A new facility, based on Twin Screw Mixer for high energy propellants

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Summary of the presentation

1 – Historical Review of Continuous Process Development at SNPE

2 - Overview of Continuous Mass Production of Extruded Composite Propellant (ECP) for Automotive Safety

3 – What we have learnt from CPOCP program [Joint Program between SNPE and NSWC/IH Div]

4 – The New Pilot - Plant Unit for NEPE Propellants

5 - Conclusion

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Continuous Process Development at SNPE

- During the 80's, an important program has been carried out by SNPE. With selected universities and potential industrial partners, all the phases of the process have been studied:
  - **Feeding**
  - **Mixing and De-aeration**
  - **Continuous Quality Control**
  - **Extrusion and Casting**

- Objective: to make a rupture in the industrial process

  – JM Tauzia "Some Comments on Processing Energetics Materials", Invited Paper, ADPA, Arlington, VA, 1989

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Continuous Process Development at SNPE

80's → **90's** → 00's

- In the 90's, several industrial production lines have been implemented:
  - 1992: solventless Extruded Double Base propellants (SNPE - Bordeaux)
  - 1996: Extruded Composite Propellants for airbags (SNPE - Bordeaux)
  - 1997: Gun Propellant for sport and hunting (300 t / year at Pont de Buis)
- 1994-2000: Continuous Processing Of Composite Propellants (CPOCP)
  - Common R&D effort between US DoD and DGA (French MOD)
  - Joint NSWC-IH/SNPE Project
- 1998-2000: Research and demonstration done in SNPE Research Center (CRB) of use of Continuous Process to produce advanced energetic propellants

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Continuous Process Optimization at SNPE

80's → 90's → 00's

- Process reliability increase
- Large mass production of ECP for Automotive Safety applications (airbags) : 3 production lines in 3 shifts.
- Industrial scale demonstration of continuous mixing for composite propellant with 1.1 ingredients (advanced energetic propellants)
- Evaluation for space launcher boosters production – in progress

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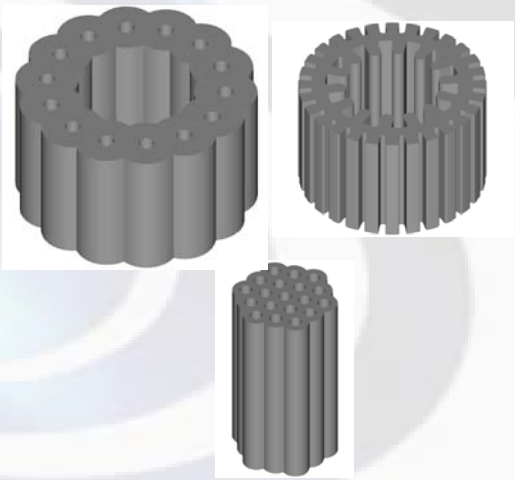
Twin Screw Continuous Process for Automotive Safety

Automotive safety requirements (airbag gas generator):

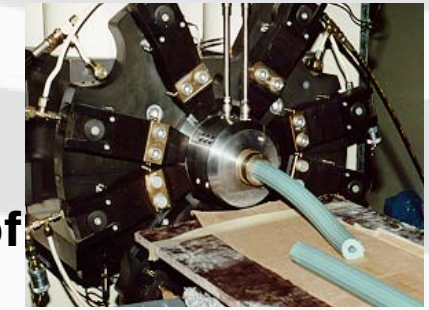
CONTINUOUS MIXING PROCESS

- **High production rate**
- **Reproducibility, flexibility**
- **Low cost**



- **Small free standing grains** (4 - 40 g)
- **A specific shape for each type of gas generator**

EXTRUSION PROCESS



2,500 tons of composite propellant giving **250 millions of gas generators** have been produced with the continuous process at SNPE in the last 10 years (1995-2005)

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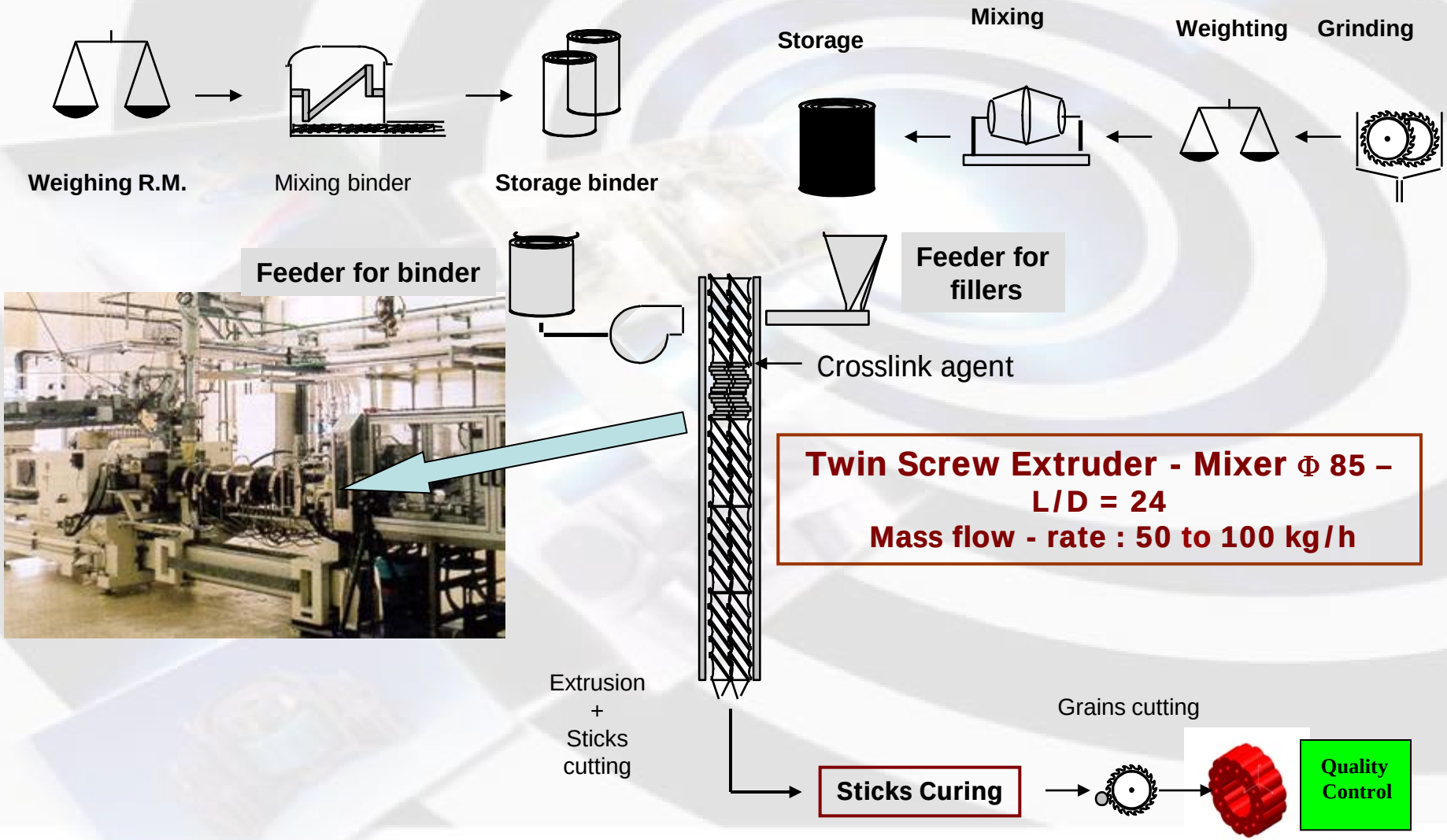
Twin Screw Continuous Process for Automotiv Security



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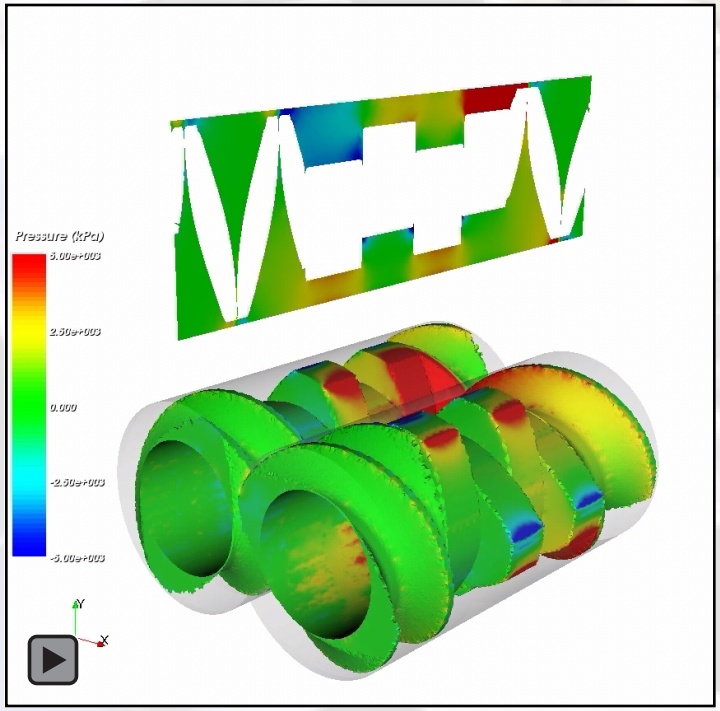
SNPE Numerical Simulation Capability

A full numerical simulation capability has been developed at SNPE for designing screw - profile and extrusion - die

<u>An example of simulation in the mixing part</u>

Collaboration with “Ecole des Mines de Paris”



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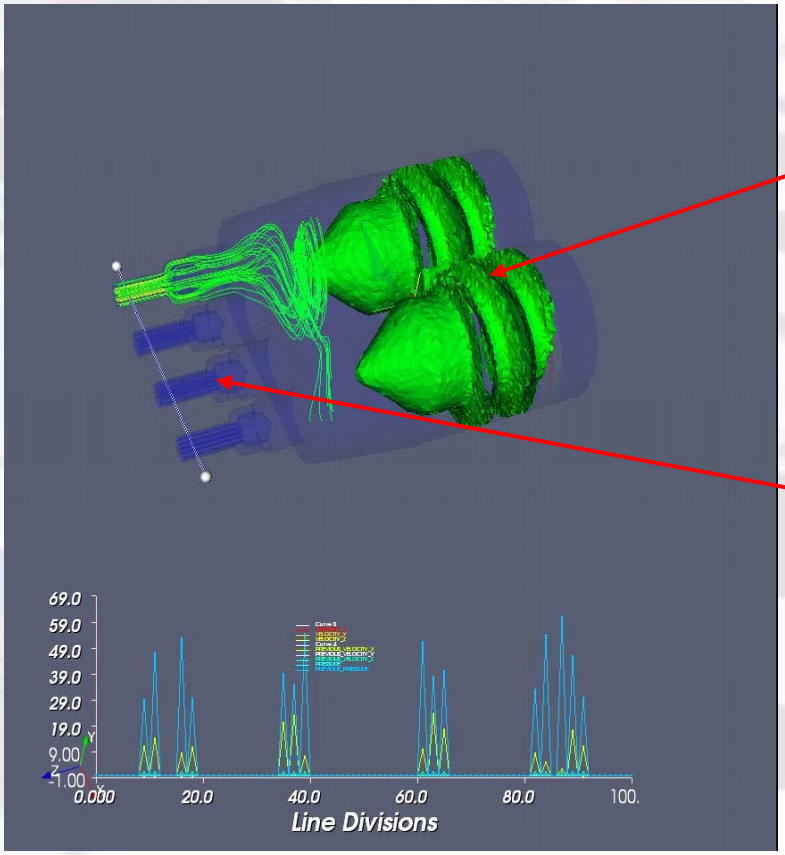
SNPE Mathematical Simulation Capability

An example of simulation in the extrusion part



Twin-screw

Multiple extrusion die

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Demonstration program : CPOCP

- Collaboration between SNPE and NSWC/IH Div :
- Objective : to demonstrate the capacity of TSE to manufacture in one week :
  - Extruded composite rocket motors
  - Composite casted rocket motors

- Trials done (1995/2000) by SNPE :
  - Saint Medard Pilot Plant at industrial scale : TSE (85mm in diameter) used at 60 kg/h

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Demonstration program : CPOCP

Extruded Composite Propellant Grains – NSWC/IH Formulation

(Test at SNPE)

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Demonstration program : CPOCP

Continuous casting process - SNPE Formulation (tests at SNPE)

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Demonstration program : CPOCP

- **Lessons learnt from this demonstration on live composite propellant:**
  - Metering and feeding continuously, in accordance with the requirements in term of accuracy of propellant formulation, is possible.
  - Mixing in a twin-screw has the same efficiency than in large vertical mixers even though the residence-time is quite shorter.
  - It is possible to de-aerate the paste in the twin-screw (vacuum)
  - Heat exchanges are more efficient in twin-screws than in large mixers
  - Versatility and reproducibility have been demonstrated

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Continuous Process for Advanced Energetic Propellant

- **Reasons why we have chosen TSE technology**
  - Hazards are greatly reduced if a few quantity of propellant is mixed at the same time
  - So, TSE technology offers safety advantages for advanced energetics made with 1.1 ingredients
  - Mixing advanced energetic propellant using TSE was studied at SNPE Research Center [CRB] in the 90's on the base of minimum smoke XLDB and GAP propellants : tests gave good results.

Continuous Process for Advanced Energetic Propellant

- **Reasons for the building of a new facility at SNPE**
  - Need to have, in a near future, an industrial production capability for advanced energetic propellants
  - Need to produce advanced energetic propellant at a reduced cost

This R&D program has been well supported by DGA

- **Specifications of the plant**
  - Able to produce propellants with 1.1 ingredients: RDX, HMX and nitrate ester plasticizers
  - Scale 1 pilot able to be upgraded into an industrial facility
  - Meeting safety and environmental requirements

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SNPE new facility for demonstration purposes

Milestones of the project

2001 : Beginning of the project - co-funded by SME and DGA

2003/2004 : Phase 1 building

2005 : First live grains manufactured

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SNPE new facility for demonstration purposes

Overview of CPA shop (Continuous Process for Advanced propellants)

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SNPE new facility for demonstration purposes

Overview of CPA shop (Continuous Process for Advanced propellants)

LIW Feeders

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SNPE new facility for demonstration purposes

Challenge:

- Metering and feeding different raw materials sensitive to friction

- Metering and feeding liquid suspension (binder containing solid particles)

- Preventing feeders and cast grains from pyrotechnic event in the twin screw mixer

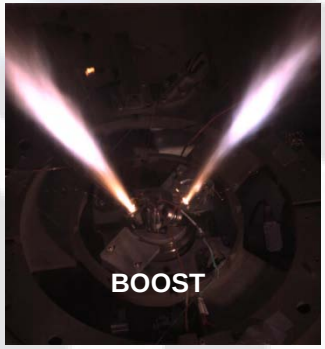
- Preventing external environment from pyrotechnic event (particularly DDT hazard)

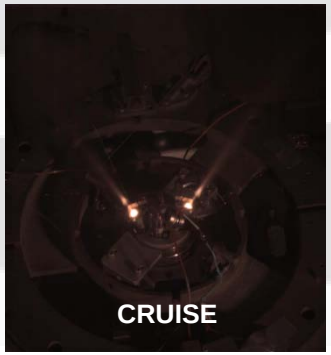
SNPE new facility for demonstration purposes

Examples of propellant grains achieved

Prototype motor with OXALITE® propellant (60kg/motor)

DIABOLO Grain with AZAMITE ® Propellant (6 kg/motor)





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SNPE new facility for demonstration purposes

- The following items validation are in progress :
  - Maximum flow rate that can be reached with a castable propellant
  - Direct casting from the twin screw
  - On line quality control of the paste

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Conclusion

- The common use of contnuous process for the manufacturing of composite propellant results from an historical evolution of processes
- A new pilot facility has been built at SNPE Bordeaux for demonstration purposes with 1.1 ingredients and many runs have been done
- Work is in progress for increasing Continuous Process Technology Readiness Level [TRL] to produce Advanced Energetic Propellants
- Evolutions of this capability are planned in order to ensure production of high performance motors in a near future, with additional equipments, upstream and downstream the twin-screw.

Thank you for your attention

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