Modeling of Detonation Propagation

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Summary

A simple methodology for propagation of detonation waves, Detonation Shock Dynamics (DSD), is presented. Theory, experiments and computational issues regarding DSD will be addressed.

Introduction

Detonation Shock Dynamics is based on a weak curvature, quasi-steady analysis of the compressible reactive Euler equations. See [1] for a recent review of the field. The key result from DSD is that to a first order approximation, a detonation wave will propagate normal to itself at a velocity related to its local curvature. This is expressed as a D_n-κ relation. This D_n-κ relation is an intrinsic propagation rule (i.e., all that is needed to propagate the detonation front is its current shape).

Results and Discussions

To be a useful theory, one must perform a calibration of the D_n-κ relation for each high explosive (HE) of interest. Typically this calibration procedure uses data obtained from a series of rate stick experiments. These experiments measure the steady propagation speed of the detonation wave along a long cylindrical charge of HE, in addition to the shock "break-out" at the end of the charge. Knowing the "break-out" time and propagation speed of a steady traveling wave allows one to determine the shape of the detonation wave. Knowing the shape and speed then allows one to determine detonation normal velocity and curvature along the detonation wave. Many rate sticks experiments are generally performed at various radii, and a global fit to all the rate stick data is used to determine D_n-κ. One such D_n-κ is shown in Figure 1 for the insensitive HE PBX 9502. The resulting calibration to data is shown in Figure 2.

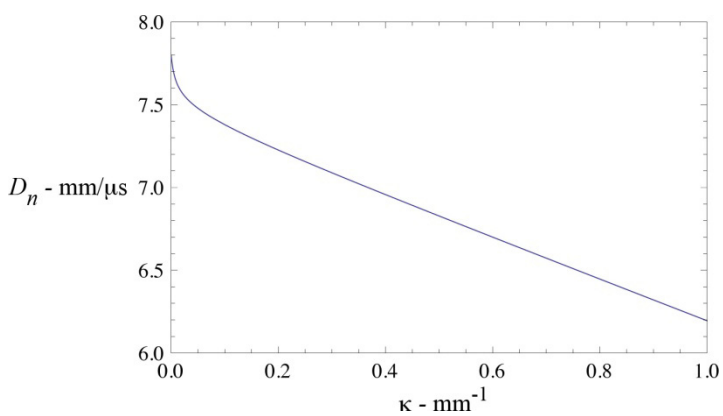

Figure 1, D_n-κ relation for PBX 9502 [2].

The resulting calibration to data is shown in Figure 2. This D_n-κ relation can then be used for more general detonation propagation modeling. Details of numerical implementation, coupling to hydrodynamic codes and validation experiments will be presented.

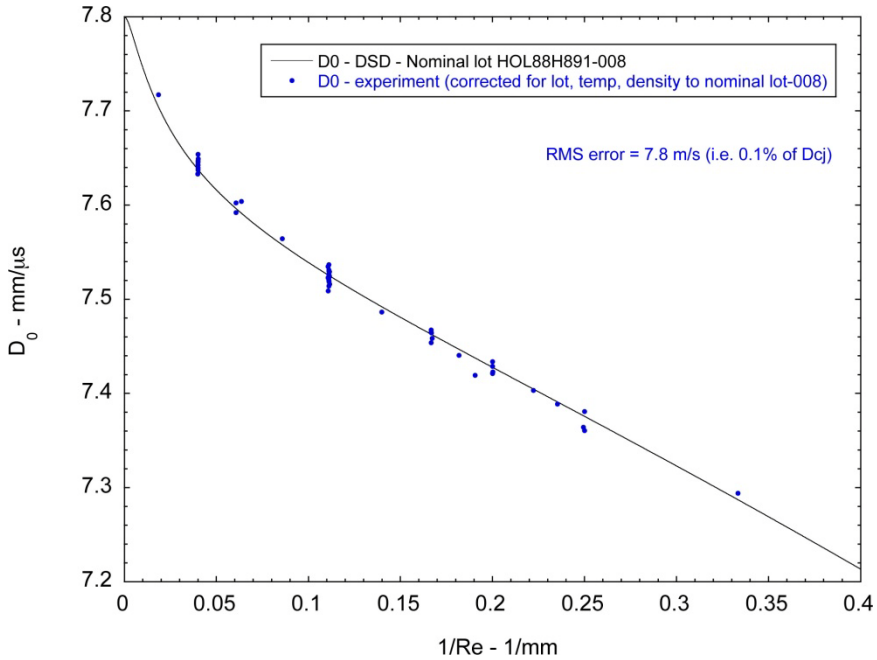

Figure 2, PBX 9502 detonation velocity versus inverse radius. Experimental data is scaled to nominal pressing density, temperature and material lot.

Conclusions

An overview of DSD will be presented. Calibration, verification, validation and related issues to hydrodynamic coupling will be demonstrated.

References

[1] J. B. Bdzil, D. S. Stewart, "The Dynamics of Detonation in Explosive Systems," Annual Review of Fluid Mechanics, **39** 263-292 (2007).

[2] L. G. Hill, T. D. Aslam, "Detonation Shock Dynamics Calibration for PBX 9502 with Temperature, Density, and Material Lot Variations," Proceedings of the 14th International Detonation Symposium, (2010), pp.779-788.

Acknowledgments

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