PROGRESS FOR THE CEA ALFA PROJECT

Atalante Laboratory For Actinides bearing fuel manufacturing

B. Boullis, M. Boidron, C. Brenneis, F. Jorion, L. Donnet, P. Dehaudt, H. Lagrave
CONTENT

1. Context
2. Atalante facility
3. Main goals for the project
4. Fuel fabrication targets
5. Fabrication process
6. Required shielded lines
7. Progress of design studies
8. Global roadmap
1. CONTEXT OF THE PROJECT

- The 1991 and 2006 French acts: frame of the program

- Three Research thematics for nuclear waste management:
  - partitioning and transmutation of MA
  - geological deep repository
  - confinement and interim storage

- A “roadmap”:
  - 2012: industrial potentialities of the diverse Partitioning and MA transmutation options,
  - 2015: repository defined, and operation by 2025
2. ATALANTE FACILITY PRESENTATION

I – Actinide and Fission Product basic chemistry

II – Fuel dissolution

III – New extractants

IV – Partitioning processes

V – Conversion processes

VI – Actinide compound synthesis

VII – Conditioning, Long term behavior

VIII – Analyses
3. MAIN GOALS

- **Produce minor actinides pins for MA bearing fuels development**
  - Irradiation program in ASTRID reactor (Advanced Sodium Technological Reactor for Industrial Demonstration) or through international collaborations.

- **Different steps for the fuel qualification:**

  1: fuel design / specifications
  
  2: feasibility: in pile behavior for specifications validation at material scale
  
  3: optimization: validation of technological options at pin scale
  
  4: qualification: full demonstration at assembly scale

Theoretical studies for fuel definition

**ATALANTE TODAY**
Few pellets ($^{238}$Pu, Am, Cm…)
100 g fuel oxyde / year
~ 10 g MA

**ALFA**
Few pins
1 Kg to 5 Kg / year
~ hundred g MA

Pre industrial facility
Few assemblies / year
~ tens Kg MA
3. MAIN GOALS

• A full demonstration of treatment and (re) fabrication:
  - Pellets fabrication
  - Capsule assembling
  - Reception of irradiated fuel
  - Fuel treatment
  - Conversion
  - Separation and purification
  - Minor Actinides supplying

• Flexible fabrication capacity / short production time (a few months)
• Prefigure the (pre) industrial scale (process, production capacity…)
• A demonstration for **innovative processes** and **technologies**
4- FUEL FABRICATION TARGETS

- **Fuel composition:** (AM = all actinides /Am alone)
  - **MABF**
    - Minor actinides bearing fuel
    - Homogeneous mode
    - U = ~ 80%; Pu = ~ 15%; MA = 1 to 5%
  - **MABB**
    - Minor actinides bearing blanket
    - Heterogeneous mode
    - U = 70 to 90%; MA = 10 to 20%

- **Fuel pellets and pins specifications for ASTRID:**

<table>
<thead>
<tr>
<th>Pin</th>
<th>Fissile column</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>~ 2400 mm</td>
</tr>
<tr>
<td>Diameter</td>
<td>~ 8 mm</td>
</tr>
<tr>
<td>Pellets</td>
<td>~ 100</td>
</tr>
<tr>
<td>Mass</td>
<td>~ 400 g</td>
</tr>
<tr>
<td>Pellets characteristics</td>
<td>Φ ~ 7 mm, h = 10 mm, M ~ 5 g</td>
</tr>
</tbody>
</table>
5. FABRICATION PROCESS

- The selection of the appropriated process must take into account:
  - MA specific constraints (high activity/thermal effects/radiolysis…)
  - Suitable technology regarding exploitation and maintenance for hot cell operation
  - Industrial extrapolation
  - Various products (according to reactors specifications)
  - Management of waste and by-product

♩ ALFA is tightly linked to two main R&D programs:

1. R&D for process qualification

2. R&D for technological development:
   - Process equipments adaptation for hot cell environment
   - Innovative hot cells architectures
5. FABRICATION PROCESS

• **On going R&D programs main goals:**
  
  • demonstrate the MA’s fuel fabrication process control at laboratory scale:
    • Heterogeneous fuel (high Ma’s concentration)
    • Fuel specifications achievement
  
  • determine the critical paths in the process
  
  • identify and evaluate alternative routes to assess the advantages in term of process simplifications (co-converted powder)
  
  • develop and test innovative technologies
  
  • evaluate the extrapolation at pilot and industrial scale
5. FABRICATION PROCESS

• The functions to fulfill:
  • The MA separation
  • The MA solutions preparation
  • The conversion
  • The pellets fabrication
  • The pins fabrication
5. FABRICATION PROCESS

- **Conversion**: different routes already under development (ATALANTE Radiochemistry and processes department):
  - Oxalic co-precipitation + thermal treatment
  - Co-immobilisation in ion exchange resins
  - With significant achievements for MA

- Sol-Gel + Thermal Treatment (European program)
- Thermal denitration
5. FABRICATION PROCESS

• **Fabrication:** different routes under evaluation (short to long term):
  - **Standard Powder metallurgy**
  - Significant achievements for experimental irradiations

• **Simplified Powder metallurgy:**
  - Function of powder and spheres characteristics

• **Spherepac**

• **Process adaptation during facility lifetime**
6. REQUIRED SHIELDED LINES FOR ALFA

- Extension
  - Pins fabrication
  - Pellets fabrication

- Characterisations
  - LNO
  - Capsule assembling

- Conversion
- Separation and purification
  - Minor actinides supplying

- Irradiated fuel reception
- Treatment

- ASTRID

- ATALANTE
  - ATALANTE C 16
  - ATALANTE CBP

- Empty existing laboratory
- Existing laboratories and shielded cells
- Facility to build
7. PROGRESS OF DESIGN STUDIES

- **The first design**: a fabrication line based on well known PWR/SFR MOX fabrication process

- Including some innovations still under evaluation
  - Shuttle for rapid reconfiguration and maintenance of critical equipment
  - Automatic remote handling / robots
7. PROGRESS OF DESIGN STUDIES

- Implementation studies in existing laboratories for the chemical process:
  - a 19m long shielded line and a 10 glove boxes lab.

- Design studies of the new building devoted to fabrication process:
  - 41m x 30.7m x 13.7m(H) 21 000m³
  - 4 levels
  - 11 shielded cells / 40m long / 270 m³
  - Up to date safety requirements
  - Connected to the existing ATALANTE design facility
7. PROGRESS OF DESIGN STUDIES

• To continue the studies in order to:
  
  • Consolidate the design:
    • Innovations, safety requirements…
  
  • Assess the impact of different processes on the design

• Optimize the investment cost
8- GLOBAL ROADMAP FOR LONG TERM INVESTMENT PLAN

Feasability studies

2009

Preliminary design

2010

detailed design

2011

Starting production

2012

Rendez-vous

2013

If decision to go on with the project

2014

2016

> 2024
9. CONCLUSION

- ALFA project calls for the construction of an experimental high activity fuel fabrication facility at a significant scale: ASTRID prototype.

- ALFA will be able to produce various MA bearing fuel and blanket types.

- This new fabrication line will be opened to international collaboration.