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

Continuous Processing of M206 Infrared (IR) Decoy Flare

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JOCG Continuous Mixer and Extruder
User's Group Conference

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  - ManTech Manager
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  - RDECOM-ARDEC, Picatinny
    - R&D and testing
    - Pilot scale processing
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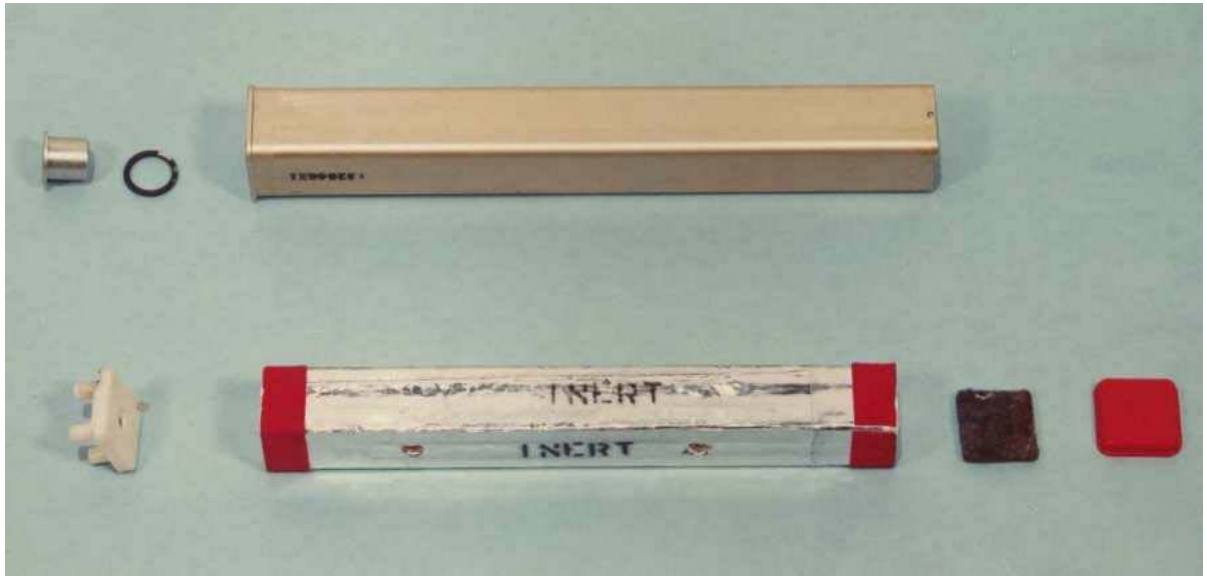
    - Leveraged ManTech Funding
  - Hill AFB
    - Leveraged Funding
    - Interpretation of flight testing results
- U.S. Navy
  - Point Magu
    - Flight testing at China Lake
- Academia
  - Stevens Institute of Technology - Highly Filled Materials Institute
    - Material characterization
    - Rheology
    - Mathematical modeling
- Contractors
  - Technical Consultants, Inc. (TCI)
    - TSE processing expertise
  - Kilgore Flares Company
    - Press/ Finish Flare Grains
    - Testing

Program Objectives

- Develop continuous process for M206 IR Decoy Flare
- Baseline process which can be transferred to full-scale operation
- Quantify twin screw extrusion process and product through testing

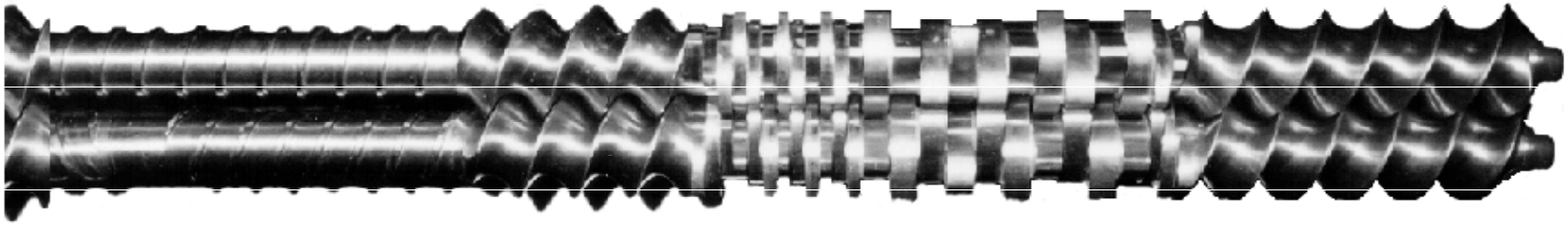


Background

- M206 IR Decoy Flare Production
  - Manufacturing conducted through batch method
  - Multiple intermediate processing steps
  - High usage of volatile solvents (Hexane and Acetone)
    - Pollutants upon evaporating into atmosphere
    - Hexane – EPA regulated air pollutants
  - Variability for lot-to-lot
    - Cross blending for performance
  - High operator interaction between energetic materials
  - Manufacturing incidents have occurred within the past 5 years

Background

- Twin-Screw Extruder (TSE) Manufacturing
  - Continuous / Remote Processing
    - No intermediate processing steps
      - Minimize transportation of “static” sensitive materials
      - Increased processing safety
    - Reduces operator energetic handling
      - Increased operator safety, minimize risk
    - Small energetic quantity are being produced at one time
      - At most 5 lbs are within the TSE
      - At most 20 lbs for entire process (from TSE to granulation to collection)
    - Material introduced into the TSE gets the same amount of mixing
      - Increased product consistency
  - Environmental Friendly
    - Reduction of processing solvents
      - Elimination of Hexane
      - Acetone Recovered/ Reused



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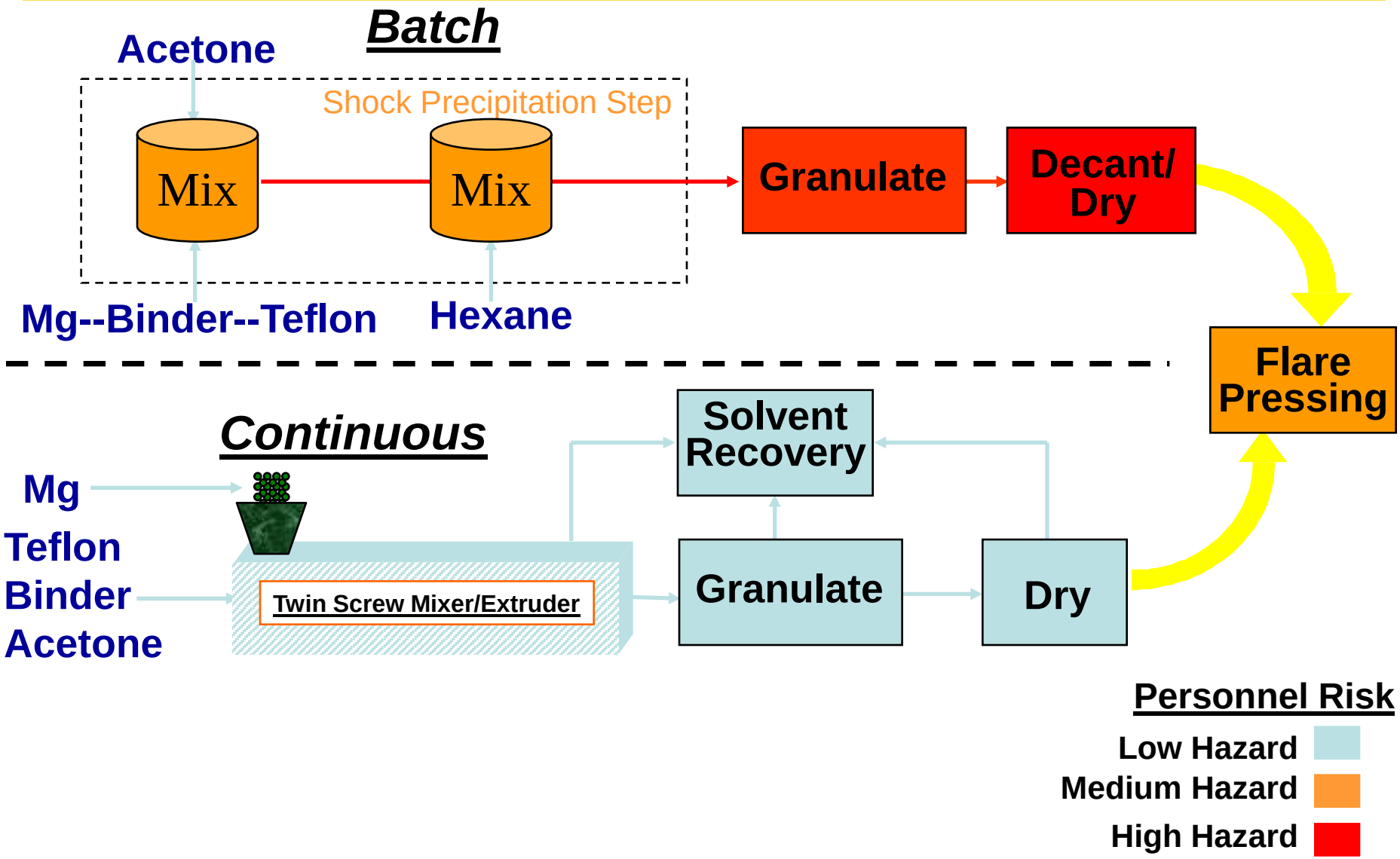
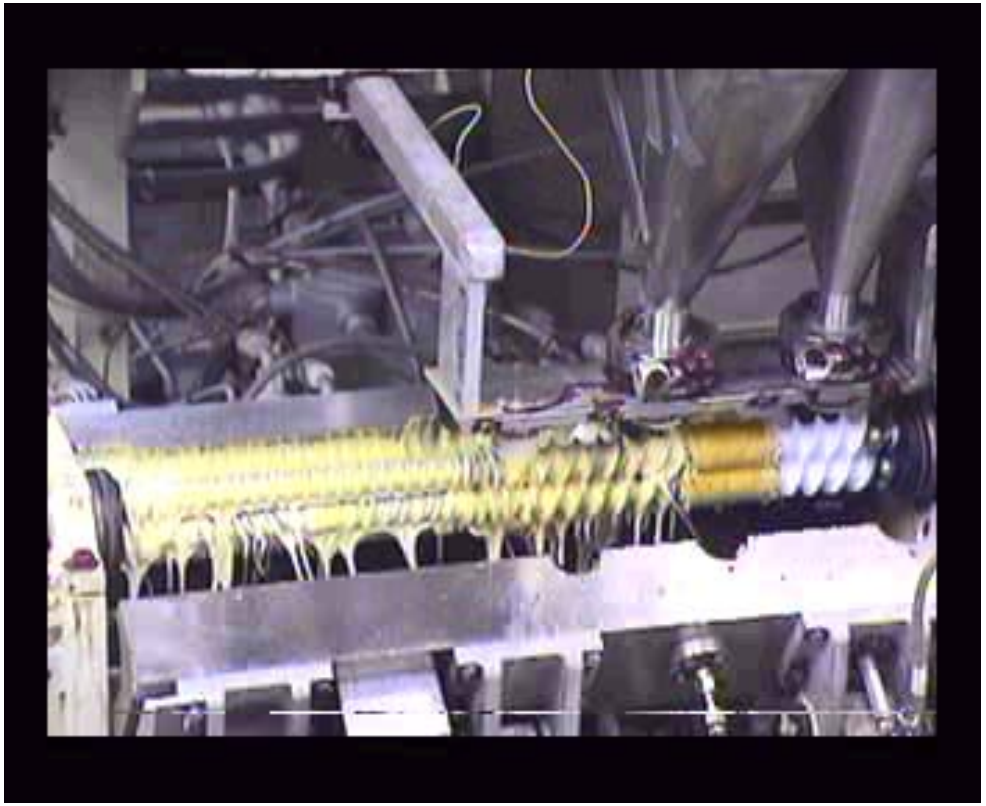

Batch
Acetone
Shock Precipitation Step
Mix
Mix
Granulate
Decant/ Dry
Mg--Binder--Teflon
Hexane
Flare Pressing
Continuous
Solvent Recovery
Mg
Teflon
Binder
Acetone
Twin Screw Mixer/Extruder
Granulate
Dry
Personnel Risk
Low Hazard
Medium Hazard
High Hazard

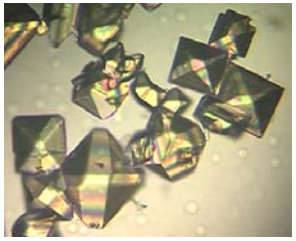
Background

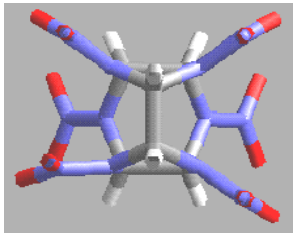


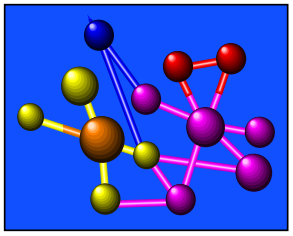
- 40-mm Baker Perkins Extruder
  - Clam Shell Design
  - Quick Open Design
  - Side Discharge
  - 10-50 lbs/hr throughput
  - Remote Operation
- Loss-In-Weight Feeders
  - Solids/ Liquid/ Viscous
- Solvent Recovery System
- In-Line Granulator
- In-Line Vibratory Dryer
- In-Line Particle Sifter
- High-Response Deluge System
- Material Handling
  - Product Conveyors
  - Product Collector
- Programmable Logic Control
  - Wonderware Interface

Program Summary

- Material Characterization / Rheological Studies
  - Inert Simulant Identified
    - Potassium sulfate (simulant for Magnesium)
  - TSE Feed Scenario
    - Teflon feed
      - Fibrous/ cohesive material, Difficulty in process control
    - Solution – Teflon/Hycar/Acetone Slurry
- Modeling/ Simulation
  - Establish initial screw configuration
  - Predict extrusion characteristics
    - Internal temperatures and pressures
    - Die pressure
    - Torque
  - Identifies critical processing regimes to avoid
  - Reduce development time
  - Enhance overall process safety

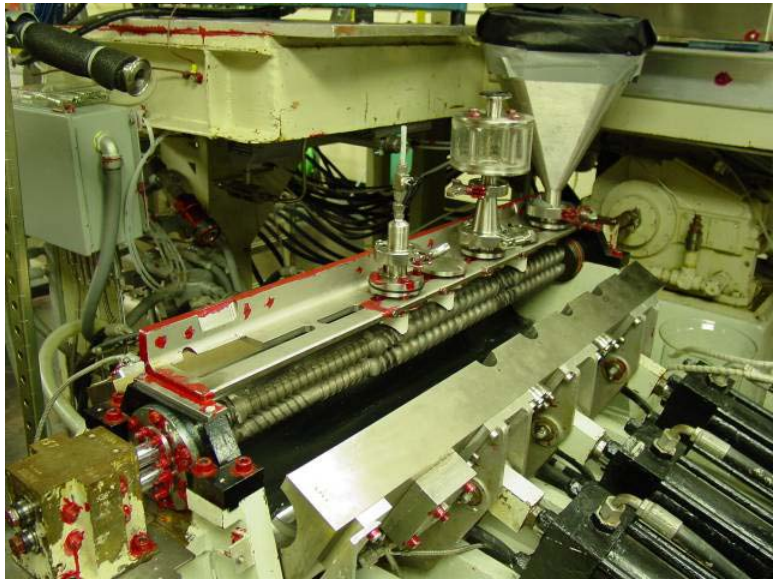






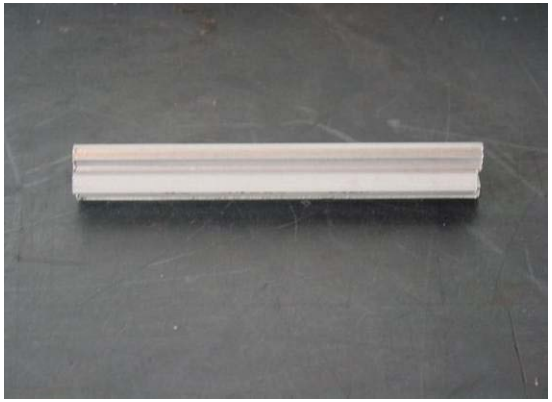
Program Summary

- Inert Processing
  - Define and optimize processing conditions
    - Feed streams
    - RPM Drive
    - Die/ Barrel Temperatures
    - Solvent Recovery/ Vacuum System
    - In-line granlation
  - Validate Model Predictions
    - Update screw configuration
- Transition to Live Processing
  - Live M206 IR Decoy Flare successfully produced
  - Conducted 4 live processing runs
  - Incident free, smooth transition
- Product finishing
  - Dry, press & finish by qualified manufacturer -Kilgore



Product Testing

- Static Testing
  - Initial Screening
    - Picatinny Pyrotechnic Research & Technology Division
      - » Comparative Testing TSE Method vs. Picatinny Pyro Batch
      - » 5 Flares Testes for Static Comparative Testing each method
      - » Results
      - » Met and exceeded Military specifications
      - » TSE consistent results, higher intensity levels, shorter rise times, longer burn times
      - » Results initially proved the viability of twin screw processing for M206
  - Product Analysis
    - Kilgore Pyrotechnic Manufacture
      - » Comparative Testing TSE Method vs. Kilgore Automated Batch Method
      - » Velocity Tests & Static Flare tests
    - Results meet mil-spec requirements



Product Testing

- Flight Testing
  - US Air Force China Lake, California, July 2004
    - » Side-by side comparison to of TSE manufactured with stock-piled flares, manufactured by Kilgore & Navy MJU-61/B flare
    - » High-speed film footage of dispensing flares

Summary

- Program Objectives Met
  - Developed safe continuous process for M206
  - Quantified product and the viability of the process through product testing
  - Developed a baseline process to the granulation step
    - In-line dryer determination needs to be confirmed
- Remaining Work
  - Awaiting full test report