Solid Rocket Motors with Particle-Free Composite Propellant at Bayern-Chemie

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Solid Rocket Motors with Particle-Free Composite Propellant at Bayern-Chemie

Outline

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- Particle-Free APC Composite Solid Propellants
- Particle-Free AN Composite Solid Propellants
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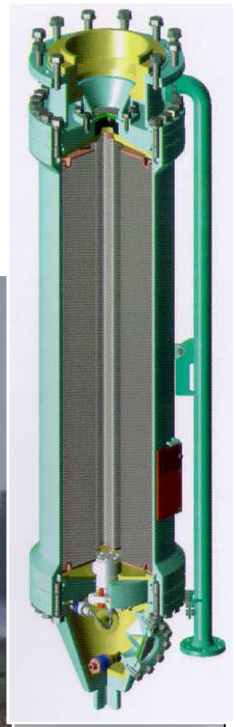
SRM with Particle-Free Composite Propellant at BC
BC Activities - Overview



+ Cross-functional capabilities: testing, hazard analysis, life time analysis, material analysis, thermal management, thermal insulation materials

SRM with Particle-Free Composite Propellant at BC
Introduction (1/3)

Solid propellant families:

- Double-Base Propellants (homogene, derived from gunpowder technology):
  - Smoke-free exhaust
  - Shortcomings in mechanical properties and temperature range
  - Limited specific impulse (I_{spec})
- Composite Propellants:
  - Good mechanical properties and temperature range
  - High I_{spec} with oxidizer APC and Aluminum content
  - Low burning rate and low I_{spec} with oxidizer AN

For specific military applications particle-free propellants are mandatory

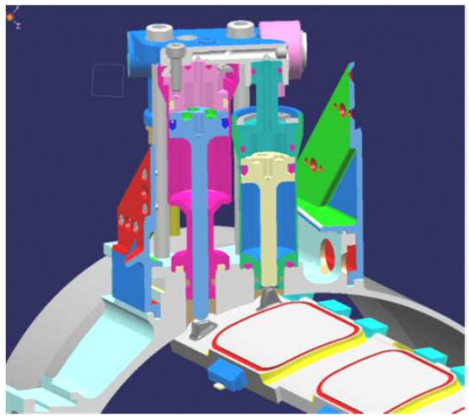
The trend turns towards particle-free composite propellants

SRM with Particle-Free Composite Propellant at BC
Introduction (2/3)

RESI: Particle-free Composite Propellants with oxidizer APC:

- Development of RESI propellant family started in late 1980´s

- RESI 166 used in:
  - VT-1 missile motor
    - R+D 1998-2003
    - Series production of 730 motors 2003 – 2007
  - A-400 M test airplane deep stall recovery system motor (2007 – 2008)
  - Solid rocket motors for GER Insensitive Munitions Program (2005 – 2015)



- RESI 172 used in Meteor pyrotechnical devices:
  - R+D 2003-2012
  - Production of > 2.000 propulsion systems 2012 – 2020f

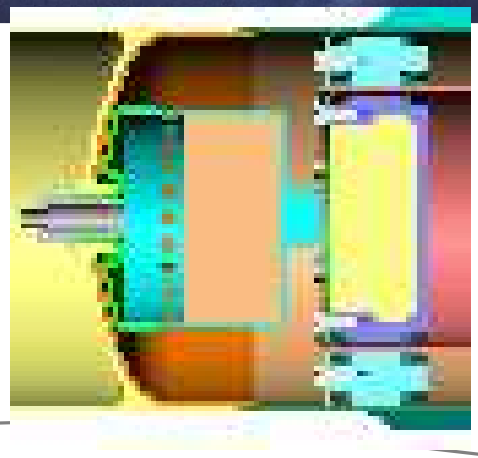
SRM with Particle-Free Composite Propellant at BC
Introduction (3/3)

Particle-free composite propellants with oxidizer AN:

- NB 410 340 for gas generator (GG) for Aspide missile.
  - R+D 1991-1994
  - Production > 1.000 GG 1994 – 2015f
- NB 410 195 for GG for Sidewinder missile:
  - D 1996-1997
  - Production > 10.000 GG 1997 – 2015f

Particle-free composite propellants with oxidizer AN + APC:

- Used in triple-grain GG for tank pressurization of gelled propellant rocket motor flight demonstrator
  - R+T 2005-2008
  - 2 flight demos 2009



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SRM with Particle-Free Composite Propellant at BC
Particle-free Composite Propellants with Oxidizer APC (1/2)

Fully qualified for MIL series production (RESI 166 and RESI 172):

- No significant impact of 6 mo. artificial ageing @ 60 °C on
  - Chemical stability
  - Sensitivity and ignitability
  - Mechanical properties and glass transition point
  - Ballistic properties

- RESI 166 propellant, 10,5 yr. artificially aged @ 62 °C (>10^2 yr. at 20 °C) had similar properties as new propellant, only the elongation at deep temperatures is a little bit under the limit
- VT-1 propellant grain qualification covers a life time of 16 yr.
- Meteor propellant grain qualification covers a life time of 12,5 yr.

SRM with Particle-Free Composite Propellant at BC
Particle-free Composite Propellants with Oxidizer APC (2/2)

Key properties of existing RESI propellants:

- Burning rate: 12 – 17 mm/s @ p = 10 MPa and T = 20 °C
- Burning rate exponent: n ≅ 0,25-0,50
- Density: ρ ≅ 1700 kg/m^3
- Specific Impulse:
  - I_{spec} ≅ 2280 - 2420 m/s @ p_c/p_e = 70
  - $I_{spec,vac}$ ≅ 2800 m/s @ p_c/p_e = ∞ ; A_e/A^* = 100

SRM with Particle-Free Composite Propellant at BC
Particle-free Composite Propellants with Oxidizer AN (1/2)

Fully qualified for MIL series NB 410 340 and NB 410 195:

- No significant impact of artificial ageing for 6 mo. @ 60 °C on
  - Chemical stability
  - Sensitivity and ignitability
  - Mechanical properties and glass transition point
  - Ballistic properties
- Aspide and Sidewinder propellant grain qualification cover life times of 16 and 18 years.

SRM with Particle-Free Composite Propellant at BC
Particle-free Composite Propellants with Oxidizer AN (2/2)

Key properties of existing NB 410 propellants:

- Burning rate: 2 – 4 mm/s @ p = 10 MPa and T = 20 °C
- Burning rate exponent: n ≅ 0,30 - 0,45
- Density: $\rho \cong 1450 - 1520\ kg/m^3$
- Specific Impulse:
  - $I_{spec} \cong 1930\ m/s\ @\ p_c/p_e = 70$
  - $I_{spec,vac} \cong 2350\ m/s\ @\ p_c/p_e = \infty\ ;\ A_e/A^* = 100$

SRM with Particle-Free Composite Propellant at BC
Particle-free Composite Propellants with Oxidizer AN+APC

Used as GG propellant for pressurization of GRM demo motor tank

Oxidizer blends:

- AN: 55 – 80 %
- APC: 0 – 30 %
- + other ingredients

Key properties of existing AN+APC propellants:

- Burning rate: 1 – 8 mm/s @ p = 10 MPa and T = 20 °C
- Burning rate exponent: n ≅ 0,3 – 0,4
- Density: ρ ≅ 1450 – 1570 kg/m^3
- Specific Impulse:
  - I_{spec} ≅ 2050 m/s @ p_c/p_e = 70
  - $I_{spec,vac}$ ≅ 2500 m/s @ p_c/p_e = ∞ ; A_e/A^* = 100

SRM with Particle-Free Composite Propellant at BC
Summary

BC has a long and verified heritage in Al-free and particle-free solid composite propellants

The engineering and design experience encompasses topics like

- Acoustic instability
- Additives
- Thermal insulation materials

BC has verified methods to define mass optimum solutions w.r.t.

- Structural mass
- Mass of thermal insulation
- Number of SRM

dependent o requirements and design features