SAND2017-0223C

COUPLED EULER-LAGRANGE SIMULATION OF METAL FRAGMENTATION IN PIPE BOMB CONFIGURATIONS: ORAL PRESENTATION

Arne Gullerud[1] and Jeromy Hollenshead[1]

[1]Sandia National Laboratories, PO Box 5800, Mail Stop 1185,
Albuquerque, NM 87185-1185; asgulle@sandia.gov

ABSTRACT

Introduction

The fragmentation of materials during and after hypervelocity impact is a key factor in the resulting debris characteristics, and of great interest to the modeler of such impacts. To ensure that modeling techniques can properly capture the essential characteristics of material fragmentation, comparison of model to experiment is vital. While capturing data from experimental hypervelocity impacts is ideal for this, a close surrogate is the fragmentation of a metal case surrounding a cylindrical explosive charge, often referred to as a pipe-bomb. Proper modeling of these configurations requires capturing shock processes within explosive detonation, the transfer of the shock into the surrounding metal, and the subsequent material response that leads to fragmentation. An array of existing experimental data is available for such comparisons, which often include fragment counts, mass distributions, fragment morphology, and velocity.

Scope of Work

This work focuses on using the Euler-Lagrange code Zapotec to model pipe-bomb experiments. Zapotec is a coupling between the Eulerian code CTH and the Lagrangian code Sierra/SM. The use of an Euler-Lagrange coupling for hypervelocity impact is of great use in bridging the inherent separate time-scales of material response: early-time shock events and damage, and late-time structural breakup. In this work, the pipe-bombs are modeled with the explosive and atmospheric effects within CTH, and the metal casing within Sierra/SM. Material failure in

Sierra/SM is modeled using element death through the Johnson-Cook failure model, and all killed elements are mapped back into CTH to preserve system mass and momentum.

The pipe-bomb experiments modeled come from several sources. The key set of experimental data are from a set of pipe-bomb tests conducted by the Naval Surface Warfare Center at Dahlgren, Virgina, USA [1]. These experiments have been modeled before using CTH only [2]. The experiments employed fragment capturing techniques that enabled the recovery of a significant proportion of the mass of the metal case, and excellent characterization of the mass distribution of the fragments. Other experiments considered in this paper investigate the velocity of case fragments, and include other pipe-bomb configurations.

Findings

A representative sample of the findings of this report are shown in Figure 1. The figure shows images of the experiment at several times alongside simulation results at the same times. The figure also shows comparison of the mass distribution of the fragments in both experiment and simulation. In general, these compare quite well. Similar results are shown for other experimental studies.

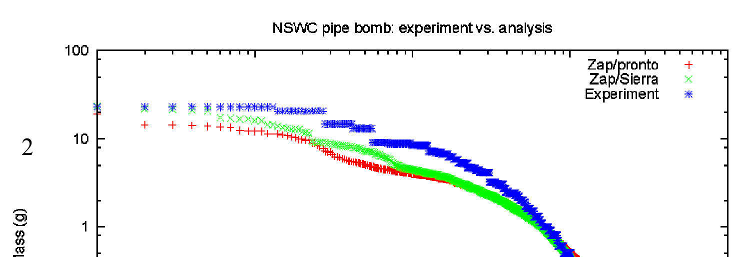

Fig. 1 Pipe bomb comparison of experiment and simulation: left side, geometry evolution through time; right side, final fragment distribution

Conclusions and Recommendations

The studies show good comparison between simulation and experiment, giving confidence in the use of Zapotec to model material fragmentation in hypervelocity impact regimes. The study has shown that there are challenges in the characterization of fragments when split between Eulerian and Lagrangian domains, and that further work in exploring mesh resolution would be highly beneficial.

References

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2) Wilson, L.T., Reedal, D.R., Kipp, M.E., Martinez, R. R., Grady D .E., "Comparison of Calculated and Experimental Results of Fragmenting Cylinder Experiments", SAND2000-1406C, Sandia National Laboratories, Albuquerque, NM (2000).