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Novel Manufacturing Process for the Thermobaric Explosive PBXIH-18

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Objective

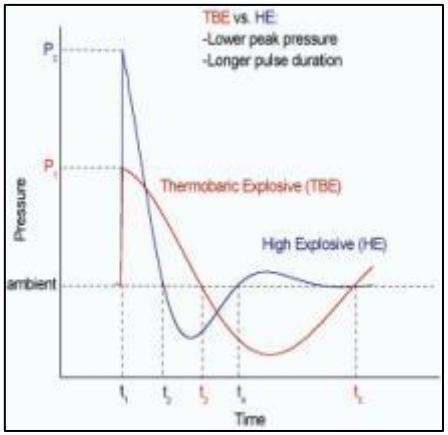
- Develop a safe, cost effective manufacturing process for Thermobaric Explosives using water slurry technology developed at BAE Systems Holston Army Ammunition Plant (HSAAP).

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



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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

					Granulation % Passing				Impact, cm	
	Press Density (g/cc)	H2O %	VTS (ml/mg) 48 hrs	Coff. Of Friction	6	8	40	70	PBXIH-18	Std.
PBXIH-18-1	1.92	0.03	0.06	150	100	100	5	2	30.04	15

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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

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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

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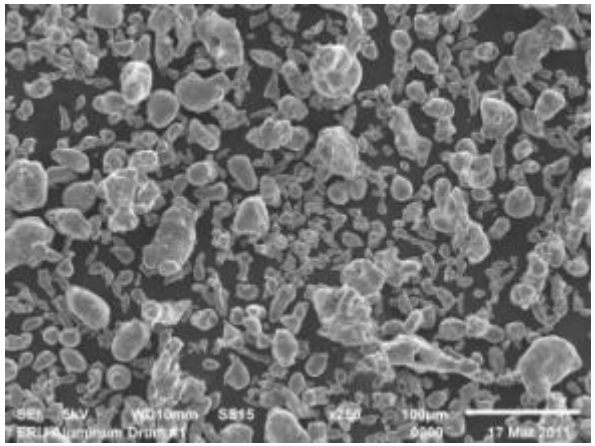
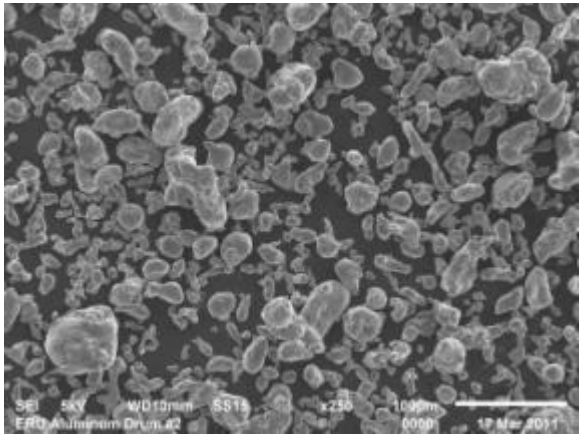
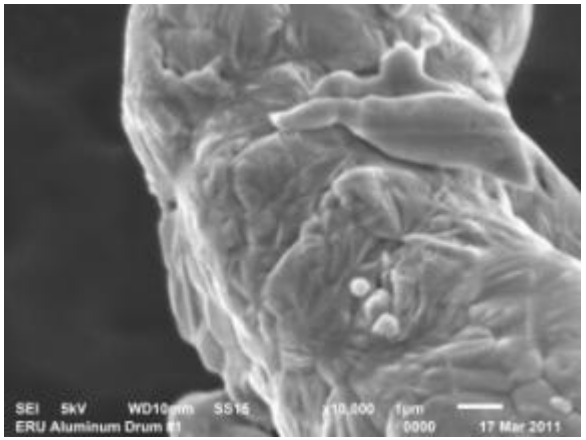
Aluminum Powder

- 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
  - 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

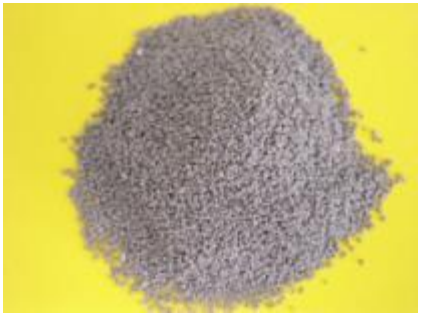
- Key parameter for acceptable product was solvent/water ratio and temperature
- Other parameter effects were negligible on the product

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

					Granulation, % Passing				ERL Impact, cm	
	Press Density (g/cc)	H2O %	VTS (ml/mg) 48 hrs	Coff. Of Friction	6	8	40	70	PBXIH-18	Std.
PBXIH-18-1	1.92	0.03	0.06	150	100	100	5	2	30.04	15
1099-43	*1.93*	*0.02*	*0.09*	*161*	*100*	*99.9*	*0.3*	*0.1*	*73.56*	*15*



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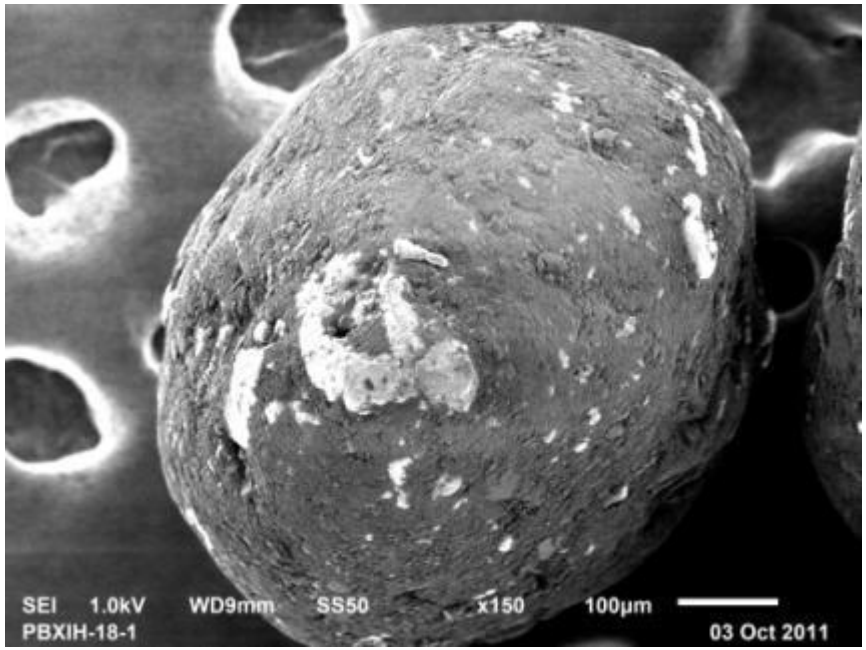
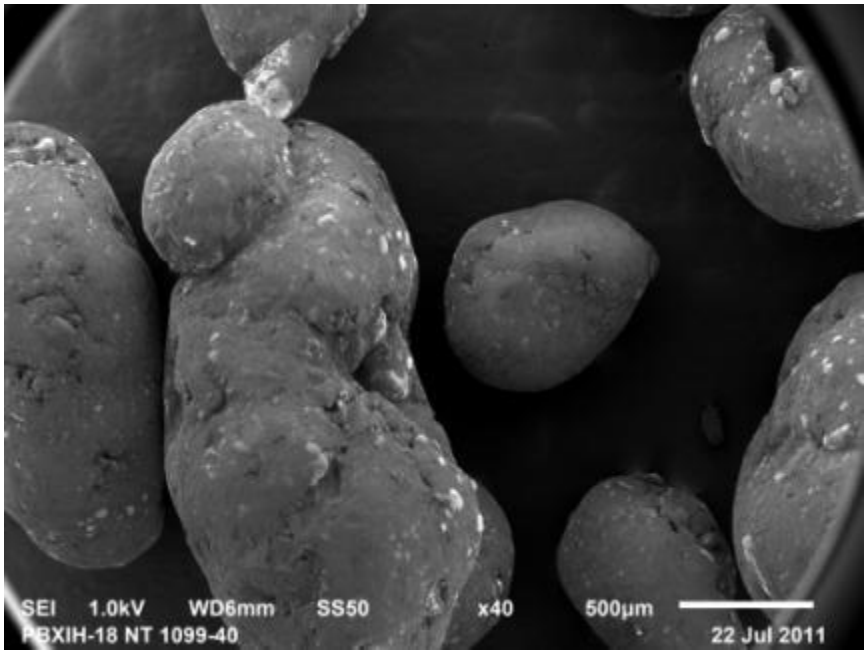
Scanning Electron Microscope



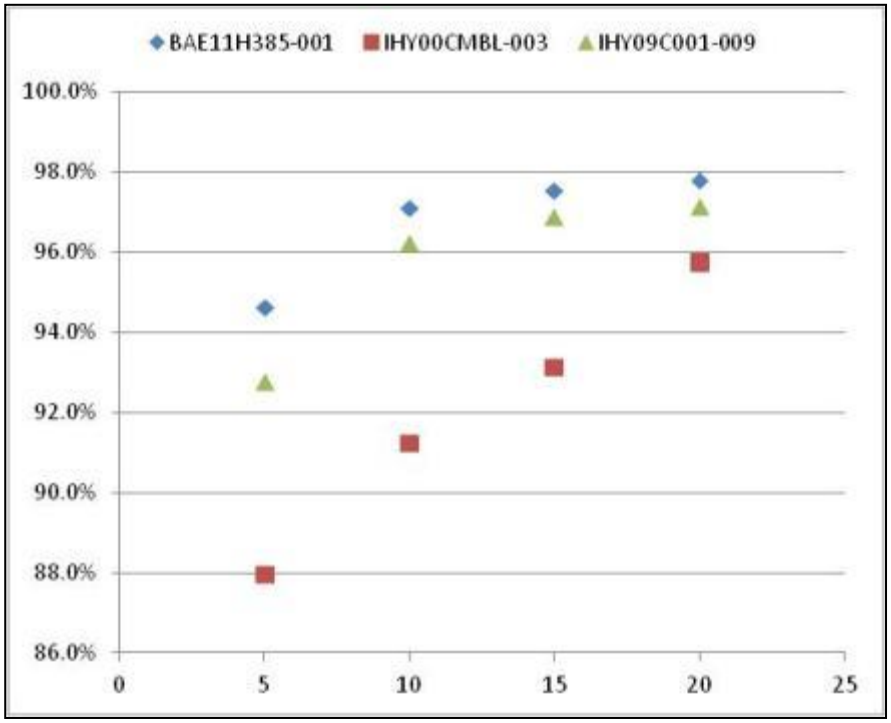
PBXIH-18-1

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

Material	%TMD	Energy of Det. (cal/g)
Holston	98.5	-1826
NSWC	98.6	-1774

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

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Acknowledgement

- Nammo Talley
  - Mr. A. Davis

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