Department of U.S. Army
Research Development Engineering Command
Armament Research and Development
Engineering Center

Processing a Novel Formulation of Black Powder

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JOCG Continuous Mixer and Extruder
User's Group Conference

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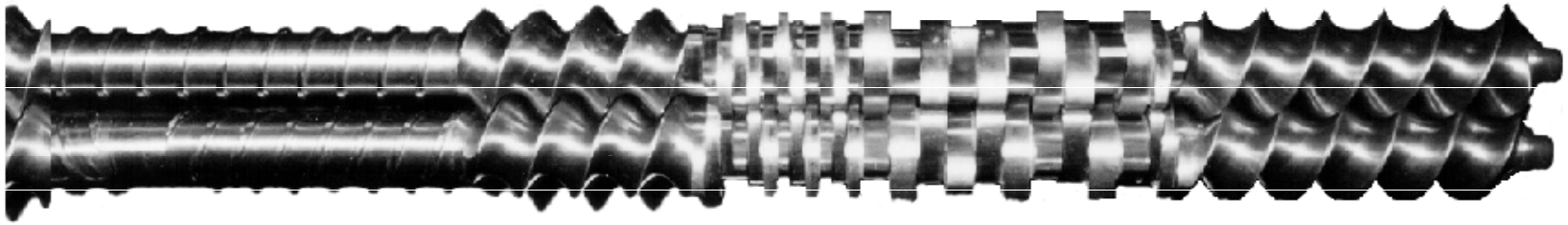
Background

- Black Powder Manufacture - Batch Method
  - Standardized manufacturing method of black powder has changed little since the 1900's
  - Single U.S. Black Powder Manufacturer
    - GOEX, Louisiana AAP
    - "Black Art" process, much of process exposed to environment
    - Charcoal key to performance
    - High operator interaction with constituents when loading/unloading equipment
    - Method has been plagued with multiple safety incidents, resulting in lives lost & equipment
    - Incidents have resulted in rising cost of black powder to the military
  - Single source represents a single point failure in manufacture
    - Multiple munitions use black powder

Photograph from the Hagley Museum and Library, Wilmington, DE

Background

- U.S. Army – PEO Ammo
  - Foreign Comparative Test (FCT)
    - To evaluate alternate sources of black powder
    - Identify alternative methods to produce black powder or substitutes
  - U.S. Army ARDEC Twin Screw Extruder selected into the test



Objectives

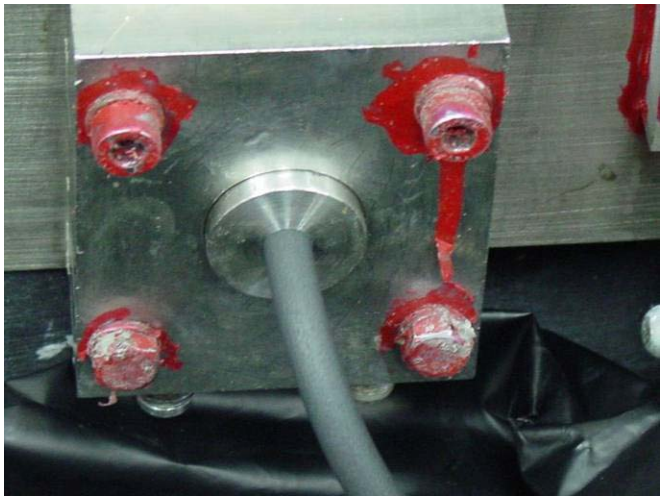
- Develop continuous process for black powder through twin screw extrusion
  - ARDEC 40-mm Twin Screw Mixer/ Extruder
- Deliver live black powder
  - 4 different class sizes for testing
- Quantify process and black powder performance through testing

Program Summary

- Raw Material Characterization
  - Identify inert simulant
    - Oxidizer – Potassium Nitrate
    - Multiple candidates for simulant
      - Sodium Chloride
      - Ammonium Chloride
      - Lithium Sulfate
- Rheological Studies
  - Standard formulation not extrudable
    - Processing agent - water
    - Constituents suspended in water
    - When suspension is pressurized, the water and solid constituents to separate
  - Formulation change
    - Binder/ carrier added to formulation
    - Formed a process gel with water
      - Allowed the constituents to be carried through and out the die

Program Summary

- Modeling/ Simulation
  - Screw configuration identified
  - Inert processing parameters established
- Inert Processing
  - Multiple Inert Runs
    - August 2003 – January 2004
  - Problem Areas
    - Process Gel
      - Increased wall slip condition
      - Feed order established to prohibit formation of gel
      - Salt fed immediately once gel past mixing section
    - Potassium Nitrate/ Sodium Chloride
      - Corrosive
        - » ID multiple replacement candidates
        - » Continued with salt based on the urgency of the program
      - Hydroscopic
        - » Material dried and stored in air tight containers
        - » Flow agent to ease feed flow



Program Summary

- Live Processing, 27 January 2004
  - 1hr 15min live processing run
  - Processed 15lbs of black powder
  - Produced the 4 required class sizes for product testing
  - Incident free
- Glazing and Sifting, 28 January 2004
  - Coated black powder with graphite
  - 15 pound capacity “Sweetie” barrel
  - 45 min glaze time, remotely operated
  - After coating, hand sifted for the 4 particle sizes
- Delivered black powder to Pyrotechnic division for testing

Product Testing

- Foreign Comparative Test (FCT)
  - FCT Objectives
    - Determine black powder performance through laboratory tests
    - Determine producibility
  - Conducted by Picatinny Pyrotechnic Research & Technology Division
  - Sources Tested
    - Germany, Swiss, Spain, French Black Powders
    - US Manufacture Black Mag
    - US Army ARDEC – TSE BP
    - GOEX BP
  - Multiple Test Requirements
    - Closed Bomb – Pressure vs. time traces
    - Heat of Explosion – Caloric Output
    - Thermal & Storage Stability
    - Chemical Analysis
    - Sieve Analysis

Product Testing

- FCT Results
  - TSE black powder vs all FCT sources
    - Testing not complete, preliminary results delivered
    - Closed bomb results indicated slower ballistics compared to control sample
    - Heat of explosion results indicated results matched foreign competitors
  - TSE a viable candidate for black powder manufacturing

Summary

- Met Program Objectives
  - Developed continuous process for a novel black powder formulation
  - Produced material to qualify for the FCT Testing

- Further Work
  - Awaiting complete black powder testing and report
  - Optimize TSE black powder process
    - Seek to optimize process
      - Introduce in-line drying & sifting capabilities to the process
    - Formulation not optimized for performance
    - Formulation was developed for processability through the extruder