Andra Call for Projects
with the support of the
Investments for the Future Programme

SCELLMA

SEALING ceramic overpacks by plasma torch

Project supported by Andra under the "Investments for the Future Programme" ("Investissement d'Avenir") - Selected under the Andra Call for Projects: "Optimisation of post-dismantling radioactive waste management", organised in cooperation with the French National Research Agency (ANR).

Duration:
46 months

Project launch:
03/2017

Total project cost: €1.87 million

Including funding under the Investments for the Future Programme: €860,000

Type of financial support:
Subsidy with ROI guarantees for the State

Locations:
Limoges, Azerables, Schiltigheim

Coordinator: Institut de Recherche sur les Céramiques (IRCER), Université de Limoges

Partners:
- Institut de Recherche sur les Céramiques (IRCER) - Université de Limoges
- Porcelaines Pierre Arquié (PPA)
- Traitements Composites Poudres et Process (TCPP)
- CETIM Grand Est
- **Certification**: Nuclear Valley

Contacts: Alain DENOIRJEAN,
alain denoirjean@unilim.fr

BACKGROUND

High-level waste (HLW) is mainly made up of materials which, following reprocessing of spent fuel from nuclear power plants, cannot be re-used. The radioactive elements contained in this waste are currently confined in a glass matrix poured into stainless steel drums to form "primary waste packages". After a period in storage to allow the waste to cool, these primary packages will be conditioned in disposal containers (overpacks) before eventual disposal in the The Industrial Centre for Geological Disposal (Cigeo), currently at the project stage. These containers must protect the vitrified HLW from coming into contact with water during the thermal phase, i.e. until the temperature of the glass has decreased to between 70°C and 50°C. This function means that the disposal containers must remain watertight for around 500 years. The current option is to use a non-alloy steel for the disposal containers (Fig.1). However, corrosion in these metal containers under geological disposal conditions (anoxic conditions) can generate significant releases of hydrogen, a gas which, above a certain quantity, can present a risk of explosion in the presence of oxygen.

Fig. 1: Diagram of a steel disposal overpack containing a primary package of vitrified waste.

Since 2007, Andra has been studying the feasibility of using ceramic disposal containers, as an alternative to the use of metal. Advances have demonstrated the feasibility of making the container body and lid at half-scale (height) of 4 cm-thick aluminosilicate porcelain (Fig.2). The technological challenge regarding these new containers remains the method used to close the system (to seal the container body and lid together) at a temperature moderate enough to prevent damage to the primary package.

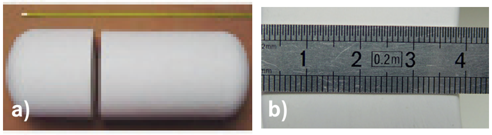

Fig. 2: a) Container at half-scale height;
b) and full-scale thickness

OBJECTIVES

The aim of the SCELLMA project is to develop a sealing process for these ceramic disposal containers using thermal plasma technology (Fig.3). The objective is to assemble two parts made of thick ceramic, the container body and lid, ensuring the whole is watertight and durable. This entails:

- defining and optimising the most suitable geometric specifications (shape, design, dimensions, etc.) to test the seal zone;
- assessing the end properties of the assembly, particularly for watertightness, resistance to leaching, and the impact on its mechanical properties of heating the assembly during the sealing process (modelling and instrumented tests);
- sealing the two ceramic parts together (laboratory scale) as per Andra's specifications, and performing the sealing process on a demonstration container that will be half-scale in height and full-scale in thickness.

SCELLMA: SEALING ceramic overpacks by plasMA TORCH

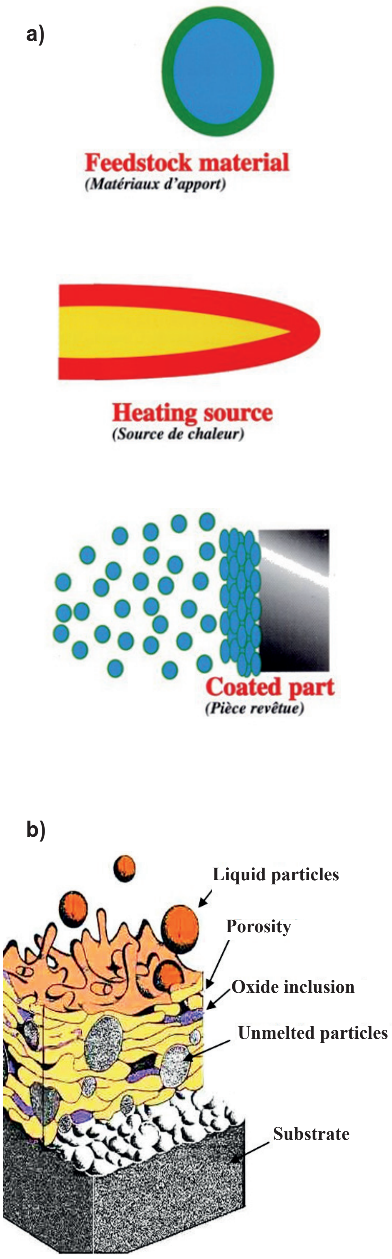

Fig. 3: Thermal plasma spraying: a) Principle; b) Microstructure of feedstock deposition.

PROJECT SEQUENCE

The SCELLMA project will run for 46 months. The aim of the first phase is to optimise the seal zone design for ceramic containers. This involves developing the feedstock material used for the seal, as well as specifying the geometry of the heat treatment zone to ensure a) the reproducibility of the operation to seal the lid to the body of the container, and b) the application or insertion of the sealing material.

The composition of the sealing material is a particular focus of this phase. It could be a commercially-available product or a composite developed specifically for this application. The sealing material will need to be adjusted to ensure that it has very similar properties to ceramic, especially in terms of watertightness.

The SCELLMA project will also identify the optimal technique, in terms of its behaviour at high temperature, to be used for applying the sealing material using a plasma torch: spraying the feedstock or pre-deposition in the joint to be sealed.

Initial in-laboratory tests will be carried out to test the sealing processes on small-scale specimens. A pilot facility will then be developed and instrumented to study the different process parameters and the different feedstock materials defined at the earlier stage.

Thermoelastic modelling of the systems will also be carried out to better understand how these types of components behave at high temperature.

It may be necessary to develop torches designed specifically for this application, integrating positioning of the container to be sealed in a specific tool, and ensuring better heat distribution across the exposed zone than is usual with a conventional torch.

The final stage of the project will involve producing a demonstrator, including the production of a ceramic container of half-scale height and full-scale thickness, implementing the most appropriate interface geometry, and sealed using the feedstock selected and the optimised plasma torch protocol. A system designed to perform the sealing operation on the demonstrator containers will therefore be constructed toward the end of the project.

EXPECTED RESULTS

Innovation

The key innovation in this project is the use of a blown arc plasma spray torch, normally used to spray feedstock onto a surface at low temperature, to weld a seal, i.e. to melt and mix the material used to form the seal and the material used to make the container to be sealed.

Economic impact

The SCELLMA project is based on the expertise of SMEs involved in the project to make the ceramic container (PPA) and to develop plasma processes at industrial scale (TCPP). It will enable these companies to expand their market in the area of radioactive waste management.

Impact on radioactive waste management

The SCELLMA project will further optimise HLW disposal facility design through the use of an inert ceramic container (that will not produce hydrogen, unlike metal containers), which is watertight and resistant to the mechanical stresses and constraints predicted throughout the facility's life cycle.

Impact on jobs

With this project, one person will be employed on a three-year contract. At the least, it will ensure that existing jobs at the SME involved will be maintained, and will probably create more jobs.

APPLICATION AND COMMERCIALISATION

Developing a method for sealing ceramic parts using a thermal plasma process will result in the creation of a range of watertight ceramic containers, midway between premium market containers made of silicon carbide (used to protect sensors in extreme environments) and the low-end mass market plastic containers (used to protect from dust, for example in ATEX environments). Such ceramic containers could prove particularly useful in applications requiring a containers sealed against fluid and dust ingress in an environment at high temperatures (1200-1300°C).