Deformation of 2024-T3 Aluminum at High Strain Rates

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Deformation and Failure of 2024-T3 Aluminum at High Strain Rates

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Abstract

This Project’s goal was to study the deformation and failure pattern of 2024-T3 aluminum under high strain rates and to validate the numerical analysis of the aluminum’s deformation and failure using experimental testing. This topic is relevant because of its use in aircraft safety in the event of an on-board explosion. The study of the aluminum was approached using two different methods. The projectile impact test involved shooting a hardened steel sphere at a clamped plate of the aluminum. Then the ballistic limits of various thicknesses of aluminum and the plate failure patterns could be examined. In the Taylor cylinder test, cylinders of the aluminum were shot at a hardened and immovable disk. The cylinders were measured before and after impact and the deformation was correlated with velocity. The results from the computer modeling were closely aligned to the experimental data when a Johnson Cook material model, a model that incorporates strain rates has been tested in simple simulations, the next step is to use it in more complex scenarios. One possible future investigation is a study into the effect of combined blast loading and fragmentation. On 2024-T3 aluminum, the study of the aluminum was approached using two different methods.

Results

- Initial and residual velocity was measured for several different 0.05 in. thick plate simulations. These measurements were used to find the simulation’s ballistic limit, the velocity at which the slug will completely penetrate 50% of the time.
- These results (shown on the graph above) were compared to the experimentally determined ballistic limit which was determined to lie between 184 m/s and 188 m/s.
- The finest meshed computer model predicted that the ballistic limit would occur at 174 m/s.
- There was a maximum error of 14 m/s which is equivalent to an error of 7.4%.
- Solid cylinders were impacted with a rigid surface across a range of velocities. The deformation was compared to simulated cylinders impacted at similar velocities. The results are shown in the table above.

Conclusions

The Johnson Cook material model used in modeling the aluminum plate produces similar results as experimental testing in both the projectile impact experiment and the Taylor Cylinder test. Therefore, it is a valid model for use in future testing.

Future Goals

Now that a valid material model for 2024-T3 Aluminum at high strain rates has been tested in simple simulations, the next step is to use it in more complex scenarios. One possible future investigation is a study into the effect of combined blast loading and fragmentation. On 2024-T3 aluminum, velocity was stepped across a range from 40 m/s to 150 m/s and the results were compared to the computer simulation.

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