Ultrasonic Fragmentation and Separation of Cast Energetic Materials

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Objectives

- Demonstrate that directed ultrasonic energy can safely fragment and remove explosives from metal container in an acceptable time frame

- Develop and demonstrate technology for cast-loaded explosives (e.g. TNT, Composition B) in medium and large caliber ammunition

Apply directed ultrasonic energy to composite type explosives for a novel recovery method

Goals

- Design, build, and operate a pilot-scale process for the recovery of energetic materials from obsolete or unserviceable munitions

- Develop a conceptional design for large-scale prototype facility

Benefits

- Eliminates OB/OD and implements resource recovery and reuse (R^3), a strategic goal of PM Demil
- For cast loaded munitions provides advantages over autoclaving
  - Faster
  - No pink water generation
  - Cleaner metal parts
  - Anticipated lower costs
- Sonication is also applicable to high melting point and polymer-bonded materials for which other demil methods are not suitable
- May also be suitable for removal of cast-cured, thermoset IM fills

Background

In 1995, ARDEC issued a Broad Agency Announcement requesting new ways of removing cast loaded explosives

- Fluorochem, Inc, Asuza, CA proposed use of ultrasonic energy for removal
- Contract awarded to Fluorochem under the Army Conventional Ammo Demil Program
- Investigated ultrasonic technology, conducted inert ultrasonic removal tests and evaluated various sonication fluids

Background (continued)

Under an Army SBIR, initiated in 2002, TPL developed a bench-scale process to remove TNT and Comp B from mortar rounds (81-mm)

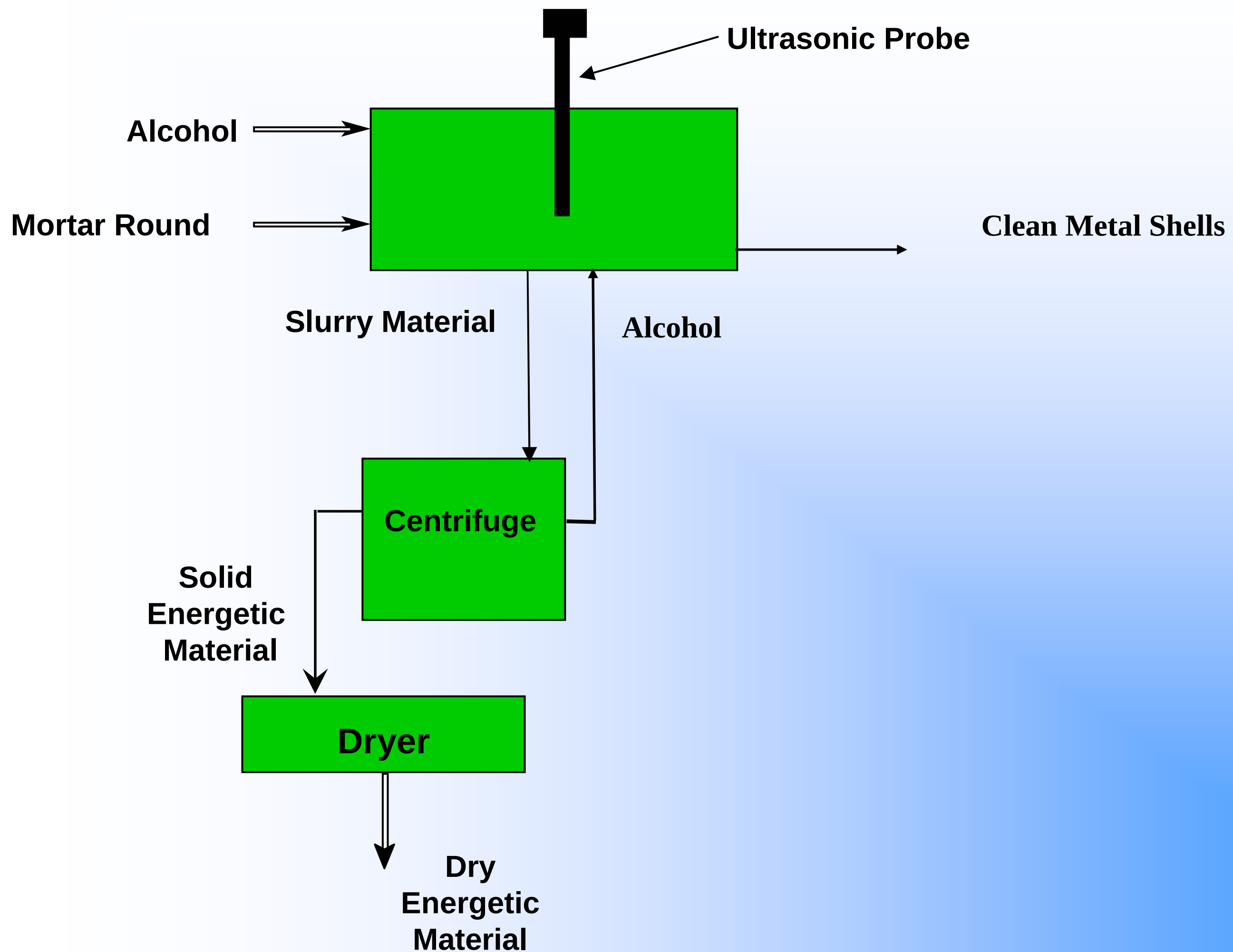
- **Use of ultrasonic energy and alcohol**
- **TNT recovered as granular material, Type III and Comp B recovered as granular material, Type II**

Sonication

An unexpected outcome of sonication of Comp B was the ability to separate the material into the constituents of TNT and RDX by selecting the appropriate solvent and filtering conditions

- **Separation was also demonstrated using Octol, which was separated into TNT and HMX**
- **Separation was investigated further under a new SBIR project**

Concept Block Diagram



Pilot Plant Facility
General Requirements

- Use the same sonication tank and basic equipment for TNT, Comp B, and polymer-bonded explosives

- Sonication tank is designed to switch between 81mm mortars, 60mm mortars, and 120mm projectiles. Future modifications will allow flexibility in handling other types of munitions

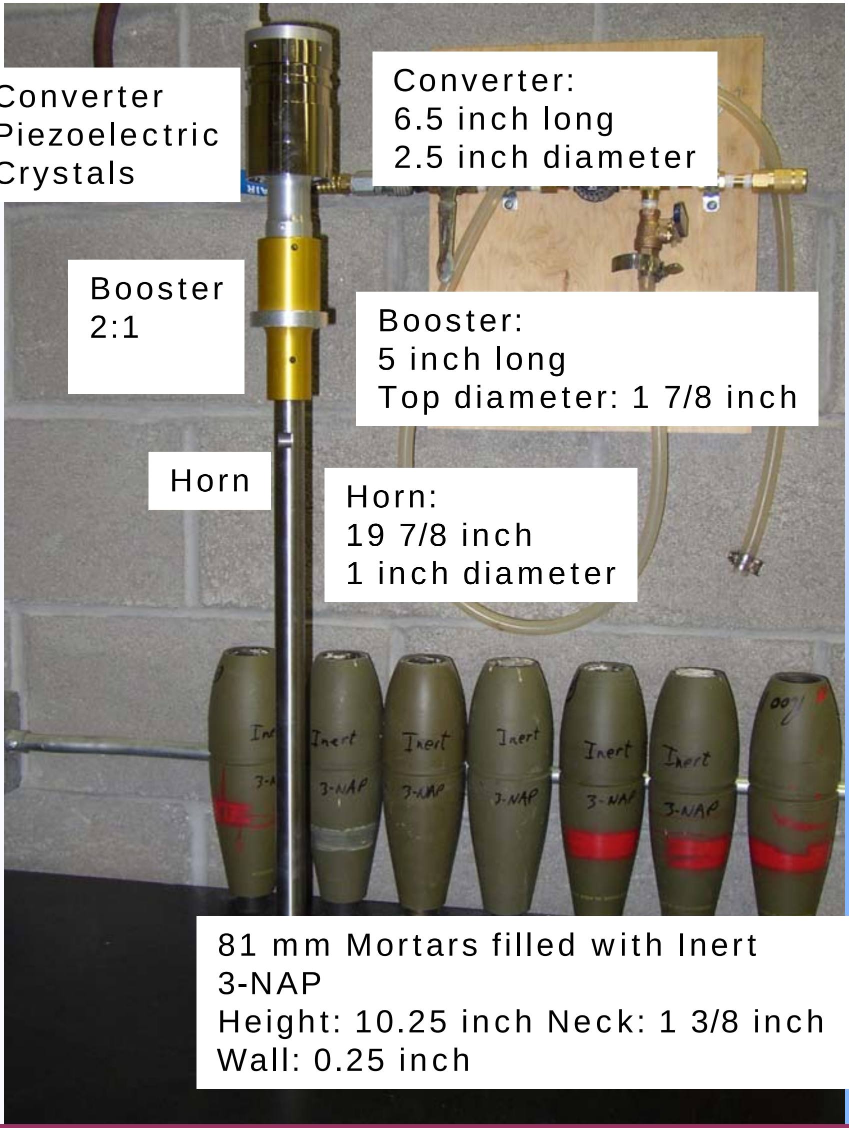
Key Pilot Process Features

- Manual loading of sonication tank
- High power sonication using 6 sonic probes
- Custom designed sonic horn design
- Alcohol as sonication fluid
- Sonication in batch mode
- After fragmentation and removal from shell, use centrifugation or other methods to separate energetic material from alcohol
- Recycle the alcohol to reduce waste stream
- Dry and package the recovered energetic material

Sonication Equipment

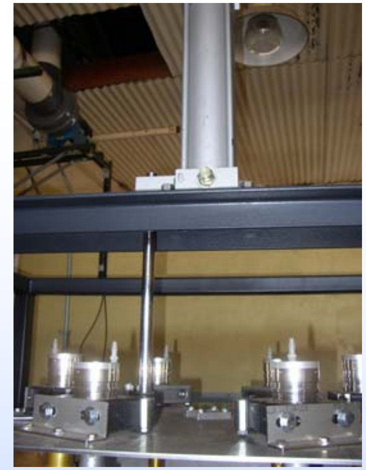
Probe stack

Total length: 31 3/8 inch
Total weight: 6 pounds



Sonication Equipment

Sonication tank positioned above centrifuge.

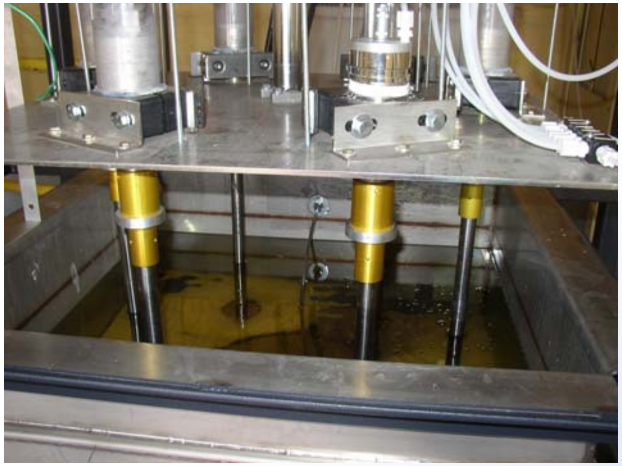


Lift plate holds 6 sonic probe converters.

Shells positioned in tank.

Vacuum cone dryer in bay 6B

Sonication Equipment



Probes in alcohol filled sonication tank.

Sonication tank with removed inert material .

Probes sonicating inert material in shells.

81mm mortar shell inert loaded.

Sonication Results

81mm shell with inert material removed.

Shells after one 30 second cycle of cleaning.

Shell after two 30 second cycles of cleaning. All inert material was removed.

Close-up of cleaned shell.

Summary of Results
for Cast-Loaded Explosives

- **Rate of material removal for autoclave method for 81-mm mortar round:**
  - **TNT: 31 minutes**
  - **Comp B: 51 minutes**

- **Rate of material removal for sonication method for 81-mm mortar round:**
  - **TNT: 20 minutes(35% improvement)**
  - **Comp B: 23 minutes(55% improvement)**

Ultrasonication Status

Cast-Explosive Removal Program

Pilot plant equipment was installed and tested using inert loaded rounds

- **A small number of TNT and Comp B loaded rounds were sonicated successfully, but problems precluded operation in the 6-shell at once mode. Solutions were identified but SBIR funding ran out.**
- **Completed a conceptual design for large-scale prototype plant**
- **TPL has vacated Ft. Wingate and moved all equipment into storage. A site for follow-on work is being sought**

Ultrasonic Separation Program

A Phase I SBIR contract was awarded in Dec 2005 to investigate and demonstrate the separation of a number of energetic compositions into their component parts

TPL has researched and demonstrated the separation of these polymer bonded explosives:

- PBXN-106 (RDX /BDNPA/F / Polyethylene glycol)
- PBXN-101 (HMX / Laminac / Styrene)
- PBXN-8 (RDX / Steric Acid / Cellulose)
- PBXN-9 (HMX / Polyacrylic elastomer / DOA)
- PBXN-4 (DATB / Nylon)
- Comp A3 (RDX / Wax)
- LX-14 (HMX / Estane)
- Magnesium flares 4.2 (Granular Magnesium / Epoxy / Polysulfide)

Ultrasonic Separation Objectives

- Identify an effective sonication fluid for each explosive.
- Demonstrate sonication separation in a small-scale laboratory operation in a detonation chamber with samples in glass beakers.
- Demonstrate the effects of sonication on quantities of explosives, which exceed the respective critical diameters, in a remote test run.
- Evaluate methods of separating the desirable explosive from the sonication fluid and any binder material.

Ultrasonic Separation Procedure

- Ten gram samples were sonicated in a detonation chamber using a 130 watt processor in a number of solvents
- Sonication took place in 150 mL beakers for 10 minutes with 100 mL of liquid, followed by filtering through filter paper and oven drying at 50oC
- The tests were done in triplicate, and the results averaged
- Depending upon the individual explosive, sonication with the solvent removed either the explosive itself or the binder material
- The filtrate and the solid material remaining after sonication were analyzed to identify the individual components

Ultrasonic Separation Results

Phase I SBIR Study

- None of the material showed any signs of deterioration upon sonication
- There have been no adverse results of any type, therefore ultrasonication can be safely used on a wide variety of explosives including PBXs
- Ultrasonic separation has been achieved for PBXN-106, PBXN-101, PBXN-9501, PBXN-9, PBXN-4, Comp A3, LX-14, Comp B, and Magnesium flares
- Ultrasonication using ketones can be used with many of the explosives for fragmentation and separation, it must be noted that certain ketones have environmental concerns which may eliminate their use

Ultrasonic Separation Results
Sonication Fluids

- **Ketones were found to be the best sonication fluids for polymer bonded materials**
- **Alcohol was best sonication fluid for TNT and Comp B energetic materials**
- **Magnesium flare material sonicated best in water**

Ultrasonication Future Work

- Phase II SBIR project submission for the separation program is currently in the review process; If selected, contract award by 1QFY08
- Phase III SBIR project (funded by PM-Demil) for cast-loaded removal and recovery process is being considered based on available funding and priority relative to other projects

General Summary

- TNT and Comp B can be safely removed by fragmentation using ultrasonic methods
- Material will be available for military or commercial reuse
- Sonication can separate Comp B, Octol, PBX and magnesium flares into their original component materials
- PBXN type explosives containing HMX, RDX, TATB, and metal containing materials can be safely sonicated, and separated into component materials
- Implementation of this technology avoids incineration and implements R^3