Explosives Coating via Advanced Cluster Energetics (ACE™) Fluid Energy Mill (FEM) Technology

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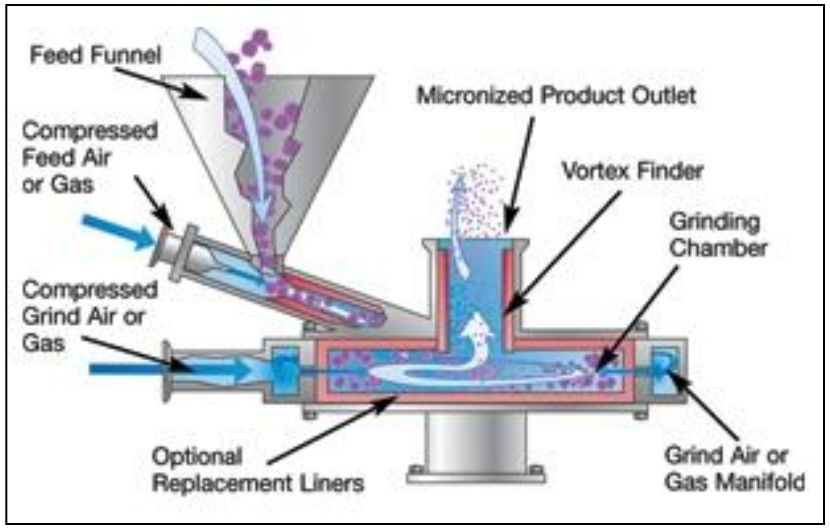
Background

- Advanced Cluster Energetics (ACE^{TM}) process developed jointly by New Jersey Institute of Technology (NJIT), Polymer Processing Institute (PPI) and RDECOM-ARDEC
- FEM technology utilizes compressed air to grind particles to less than 10 microns in size
- The ACE-FEM technology has potential to eliminate traditional coating processes
- Coated particles are subjected to particle to particle impact during the mill process where the coating is then re-distributed in-situ to the newly ground product
- Demand for smaller particle size materials to meet IM requirements is increasing

The ACE-FEM Process

- Pre-coated material added to mill system
- Feed air/grind air set to pre-determined position
- Feed rate adjusted for each material
- Product collected
- Analysis of product

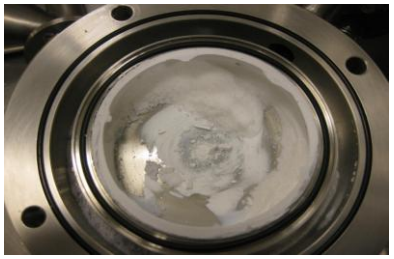


RDX / DOA Milling

- 220 lbs of RDX Class 1 coated with Dioctyl Adipate (DOA)
  - Standard HSAAP slurry coating technique
  - Target 5% DOA coating across the product
  - UV activated dye added to DOA to give visual representation of coating

RDX / DOA Milling

- 11 Trial Runs conducted on coated RDX
  - Target: 4.0 micron FEM specification
  - Particle Size measurement using Malvern Mastersizer 2000
  - No milled product meet target specification
  - Material build-up in the mill chamber



		Particle Size Distribution			
		d0.1	d0.5	d0.9	
Feed Pressure (psi)	***Grind Pressure (psi)***	***10th***	***50th***	***90th***	***% DOA***
Med	Med				4.66
High	Med	1.911	5.956	16.654	4.95
High	High	2.027	6.869	21.139	4.92
High	High	2.709	8.702	25.632	4.88
Med	Low	2.045	6.231	17.193	4.83
High	High	2.345	7.268	20.769	4.74
Med	Low	2.398	5.73	14.11	4.69
Med	Low	2.859	7.59	18.931	4.64
Med	Low	2.693	7.408	18.143	4.8
Med	Low	3.052	8.346	20.079	4.71
Med	Low	2.814	8.935	27.274	5.03

Compressor Equipment

- Inadequate particle size reduction during RDX milling trials
- Ingersoll-Rand compressor investigated
  - Mechanical failure of the compressor
  - Air pressure drop during reservoir filling cycles
  - No consistent air feed from the compressor
- HSAAP Compressor Upgrade
  - Hitachi Model DSP-22AT6I-125 Oil Free Dry Screw Compressor
    - 114 CFM @ 125 psig
    - 240 Gallon epoxy lined reservoir tank
    - Airtek Model TWB200-EB Blower Purge Desiccant Dryer

RDX Feasibility Trials

- Risk mitigation effort
  - Grind RDX Class 1 (uncoated) to determine if 4.0 micron specification can be achieved
  - 50% of trials met spec.
  - 4 non-conformances
    - Missed by less than 2 microns on 90th
  - Feasibility trials produced material that fits spec requirements for:
    - RDX FEM 2.8 micron
    - RDX FEM 4.0 micron

	Malvern Analysis		
Batch #	10th	50th	90th
1099-1205-1	1.393	2.483	4.581
1099-1205-2	1.28	2.532	12.004
1099-1205-13	1.949	3.678	7.074
1099-1205-4	1.745	2.906	4.909
1099-1205-5	1.407	2.596	5.107
1099-1205-14	1.425	2.628	5.261
1099-1205-7	2.106	3.62	6.164
1099-1205-10	3.002	5.827	10.66

RDX/DOA Test Grind

- Coated RDX test grind was conducted to determine particle size reduction with the new air handling equipment
- RDX/DOA maintained higher 90th than RDX Class 1
- Limited data verified suitable parameters to conduct extended milling

			Malvern Analysis (4 um spec)			% DOA
Batch #	Feed Air (psi)	Grind Air (psi)	10th	20th	90th	
1099-1211-1	Med	Low	2.819	5.474	10.059	4.63
1099-1211-2	Med	Med	2.935	6.149	12.117	4.69
1099-1211-3	High	High	2.229	4.716	9.652	4.71

Product Milling

- Generate 4.0 micron material for incorporation into MNX-795
  - 1099-1218-1 Produced non-spec compliant material
    - Material build up in exit pipe
  - Repeat of 1099-1218-1
    - Labeled as 1099-1218-2
      - Two separate grinds to confirm free flow mill conditions
  - 1099-1220-1
    - Extended milling yielded spec FEM grad RDX

				Particle Size Distribution			Comp
Milling Date	***Compressor Type***	***Feed Pressure (psi)***	***Grind Pressure (psi)***	**10th**	**50th**	**90th**	***% DOA***
1099-1218-1	HT	High	High	4.427	12.287	35.689	3.88
1099-1218-2	HT	High	High	2.007	4.849	15.307	4.94
1099-1220-1	HT	High	High	2.055	4.725	10.004	5.02

CXM-AF-7 Characterization

- Milled FEM RDX was incorporated with RDX Class 1 w/ DOA
  - Small clumps of FEM still noted after blending
  - Blended sample passed all spec attributes
    - Blended sample by use of twin cone blender
    - Future blending to be conducted with Nauta mixer system for mechanical shear

Batch #	***H2O %***	***Impact (cm)***	***Impact Std (cm)***
Spec	***<0.10***	-	***RDX, Cls 5***
1099-130	0.0167	45.71	22.91

MNX-795 Processing and Test

- MNX-795
  - Wax based melt pour explosive
  - Incorporates CXM-AF-7
    - Lecithin
    - Aluminum Powder
- NOL LSGT Evaluation
  - Conducted at HSAAP Explosives Test Site
  - Standard CXM-AF-7 vs. Milled CXM-AF-7

Material	Card Gap (Cards)	Result	Pressure (kbar)	Density (g/ml)
MNX-795 lit. Value	146.125	GO	40.96	1.634
MNX-795 lit. Value	146.8	No-GO	40.58	1.641
MNX-795 HSAAP	156	GO	35.8	1.615
MNX-795 HSAAP	157	No-GO	35.4	1.611

Conclusion

- ACE FEM technology successfully demonstrated the ability to manufacture CXM-AF-7
- Evaluation of the milled product met all current military specifications
- Large Scale gap Testing showed similar results to literature values
  - The 5kbar variance from literature values most likely due to density variation between the tested and reported charges
- The ACE technology demonstrated the capability to manufacture CXM-AF-7 and similar products on the production scale while increase safety and material handling

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Questions?