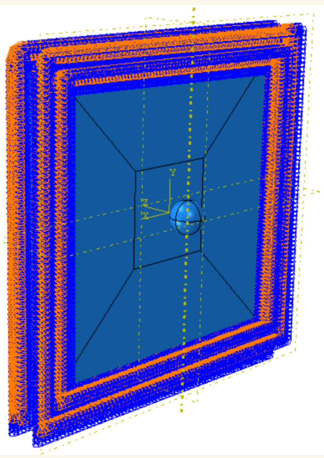
Multiple mesh densities were used in this study, with C3D8R elements for each. The meshes for the Al7085-T711 Targets impacted by S2 Steel Sphere used 1mm, 0.5mm, and 0.25mm element characteristic lengths. The meshes for the Al6061-T6 Target impacted by 4340 stainless steel used 1mm, 0.8mm, and 0.6mm element characteristic lengths.



FURTHER DETAILS

- The finest mesh for Al7085 Targets had 1,845,184 total elements.
- The finest mesh for Al6061 Targets had 3,322,352 total elements.



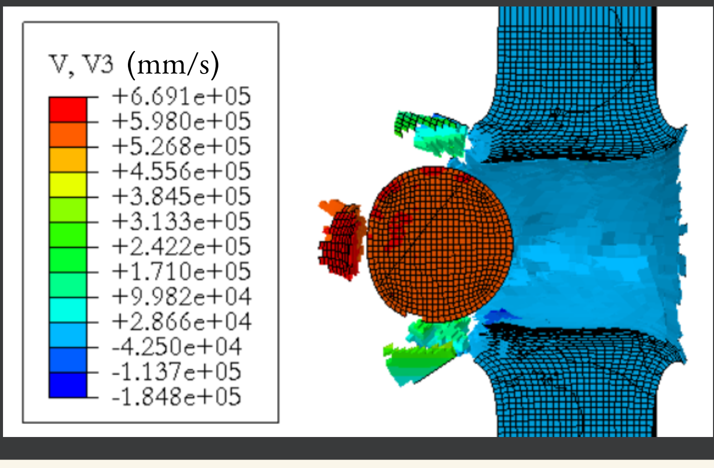


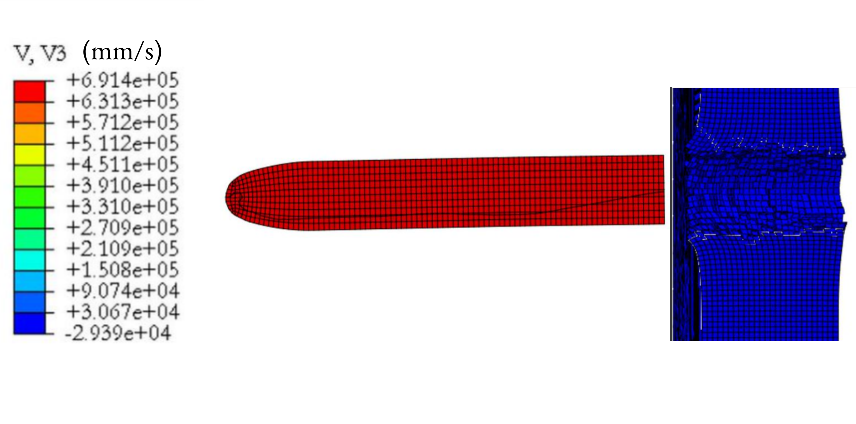
BOUNDARY AND LOADING CONDITIONS

The Al7085-T711 Targets are fixed in the front and rear to simulate how the experimental data was captured. The Al6061-T6 Targets are fixed in a similar manner. The loading conditions for the projectiles used a node set to apply an initial velocity to the entire projectile. Initial temperatures were also applied where applicable for adiabatic analysis.

DYNAMIC - EXPLICIT ANALYSIS

Abaqus explicit was utilized for this project to run dynamic simulations. Each dynamic simulation allowed the team to gather residual velocity data (velocity after perforation) in the z-direction. This residual velocity data is then compared to experimental data to determine each material models fidelity.





RESULTS

The J2 material model outperforms the JC material model for all thicknesses of the Al7085-T711 targets impacted by a 12.7mm diameter S2 Steel sphere.

The JC material model performed best for the Al6061-T651 target impacted by the Steel 4340 ogive projectile. These results can be see in the graph on the right, with the JC model shown by a blue line overlapping experimental data, shown by red points.