2001 Continuous Mixer and
Extruder User's Group
Picatinny Arsenal

2.75" MK 90 Propellant Grain Advanced Processing Demonstration

Project Overview and Inert Processing

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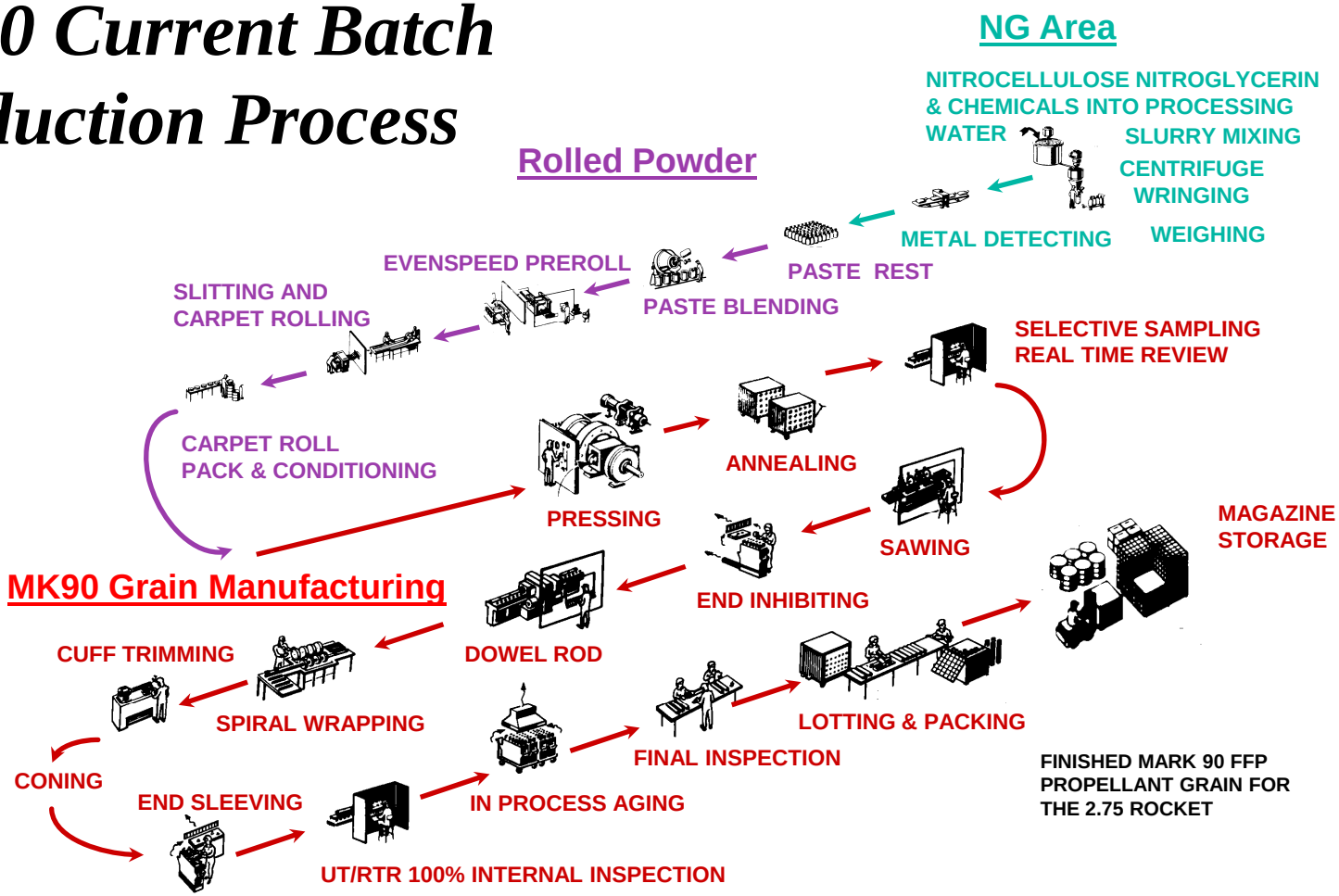
2 May 2001

Program Overview

- Demonstrate advanced 2.75" rocket motor grain manufacturing process using a shear roll mill and twin screw extruder
  - Reducing cost, waste streams and VOC emissions
- The players and their responsibilities
  - Indian Head Division, NSWC: TSE process;transition process to ATK
  - Alliant TechSystems: shear roll mill process; environmental & cost analysis
  - ARDEC: SRPM process model; independent environmental & cost analysis
- Multiple funding sources
  - ESTCP office
  - * Army 2.75" PM office
  - Army Mantech
  - ATK IR&D
- Lost financial support from Army 2.75" PM office
  - FY01: $1M and FY02: $1M
  - Significantly reduced scope of project

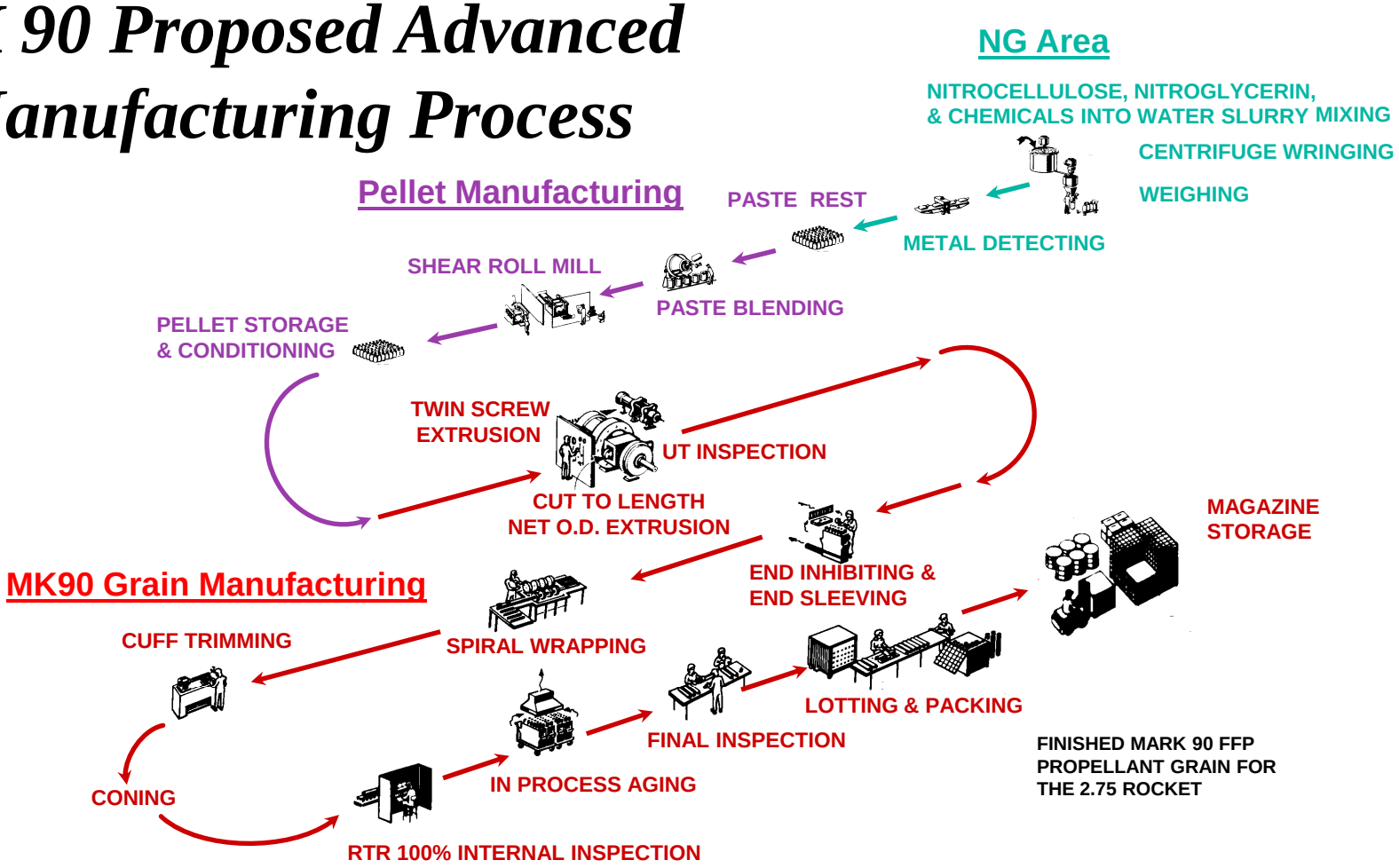
Process Description

MK 90 Current Batch Production Process



Process Description

MK 90 Proposed Advanced Manufacturing Process



Introduction

- Continuous processing of double base propellants is common in Europe but new to us
- We are focussed on safety
  - Two experts currently under contract
    - Dr. Dietmar Mueller; ICT (Karlsrhue, Germany)
    - Mr. Hays Zeigler; ATK (Radford)
- Must satisfy Process Review Board
- Key actions
  - Hazard Analysis
  - Facility and equipment modifications
  - Inert Processing

Inert Processing

- Objective: Develop safe operating parameters and screw/barrel design before attempting live operations
- Operating parameters evaluated
  - Barrel and die temperature
  - Screw speed
  - Throughput
  - Screw and barrel design
    - Conveying, kneading, and left-handed kneading elements; L/D ratio
  - Screw fill using Q star
  - Startup/Feed method
    - Flood vs. starve
- Working with two simulants (parallel effort)
  - ATK Sim #5
  - CAB-D

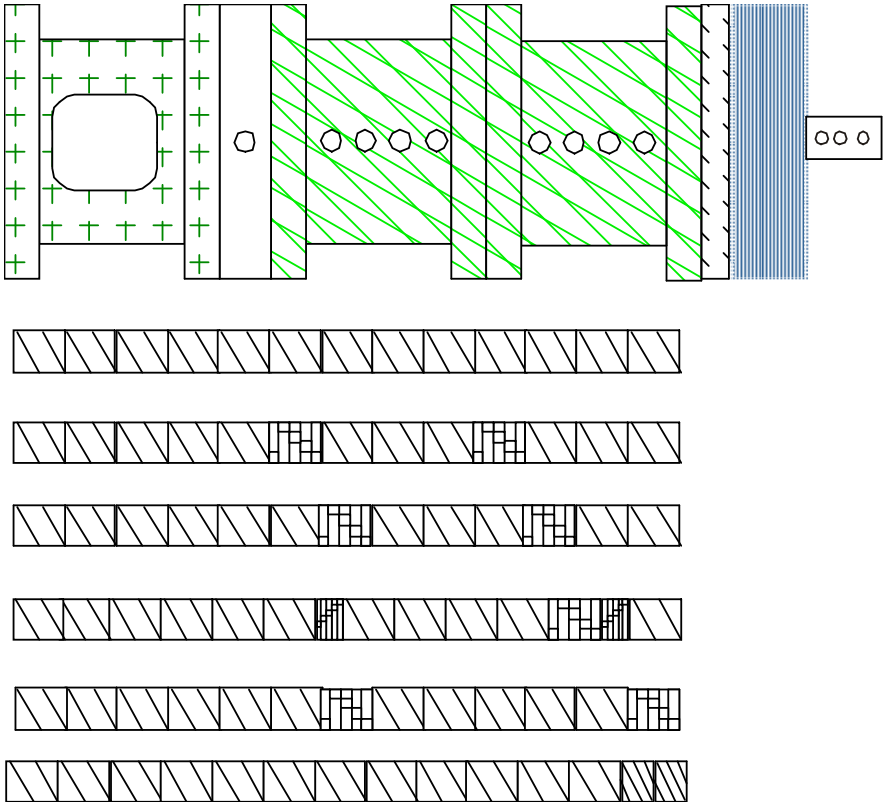
Inert Processing

- Worked with two processing methodologies
  - Low RPM and flood fed screws
  - **"High" RPM and starve fed screws**
- Conducted seven inert runs (w/ H. Zeigler and D. Mueller)
  - Using both inert formulations
- Evaluated flow through die
  - A number of incidents have started in the die
- Developed start-up an shut down techniques
- Finalized screw design
- Finalized operating parameters

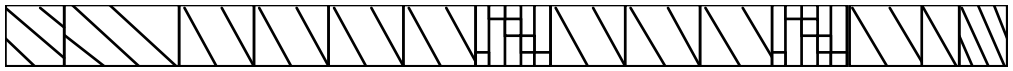
Inert Processing

- Measured responses
  - Product density, maximum temperature rise, pressure response along screw, die pressure, torque, screw speed accuracy under load
- Seven screw designs evaluated using…
  - Right-handed conveying
  - Right-handed kneading
  - Left-handed kneading

  … screw elements



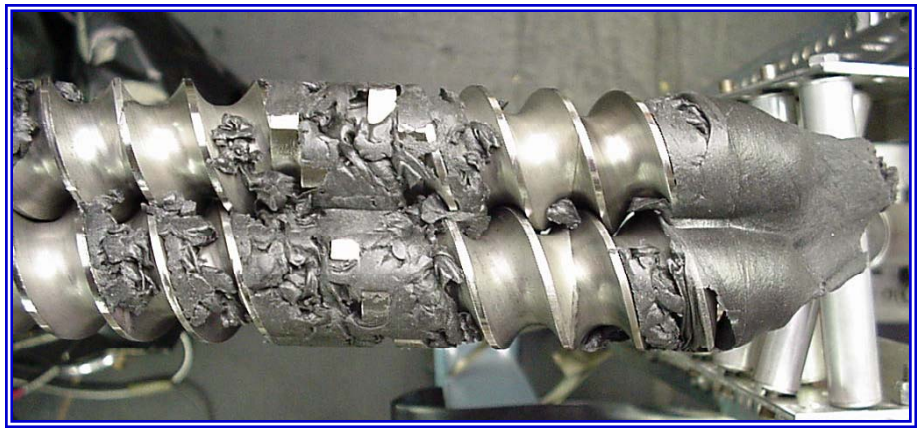
And the final screw design is -



Inert Processing

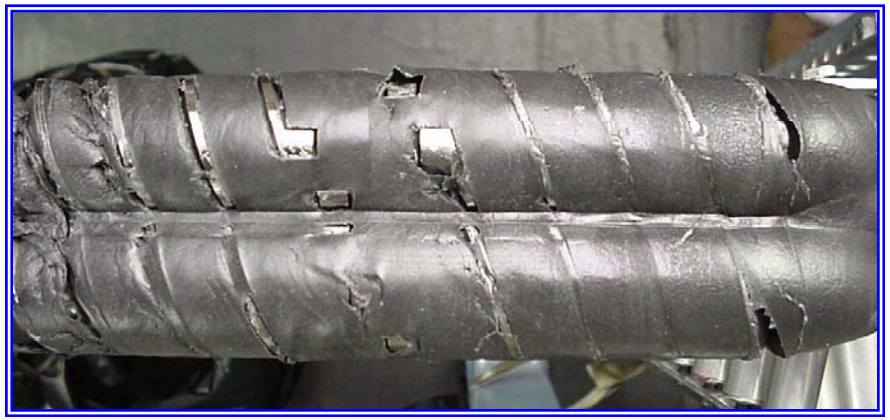
Screw Fill

- Q Star - an indicator of screw fill is a dimensionless number that correlates throughput and screw speed, accounting for material density and machine diameter.



Q Star = .0761

Starve Fed

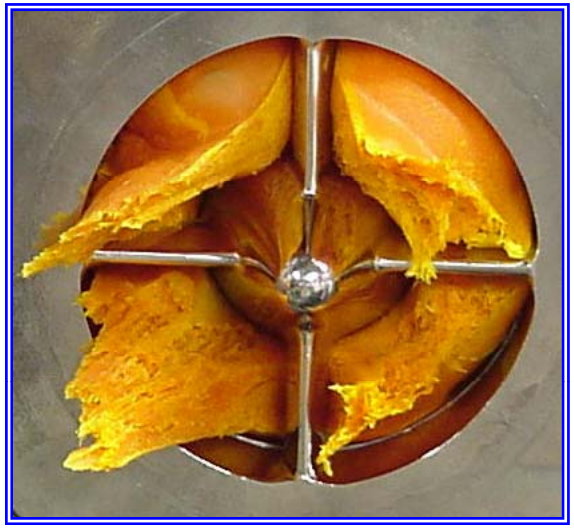


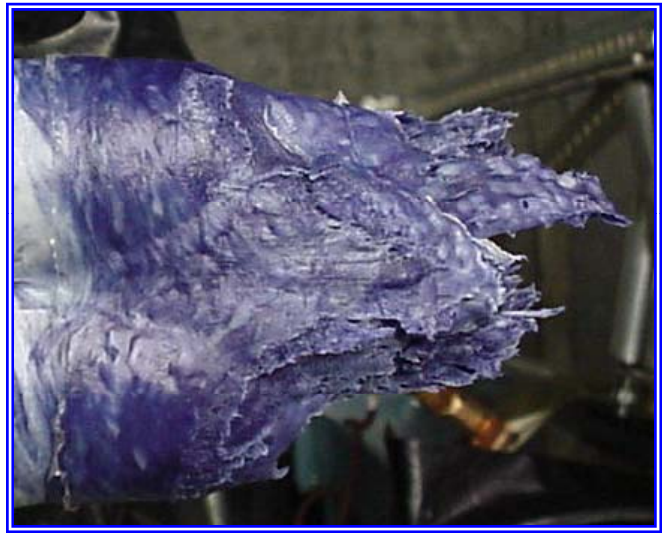
Q Star = .1826

Flood Fed

Inert Processing

Die Flow





Inert Processing

Lessons Learned

- Operate at Q Star between .063 - .077
- Conduct first live run at 10 lb/hr and 15 RPM
- Use right-handed kneading elements - two places
- Do not use left-handed kneading elements
- Use barrel with 13 L/D ratio
- Use existing 2.75” die for initial live work
- Barrel and die temp of 160°F
- Motor RPM is under control

Future Work

- Complete installation and checkout of new equipment
- Conduct 1 final inert run
  - Verify screw design
  - Color trace material flow using new 8-to-round transition piece
  - Verify start up and shut down procedures
  - Measure die swell using laser micrometer
- Implement new screw alignment procedures
- Complete compression calculations
- Obtain Process Review Board approval
- Run live in June