Novel Manufacturing Process for the Thermobaric Explosive PBXIH-18

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Objective

• Develop a safe, cost effective manufacturing process for Thermobaric Explosives using water slurry technology developed at BAE Systems Holston Army Ammunition Plant (HSAAP).
Briefing Outline

• Background
• Prior Effort
• Investigation
• Aluminum Concerns
• Laboratory Processing
• Conclusion
• Acknowledgements
Background

• Thermobaric Explosive (TBE)
  • Principles of unconfined vapor cloud explosion (UVCE)
  • Produces blast wave of long duration
  • Higher sustained blast overpressures
• Increased lethality in confined spaces
• Mechanism
  1. Primary detonation of explosive charge
  2. Combustion of fuel particles not consumed in primary detonation
  3. Flame front accelerates to a large volume producing pressure fronts with fuel/oxidant mixture and surrounding air
HSAAP Explosive Processing

- Solvent-Lacquering Technique
  - Explosive intermediates slurried in water
  - Polymer/plasticizer dispersed in organic solvent (Lacquer)
  - Lacquer gravity feed into slurry
  - Coating precipitates onto explosive intermediates
  - Recovery of organic solvent

- Production Operations at HSAAP
  - 500 Gallon (Vacuum Stills)
  - 4,000 Gallon (7A Stills)
Prior Effort

- 2003-2004 timeframe
  - NSWC Indian Head, Yorktown Detachment approached BAE Systems, OSI for implementation of full rate manufacture prove out at the Holston Army Ammunition Plant

- Coating Technique
  - Traditional Solvent-Lacquering coating system
    - Incompatible with Thermobaric processing
    - Aluminum powder oxidized by water
    - Safety hazard due to aluminum powder interaction with water forming Hydrogen gas
  - Elimination of water from coating system
    - Water replacement fluid (perfluorocarbon compound)
    - Non reactive with metal powders
    - Similar boiling point as water
2005 Production

- 300 pound pilot scale manufacture
- Product met MIL Detail Specification

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<th>Press Density (g/cc)</th>
<th>H2O %</th>
<th>VTS (ml/mg) 48 hrs</th>
<th>Coff. Of Friction</th>
<th>Granulation % Passing</th>
<th>Impact, cm</th>
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Lessons Learned

• 2005 Production
  • Impact data shows a reduction in sensitivity using a HMX/DOA Premix
  • All attributes of the product meet previous laboratory produced materials

• Perfluorocarbon
  • Manufactured by 3M
  • Fluid is cost prohibitive for large scale full rate production
    • Special delivery and handling equipment
    • Multiple decants to filter PF
  • PBXIH-18 Cost is dependant of recovery and re-use
    • Recovered >97% of PF from production run
    • Loss mostly contributed from liquid barrier seals in processing equipment

• 3M discontinued manufacture of specific perfluorocarbon fluid
  • Several new products offered with identical properties
OSI Investigations

• Several customers seeking TBE pressable warheads
  • Applications: Grenades, SOCOM, Warheads…
  • Many different binder matrixes (Viton, Hytemp, CAB, etc…)

• OSI R&D to investigate cost saving measures to make affordable product
  • Perfluorocarbon fluid vs. filtered water

• Water Advantages
  • No special delivery or handling equipment
  • No targeted training for operations staff
  • Readily available
  • “Virtually” free as compared to PF
  • Standard processing at HSAAP
Experimentation

• Aluminum-Water interaction
  • Temperature
  • Time
  • pH monitoring
  • Hydrogen detection

• No Hydrogen generation observed when varying temperature with time
  • 30 min – 24 hour period

• As expected, pH change did expedite the limited oxidation reaction
  • Altering the pH of the slurry medium allowed the operation of move forward slowly
  • No Hydrogen was generated (Real time monitoring)

• Addition of explosives and binder components
  • Did not affect the reaction
Aluminum Powder

- Suppliers
  - Toyal America, Inc.
  - Alcoa Inc.
- Both suppliers' products were evaluated
  - Production process for the metal powders leave product oxidized
  - Explanation for lack of Hydrogen formation over extended periods of processing
Laboratory Processing

- All experiments were conducted in the HSAAP 10L coating still
  - Replicate of production equipment
  - Used to make PBXN-9, PBXN-5, Comp A-5, etc...
- Trials were conducted with production filtered water
- Standard parameter evaluation was conducted
  - Time
  - Temperature
  - Agitation Rate
  - Age Time
  - Solvent-to-water ratio
  - Distillation rate
  - Lacquer addition rate

- Key parameter for acceptable product was solvent/water ratio and temperature
- Other parameter effects were negligible on the product
Assessment

- Water Slurry Process Results
  - Achieved >30% reduction in solvent usage
  - Reduced process cycle time by 67%
  - Product batches met the MIL Detail (MIL-DTL-32156 REV A)

- Analysis Comparison

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Scanning Electron Microscope

PBXIH-18-1

PBXIH-18-1099-40
Product Evaluation

- OSI partnered with Nammo Talley for pressing studies and calorimeter testing
  - Supplied 20 pounds of PBXIH-18 manufactured from the water slurry processing
- Pressing Study
  - OSI and NSWC materials evaluated at 5 ksi, 10 ksi, 15 ksi and 20 ksi
Product Evaluation

- Calorimeter Testing
- Average of 2-15.00g pellets; booster 5.00g C-4; RP-80 detonator

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<th>Material</th>
<th>%TMD</th>
<th>Energy of Det. (cal/g)</th>
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<tr>
<td>Holston</td>
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<td>NSWC</td>
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Conclusion

• Implementing water as the slurry medium showed no adverse effects to the Thermobaric Explosive product

• Process Improvements
  • Achieved significant reductions in processing times and raw material usage
  • Significant saving in raw material cost, utilizing water instead of PF

• Testing conducted by Nammo Talley show that the OSI and NSWC materials are comparable
  • Both materials had comparable results from pressing and calorimetric testing

• OSI has successfully developed and demonstrated a repeatable water slurry method for manufacture of PBXIH-18
Acknowledgement

- Nammo Talley
  - Mr. A. Davis

- BAE SYSTEMS Holston Army Ammunition Plant
  - Mr. M. Hathaway, Ms. K. Guntrum, Mr. V. Fung, Ms. D. Painter