Flexible Manufacturing of Nitrogen Gun Propellants

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Presentation Overview

- Program Objectives
- Update of Colayered Propellant process development effort.
  - Description of project
  - Review of ’04 Users Group status.
  - Process Development Update
  - Future Work
- 2nd formulation process development effort
  - Program Plan
  - Current Progress
  - Future Work

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Program Objectives

- Develop the technology for manufacturing Nitrogen-based gun propellants
  - Develop a continuous process for manufacturing colayered propellant scrolls
  - Develop a process for scaling new high-nitrogen propellant formulations from the lab to production

Propellant Formulations

Thermoplastic Elastomers

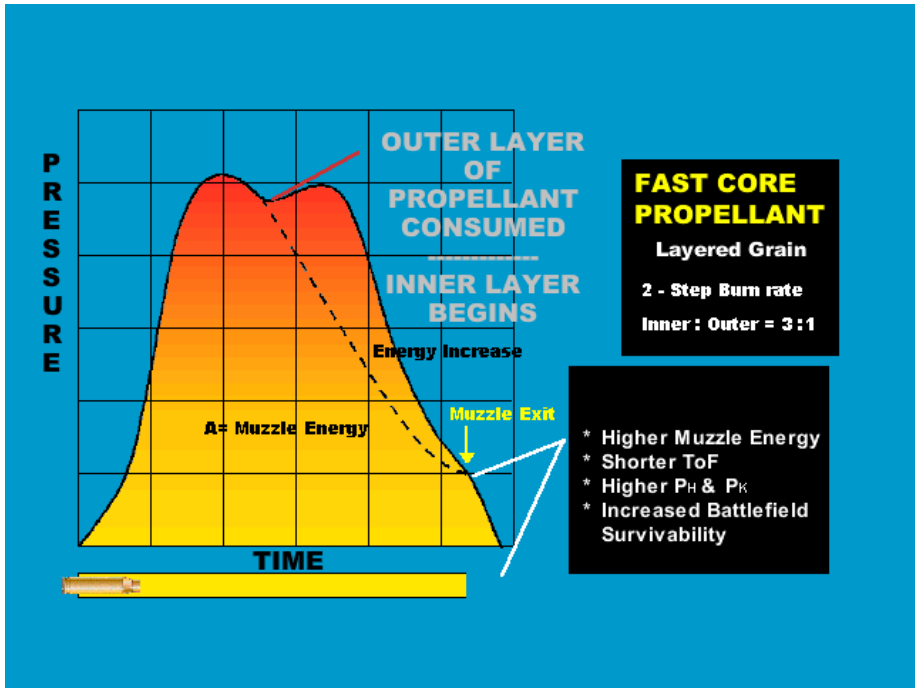
- Processing versatility
- Environmentally friendly
- Leverage previous work

High Nitrogen Materials

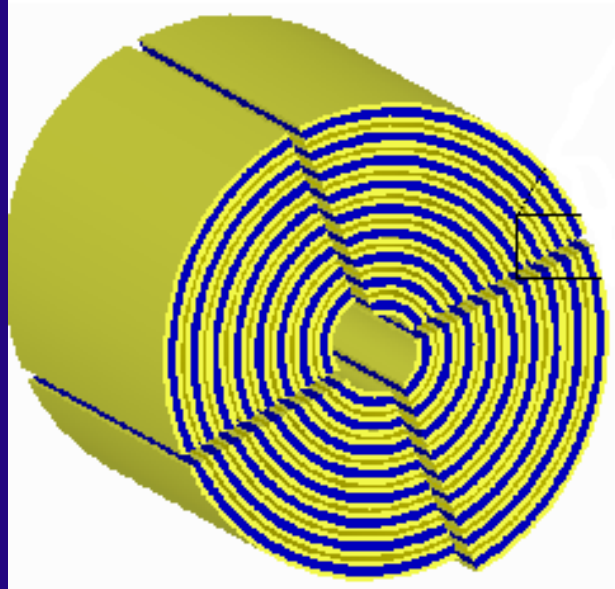
- High impetus
- Lower flame temperatures
- Reduced barrel erosivity
- Tailorable burning rates

Colayered Gun Propellant Objective

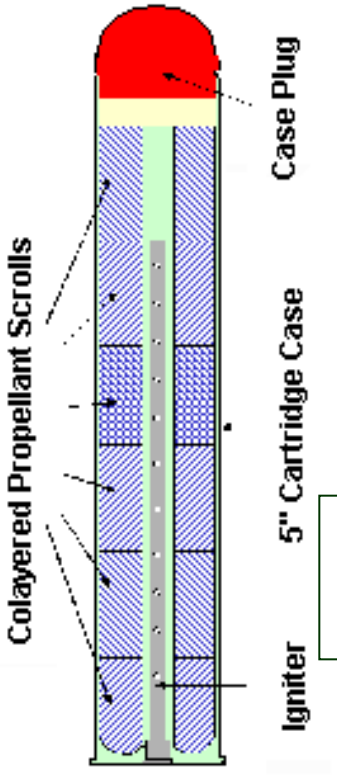
- Develop and demonstrate a continuous process to manufacture co-layered propellant using two twin-screw extruders
  - High energy density charges
  - Controlled pressurization
  - Continuous processing using TSEs

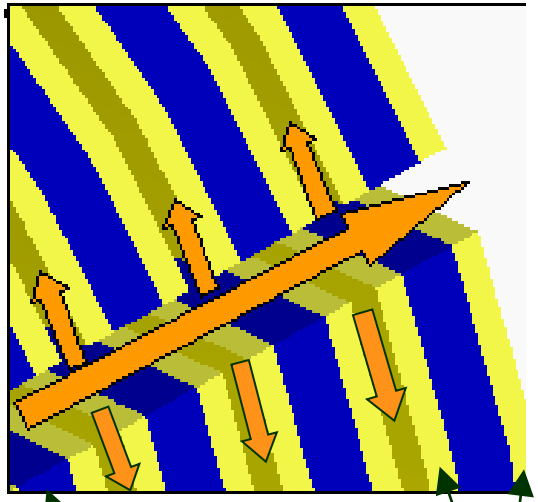


Colayered Gun Propellant Concept



Colayered Propellant Scroll



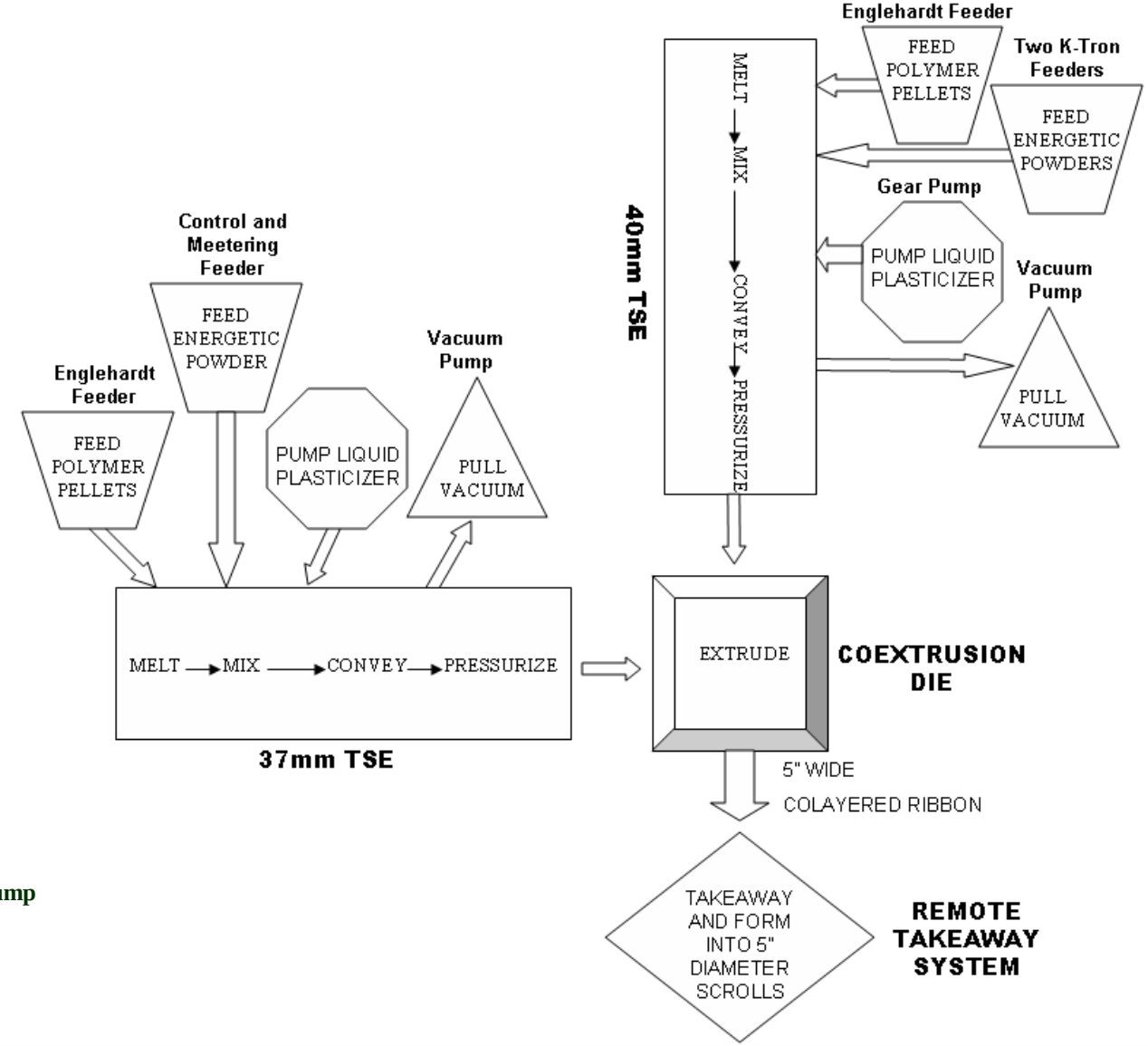


Flame Propagation

Fast Burning Core Layer

Slow Burning Outer Layers

Coextrusion Process



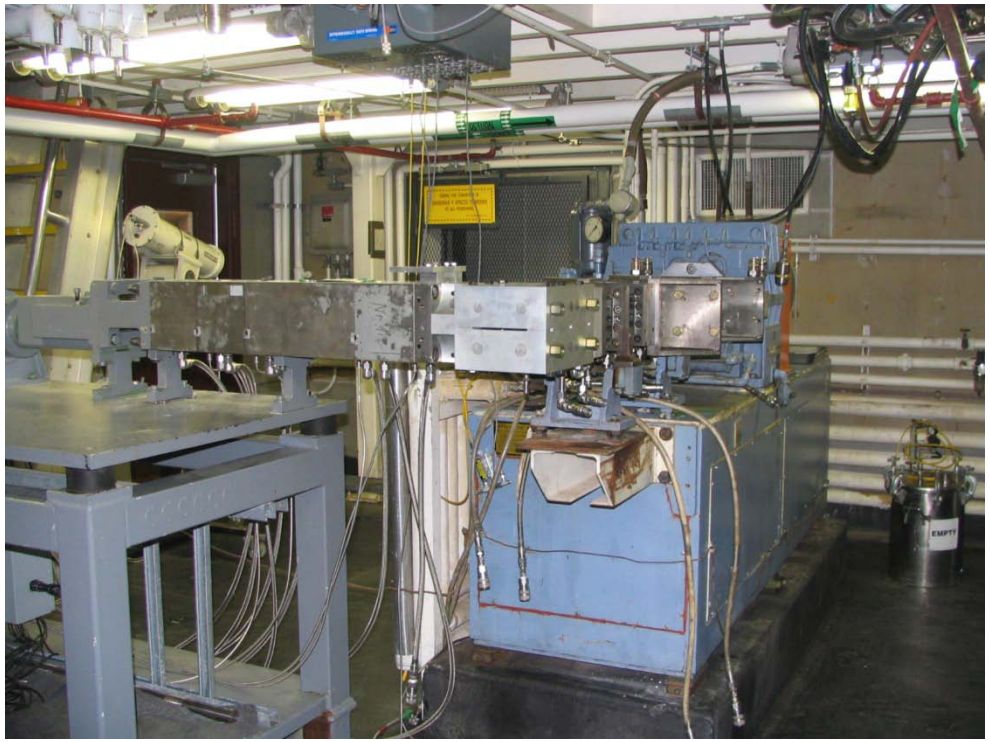
Gear Pump

Colayered Status at ’04 Users Group

- Takeaway System design 75% complete
- Fabrication of coextrusion die 90% complete
- Processed both live formulations using 40mm TSE
  - Chose final formulation
- Developed inert simulant on 40mm TSE
- 1st inert decomposition (40mm TSE) investigation was ongoing.

Tooling Update

- Received coextrusion die
- Installed Takeaway System
- Integrated 37mm & 40mm TSE control systems



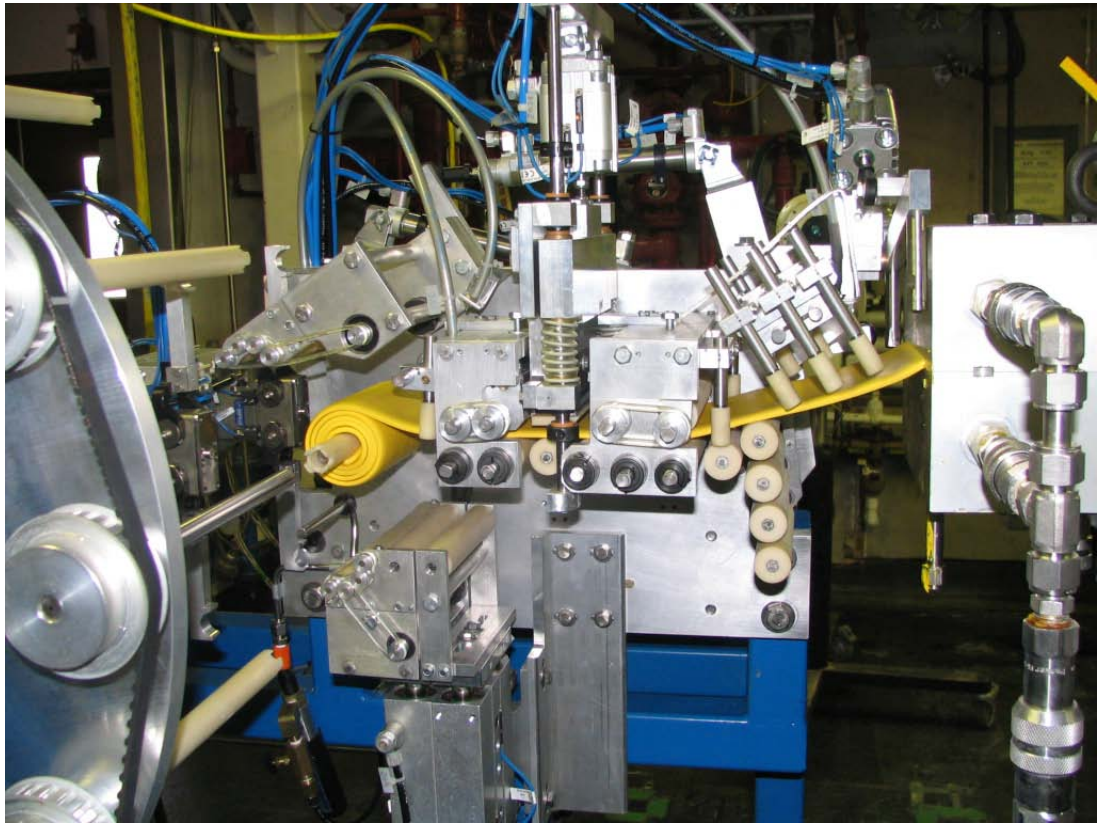
Processing Update

- Commissioned 37mm TSE for live operations with MK-99 LOVA run
  - Burn Rate testing
- Processed Colayered simulant using 37mm TSE
- Performed several Colayered simulant runs using 40mm TSE, ‘blocked-off’ coextrusion die, and Takeaway System
- Attempted one coextrusion run with Colayered simulant

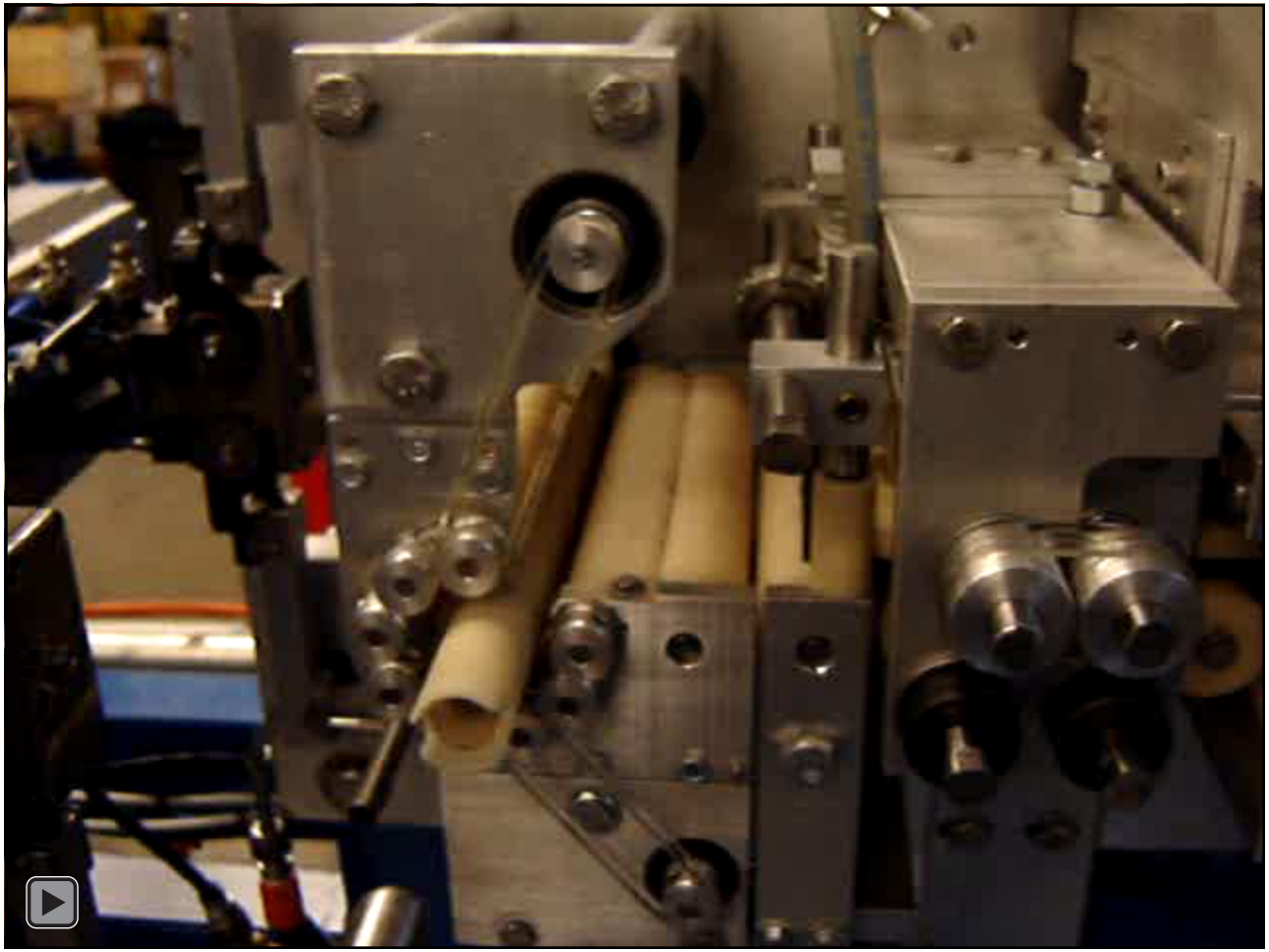
Coextrusion Die

Takeaway System

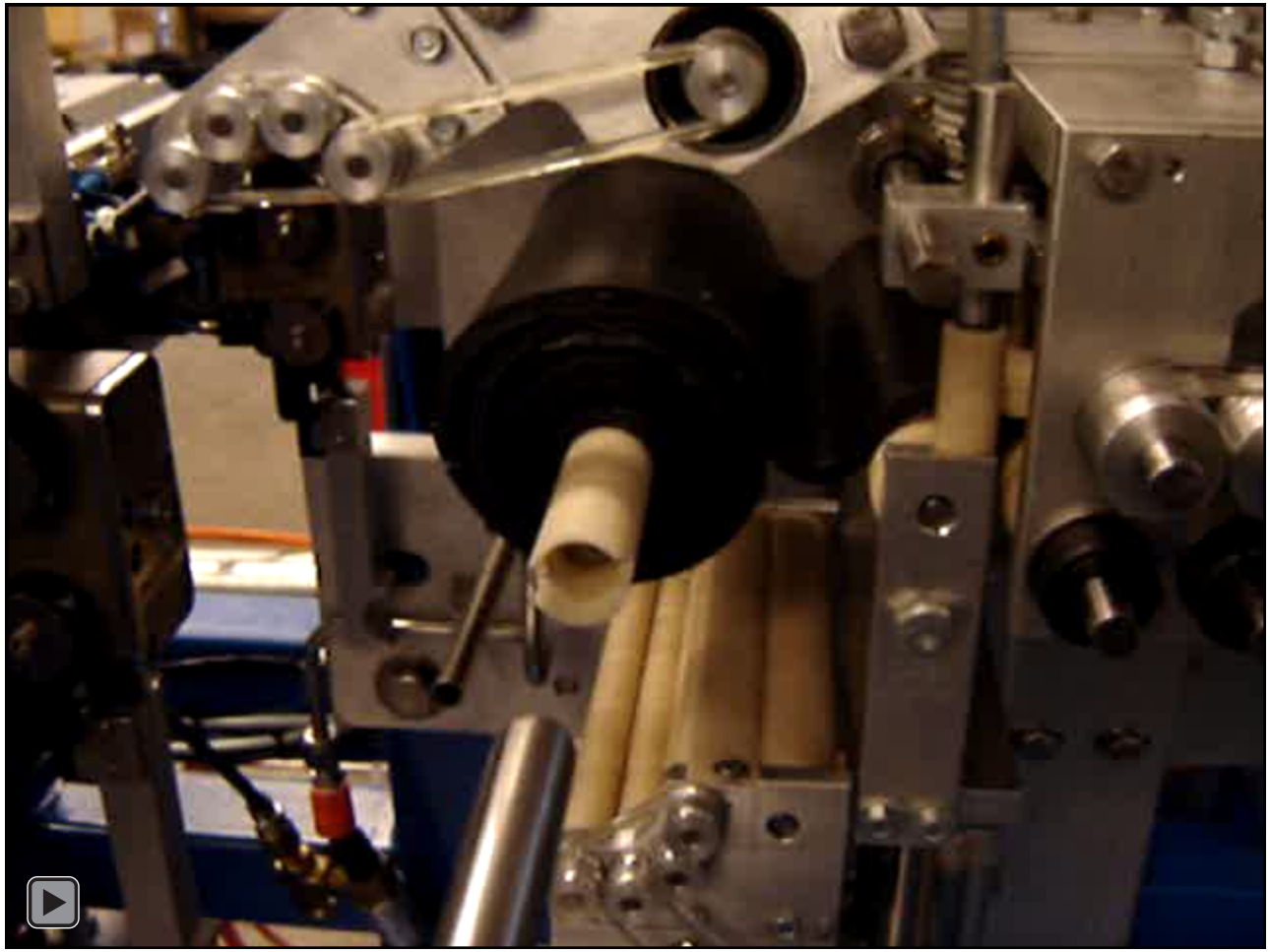
- Designed and fabricated by Windham Automated Machines
- Requirements:
  - Completely remote process
  - Meet Class I hazardous location requirements
  - Portable
  - Maintain dimensional accuracy/minimize surface defects
  - Create up to 12 scrolls
  - Maintain path for air between scroll layers



Scroll Threading



Scroll Exchange



Future Colayered Work

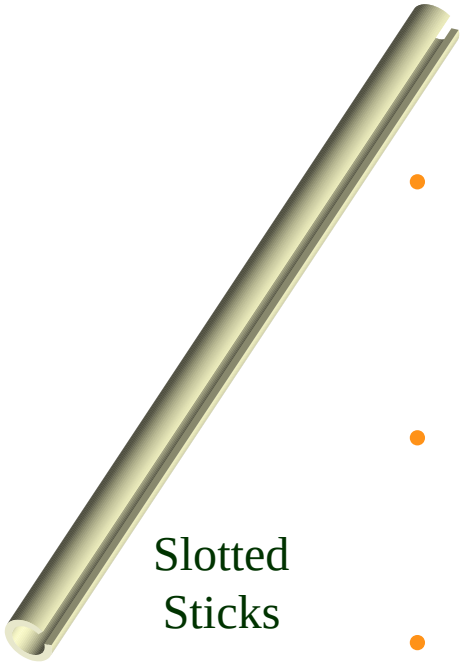
- Incorporate thermal decomposition recommendations
- Gain coextrusion processing experience
  - 2 TSE processes
  - Multiple operators
- Run live slow colayered using 37mm TSE
- Live Colayered Propellant coextrusion processing
- Gun fire colayered scrolls

2nd Flex Man Formulation

Objectives

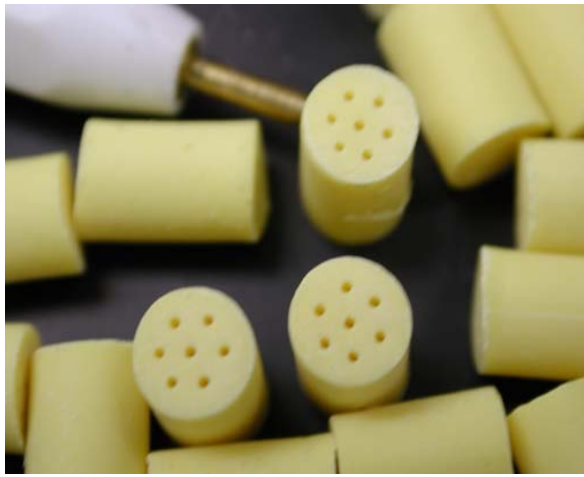
- Evaluate multiple polymers, plasticizers, and high nitrogen compounds
- Manufacture one formulation into two configurations
- Scale process from 20mm to 88mm TSE

2nd Formulation: Current Status



Slotted Sticks

- Selected final formulation
  - Nit amine, high Nitrogen material, TPE binder system
- Selected configurations
  - Grains, Slotted Sticks
- Completed installation of Torque Rheometer



Grains

2nd Formulation Selection

- Evaluated two binders, two plasticizers, and three high nitrogen compounds
- Performed 144 Thermo-Chemical Analysis Calculations
- Performed Interior Ballistic Analyses
- Performed DSC compatibility testing
- Completed 8 mix matrix plus repeat of slow and fast burning propellants
- Performed ballistic computational screening analysis for 5”/54 and 5”/62
- Performed closed bomb testing
- Reviewed Burn Rate data

Torque Rheometer Installation

- Small Scale Compounder (~60 cm^3 of Material)
- Monitor Torque vs. Time
- Binder Melt
- Solids Incorporation
- Monitor Torque vs. Rotor Speed

Future Work – Near Term

- Rheological testing
  - Capillary dies on 2” extrusion press
  - Torque Rheometer
- Propellant runs on 20mm TSE
  - Manufacture samples for testing
- Address scale-up issues: 20mm → 40mm → 88mm
  - Minimize use of expensive ingredients during ramp-up and ramp-down
  - Ensure that consistent work/energy input is going into the propellant at each extruder

Future Work – Long Term

- Design and fabrication of dies for 40mm TSE
- Modification of existing 40mm TSE collection equipment
- Manufacture samples on 40mm TSE – test burn rate
- Scale 40mm TSE process to 88mm TSE
- Design and fabricate 88mm TSE die
- Modify existing 88mm TSE grain pelletizing system
- Manufacture production quantity of Nitrogen Based Gun Propellant for gun testing