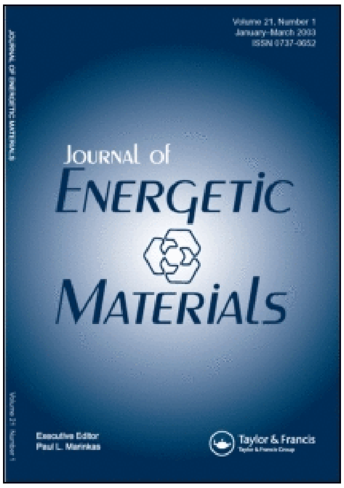

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Detonation of dense mixed explosives systems

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DETONATION OF DENSE MIXED EXPLOSIVES SYSTEMS

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ABSTRACT

Detonation velocity/charge diameter data has been obtained for an emulsion explosive composition containing 30% w/w of either of two surface area fractions of RDX. The data is analysed using a slightly divergent flow code CPEX. The results are compared with those for analysis of literature data for composition B. Significant differences were noted which seem to be related to the behaviour of the emulsion or TNT matrix.

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INTRODUCTION

Mixtures of explosives, typically as pressed powders or cast suspensions of the higher melting component in the lower melting component are widely used in the explosives industry. Typical of these are Pentolite and Composition B. In these PETN or RDX is added to TNT to gain sensitivity/energy or density/energy improvements.

The kinetics of detonation in this type of explosive in terms of the reactivity of the two components seems to have been little studied. Campbell and Engelke[1] determined the diameter effect in high-density heterogeneous explosives (mostly >95% TMD). In heterogeneous solids it was postulated that both hot spot and homogeneous burn mechanism were present whilst in homogeneous systems only the burn was present. Malin et al[2] studied RDX particle size effects in Composition B. Significant differences in critical diameter and failure velocity were observed.

Smaller but still significant changes were noted between slow and fast frozen samples - a consequence of the change in particle size of the TNT crystallites and of the recrystallised RDX.

Cowperthwaite and Rosenberg[3] used a Lagrange gauge technique to study the detonation processes in Amatex 20 and Composition B. The results were consistent with the hypothesis that ammonium nitrate and TNT were the slow reacting ingredients respectively.

In this paper we present results for the detonation properties of emulsion explosive/RDX mixtures as a function of the RDX particle size. The results are analysed using the slightly divergent flow code CPEX[4] and compared with our analysis of the literature results for Composition B. Both explosive types fail at a substantial VOD decrement compared with the ideal detonation VOD. The decrement may be both hydrodynamic (lateral loss) and kinetic in origin.

Some comparison of the results with our study of void size effects[5] on the detonation properties of emulsion explosives is made.

EXPERIMENTAL

The emulsion explosive used consisted of:

	%
Oxidisers	78.7
Water	16.0
Oil + Surfactant	5.3

The number average droplet size was ca. 1.3 micron. After blending in 30% w/w RDX the mix was subjected to vacuum to remove as many air bubbles (entrained by the mixing process) as possible. The small residual voidage remaining would be considerably below that required for sustained detonation in the emulsion in the absence of RDX in the charge diameters under consideration. However in the presence of RDX both the ideal velocity and the failure velocity are raised in comparison to an undoped emulsion. In consequence the shock temperature in the emulsion matrix is also raised. The rate of outward burning from the collapsed voids will therefore be higher than in an undoped emulsion.

RDX had surface areas 55.6 m^2/kg (coarse) and 592.5m^2/kg (fine). The availability of RDX in well characterised surface area fractions made it a more suitable sensitiser in this study than the other common sensitising explosive - PETN - would be.

VOD/DIAMETER DATA

The VOD/inverse charge diameter data for the emulsion/RDX mixtures at density 1.45 g/cc is shown in Figure 1, together with the CPEX fits. The critical diameter with fine RDX was 12 mm, with coarse RDX 32 mm. Ideal velocities were estimated using the JCZ equation of state.

The data of Malin et al is reproduced in Figure 2 together with the CPEX fits. CPEX has more difficulty fitting this data than that of the emulsion. The reason for this is evident in the plot of fraction reacted at the CJ plane/inverse charge diameter (Figure 3). The extent of reaction at failure is about 99% - the velocity decrement is almost totally due to flow divergence. The CPEX code was designed for studies of Price Group II type explosives where a substantial proportion of the explosive is unreacted at the CJ plane at the critical diameter. In contrast to composition B the emulsion/RDX mixtures fail with a substantial proportion of the explosive unreacted at the CJ plane (Figure 4).

FRACTION REACTED AS A FUNCTION OF TIME

Using the pressure dependent kinetic routines of CPEX we can display the fraction of explosive reacted as a function of time normalised to a given pressure. This is shown in Figures 5 and 6 for emulsion/RDX and composition B at 30 GPa.

The emulsion/RDX curves are qualitatively similar to those for void sensitised emulsion[5] except that the fine RDX always gives a higher reaction rate in contrast to void sensitisation where small voids give a lower initial rate followed by a rapid burn[5]. For composition B the reaction proceeds fairly slowly to about 40% reaction at which stage the remainder of the explosive is consumed in a very rapid reaction. This is reflected in the plots of reaction rate/extent of reaction for composition B (Figure 8). The initial rate is low but becomes much higher at about 40% reaction with the rate for fine RDX being greater than that for coarse RDX. This behaviour is typical of a thermal explosion type mechanism.

For emulsion/RDX the reaction rate/extent of reaction is again qualitatively similar to that for void sensitised emulsions and can be approximated to the situation where RDX forms the hotspot which burns outwards into the emulsion matrix.

DISCUSSION

In a conventional void sensitised emulsion explosive[5] shock induced void collapse produces hot spots of about the same volume as the original void. Heat loss from these occur due to thermal conductivity and also from intense turbulent processes resulting from the void collapse. Small voids show a slower hot spot phase but a faster burning phase.

Consideration of the shock temperatures in the emulsion and RDX (Figure 9) shows that the emulsion has a slightly higher shock temperature. Heat flow will be into the RDX particles and we expect a higher reaction rate for the small RDX particle containing emulsion.

In addition because of impedance mismatch at the RDX/emulsion boundary there will be a reflected shock into the emulsion matrix raising the temperature of a layer surrounding each particle. A likely site for ignition is therefore at the emulsion/particle boundary with reaction proceeding into the RDX particle and outwards into the emulsion matrix. The rate of reaction into the RDX will be much higher than the outward burn into the less reactive emulsion. We can therefore approximate the RDX as the hotspot.

For composition B we again speculate that reaction starts at the RDX/TNT interface because of the higher temperature in the TNT phase. Whilst the effect of RDX is to act as a sensitiser this effect is not evident in the steady detonation results where we are unable to separate the reaction into hot spot and burn phases.

We expect that the progress of reaction will depend on both the amount of RDX present and its surface area - as these factors affect the particle-particle distance. The emulsion/RDX mixtures contain half the amount of RDX as composition B but of a rather smaller particle size. Whilst emulsion/RDX and composition B are not comparable quantitatively from our study what we demonstrate is the use of a slightly divergent flow code to analyse reaction progress in two explosives both sensitised by RDX but having rather different reaction characteristics.

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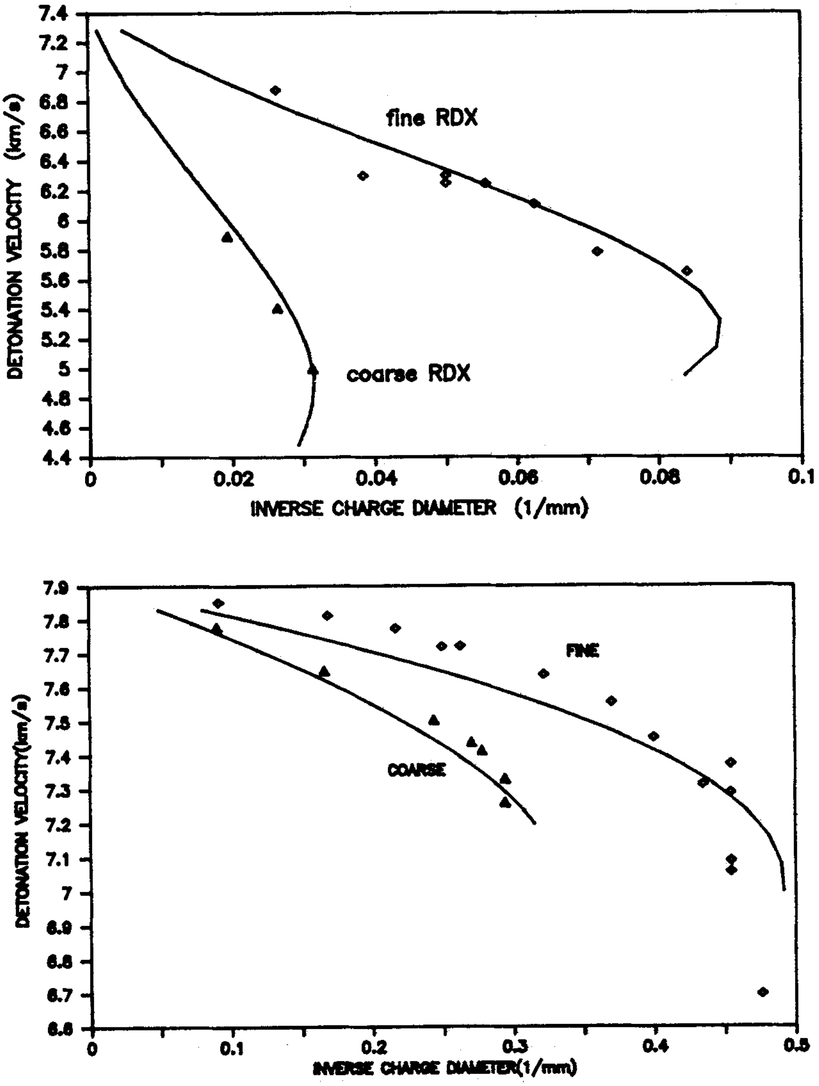
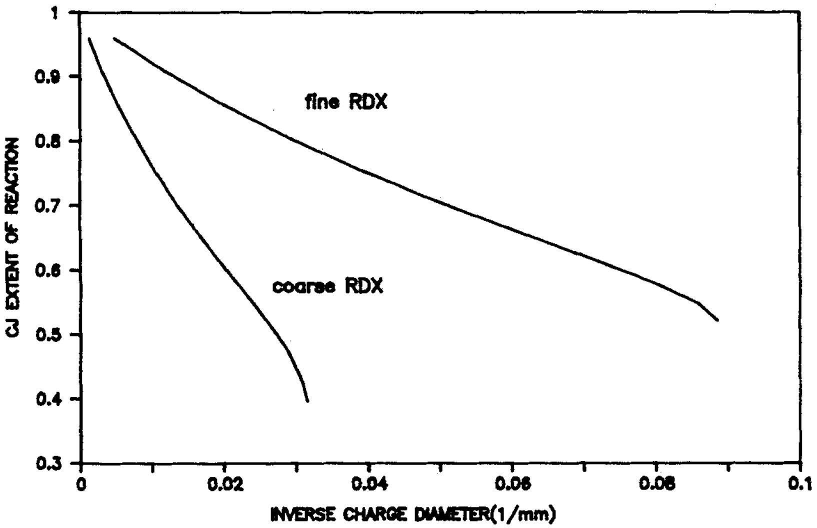
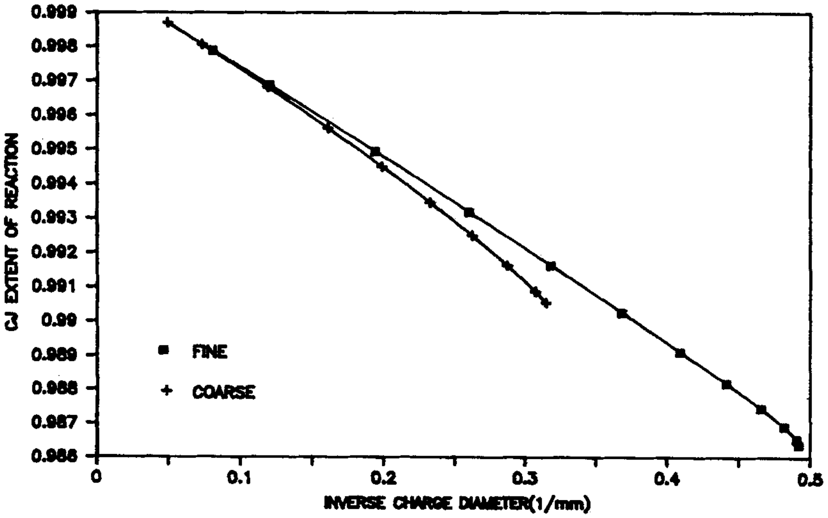


Figures 1 and 2

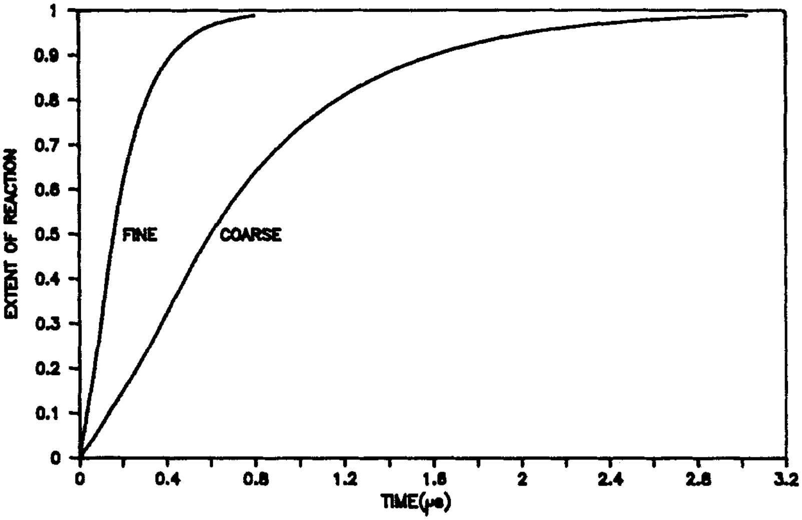
Detonation velocity/inverse charge diameter and CPEX fits for emulsion/RDX and composition B.

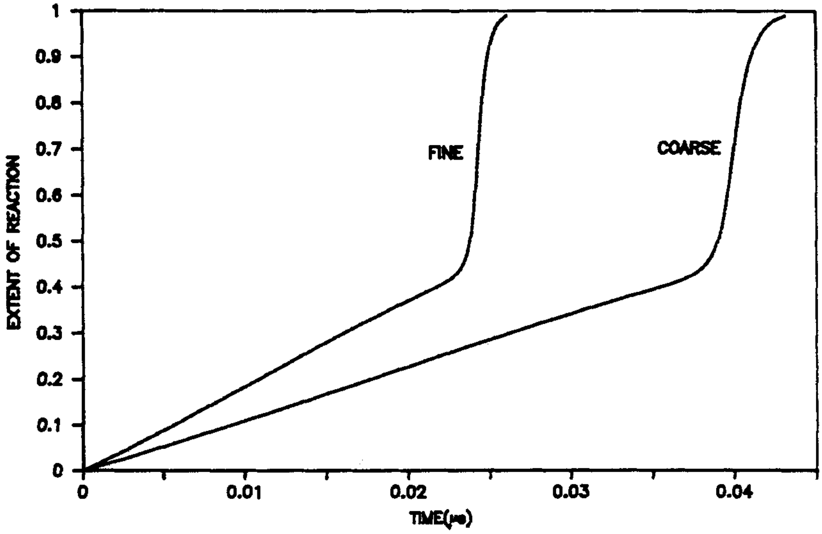




Figures 3 and 4

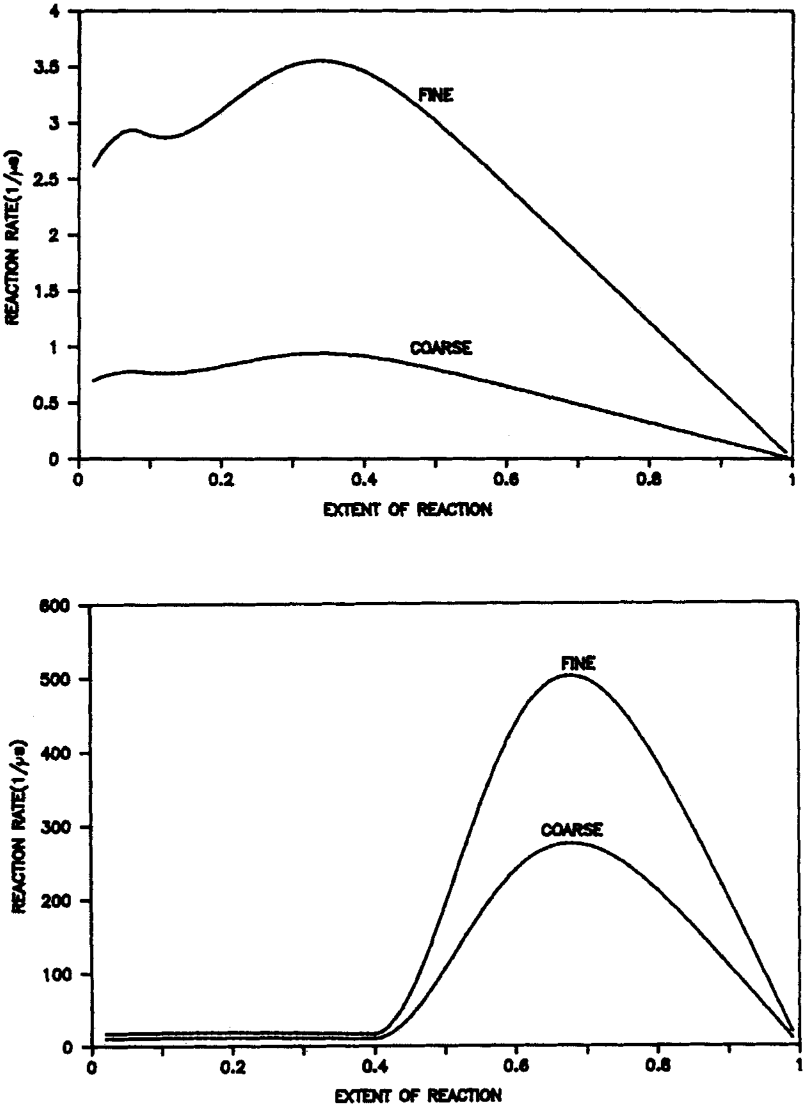
CJ Extent of reaction/inverse charge diameter for emulsion/RDX and composition B.





Figures 5 and 6

Degree of reaction/time (microseconds) for RDX/emulsion and composition B at 30 GPa.



Figures 7 and 8

Reaction rate/degree of reaction for RDX/emulsion and composition B at 30 GPa.

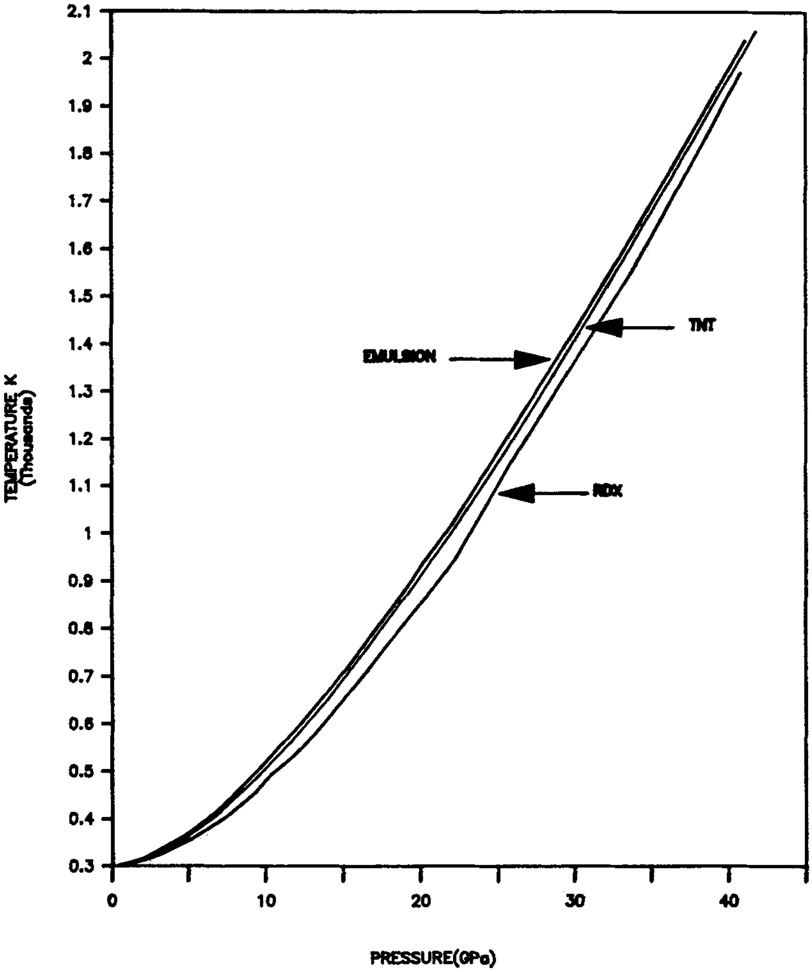


Figure 9

Shock Temperature/Shock Pressure for emulsion, TNT and RDX by the Walsh-Christian method with consant C_v.