Processing and Characteristics of Foamed Propellants

Dr. J. Böhnlein-Mauß, H. Kröber

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Fraunhofer ICT

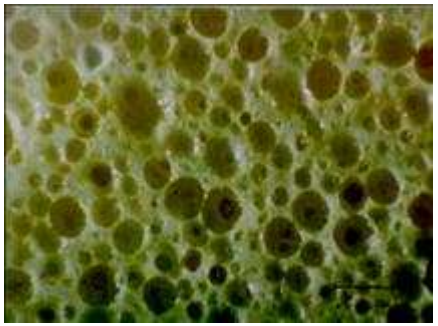
Outline:

- Introduction
- Basic parameters and components
- Processing and manufacturing
- Material characteristics
- Application
- Conclusion

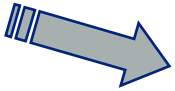
General Requirements for the Application as Combustible Cartridge Case:

- High energy content
- High burning rate
- No combustion residues
- Good mechanical stability
- High long term stability
- Low sensitivity
- Simple and cheap manufacturing
- High reproducibility
- ….

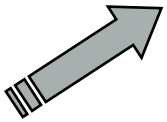
Basic Parameters and Components:



Binders

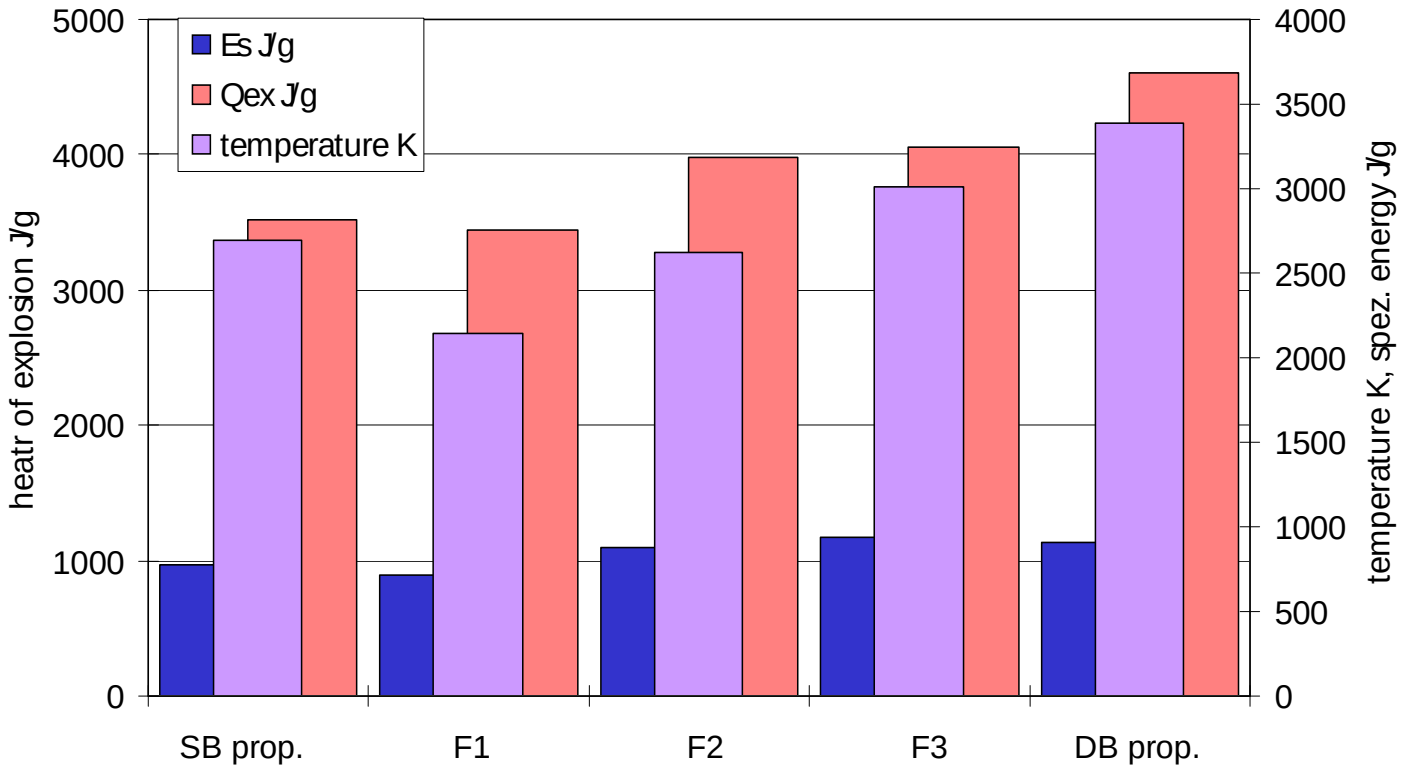


Fillers



Processing Aids

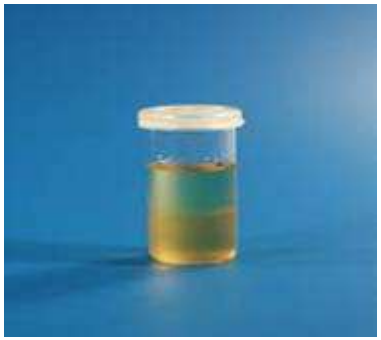
Thermodynamic Calculations:

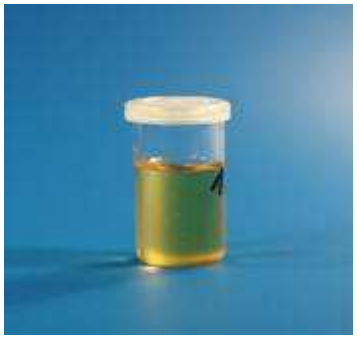


→ High energy content possible and lower combustion temperatures!

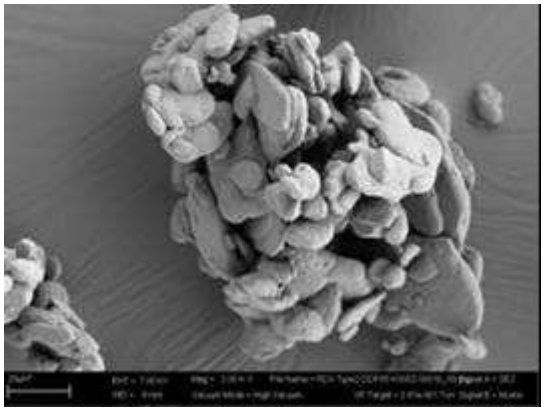
Characterization of the Components:

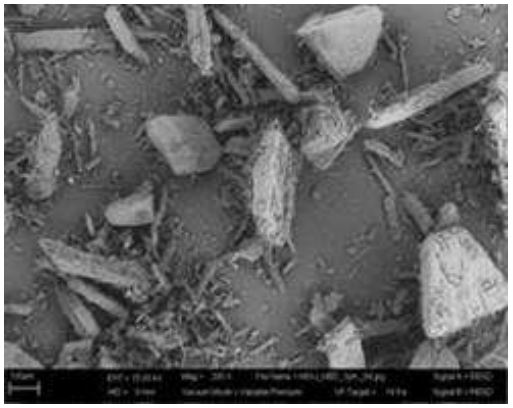
Miscibility of the different Binder Components

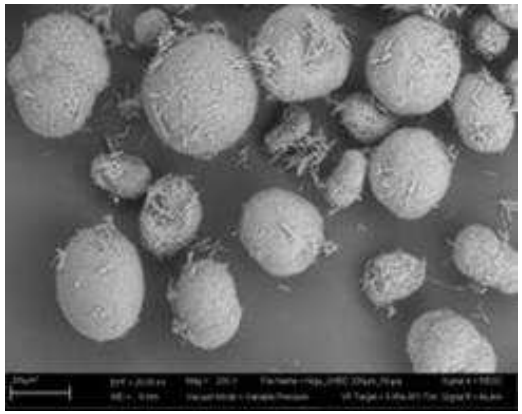




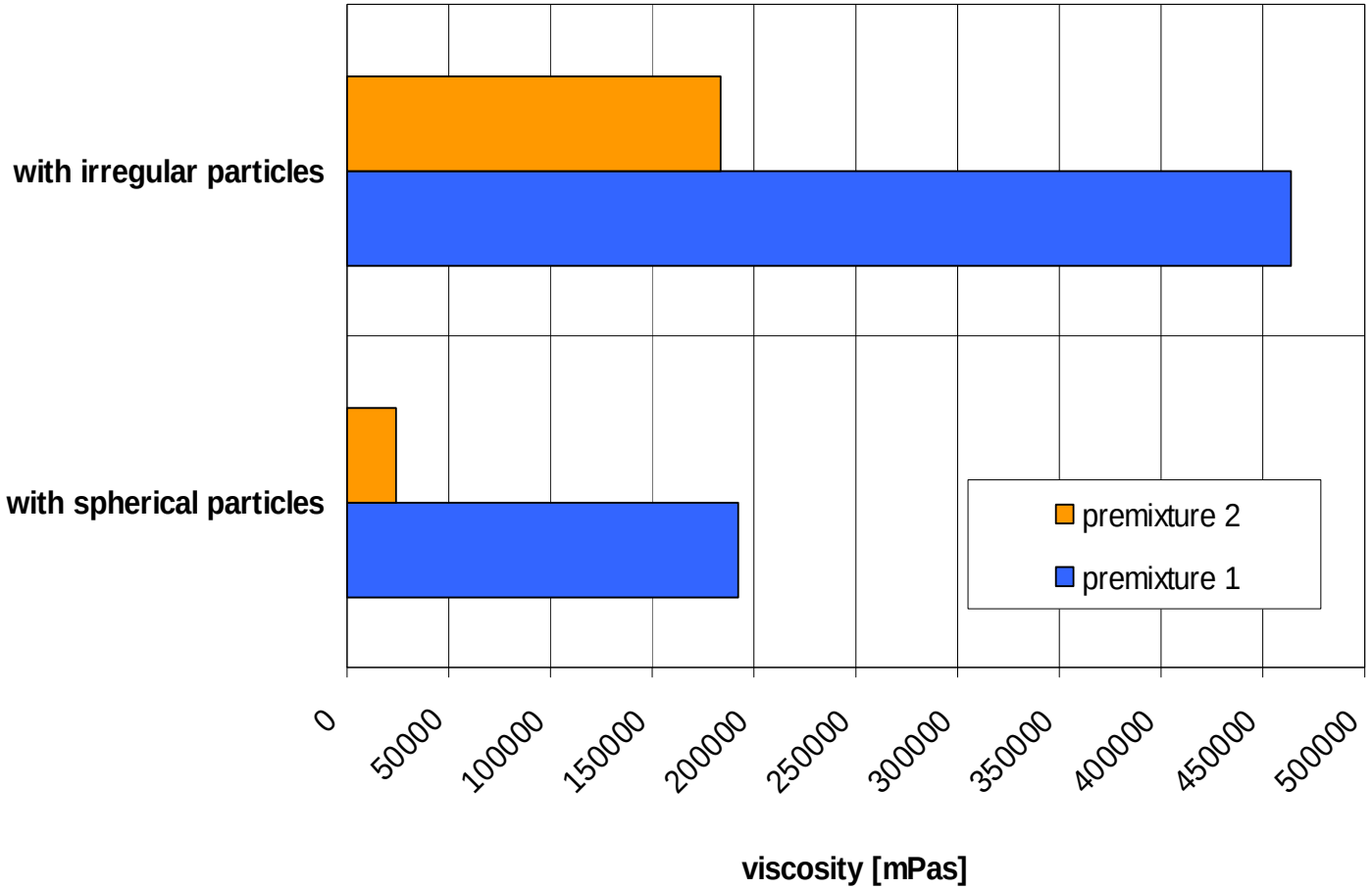
Scanning Electron Microscopy



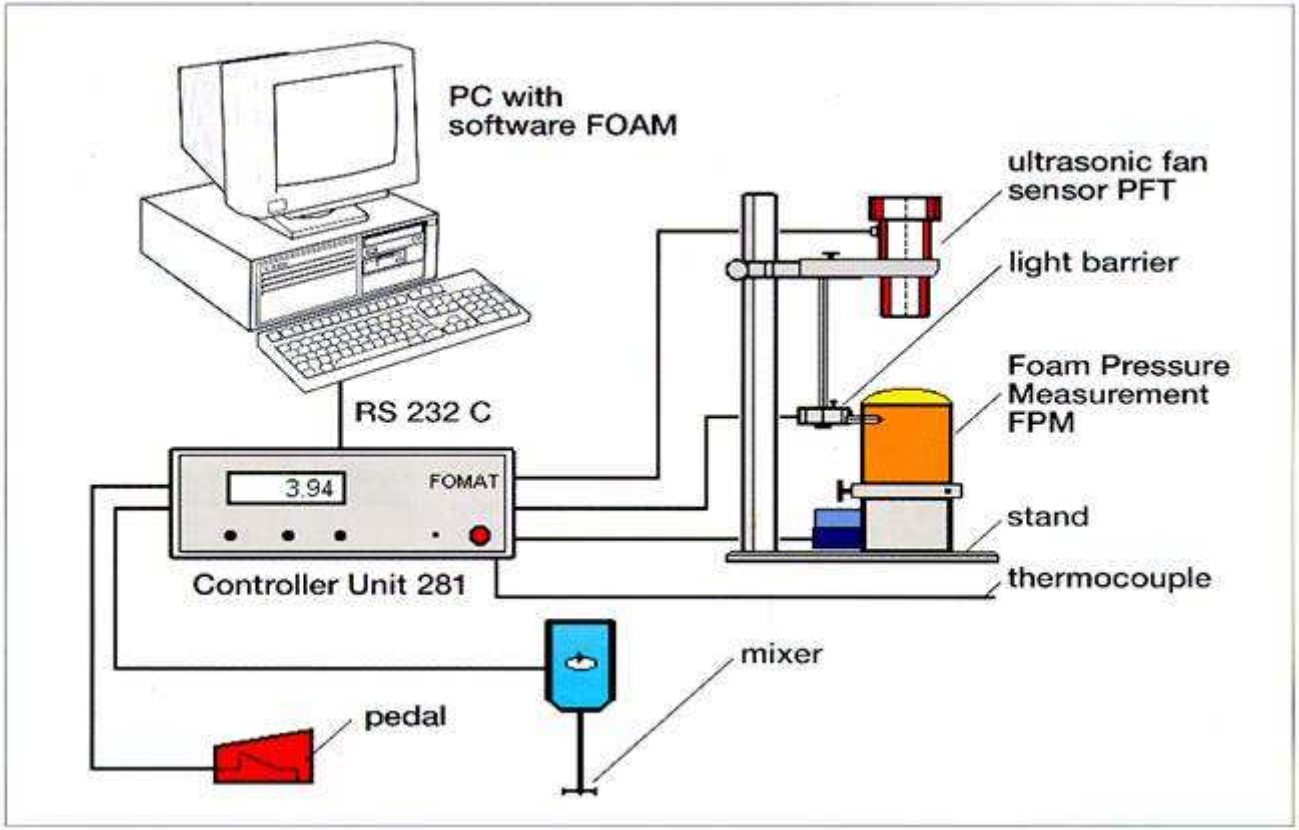




Influence of spherical Particles on the Flowability of the Premixtures:



Qualification of Polyurethane Foams:



→ Measuring physical parameters during foam formation

Qualification of Polyurethane Foams:

Good adjustment of foaming and curing process is necessary!

Processing and Manufacturing

Development of RIM Processing Machinery for Explosives

- based on low pressure injection moulding process
- modifications necessary because: - high filler content (more than 60 wt%)
  - explosive particles

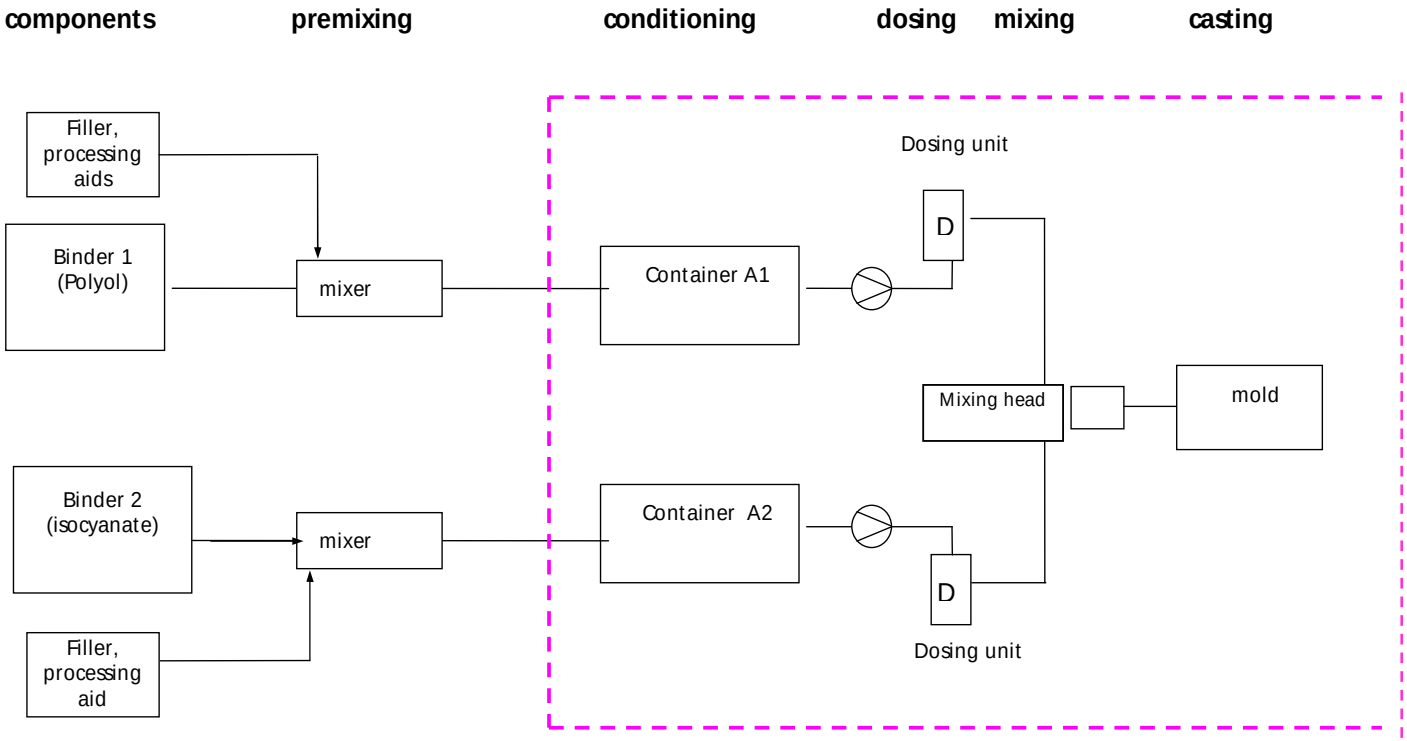
Main points:

- Engineering and Processing: - conveyability, pompability (high viscosity)
  - precision of dosing
  - mixing quality

- Safety: - mechanical stress in pumps and valves
  - thermal stress due to friction and heat of reaction
  - safety tests with the used materials

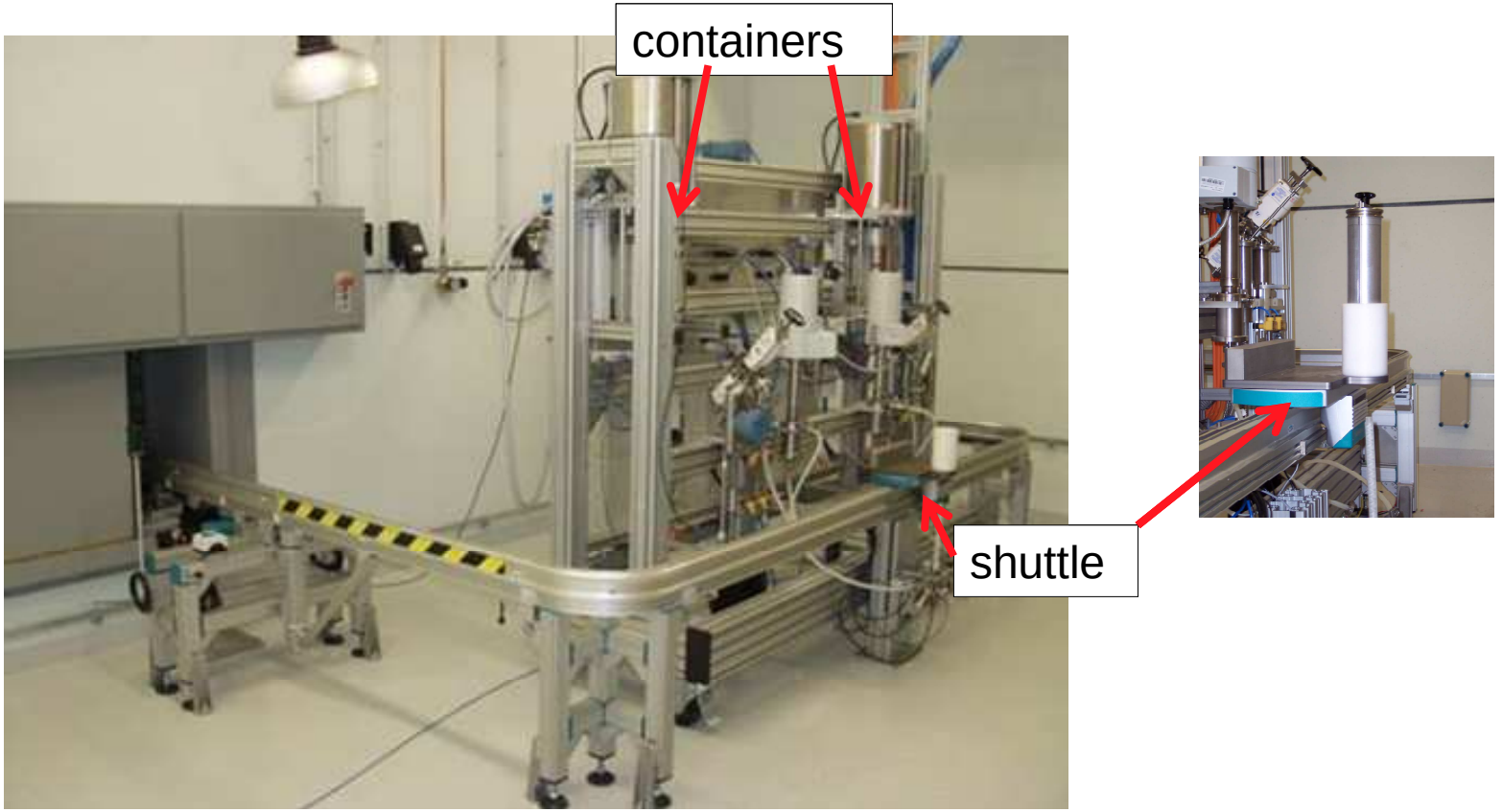
Development of RIM Processing Machinery for Explosives

Flow Chart



adaption for processing of energetic materials

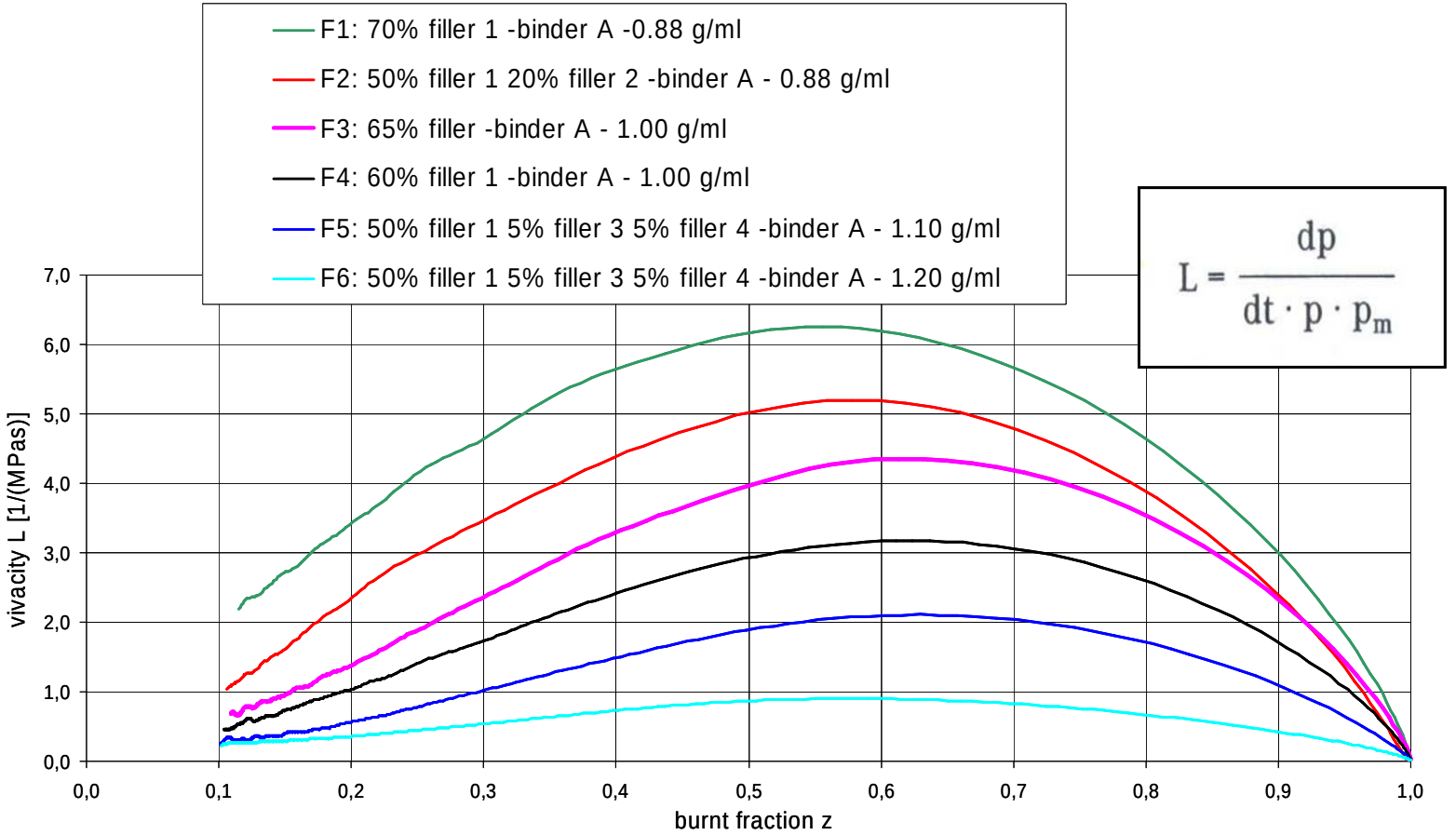
Development of RIM Processing Machinery for Explosives:



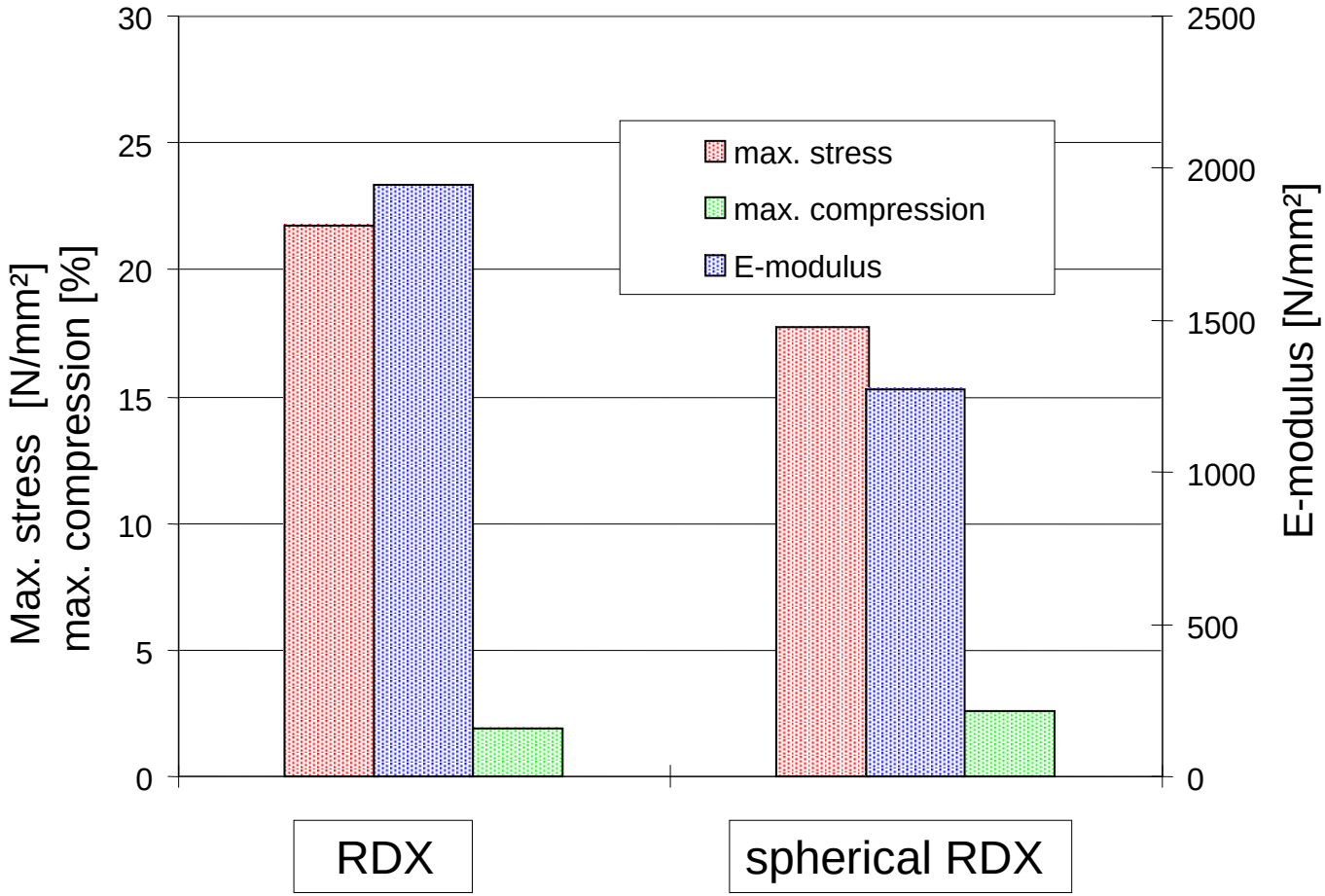
50 propellants per batch, fully automated process

Material Characteristics:

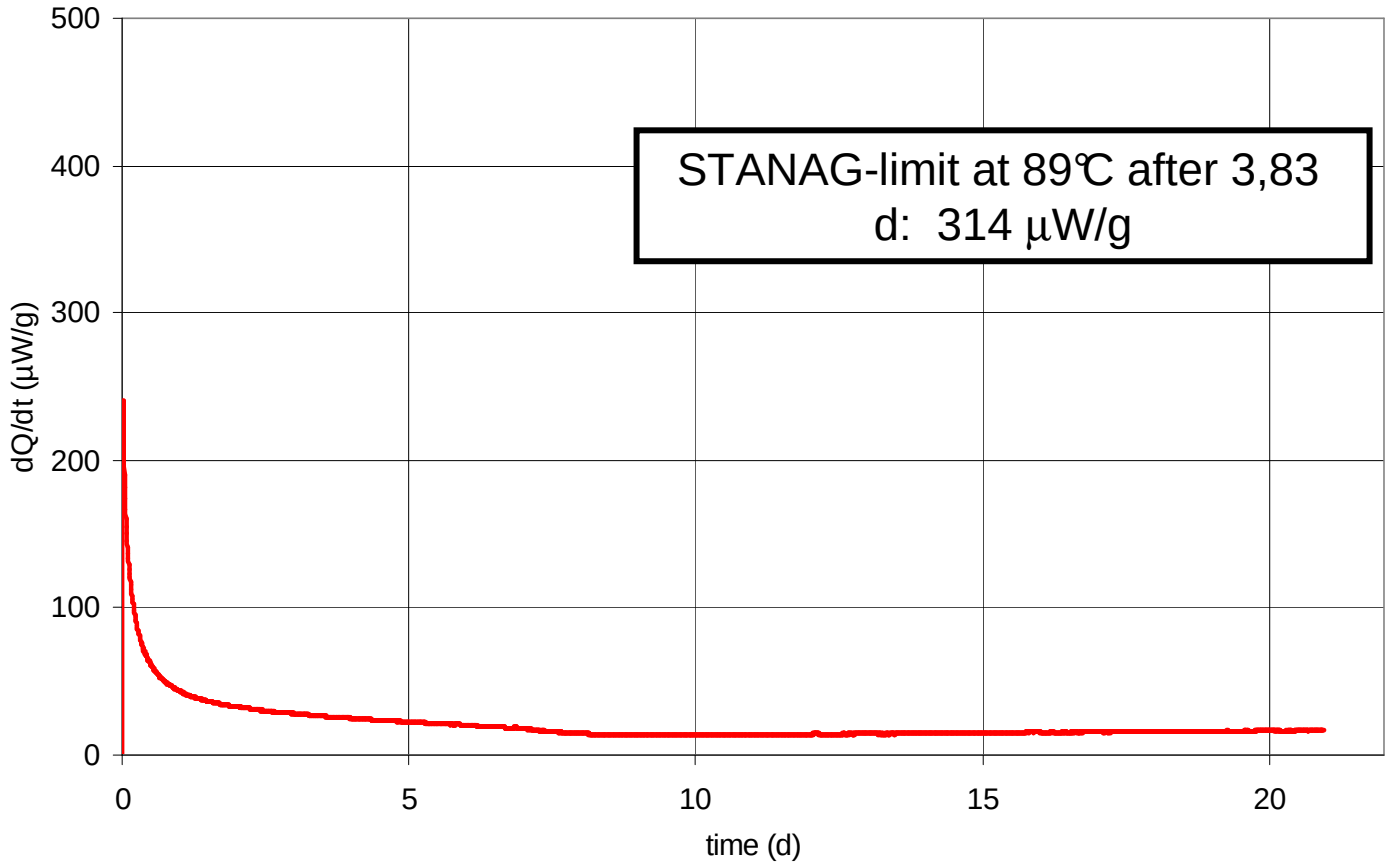
Burning Behaviour: Influence of the Density and Composition



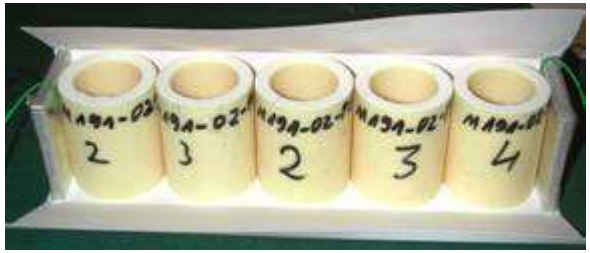
Mechanical Behaviour: Influence of the Morphology of the Filler Particles



Chemical Stability: Heat Production Rates



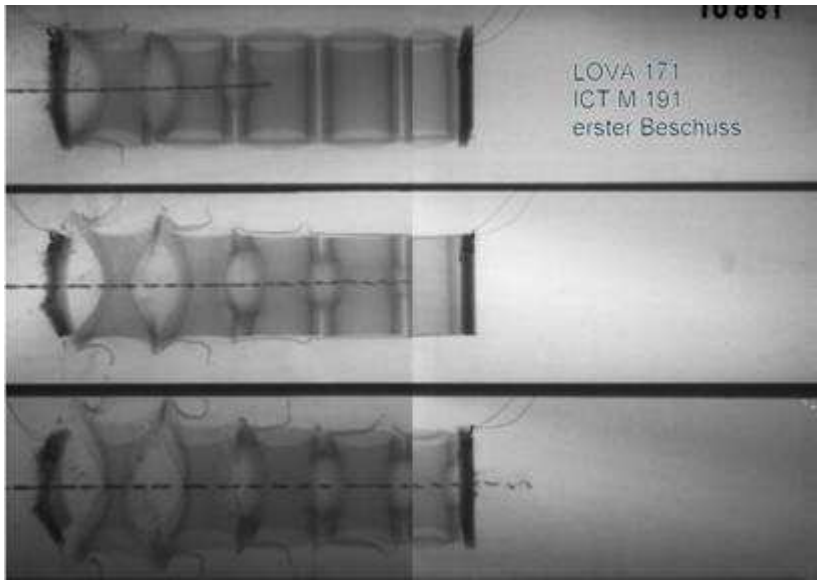
Low Sensitivity: Shaped Charge Impact Test (FhG-EMI)

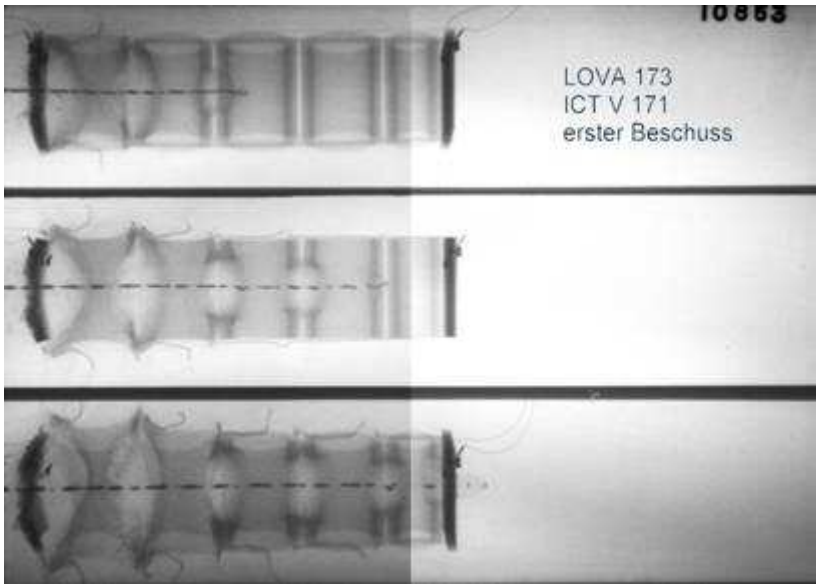


Experimental set up

Only burning or weak deflagration
Velocity of reaction about 500 m/s (estimated from x-ray pictures)

⇒ LOVA-property





Variety of Shapes: No Restriction in Geometry

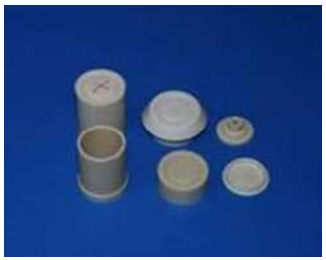






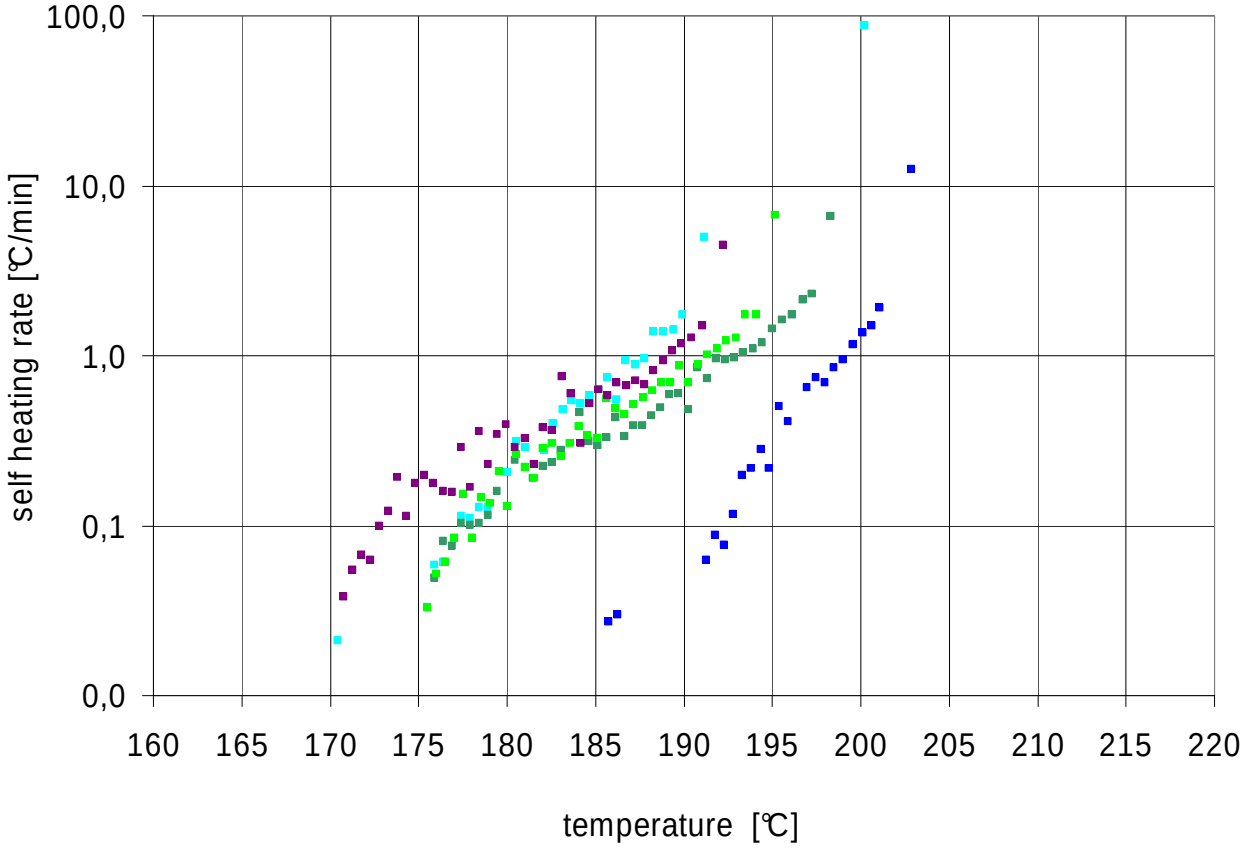






Application: Foamed propellant as caseless ammunition

Selection of thermally stable compositions (cook off)



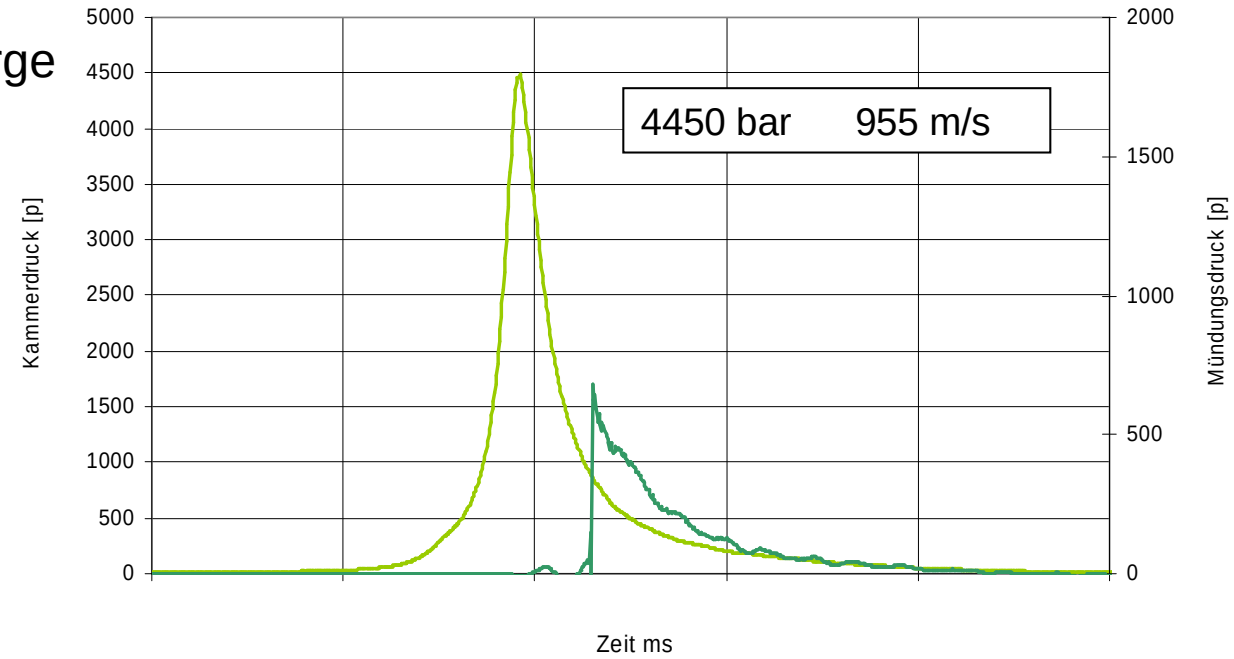
Application:

Foamed propellant as caseless ammunition

Firing experiments

Ignition by a firing pin

Priming cap/ booster charge



Conclusions:

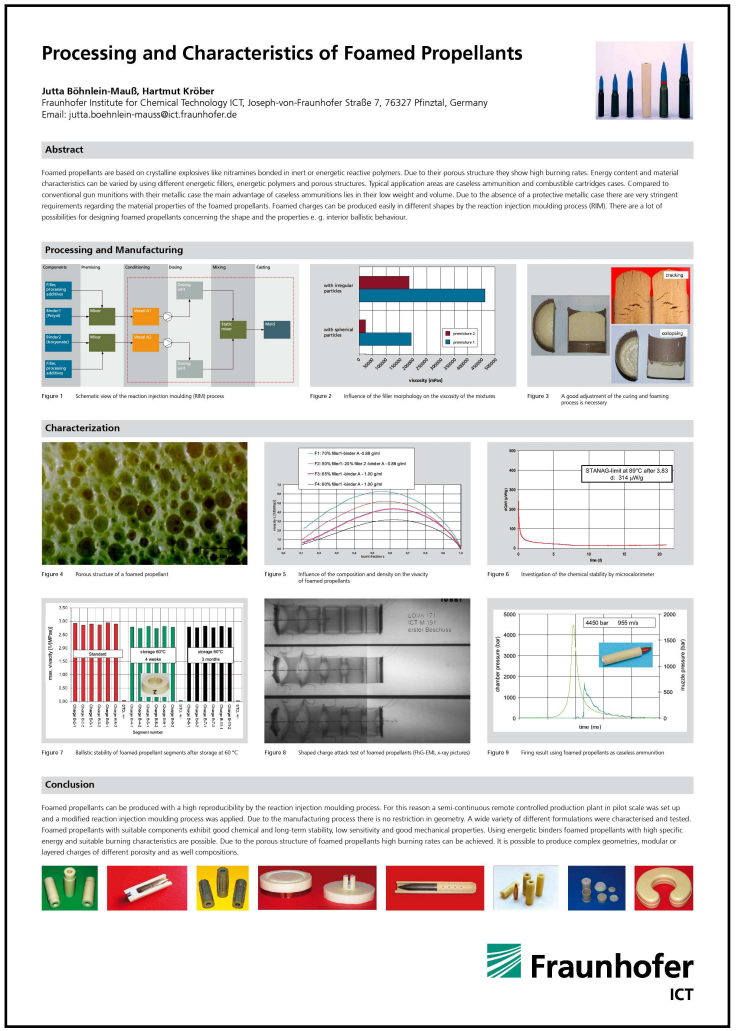
- Caseless ammunition and combustible cartridge cases are an interesting alternative for conventional ammunition with metallic casing in the small and middle caliber range.

- ICT is developing foamed propellants for this reason. A wide variety of different formulations were characterized. There is no restriction in geometry due to the reaction injection moulding process.

- Additionally it is possible to produce modular or layered charges with different composition or density. Fixing of ammunition components by surrounding foam is also possible.

Processing and Characteristics of Foamed Propellants

Please come to the poster!



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Jutta Böhnlein-Mauß, Hartmut Kröber
Fraunhofer Institute for Chemical Technology ICT, Joseph-von-Fraunhofer Straße 7, 76327 Pfinztal, Germany
Email: jutta.boehnlein-mauss@ict.fraunhofer.de

Abstract

Foamed propellants are based on crystalline explosives like nitramines bonded in inert or energetic reactive polymers. Due to their porous structure they show high burning rates. Energy content and material characteristics can be varied by using different energetic fillers, energetic polymers and porous structures. Typical application areas are caseless ammunition and combustible cartridges cases. Compared to conventional gun munitions with their metallic case the main advantage of caseless ammunitions lies in their low weight and volume. Due to the absence of a protective metallic case there are very stringent requirements regarding the material properties of the foamed propellants. Foamed charges can be produced easily in different shapes by the reaction injection moulding process (RIM). There are a lot of possibilities for designing foamed propellants concerning the shape and the properties e. g. interior ballistic behaviour.

Processing and Manufacturing

Figure 1 Schematic view of the reaction injection moulding (RIM) process

Figure 2 Influence of the filler morphology on the viscosity of the mixtures

Figure 3 A good adjustment of the curing and foaming process is necessary

Characterization

Figure 4 Porous structure of a foamed propellant

Figure 5 Influence of the composition and density on the vivacity of foamed propellants

Figure 6 Investigation of the chemical stability by microcalorimeter

Figure 7 Ballistic stability of foamed propellant segments after storage at 60 °C

Figure 8 Shaped charge attack test of foamed propellants (FHG-EMI, x-ray pictures)

Figure 9 Firing result using foamed propellants as caseless ammunition

Conclusion

Foamed propellants can be produced with a high reproducibility by the reaction injection moulding process. For this reason a semi-continuous remote controlled production plant in pilot scale was set up and a modified reaction injection moulding process was applied. Due to the manufacturing process there is no restriction in geometry. A wide variety of different formulations were characterised and tested. Foamed propellants with suitable components exhibit good chemical and long-term stability, low sensitivity and good mechanical properties. Using energetic binders foamed propellants with high specific energy and suitable burning characteristics are possible. Due to the porous structure of foamed propellants high burning rates can be achieved. It is possible to produce complex geometries, modular or layered charges of different porosity and as well compositions.

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