Def Sci J, Vol 39, No. 1, January 1989, pp 95–98

Spheroidization of RDX and Its Effect on the Pourability of RDX/TNT Slurries

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ABSTRACT

A technique for spheroidization of RDX has been developed using acetone as medium. Effect of spheroidized RDX vis-a-vis ordinary crystals of RDX on the pourability of RDX/TNT slurries has been studied. It is seen that mixture of different sizes of RDX crystals and ratio of coarse to fine plays very important role in increasing the pourability as well as the content of RDX in RDX/TNT charges up to 75 per cent.

1. INTRODUCTION

Cyclotrimethylene trinitramine (RDX or Cyclonite) is one of the most powerful explosives. Its velocity of detonation is 8754 m/sec at 1.8 g/cc density[1]. Due to its sensitivity, it cannot be used neat but always desensitized with wax or polymers or with Trinitrotoluene (TNT) to get pressed charges or cast charges. RDX in conjunction with TNT is used for filling shells, bombs and warheads. The power of RDX/TNT compositions depend upon the quantity of RDX, as it is more energetic explosive than TNT. It is observed that ordinary crystalline RDX can be incorporated to TNT upto 60 per cent to get pourable slurry at ~ 90°C but beyond 60 per cent its slurry with TNT becomes viscous which has adverse effect on cast charges. The homogeneity and pourability of the slurry depends upon the shape and size of the crystals of RDX. The concentration of RDX can be increased by better packing of crystals. Ordinary RDX lacks close packing due to sharp edges and corners of its orthorhombic crystals. Better packing can be achieved if the corners and edges are rounded off. Even in good packing of crystals, interstitial spaces are left which depend upon the size of the

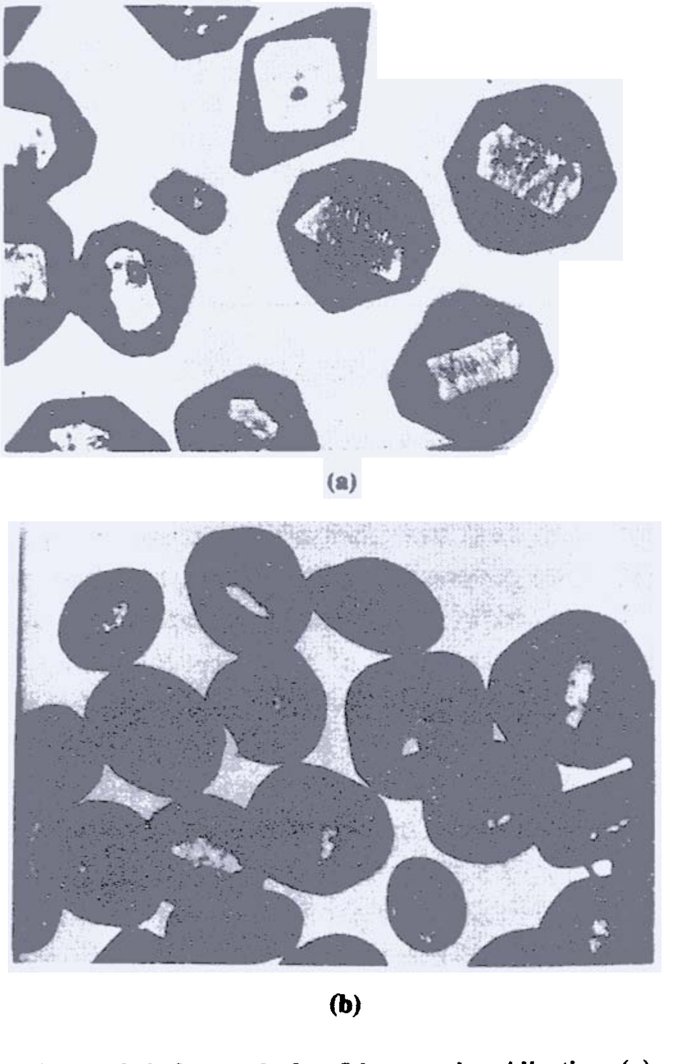
Received 4 August 1987; revised 22 September 1988

crystals. To have more concentration of RDX the voids are filled with smaller size of crystals. Lavertu et al[2] took patent on spheroidization of RDX in cyclohexanone. As cyclohexanone is expensive and toxic solvent, it is thought to develop a process using low cost and less toxic solvent like acetone. The effect of spheroidized RDX vis-a-vis ordinary RDX on the pourability of RDX/TNT slurry was also studied.

2. PROCEDURE FOR SPHEROIDIZATION OF RDX CRYSTALS

The process comprises two steps : (i) Erosion of RDX, and (ii) Partial dissolution of eroded crystals.

To a round bottom flask (5 litres) which was equipped with condenser and stirrer ~ 1.6 litres saturated solution of RDX in acetone was added at 20°C. Then 500 g of RDX crystals were added. The slurry was agitated with stirrer having RPM 400 (approx.) for three hours at 20 ± 2°C. At definite interval crystals were examined under microscope. When the crystals were partially rounded off then the temperature was slowly raised to 50 ± 2°C during 30 minutes. The contents were agitated further for two hours to spheroidize the eroded crystals at 50 ± 2°C and filtered under vacuum (Fig. 1).



(a)

(b)

Figure 1 RDX crystals before and after 5 hours spheroidization. (a) ordinary RDX crystals, (b) spheroidized crystals.

The experiment was repeated with different crystal sizes of RDX with different speed of the stirrers and with different solvent like DMF, acetonitrile, cyclopentanone etc, but acetone was found most suitable considering its cost and low toxicity.

3. PREPARATION OF RDX/TNT SLURRY AND DETERMINATION OF EFFLUX VISCOSITIES WITH KOCH FREIWALD VISCOMETER USING NOZZLE NO. 8 (8 mm dia)

To a double jacketed stainless steel vessel which was equipped with stirrer, 175 g of TNT was added. It was heated with steam to melt the TNT and to molten TNT 325 g of RDX was added in small instalments while stirring. After addition of RDX, it was further agitated for 15 minutes at 90 ± 1°C to make the homogenous slurry.

The slurry was transferred to the cup in Koch Freiwald viscometer which was maintained at 90°C. The slurry was allowed to fall and time is noted between the two markings in cup. This experiment was repeated with different compositions of RDX/TNT.

4. RESULTS AND DISCUSSION

The object of study is to incorporate maximum quantity of energetic component that is RDX to RDX/TNT to get powerful compositions which should have good pourability to get homogenous cast charges.

The effectiveness of the spheroidized RDX was verified experimentally, from the various compositions of RDX/TNT (Table 1 to 3). It is evident from the Table 1

Table 1. Effect of spheroidized and ordinary RDX crystals on efflux viscosity of RDX/TNT (60 : 40) slurry at 90°C

S.No.	Particle size (micron)	Flow time (s)	
		Ordinary RDX	Spheroidized RDX
1.	500 – 710	8.5	6.2
2.	420 – 500	10.5	7.1
3.	250 – 420	15	9.5
4.	150 – 250	21	12.5
5.	105 – 150	180	120

that slurry containing spheroidized RDX take less time than the slurry containing ordinary orthorhombic RDX. It also indicates that a decrease in particle size increases the viscosity which adversely affects the pourability.

It is well known that when crystals are packed, some interstitial spaces are left in them. To get the maximum density the void should be filled with fine crystals.

Table 2 reveals that viscosity depends upon not only the shape of RDX but also on the ratio of coarse to fine RDX mixed in TNT slurry. It is seen in two formulations of spheroidized and ordinary RDX, each having the same percentage of RDX of comparable particle distribution, have different flow time. The composition containing spheroidized RDX takes less time than the composition containing ordinary RDX. In Table 2 it is further seen that the ratio of the size of coarse and fine particles has

Table 2. Effect of mixed crystals on efflux viscosity of RDX/TNT (65 : 35) slurry at 90°C

S.No	Particle size (microns)				$\frac{d1}{d2}$	Flow time (s)	
	Coarse 75%		Fine 25%			Ordinary RDX	Spheroidized RDX
	Particle range	Average size (d1)	Particle range	Average size (d2)			
1	500 – 600	560	60 – 150	105	5	10.5	7.5
2	600 – 710	655	53 – 75	64	10	8.0	5.8

great effect on the viscosity. When this ratio was 5, the viscosity was more than with the ratio equal to 10. The percentage of fine and coarse particles depends upon the voidage value which vary with the nature and size of the crystals, but in our experiment 25 per cent voidage value was taken just for comparison sake between ordinary and spheroidized RDX crystals. The experiments reveal that by employing spheroidized RDX and correct bimodal mixture (coarse to fine), energetic compositions containing RDX up to 75 per cent can be cast, as the slurry has good pourability (Table 3).

Table 3. Effect of mixed crystals on efflux viscosity of RDX/TNT (70 : 30 & 75 : 25) slurries at 90°C

S.No.	Particle size of RDX microns		RDX/TNT ratio	Flow time (s)	
	Coarse 75%	Fine 25%		Ordinary RDX (average value)	Spheroidized RDX (average value)
1.	500 – 600	53 – 75	70/30	18.5	13.5
2.	600 – 710	53 – 75	75/25	43.3	31.2

ACKNOWLEDGEMENTS

The authors are very grateful to Air Cmde S.K. Sen, Director Terminal Ballistics Research Laboratory (TBRL), Chandigarh for his encouragement and they also wish to express their sincere thanks to Shri M.S. Bola, Deputy Director, and Dr. S.K. Vasudeva, Asstt. Director for their keen interest in the work.

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