Highly Filled Small Particle PBX Processing Using TSE Technology

Richard S. Muscato

NSWC/IHD

13th Joint Ordnance Commanders Group

Continuous Mixer and Extruder Users Group

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Outline

- Objectives
- Background
- HTCE Processing
- Test Results
- Safety Lesson Learned
- Conclusions

Objectives

- Sponsor: Mr. Don Porada/NOSA, IMAD
- Program Manager: Ms. Lori Nock/NSWC, IHD

- Develop/Formulate a high performance and insensitive explosive containing fine particle HMX.

- Evaluate the use of a degradable binder that permits reclamation and reuse of HMX

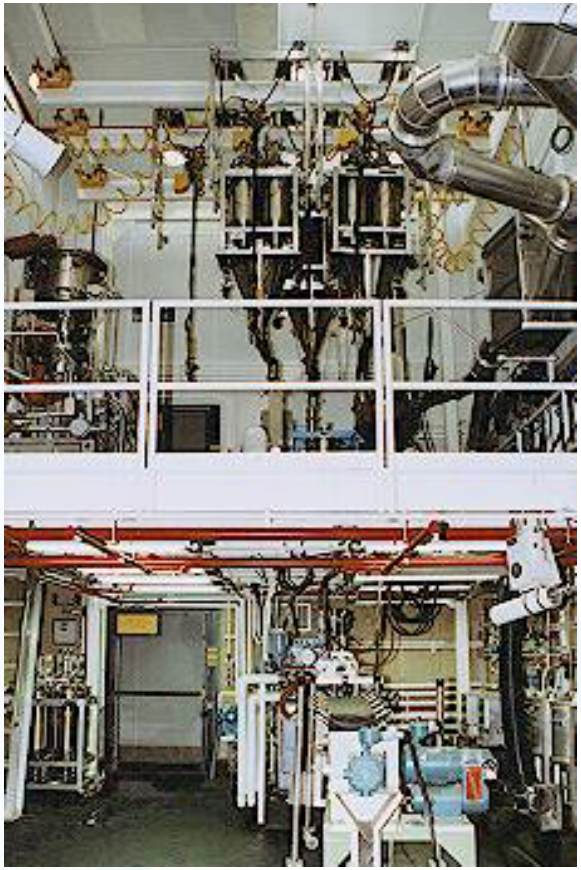
- Develop processing techniques to increase HMX solids loading (monomodal) to greater than that of PBXW-128
  - Sensitivity target of PBXW-128 (77% monomodal)
  - Performance target of PBXN-110 (88% bimodal)

Background

- 1998 Deformable PBXW 128 work used a HTPB binder with IPDI curative
- 2003 JANNAF PDCS Presentation, Charlottesville, VA
  - Titled “Small Particle Plastic Bonded Explosives Formulations and Processing Using a Twin Screw Mixer/Extruder”
  - Batch mixing limited in solids loading (monomodal)
- 2004 JANNAF PDCS Presentation, Seattle, WA
  - Titled “Small Particle PBX Processing Using Twin Screw Extruder Technology”
- Emphasis to increase performance while maintaining/improving sensitivity AND use an environmentally friendly binder

IHD 40mm TSE Capabilities

- W&P ZSK-40 twin-screw mixer/extruder
- Process development facility
  - Class 1.1 – 500 lbs
  - Class 1.3 – 1000 lbs
- Processing rates
  - 10 - 30 lb/hr (gun propellant)
  - 25 - 50 lb/hr (extruded propellant)
  - 25 - 100 lb/hr (cast composite propellant/PBX explosives)
- Seven solid feeders (four feedstreams simultaneously)
- Five liquid pumps
- Limited automatic refill
- Product handling systems
- Extensive instrumentation/diagnostics



W&P 40-mm extruder
Building 1119

HTCE Ingredients/Function

Existing PBXW 128 (.45 plasticizer/binder system ratio)

Modified Formulation rev 0 (.48 ratio)

rev 1 (.70 ratio)

PBXW 128	Function	Mod 128	Function
HMX	Nitramine	HMX	Nitramine
R45	Binder	Capa 7201A	Binder
		Capa 4101	Binder
IDP	Plasticizer	DOA	Plasticizer
IPDI	Curative	IPDI	Curative
Ethanox 702	Antioxidant	Ethanox 702	Antioxidant
TPB	Catalyst	TPB	Catalyst
Lecithin	Surfactant		

Based on a NCO/OH of 1.05(0.85/0.15) as recommended by Dr. Bob Gill

Processing Progress

Conducted multiple live 40 mm TSE processing trials

Obj: Process formulation at 83% HMX solids fill through a .902 " die and collect samples for testing; Safety Testing, DSC, X-Ray, Density, SEM, VCCT, IHE, and Aquarium Testing

Results: Collected 14 lbs of 83% HMX filled samples for testing

Cured material for four days at 140 º F.

HTCE Feedstream Scenarios

Preblend Ingredients and Feeders

Binder- fed using the Zenith Gear Pump

DOA

Capa 7201A needs to be above 95 F(melting pt)

Capa 4101

TPB

Ethyl 702

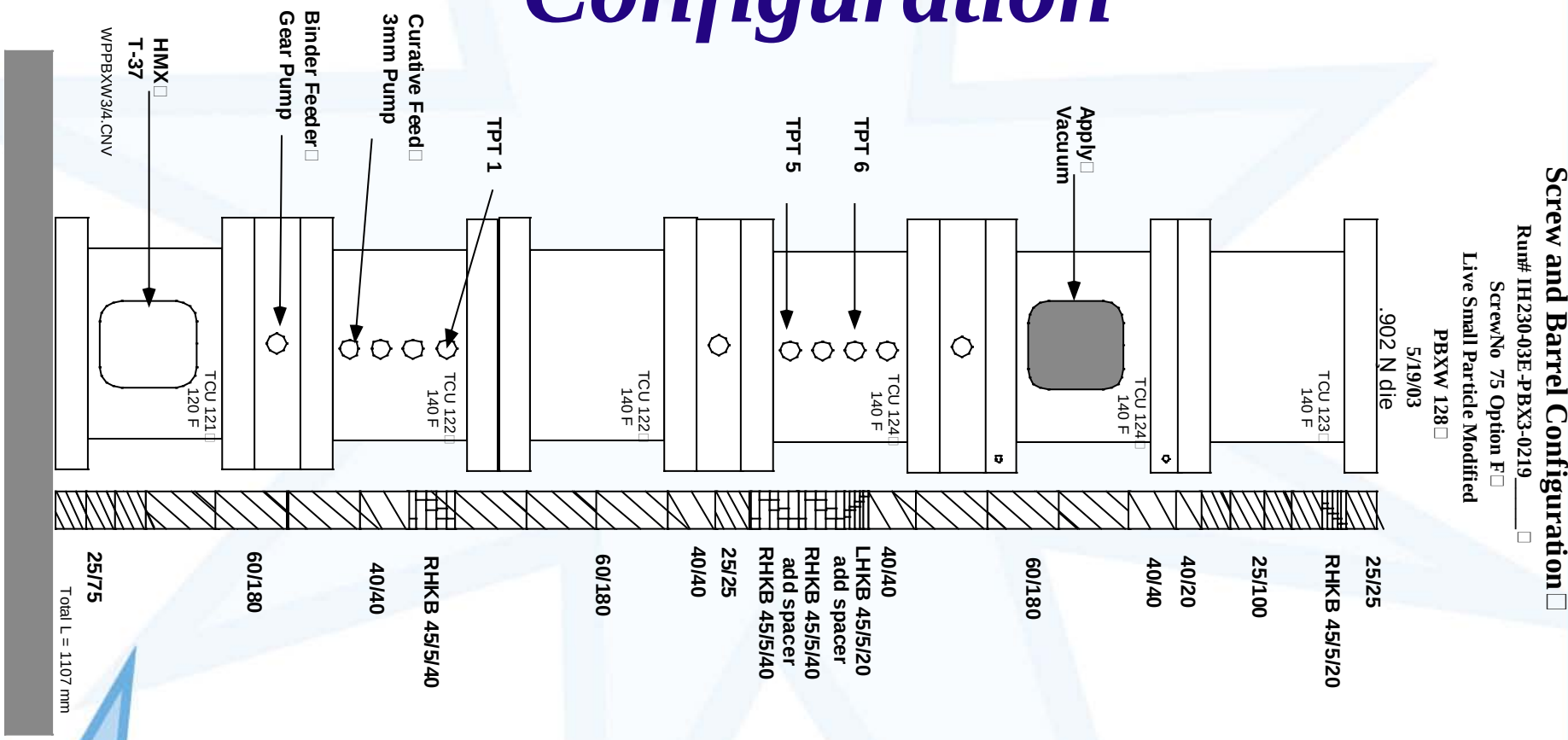
Curative- fed using the 3mm Triple Piston Pump

DOA

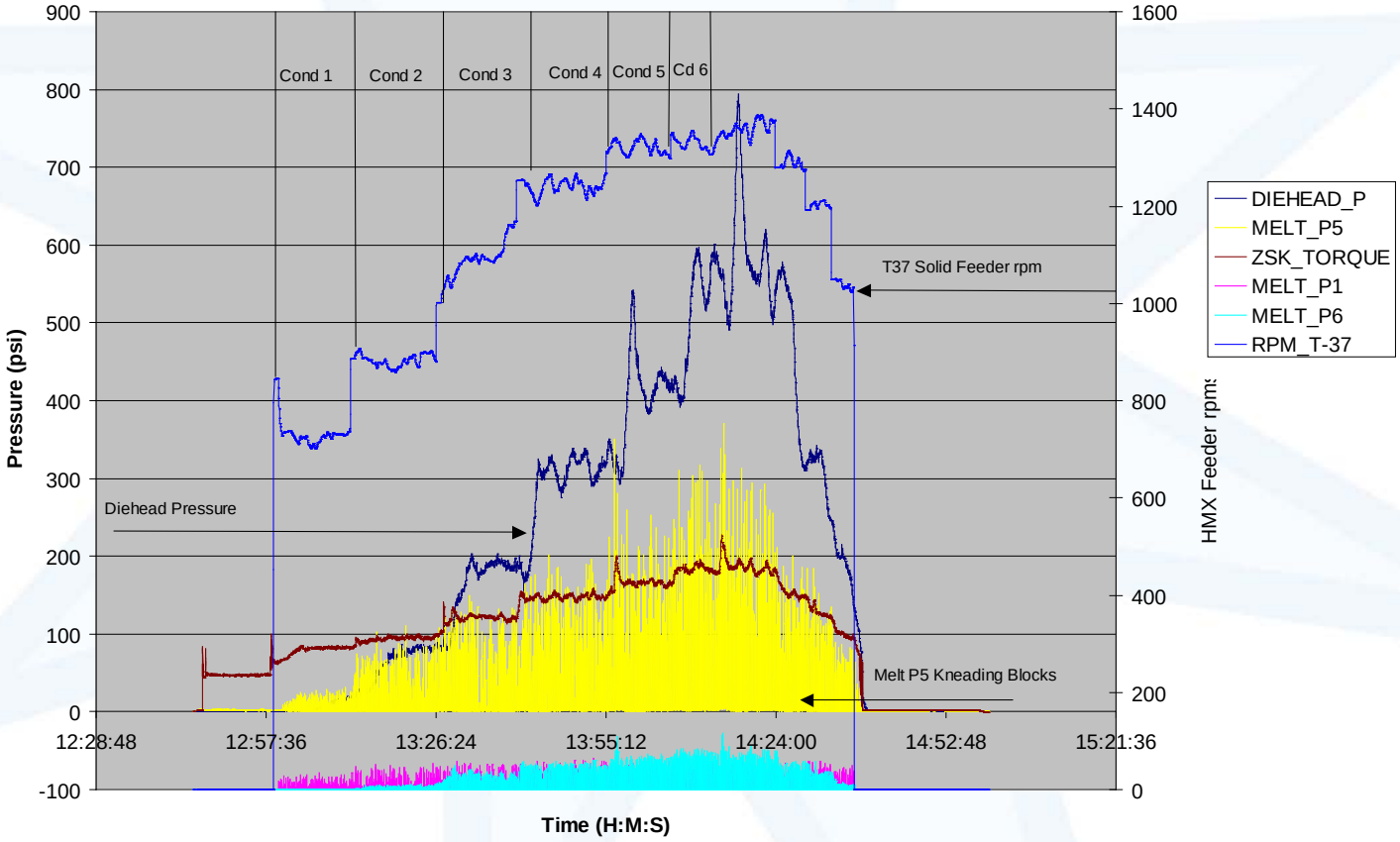
IPDI

HMX- fed using the Ktron T37 twin screw feeder

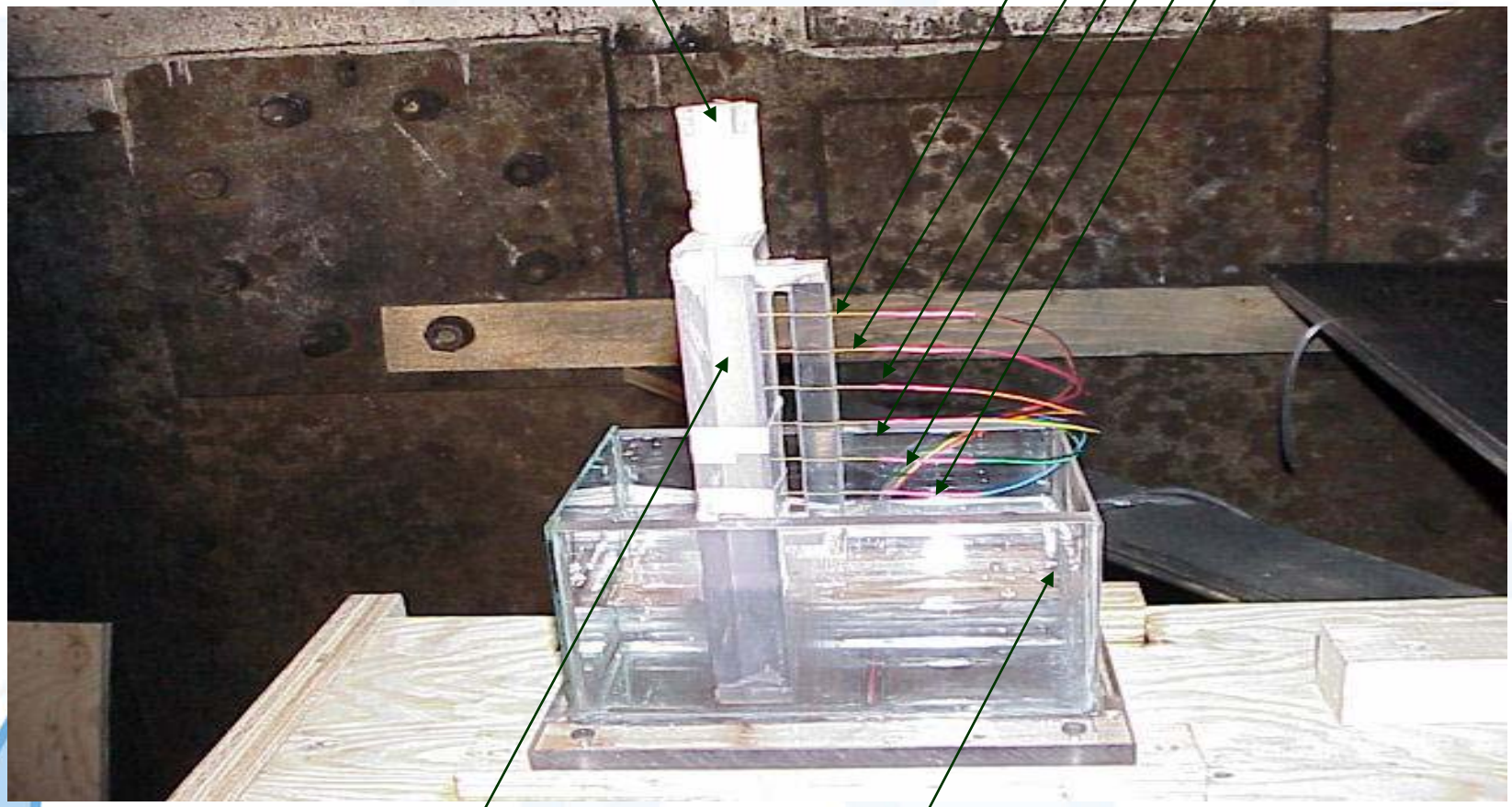
40mm TSE Barrel and Screw Configuration



Material Pressure Traces/ Solid Feed rpms



IHD Aquarium Test Setup

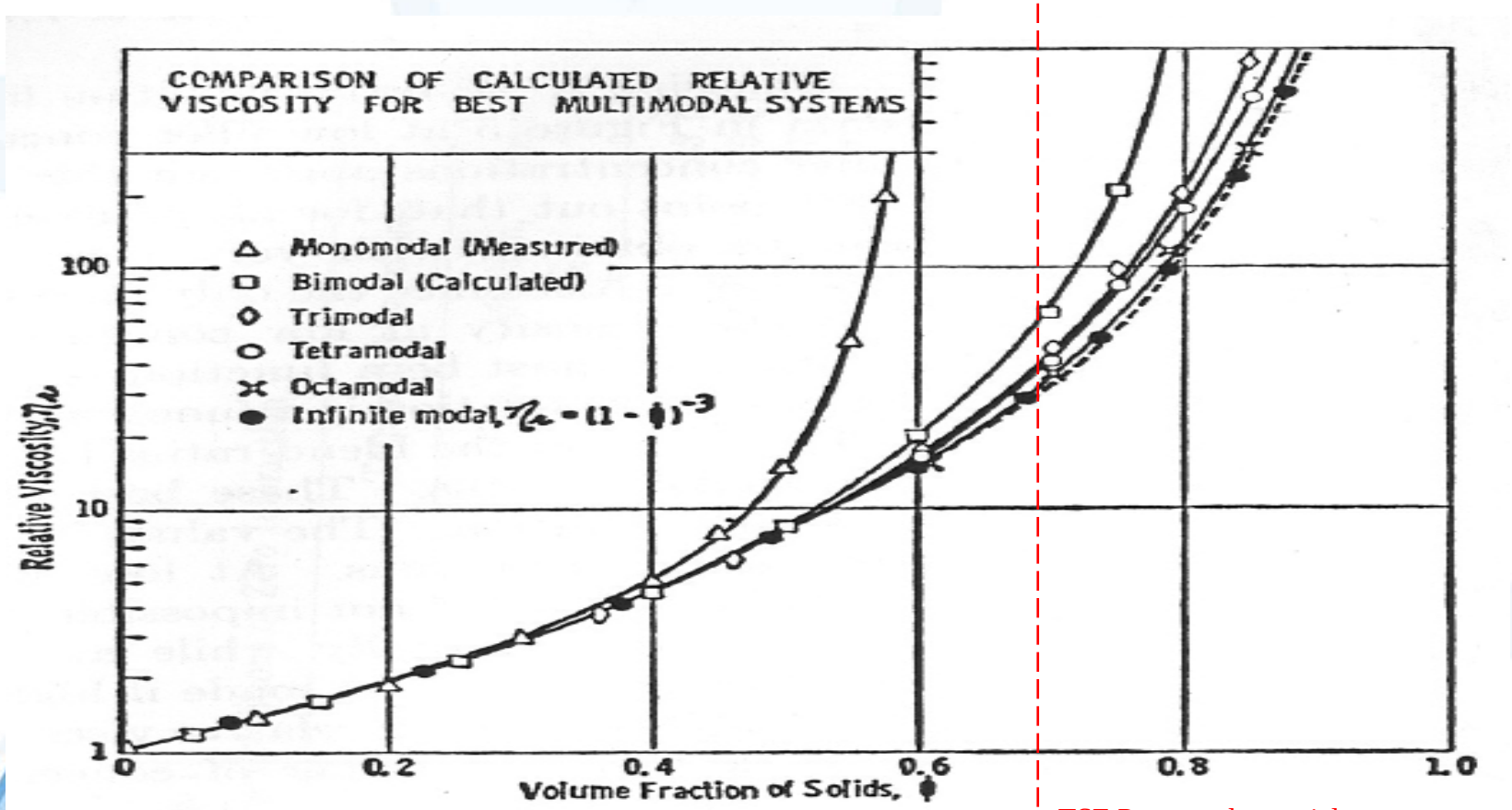


Test Results

- IH230-03G-PBX5-0230 Trial Results at 83% HMX (>.6XX volume fraction)
  - **Shore A** ~ 58
  - **Safety Testing**
    - NOS Impact 395 mm (M)
    - ABL Friction >980 psig (L)
    - ABL ESD 0.853 joules (M)
  - **DSC** 260 ºC onset of exotherm
  - **X-rays** Acceptable: No foreign material
  - **Density** > 99 % TMD
  - **SEM** Qualitatively good mixing of HMX with binder
  - **IHE** Good Shock Sensitivity. In line with PBXW-128 and PBXN-110
  - **VCCT** Poor Cookoff Sensitivity with HTCE binder
  - **Aquarium** Slight increase in detonation pressure and detonation velocity.

    In line with PBXW-128 and PBXN-110

Volume Fraction Comparison



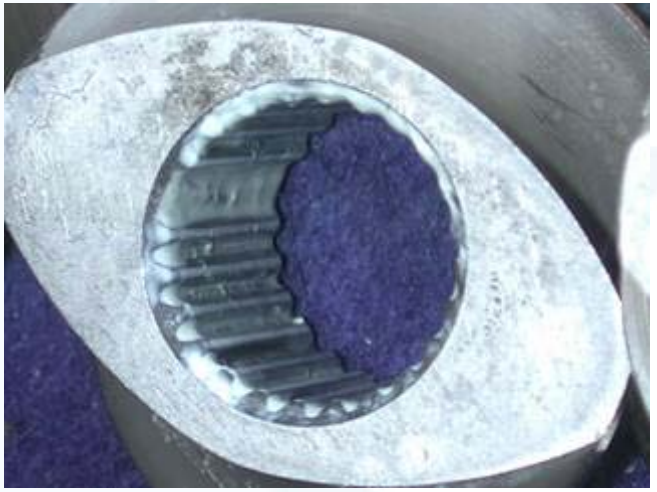
TSE Processed material at
> .6XX Volume Fraction

Per R. J. Farris, Prediction of the Viscosity of Multimodal Suspensions from Unimodal Viscosity Data, 1968

Material Seepage

Available Space for Material to Seep

Material Seepage



Safety Lesson Learned
Material Seepage

- Issue: Material seepage was observed along ONE screw shaft during post inspection

- Conclusions: Seepage caused by improperly torqued screw elements due to two interrelated factors:
  1. Insufficient screw element overhang past shaft (too short of a screw)
  2. Oversize stud shoulder that prevented screw elements from being torqued
- Recommendations:
  - Establish minimum screw length of 1108 mm in combination with established maximum screw length
  - Share analysis and corrective actions with TSE users

Conclusions

- Successfully and safely processed a modified PBXW-128 formulation with an HTCE Binder on a 40mm TSE
- Used TSE technology to load solids higher than previously accepted limits
- Enhanced explosive data base for sensitivity and performance
- Learned and implemented increased TSE safety procedures