

# Simulation of detonation of aerated ammonium nitrate based emulsion explosives

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## Introduction

Indubitable advantages of emulsion explosives (EE) based on ammonium nitrate attract attention of many researchers investigating their detonation mechanisms. However, even up to date we have not come across a generally accepted point of view as regards the processes taking place in the front of shock detonation wave during EE explosion.

In the present work, the authors propose a view on the problem based both on their own hypotheses and on the results of analysis of extensive empirical data.

## Assumptions

Some basic statements are considered as hypotheses, since no special attention is concentrated on proving them, due to their logicity or obviousness.

So, for the EE based on ammonium nitrate:

1. initiation of the detonation process is associated with sensitizers (gas pores), and the process propagates from their surface;
2. propagation of the detonation process is limited by the «domain of influence» of gas pores, which are below referred to as micro-spheres (MS);
3. total volume of the emulsion matrix under the "domain of influence" of all the MS determines the detonation possibilities of EE;
4. only the part of reaction region limited by the jump at the front of the shock detonation wave and by Chapman-Jugue point is essential for the detonation process (below we will mean only this region speaking of the reaction zone);
5. physico-chemical transformations accompanying EE detonation are a sequence of two kinetic processes: a rapid monomolecular decomposition of ammonium nitrate and a second-order reaction of oxidation of the combustible components of EE by the products formed in the decomposition of ammonium nitrate.

## Simulation

The model is composed assuming that for an EE with the porosity of  $\alpha = V_{gas} / V_{EE}$  the equation of state is approximated by the power function  $p = \rho^{n(\alpha)}$ . In this case,

$$D = \sqrt{2 \cdot (n(\alpha)^2 - 1) \cdot P(\alpha) \cdot q} \quad ,$$

where  $P(\alpha) = 1 - \exp(-\alpha R^3/d^3)$  is a factor taking into account porosity characteristics and the stochastic nature of pore distribution,  $q = q_{\text{det}} + \sigma \cdot q_{\text{burn}}$  is specific heat evolution,  $\sigma$  is a correction for the «quality» of the emulsion basis,  $R$  is mean distance between the centres of MS for the porosity providing maximal detonation rate,  $d$  is mean diameter of MS.

Using the  $D$  maximization condition for different  $d$ , we may reveal the empirical dependence  $n(\alpha)$ , which is a decreasing function, as suggested by the condition  $dD/d\alpha = 0$ . It is clear that for  $\alpha=1$   $n(\alpha)$  is equal to  $\gamma$  for a gas (1.1 for the air), for  $\alpha=0$   $n(\alpha)$  corresponds to the adiabatic exponent for the condensed state (emulsion matrix), which is usually accepted in calculations to be equal to 3.

Since  $D > C$ , the latter being the equilibrium sound speed at the point C-J, the  $D(\alpha)$  dependence is limited from below by the curve for  $C(\alpha)$ .

## Conclusion

The developed model exhibits good agreement with the experimental data. Within the model, an explanation has been provided to the "anomalous" (from the viewpoint of high explosives) detonation behavior of EE at relative density close to unity.

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