Process for Incineration and Vitrification In-Can

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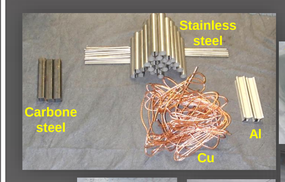
Context :

The PIVIC process (Process for Incineration and Vitrification In Can) has been studied as a conditioning solution of wastes generated by nuclear fuel cycle industry and composed of variable mixtures. Following the commissioning of an inactive prototype in 2018 at the CEA R&D vitrification facility in Marcoule site, an R&D program has been carried out to provide proof of concept. This R&D collaborative project, conducted with Orano, CEA and Andra, was supported by the French government program "Programme d'Investissements d'Avenir". This poster intends to describe the key features of the PIVIC process, and to present some scientific and technical issues as well as the main results and achievements obtained after 4 year of tests and developments.



Metal

Ceramics (4%)
Organics (46%)
Metals (50%)

Organic

Media

PuO_2 boxes

High waste variability

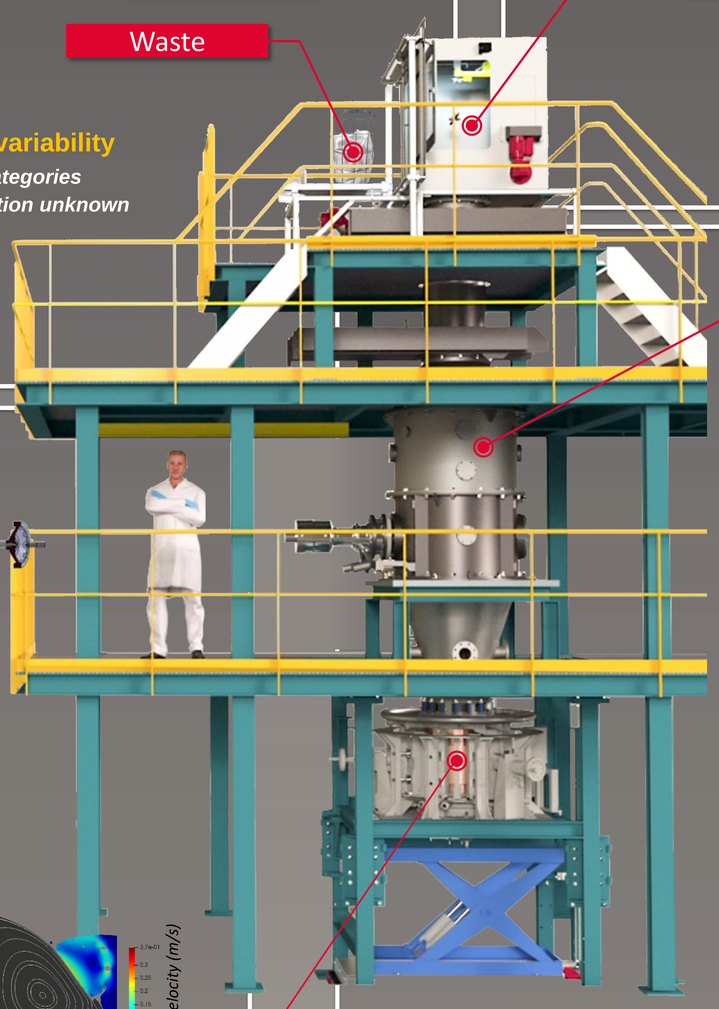
- *4 waste categories*
- *Exact composition unknown*

Direct feeding without pre-processing

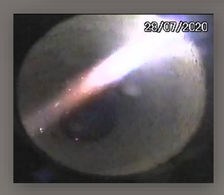
- *Transfer of the waste from the drum to a consumable vehicle*
- *Basket attached to a gripping device*
- *Cable connected to a load cell for mass monitoring*
- *Gradual lowering of the load into the reactor*

Introduction chamber
AND AIRLOCK

Waste

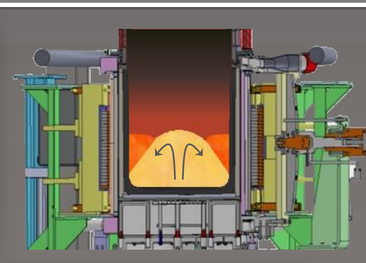


Combustion chamber



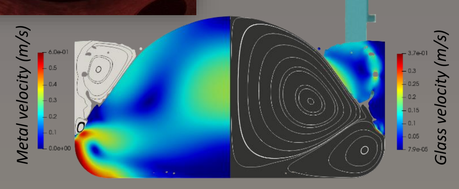
Low frequency induction melting

- *Biphasic system*
- *Power deposited in the metallic phase*
- *Electromagnetic stirring*
- *No stirring device*



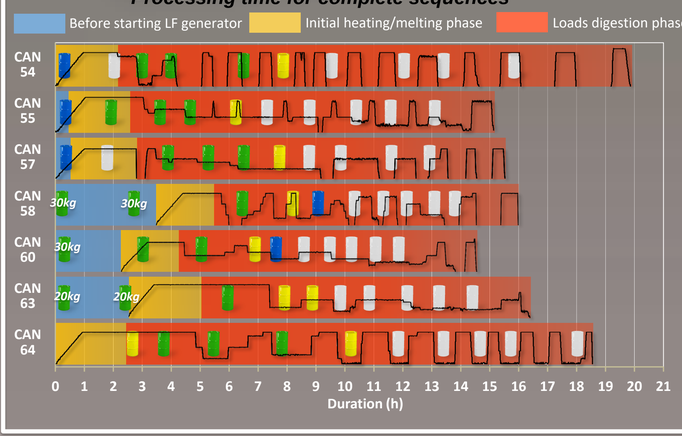
In Can metling

- *The crucible is the container*
- *No casting system*
- *Immobilisation of alpha nuclides in the glass melt*



Melting furnace
BIPHASIC GLASS/METAL FUSION

Processing time for complete sequences

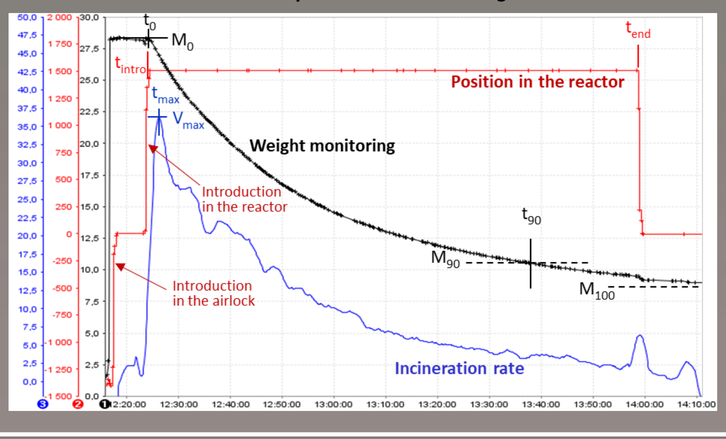


Main R&D achievements

Demonstration of the complete processing of a representative sequence (10 baskets) with :

- *single piloting mode for all types of waste*
- *global processing rate of 15-16kg/h*
- *automatic deposit of the baskets in the melting fusion*
- *Al incorporation up to 12kg in a can*
- *use of a unique vitrification adjuvant*
- *can endurance proven up to 25 hours*

Incineration parameters monitoring

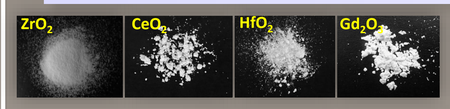


Oxygen plasma assisted combustion

- *Destruction of organic materials*
- *Reduction of gas production (TG size reduction)*
- *Water-cooled metal walls*
- *Internal afterburner*

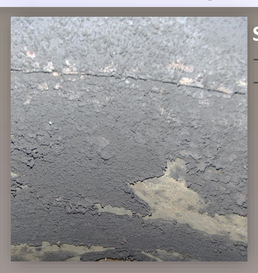
Radiological deposition rate on reactor wall

The input wastes contain alpha emitter radionuclides (mainly Pu as oxide powders) → The PuO_2 hold-up in the reactor must be monitored for safety operation (H_2O and CH_2 moderated system) → Measurement of the deposition rate is required to assess the impact on global operating time



Loads preparation
-Surrogate (nature/ amount)
-Introduction mode

Inactive tests
→ Use of PuO_2 surrogates for the prototype tests (ZrO_2, HfO_2, CeO_2, Gd_2O_3)
→ Collection of deposits samples on reactor wall
→ Chemical analysis (surrogate concentration)
→ Experimental retention rate

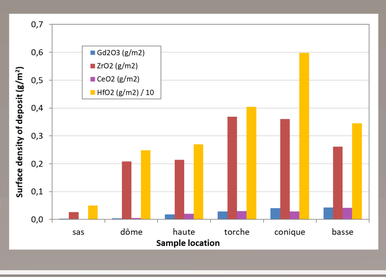


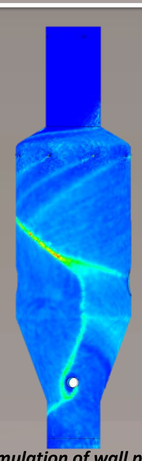
Sampling
-Wall examination
-Samples collection (local→integral)

$$\tau_{\%} = 100 \times \frac{M_{Pu}^{wall}}{M_{Pu}^{waste}}$$

Analysis
-Drying (humidity level)
-Chemical analysis

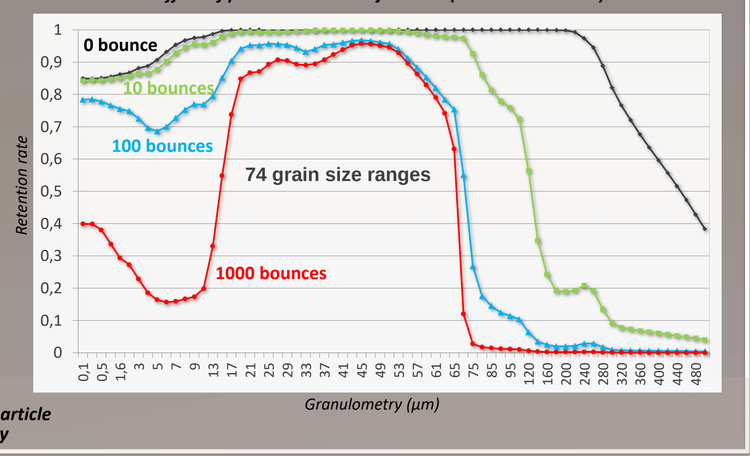
Retention rate < 1%





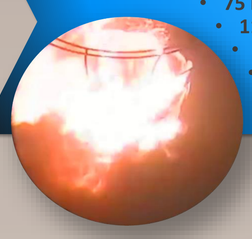
Simulation of wall particle impacts density

Effect of particle size on trajectories (simulation results)

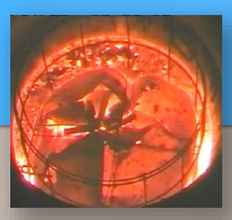


13 test campaigns carried out on the prototype over 4 years of operation

214 incinerated baskets
2363 kg of organic materials
- 75 M&D
- 119 Organics
- 7 PuO_2 boxes
- 13 Media



84 deposited and digested baskets
1768 kg of metal (including 108 kg of Aluminium)
- 71 M&D
- 49 Organics
- 6 PuO_2 boxes
- 12 Media



28 elaborated cans

Summary

- No pre-treatment (neither sorting nor crushing)
- Possible compatibility with waste variability
- Organic fraction of the waste totally incinerated
- Conditioning of the activity in a stable vitreous matrix
- Waste volume reduction (up to 10 x 120L drums → 1 can)