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Structure Characterization and Performance Estimate for Thermal Solidified RDX Explosive by μCT

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The inner structure characteristic of RDX base explosive has been studied by μCT technology before and after fully thermal solidification. The three-dimension information has been obtained including RDX crystal grain characteristic, adhesive packing status and change, crystal and adhesive characteristics. The composite explosive is composed of 85% RDX crystal (grain crystal and powder crystal) and 15% adhesive with a small quantity of assistant in this experiment. The big grain crystal dimension is between 250 μm and 400 μm. The samples used for analysis are solidified deficiently (A) and solidified fully (B). The dimension of sample A is 3 mm × 5 mm × 2.5 mm and sample B 4 mm × 4 mm × 2.5 mm. The industrial CT system adopts 225 kV x-ray tube and flat detector with resolution 5 μm. The test time is about 10 minutes and reconstruction time 4 minutes with voltage 90 kV, current 90 μA, magnification ratio 44.87 and voxel dimension 8.92 × 8.92 × 8.92 μm.

The CT image is illustrated in Fig. 1 for RDX base explosive before and after thermal solidification. Fig. 1c is the CT value histogram of inner structure of sample A. The peak value at 25400 corresponds to RDX grain crystal and 23800 corresponds to the admixture of RDX powder crystal and adhesive. The slice (Fig. 1a Fig. 1b) images have been obtained through CT threshold treatment.

The three-dimension distribution and size distribution of inner pore for sample A is illustrated in Fig. 2a. Porosity in sample A and B is 0.22% and 0.13% respectively. The result indicates that a great deal of fine pores exist in crystal whose dimensions are between 9 μm and 100 μm. An initial damage is inevitable in this kind of crystal explosive molding parts, which makes the actual density of explosive parts descending and instable, but has little effect on the crystal density.

The separate CT images of inner substance phase of sample A are illustrated in Fig. 2b and Fig. 2c, and the CT separate results of grain and adhesive system are listed in Table 1. Supposing gain crystal ρ_1 for density, V_i for volume and C_1 for CT gray value, the power crystal/adhesive/additive system ρ_2 for average density, V_2 for volume, C_2 for CT gray value and C_{air} for air phase CT gray value, then the whole average density is:

$$\bar{\rho} = \frac{\rho_1 \sum_{i=1}^{n} V_i + \rho_2 V_2}{\sum_{i=1}^{n} V_i + V_2} = \rho_1 \left(\frac{\sum_{i=1}^{n} V_i + \frac{\rho_2}{\rho_1} V_2}{\sum_{i=1}^{n} V_i + V_2} \right) = \rho_1 \left(\frac{\sum_{i=1}^{n} V_i + \frac{C_2 - C_{\mathrm{air}}}{C_1 - C_{\mathrm{air}}} V_2}{\sum_{i=1}^{n} V_i + V_2} \right) \tag{1}$$

The average density of sample A and B is 1.632 g·cm^{-3} and 1.648 g·cm^{-3} separately according to formula (1) and table 1 and RDX density of 1.816 g·cm^{-3}, which are accordant with average density of actual product (1.642 ~ 1.652 g·cm^{-3}) of sample B at the same techniques, and it also shows that complete solidification enhances density obviously compared to solidification deficiency.

The CT gray value distributions of the grain crystal, power crystal/ adhesive system and their sections are illustrated in Fig. 3 for sample A and B with the maximal gray differences of 100 and 50 for most sections and area 8.30 mm^2 for analysis. The maximal density differences among the sections are 0.05 g·cm^{-3} and 0.02 g·cm^{-3} for sample A and B according to formula (1) and RDX density

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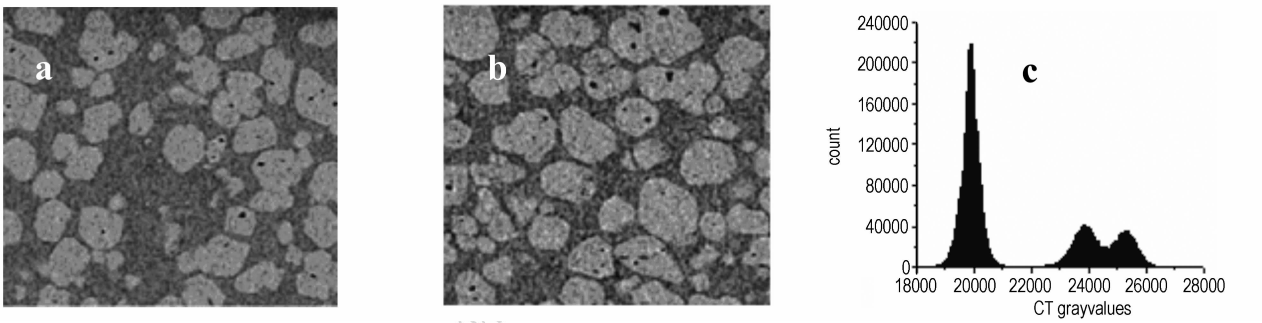
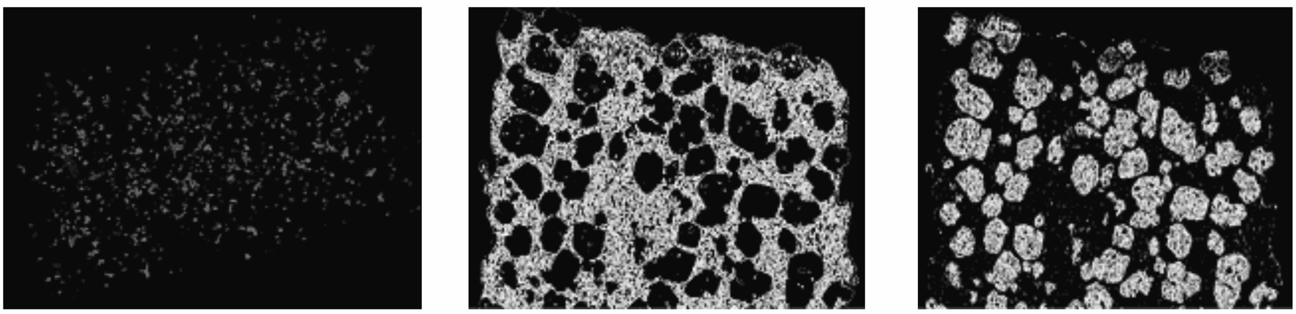
of 1.816 g · cm^{-3}. The average density differences between big grain crystal and power crystal/adhesive system are 0.460 g · cm^{-3} and 0.430 g · cm^{-3} for sample A and B, which shows that sufficient solidification enhances density and density uniformity for the adhesive system.



a. CT slice of inner structure of sample A(45 ×)　b. CT slice of inner structure of sample B(45 ×)　c. CT value distribution histogram of inner structure of sample A

Fig. 1 CT images of inner structure of grain RDX based explosive

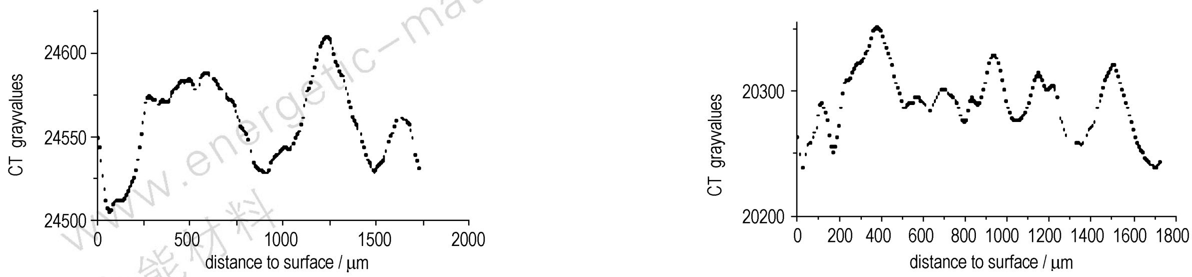


a. distribution of inner pores　b. interior power crystal and adhesive　c. interior grain crystal

Fig. 2 CT separate images of interior grain, adhesive and distribution of inner pores of sample A(45 ×)

Table 1 CT separate results of grain phase and adhesive system of the samples

	total volume / mm^3	grain RDX volume / mm^3	RDX grain CT average gray value	power RDX/adhesive system volume/ mm^3	base CT average gray value	air phase CT average gray value
sample A	44.85	27.28	25041	17.57	23714	19800
sample B	38.02	23.40	20493	14.62	19653	16950



a. sample A　b. sample B

Fig. 3 CT gray value distributions of different sections of sample A and B

Key words: materials science; computed tomography; thermal solidified explosive; structure characteristic; pore; density

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