The Influence of Spherical RDX on the Properties of Foamed Propellants

Der Einfluss von sphärischem RDX auf die Eigenschaften von geschäumten Treibladungen

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Abstract

Foamed propellants are based on crystalline explosives bonded in inert or energetic reaction polymers. Due to their porous structures they show high burning rates.
Energy content and material characteristics can be varied by using different energetic fillers, energetic polymers and porous structures.

Using nitramines as explosive fillers in a spherical grain morphology yields in a change in the material characteristics in comparison to formulations with nitramines with the commonly used morphology.

Kurzfassung

Geschäumte Treibladungen bestehen aus kristallinen Explosivstoffen, die in einer inerten oder energetischen Polymermatrix eingebunden sind. Aufgrund ihrer porösen Struktur zeigen sie hohe Abbrandgeschwindigkeiten.

Der Energieinhalt und die Materialeigenschaften der geschäumten Treibladungen können in weiten Bereichen durch Auswahl der energetischen Füllstoffe, der energetischen Polymere und Einstellung von verschiedenen Porositäten variiert werden.
Der Einsatz von Nitraminen in einer sphärischen Partikelform führt zu Änderungen in den Materialeigenschaften im Vergleich zu Formulierungen mit der üblicherweise eingesetzten Kornform der Nitramine.

Introduction

The properties of foamed propellants can be modified to a wide extent by the selection of ingredients as well as by the porous structure. Typical application areas are caseless ammunition and combustible cartridges [1-16]. Due to the chosen manufacturing procedure - the reaction injection moulding - it is possible to achieve complex geometries [17]. Beside of this it is also possible to produce modular or layered charges of different porosity and as well composition.

Experimental

Samples of foamed propellants based on hexogen and polyurethane were produced manually according to the reaction injection moulding process. The particle size distribution of the filler used was a bimodal one (coarse: fine= 50:50). The coarse hexogen was used in one line of experiments (F67) in a common particle morphology (fig. 1) and in the other line of experiments (F69) as spherical particles (fig.2).
Additives and processing parameters were adjusted in order to achieve charges with smooth surface and closed-cell structure.

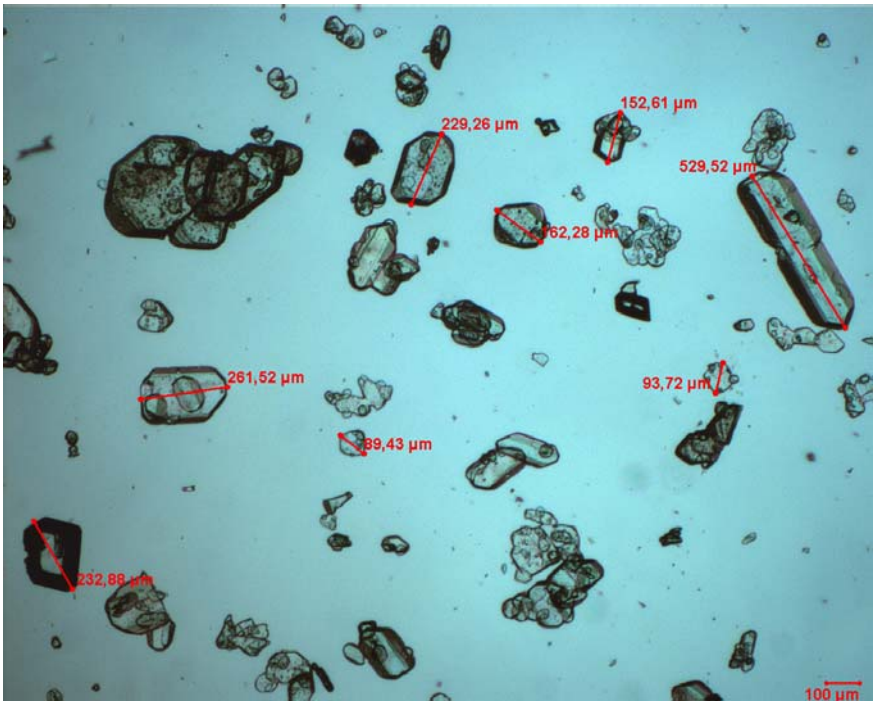

Figure 1 : Microscopic characterisation of the coarse RDX

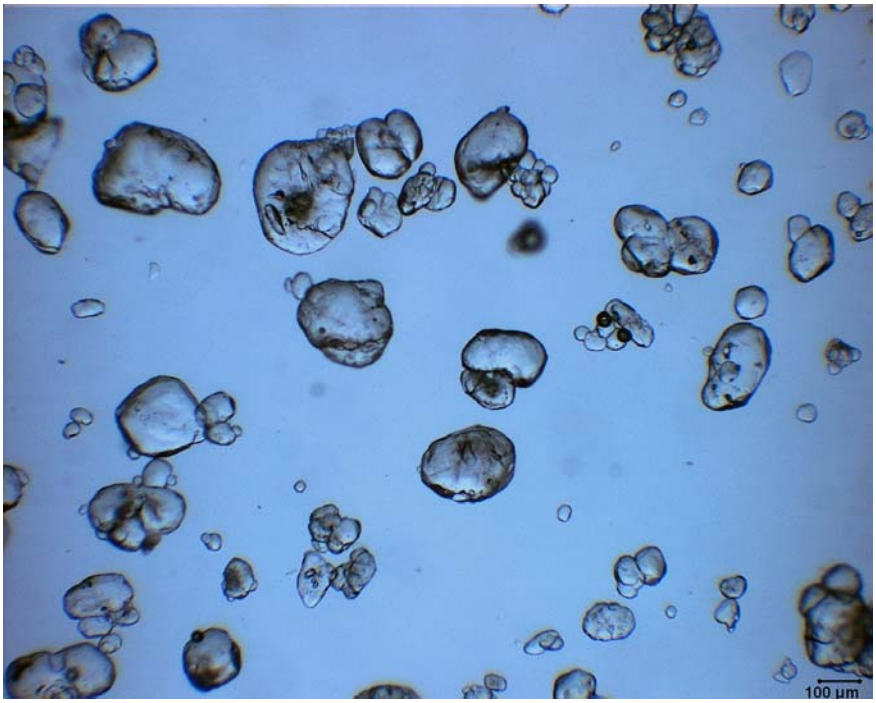

Figure 2: Microscopic characterisation of the coarse RDX in a spherical morphology

Viscosity

The viscosity of the polyol- and isocyanate premixtures filled with RDX was measured with a Brookfield viscosimeter at ambient temperature. The particle morphology of the hexogen used depicts a clear effect. Using spherical RDX the viscosity of the polyol premixes could be reduced by nearly 35% and the viscosity of the isocyanate premixes could be reduced by nearly 75% (fig.3).

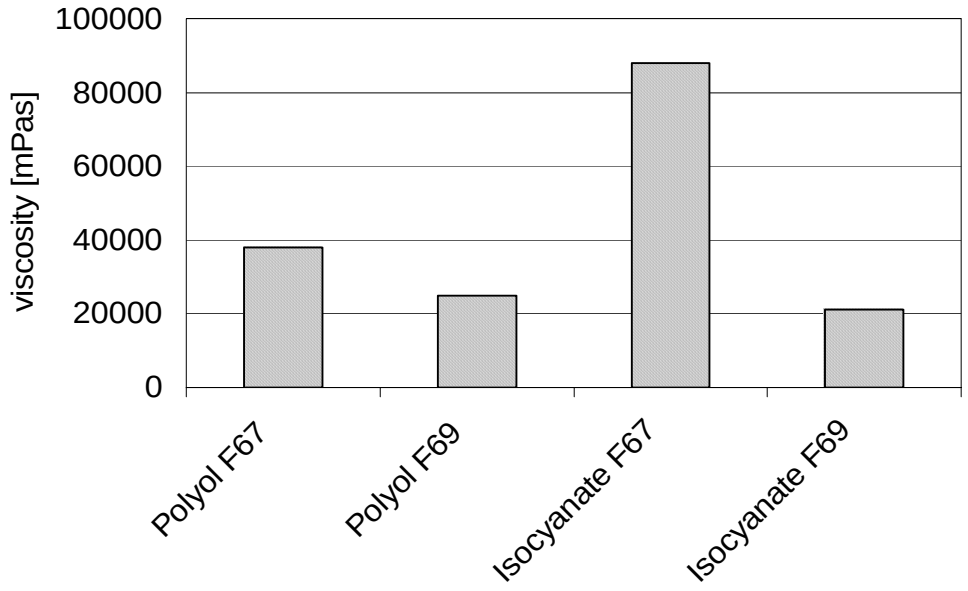

Figure 3: Viscosity of the polyol- and isocyanate premixtures at ambient temperature
F67 with the commonly used RDX grain morphology
F69 with RDX in a spherical grain morphology

Curing time

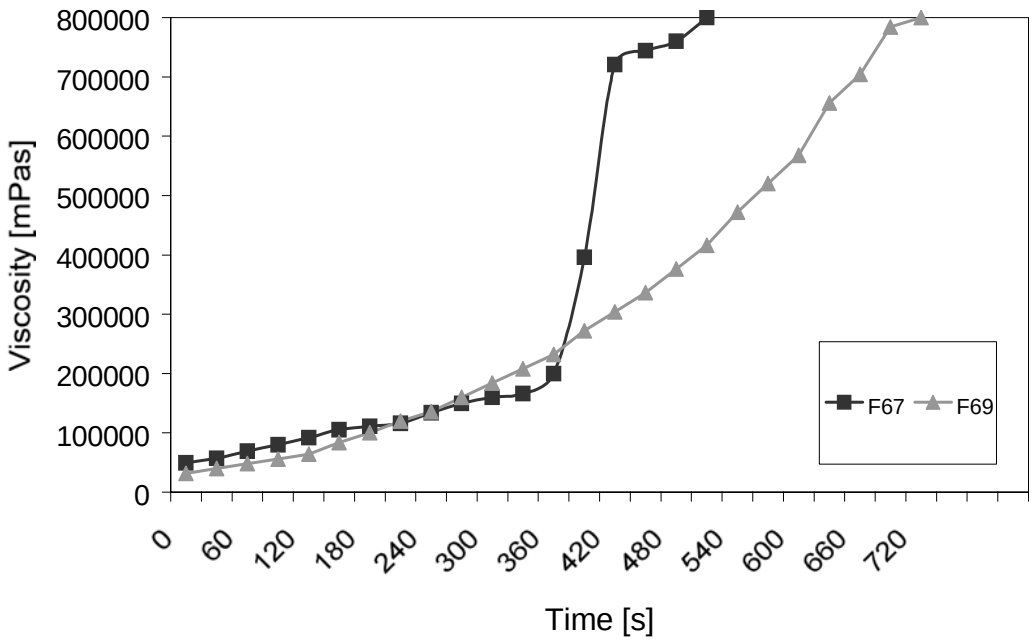

Figure 4: Curing time of the RDX filled reaction mixtures
F67 with the commonly used RDX grain morphology
F69 with RDX in a spherical grain morphology

The curing time of the reaction mixtures was measured with the Brookfield viscosimeter at ambient temperature. Figure 4 depicts the measurements for the formulations F67 and F69. The grain morphology of the filler shows an influence of the curing time of the polyurethane reaction polymer.

Pore size distribution

The pore size distribution (fig. 5) of both types of foamed propellants F67 and F69 based on RDX and polyurethane are very similar and independant from the particle morphology of the hexogen used.

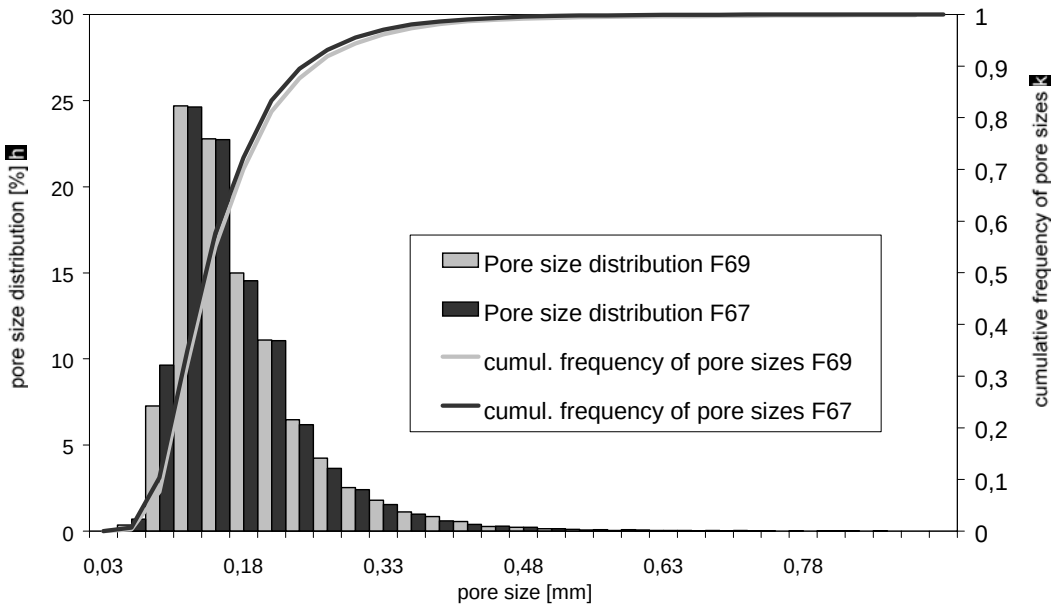

Figure 5: Pore size distribution of foamed propellants
F67 with the commonly used RDX grain morphology
F69 with RDX in a spherical grain morphology

Mechanical Properties

The mechanical properties of foamed propellants were measured in a one dimensional pressure test at ambient temperature. Figure 6 and 7 show the correspondend results. It can be seen using spherical RDX (F69) the E-module and the maximal tension decrease whereas the maximal compression increases.

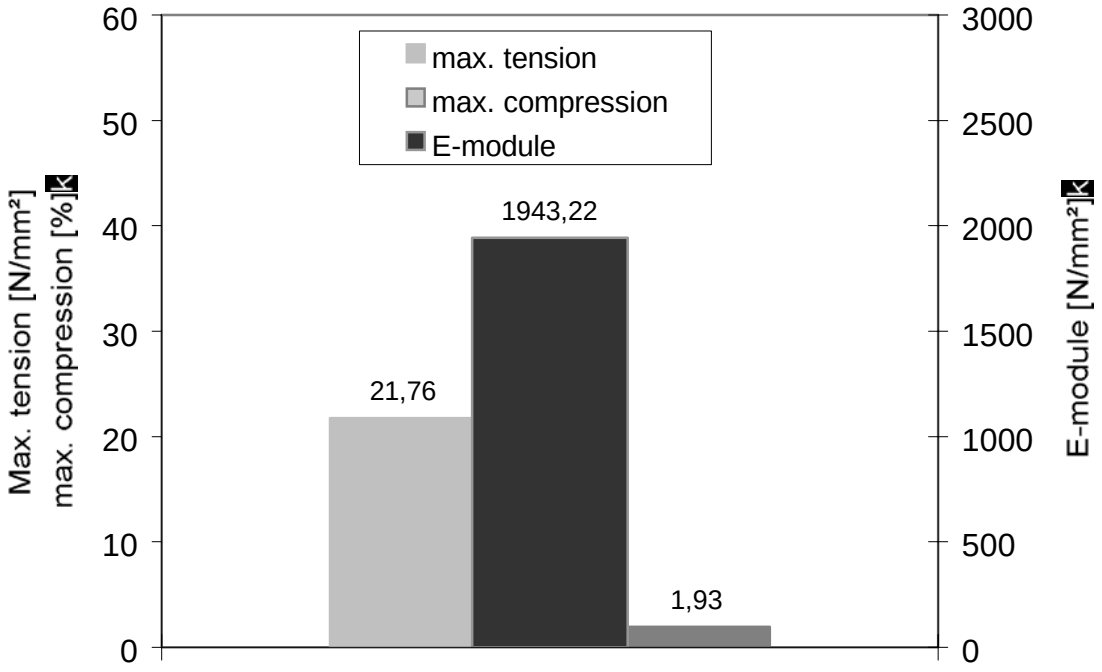

Figure 6: Mechanical properties of the RDX-polyurethane based foamed propellant F67 with the commonly used RDX

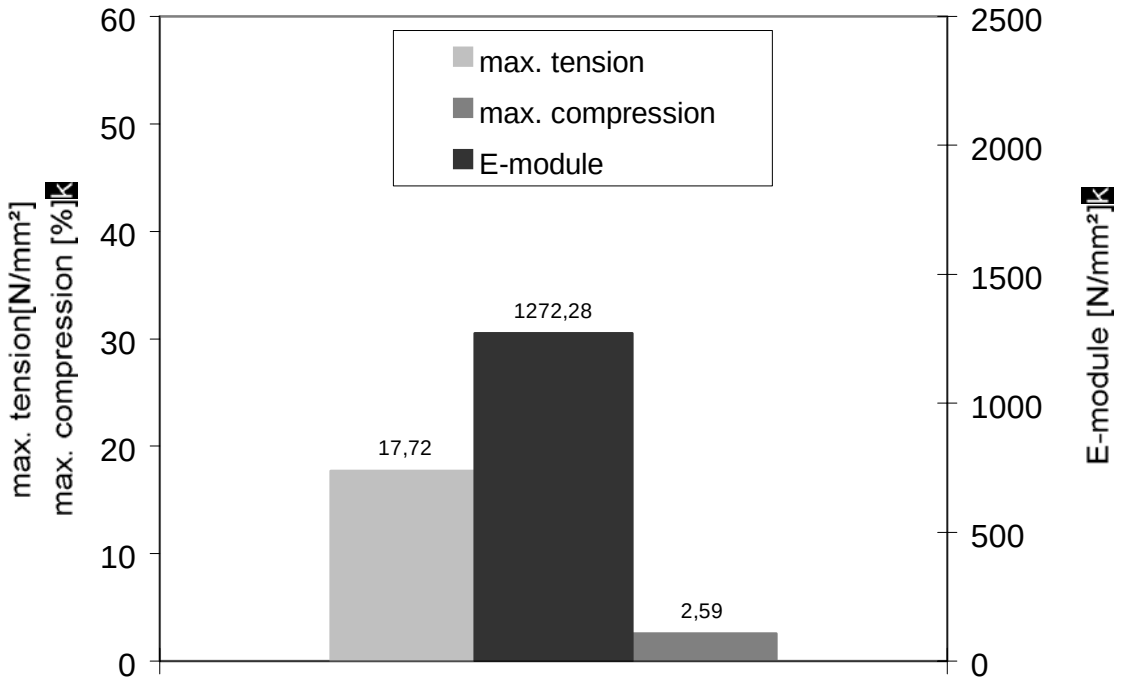

Figure 7: Mechanical properties of the RDX-polyurethane based foamed propellant F69 with the spherical RDX

Burning characteristics

The burning behaviour of foamed propellants was examined using a closed vessel. Cubic samples (10^3 mm^3) were produced and tested with different loading densities in a 100 ml vessel with reduced volume. Some results of these tests are represented in figure 8. The usage of spherical RDX in foamed propellants (F69) yields in a decrease of vivacity in comparison to the samples with the commonly used RDX morphology (F67).

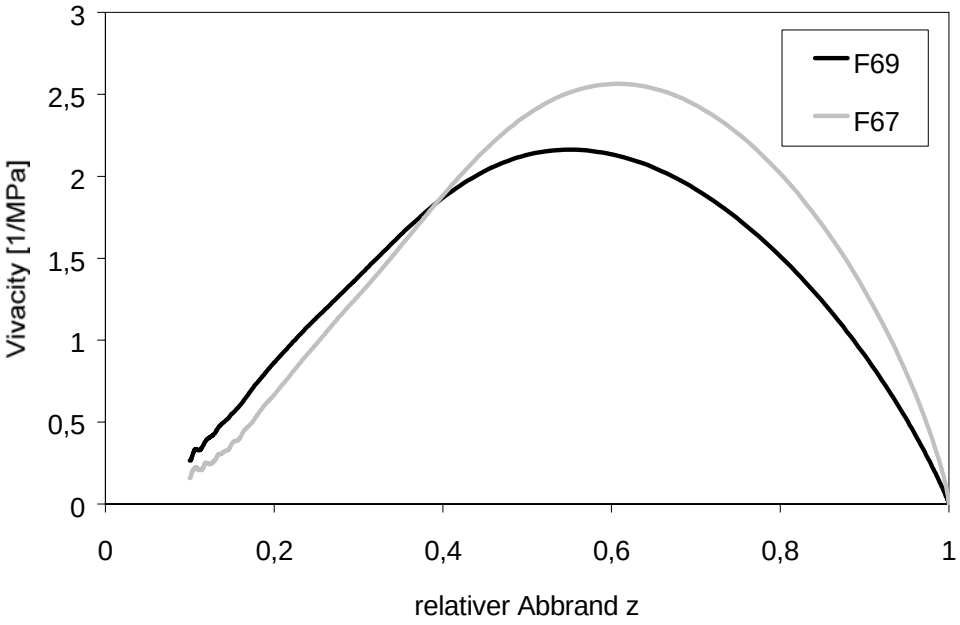

Figure 8: Vivacity of foamed propellants based on RDX and polyurethane, LD 0,2 g/ml
F67 with the commonly used RDX grain morphology
F69 with RDX in a spherical grain morphology

Summary

There is a clear influence of the usage of spherical RDX in comparison to hexogen of commonly used particle morphology in the material properties of the foamed propellants. The decrease of viscosity and therefore increased flowability of premixes with spherical RDX is specifically advantageous.

On the other hand yields the use of spherical RDX in a decrease of E-module and the maximal tension and as well a reduction of the burning rate and vivacity of the correspondend foamed propellants. These effects have to be considered in the development of new formulations of foamed propellants.

Literature

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