Analyzing Production Processes of Energetic Materials using Ultrasound Technology
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Overview

Ultrasound is being used in the following applications at ARDEC

- Melt Cast Analyzer
- Press Analyzer
- Primer Press Analyzer

Ultrasound Technology has proven to be highly viable for characterization

- Extensive amount of information available
- Can be obtained Real Time
- Low Energy, safe for operators and explosives
- Easily pass through metal
- Non-intrusive
  - No damage to item
  - Fast measurement
- Sense material changes
  - Polymerization
  - Density
  - Mix composition
  - Temperature
- Low energy for monitoring energetics (< 0.1 Watt)
- On-line process sensors provide continuous measurement
- Sense large areas with multiple or movable transducers
• Ultrasound can use attenuation to detect time of solidification throughout the munition.

• Ultrasound can also be used to detect settling
Results from Initial Tests of Equipment

Plot of measured ultrasound velocity versus cooling time for comp B using 1MHz transmitter and receiver

Plot of measured ultrasound velocity versus cooling time for TNT using 1MHz transmitter and receiver

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.
• Ultrasound technology will be added to Large Press

• Will detect voids and defects

• Will also be able to provide characterization such as mechanical properties
Velocity tracks density for PAX-2A billets

Fitted line shows linear relation of TOF to ram force

Velocity increases with density increase (nonlinear)

Press Force (lbs)

Velocity (in/usec)

- Velocity (Top Sensor)
- Measured Density
- Linear (Velocity (Top Sensor))
Press contaminant detection

Pure PAX-2A versus PAX-2A with 15% brass powder mixed in at top of billet

Results:

1. The two pressings are consistent except for sensor locations where brass is concentrated.

2. The significant change in velocity may provide sensitive indications of contaminants or explosive material variations.

Both pressings used 15K pounds force for 1” ram.
Compaction in two different explosives

Results:

1. The bottom of the LX-14 billet takes much more time to compact than the top (may be due to increased binder in LX-14)

2. Much higher sound velocity in LX-14 is characteristic of the constituents of this material

3. PAX-2A compacts almost immediately compared to LX-14
Results from Last Pax 2a Pressing

- Velocity reading is noise before good signal amplitude
- Line shows density increases for each compaction of Pax 2A
- Apparent Velocity (density) readings even when force released
- Time of pressure increase matched to velocity front at this point
• Detonator project at ARDEC have some problems with inconsistency and quality in product
• Consistency and Quality can be improved with use of Ultrasound Equipment
• Major challenge is design of equipment which can fit small sizes
Two radial ultrasonic sensors (C,D) for two-level sensing through detonator.

Yellow arrows show path of ultrasound.

Axial ultrasonic sensors for sensing along axis of detonator.
• Initial feasibility study is good
• Time of Flight and Amplitude can be detected through detonator
Primer Press Set Up and Output Screen

- Noise when amplitude too low
- Travel time valid when amplitude high
- First wave through powder
- Three pressings for NLO, Lead Acide, RDX
Results from Primer Press
Other Areas of Interest

Proven that Ultrasound Applications exist in the following

- Viscosity Detection
- Water Content Analyzer
- Advanced Characterization of Aging
- Acoustic Sensing of Combat Threats
- Detection of Closed Cracks in Explosives

Ultrasound at ARDEC is currently pursuing 3 main efforts:

- Ultrasound Large Press Analyzer
- Ultrasound Melt Cast Analyzer
- Ultrasound Primer Press Analyzer
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