Detonation Failure Characterization of Non-Ideal Explosives

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Abstract

Non-ideal explosives are currently poorly characterized, which limits the modeling of them. Current characterization requires large-scale testing to obtain detonation wave characterization for analysis due to the relatively thick reaction zones. Use of a microwave interferometer applied to small-scale confined experiments is being implemented to allow for time resolved characterization of a failing detonation of non-ideal explosives. A non-ideal explosive is initiated with a booster charge and a measurement of the failure distance and a continuous position-time trace of the detonation front location can be obtained. Successful results of this method would allow for the calibration of detonation models for many different non-ideal explosives. It is also seen that results are also applicable to micro-detonation studies of ideal explosives.

Relevance

- Due to the large scales required, characterization of non-ideal explosives is limited causing difficulties in modeling explosive devices.
- Small-scale tests using water-filled cylinders to characterize non-ideal explosives have been shown feasible [1]. The pressure from the water allows for the explosives to react.
- Microwave interferometry allows for small-scale characterization experiments using gram quantities of non-ideal explosives without having the complex set up of water-filled cylinders.
- Microwave interferometry has been successfully used with ideal explosives to measure deflagration-to-detonation transition (DDT) [2].
- Studying the failing detonation of non-ideal explosives using the microwave interferometer has the potential to calibrate models for explosive devices.
- It has been seen that the diameter effects the detonation front velocity for ideal explosives and if the diameter is small enough, the detonation will not propagate [3].
- Micro-detonation experiments are possible with the microwave interferometer to study the failing of a detonation front using an ideal explosive.

Technical Approach

- A microwave from the interferometer travels through a waveguide into a ¼" I.D. tube filled with Primasheet® and non-ideal explosive.
- Microwaves reflect off of the detonation front that is propagating through the Primasheet® and non-ideal explosive.
- The reflected wave returns to the interferometer and gives the position of the detonation front as a function of time.

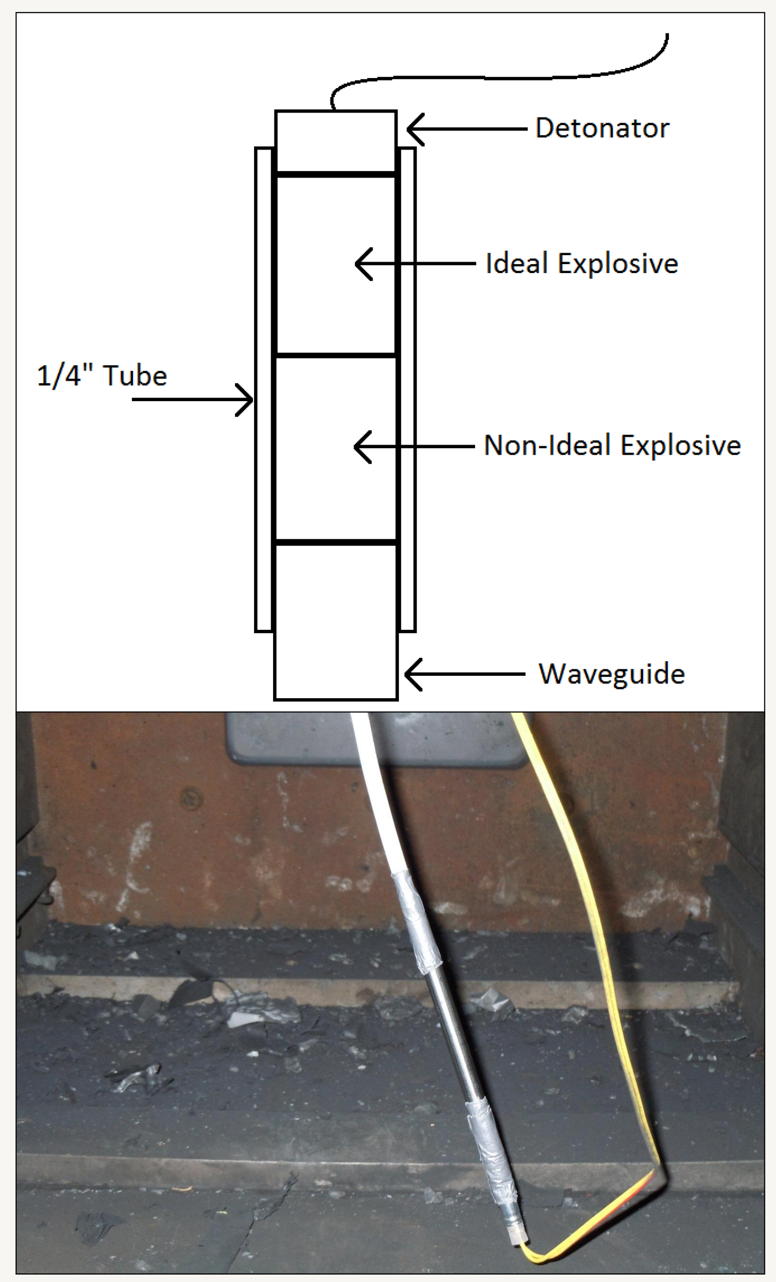

Figure 1 – Schematic and experimental setup.

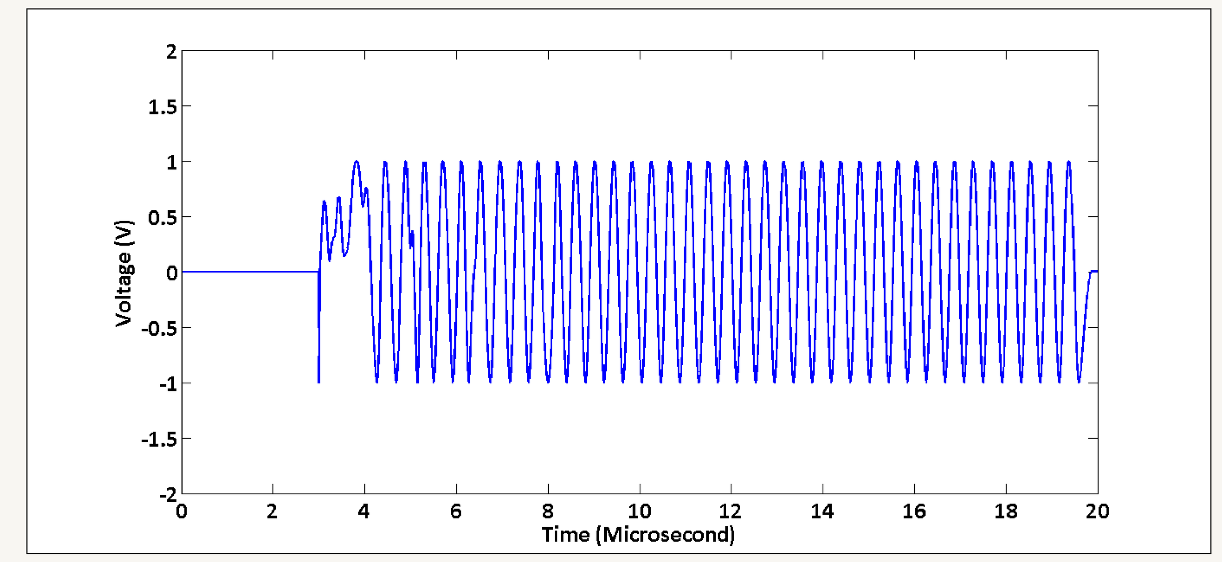

Figure 2 –Normalized data from the microwave interferometer of only Primasheet®.

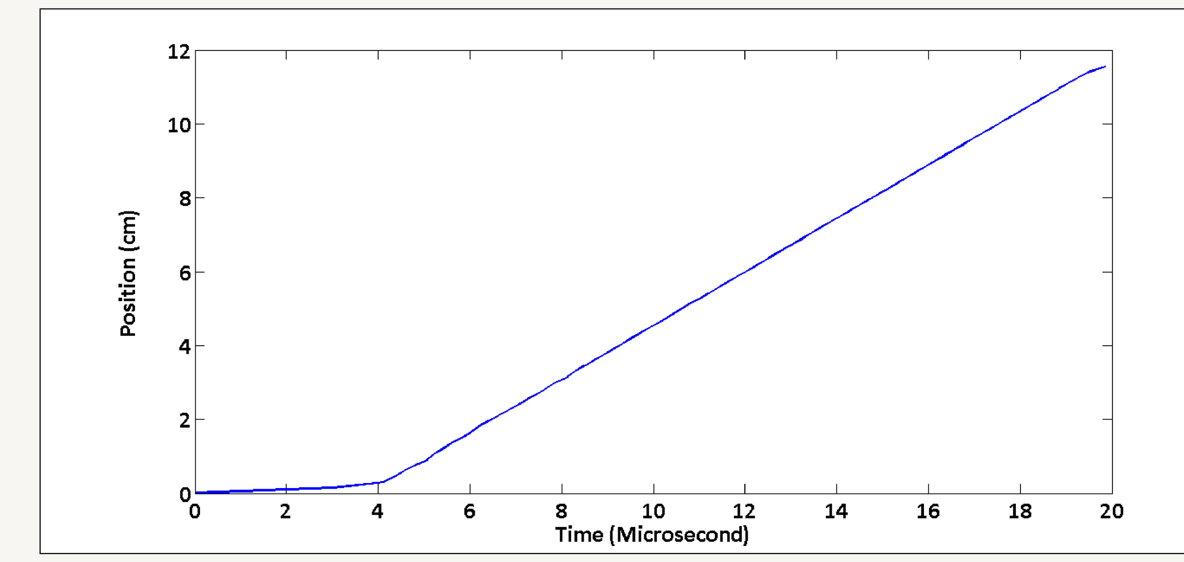

Figure 3 –Position of the detonation front as a function of time.

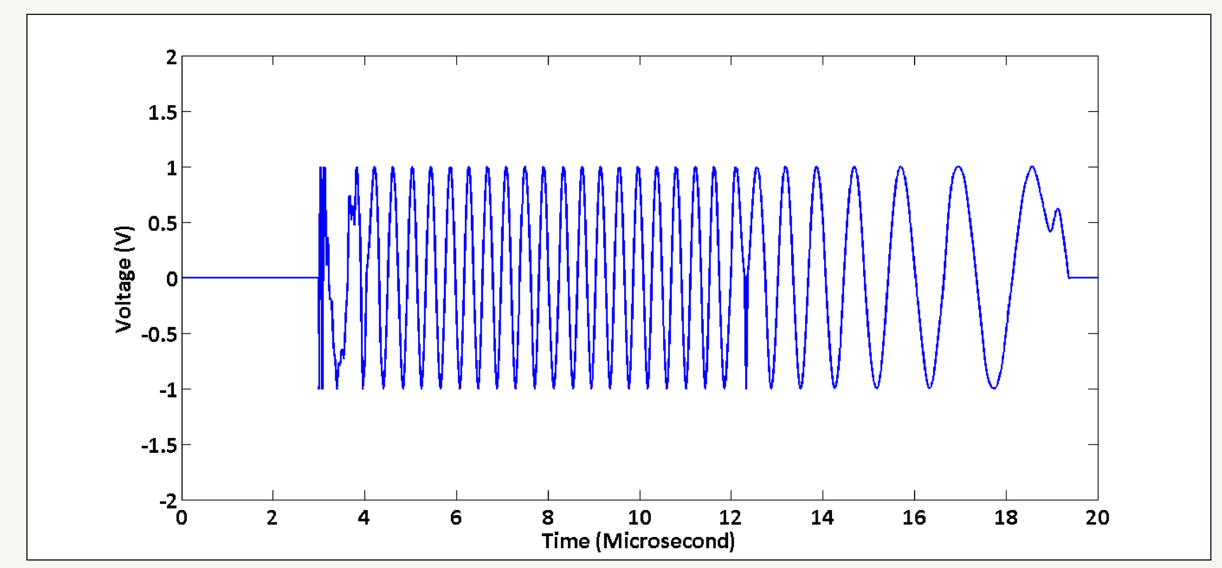

Figure 4 –Normalized data from microwave interferometer of Primasheet® and ANFO.

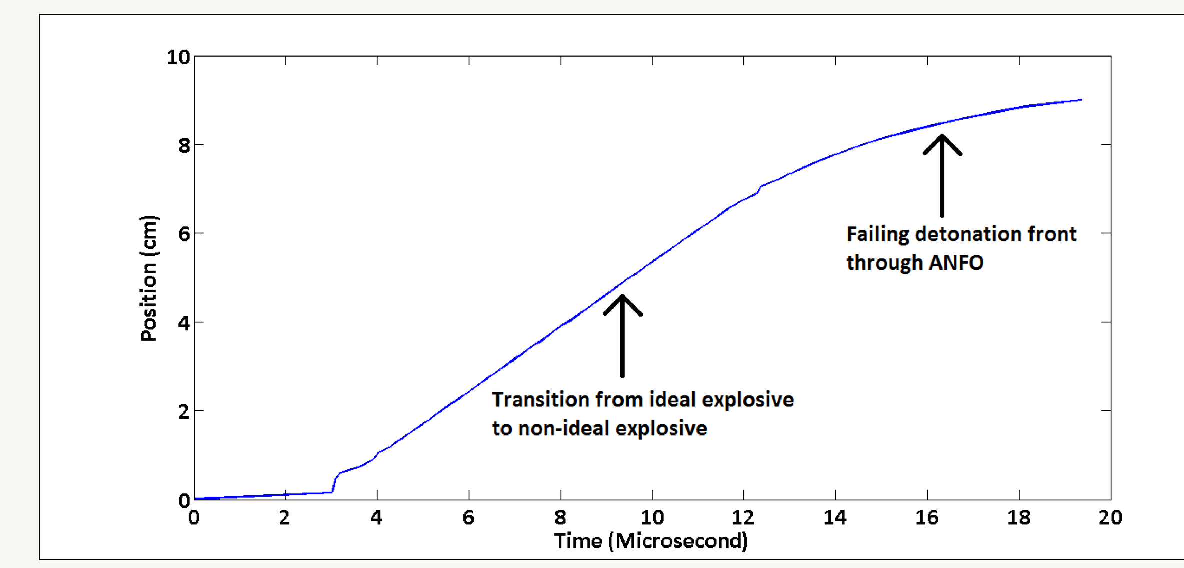

Figure 5 – Position of the detonation front with ANFO causing it to fail.

- Initial tests have shown that the microwave interferometer with the code developed are capable of producing the position of the detonation front as a function of time.
- Tests consisting of 5 cm of Primasheet® followed by 5 cm of Ammonium Nitrate and Mineral Oil (ANFO) were performed.
- Figure 4 shows frequency of the microwave interferometer signal slowing down which represents the slowing down of the combustion front once it makes contact with ANFO.
- The ANFO is seen to gradually slow down the detonation front until it dies. The large reaction zone of the non-ideal explosive slows down the detonation until it can no longer be sustained.
- The experimental setup allows for variable wall thicknesses to control full detonation of the non-ideal explosives. This allows a pressure buildup in the reaction zone that allows for propagation of the combustion front similar to the water-filled cylinder tests.
- Future tests will utilize different compositions of ANFO for characterization.

Accomplishments Through Current Year

- Developed code that reduces the data from the microwave interferometer to represent a function of position with time.
- Successfully showed the failing of a detonation front using the microwave interferometer.

Future Work

- Continue testing different non-ideal explosives to produce data that will be used to calibrate detonation models.
- Test with variable wall thicknesses to control the success of the detonation front through non-ideal explosives.
- Compare results with large-scale experimental data to validate results.
- Use data to simulate and calibrate models using CTH, a shock wave physics computer code developed by Sandia National Laboratories.

Opportunities for Transition to Customer

- Successfully characterizing the failure of the detonation of non-ideal explosives using the microwave interferometer will help develop the modeling needed to further predict differences between specific types of non-ideal explosives.
- This method is very inexpensive compared to the current large-scale methods in terms of the amount of explosives used and the experimental setup per test.
- Better modeling of non-ideal explosives will help develop methods for mitigating explosives that are increasingly used by terrorists.

Publications Acknowledging DHS Support

- Abstract submitted on 2/15/11 to:
  - 17th Biennial International Conference of the APS Topical Group on Shock Compression of Condensed Matter
- Paper in Progress

Other References

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