CERAMIC MATRIX COMPOSITES FOR LINER SYSTEM OF RADIOACTIVE WASTE DISPOSAL CELLS

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Key Words: CMC ; radioactive waste ; geological storage ; mechanical study ; numerical modeling

The Composite Ceramic Nuclear Liner project is part of the Cigéo project, a deep geological disposal facility for high-level and long-lived intermediate-level radioactive waste led by Andra, the French national agency for radioactive waste management. The concept of high level radioactive waste (HLW) disposal cells involves the installation of a liner consisting of a hollow cylinder inserted into a micro-tunnel dug into a clay formation (Fig. 1). The main function of the liner is to allow the emplacement and the potential recovery of the HLW packages, during the entire period of reversible operation of the facility, estimated to be 100 years. The current preferred solution is a steel liner. However, corrosion of metals under anoxic conditions is likely to generate hydrogen. Among the potential areas of development of the disposal facility, Andra is studying alternative materials to metals for the liner. On top of the mechanical requirements already met by the metallic solutions identified, the new materials must be chemically inert with respect to the vitrified waste and the host rock [2].

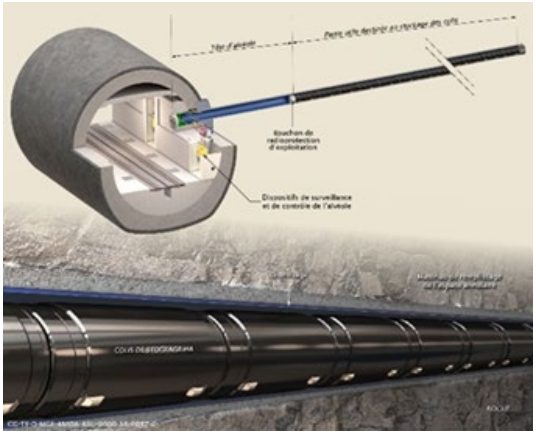

Figure1 the high-level waste repository concept [1]

The objective of the feasibility assessment was to remove the technological barriers associated with the use of ceramic matrix composites (CMC) for the lining of HLW cells. It is an innovative application for materials initially developed for extreme temperatures applications. The project was divided into three parts: (i) literature study and characterization of commercial materials; (ii) in-situ conditions definition and structural analysis; (iii) production of a prototype and pre-industrial implementation. In the first step a state of the art was established and CMCs that could potentially meet the specific requirements of the HL cell liner have been preselected. These materials were of different nature, both in terms of reinforcements and matrix : Oxide/Oxide ; Carbon/Geopolymer (PyroKarb) and Oxide/Geopolymer (PyroXide) produced by the Pyromeral company ; Carbon/Carbon produced by the company Mersen - AW252 long fibres 2.5 D, A202 long fibres 2 D and A015 short fibres. In the second phase, a mechanical study was carried out on these potential materials [3] leading to a design of the liner architecture. Finally, proofs of concept were manufactured in order to validate {material/process} pairs (see e.g. Fig.2).

Figure 2 : Proof of concept in PyroKarb made by filament winding

[1] ANDRA, « The Cigéo project». https://international.andra.fr/solutions-long-lived-waste/cigeo. .
[2] ANDRA, "30 years of scientific expertise at the service of the Cigéo project", https://international.andra.fr/30-years-scientific-expertise-service-cigeo-project .!
[3] AFNOR, French Standard on tensile testing of composite ceramics at ambient temperature, NF EN 658-1, nov. 1998.