2001 Continuous Mixer and
Extruder User's Group
Picatinny Arsenal

Continuous Processing of Green Energetic Material (GEM) Rocket Propellant
Lessons Learned

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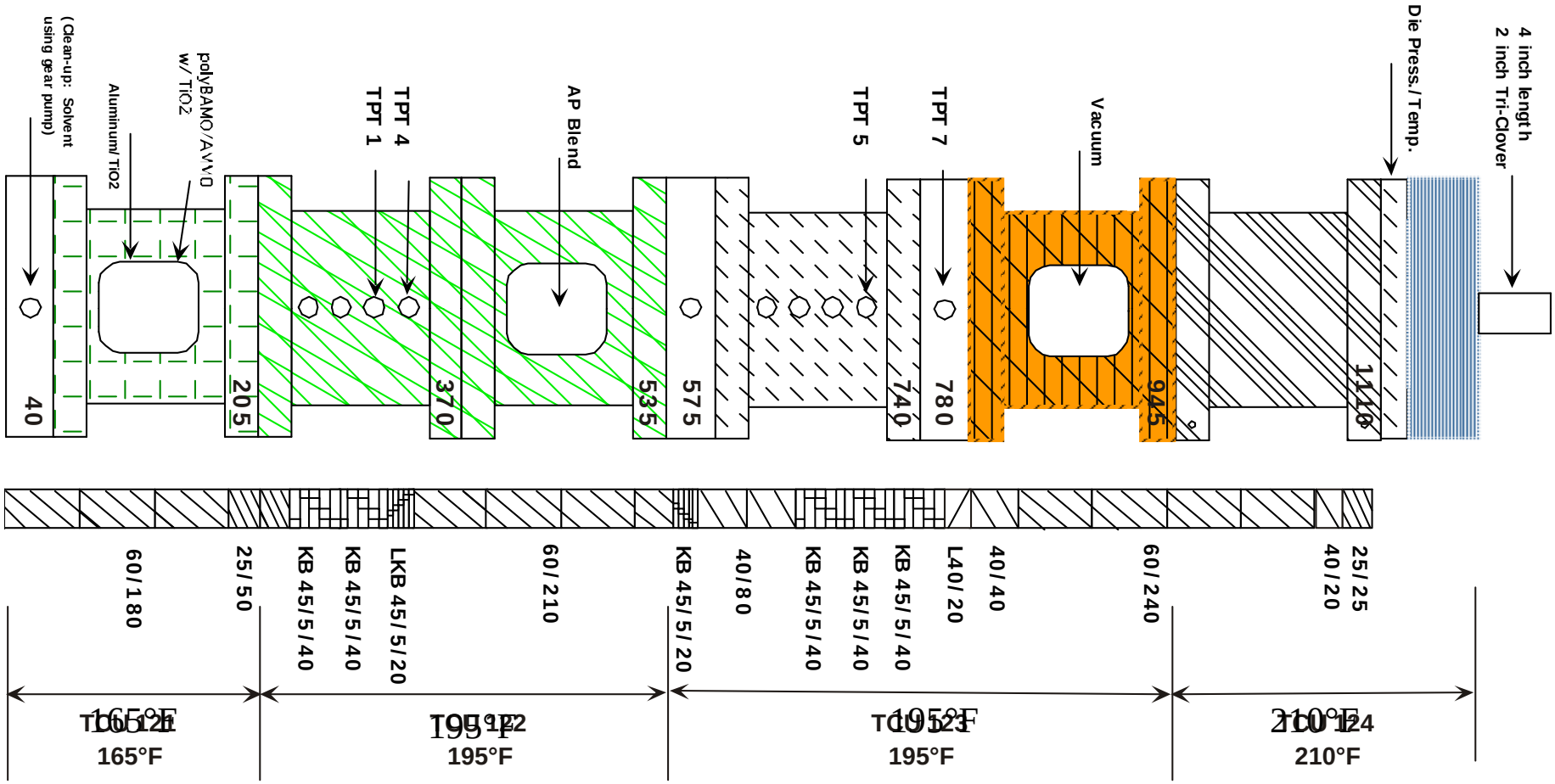
Program Objective

- Develop TPE based rocket propellant which:
  - meets the requirements of the ERGM system
    - Burn rate slope $\leq$ .57
    - Burn rate @ 8000 psi = 2.2 in/sec
  - reduces life cycle cost
  - supports R^3 - recover/recycle/reuse
- Develop and demonstrate a continuous manufacturing process using a twin screw extruder
- Design and build a continuous rocket motor molding system
  - Mr. Richard Muscato will present "Continuous On-Line Molding of TPE Rocket Propellant"

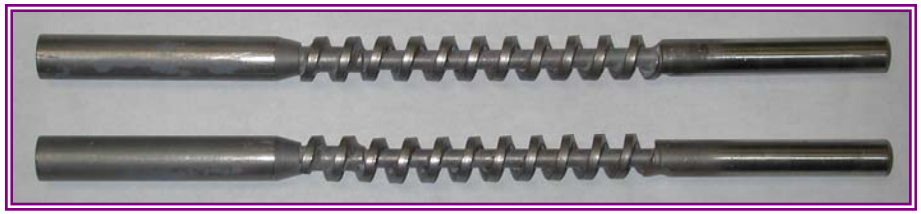
Barrel & Screw Design



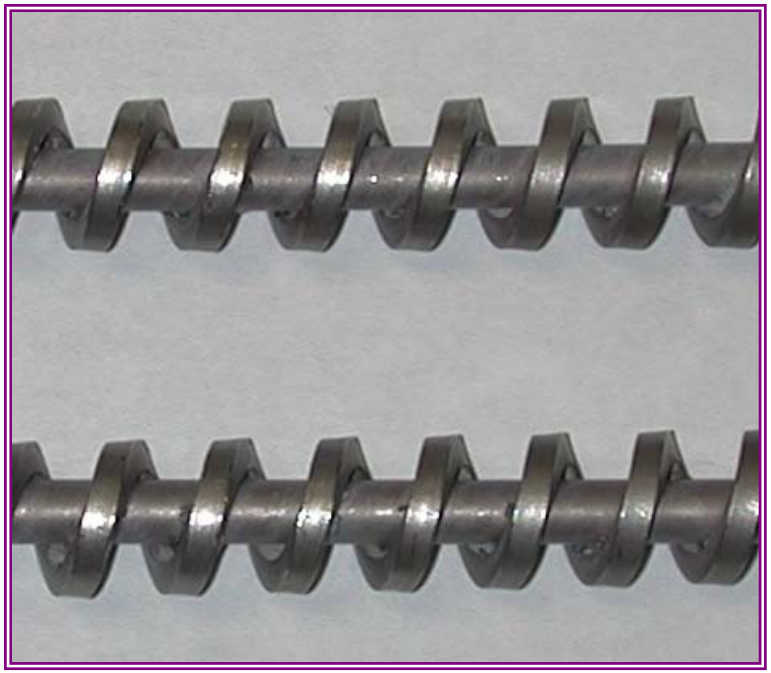
Lessons Learned

Aluminum Foiling

- Problem: Aluminum foiling on screw tips and barrel wall
- Approach: Investigated...
  - Raw material/screening process
  - Feeder screws
  - Feed barrel temperature
  - Feed location



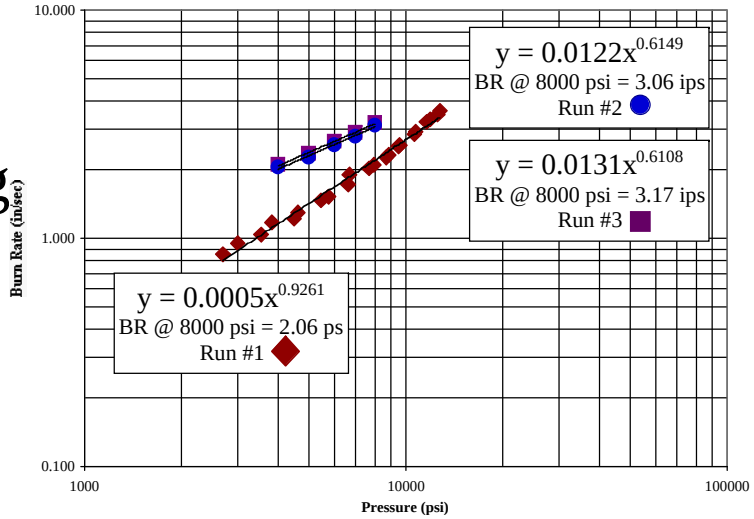
- Conclusion: Feeder was foiling the aluminum
- Solution:
  - Changed to spiral screws
  - Used a finer mesh screen
  - Directed feedstream to "down turning" screw
  - Increase barrel temperature



Lessons Learned

Burning Rate Slope

- Problem: High burn rate slope of TSE processed material
  - First live TSE run gave high burning rate slope: 0.926 (BR = 2.1 ips @ 8K psi)
    - Batch baseline burning rate slope: 0.540 (BR = 3.7 ips @ 8K psi)
- Approach: Investigated...
  - moisture contamination of binder feedstream
  - ingredients/preblends preparation
  - TSE Process
- Conclusion: Poor storage and handling of TiO_2 caused agglomeration
- Solution:
  - Store TiO_2 in desicator
  - Vacuum dry prior to using



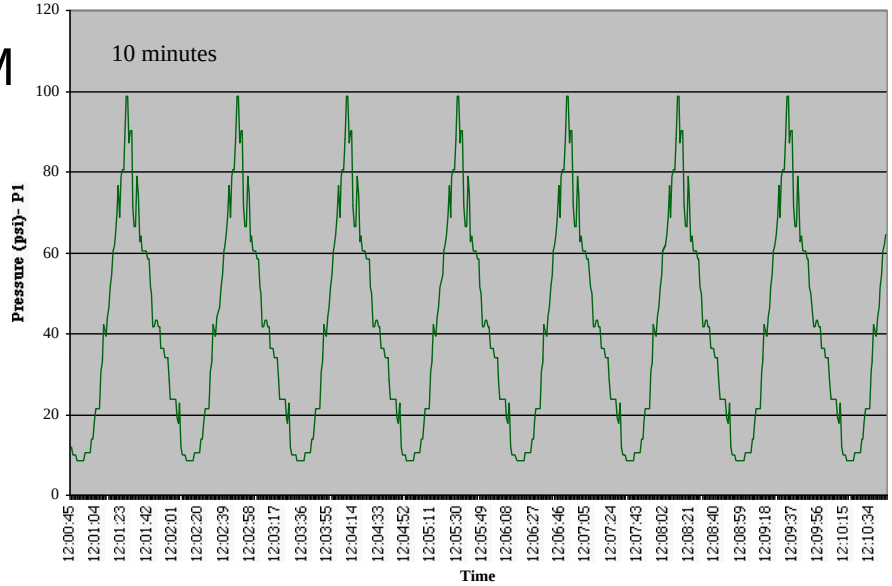
Lessons Learned

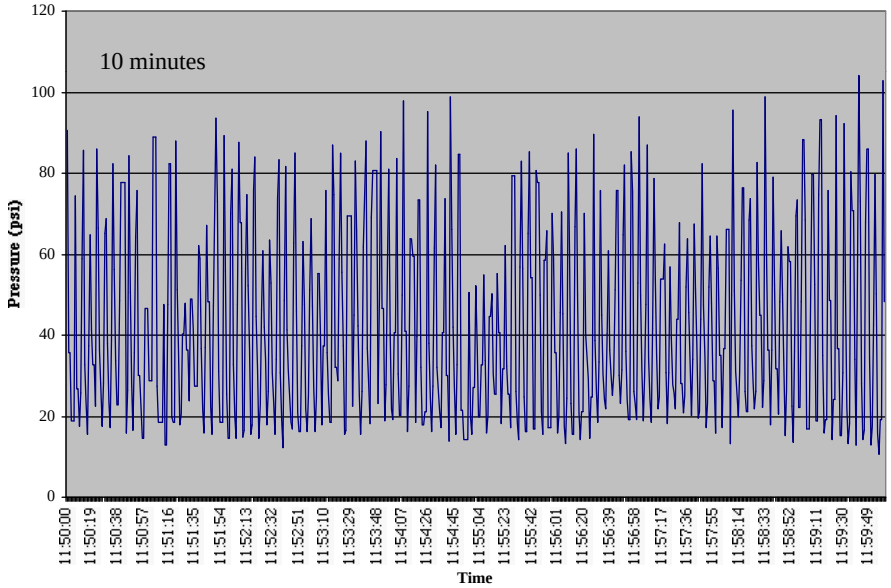
Pressure Response in Binder Mixing Zone

Effect of screw speed

@ 25 lb/hr

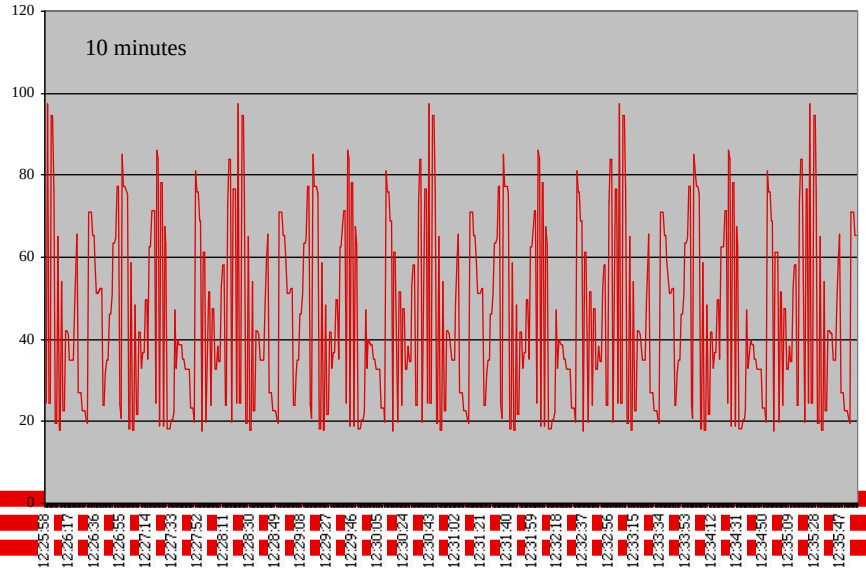
40 RPM





45 RPM

60 RPM



Lessons Learned

Binder Lot Variation

- Two lots of poly BAMO/AMMO were used
  - Molecular Weight:
    - Lot 1 = 91,240
    - Lot 2 = 124,920
  - Material processed differently
    - Material preparation was more difficult
    - Die pressure increased by 65%
    - Torque increased by 14%
- Process was sensitive to changes in the binder
  - Was not an issue in this process
    - Well within the limits of the TSE
  - Could be a issue for scale up

Accomplishments

- Developed optimized process on 40-mm TSE that was
  - Safe
  - Repeatable: run-to-run
  - Stable: throughout a run
- Solved aluminum foiling problem
- Solved high burning rate slope issue
- Transitioned process to Thiokol
- Successfully fired three high pressure motors at Thiokol
  - Material made in IHD's TSE
  - 8000 psi
- Molding system delivered this week