

Priority Subjects — **Establishment of Optimal Risk Management**

Development of Long-Term Storage Management Technologies for Spent Fuel

Background and Objective

The interim storage of spent fuels generated from nuclear power plants until they are reprocessed is necessary. Furthermore, it is important to prepare for an increase in storage amount and an extended storage period. Many dry interim storage facilities using metal casks exist in countries around the world, including Japan. It is also necessary to evaluate the safety of post-storage transport, taking into account aging of the components during the storage period. The

early realization of interim storage facilities using concrete casks is demanded in Japan from an economical point of view.

In this project, we aim to develop an evaluation method for confinement of metal casks taking into account its aging. For the practical use of concrete cask technology, we aim to improve countermeasures for stress corrosion cracking and the investigation method for welding of canisters*1.

Main results

1 Development of an evaluation method for the long-term sealability of metal gaskets

To obtain the data necessary to validate the long-term sealability evaluation method of metal gaskets, we performed relaxation tests using test flanges with metal gaskets^[1]. The outer liner of the gasket is made of silver and we used gaskets with two different cross section diameters for

the tests. The results obtained from the data of 50,000 hours show that the residual linear load of the gasket and Larson-Miller parameter (LMP) have good correlation (Fig. 1). This development of the evaluation method contributes to the long-term storage of spent nuclear fuel.

2 Proposal of a draft revision for the Japan Society of Mechanical Engineers (JSME) concrete cask code

Defects may occur in the initial welding layer of the primary lid of the canister when the primary lid is welded under moist conditions. To understand the effects of moisture in welding, we performed a welding test. The results showed that unstable flow rate of back shield gas and insufficient oxygen control (less than 5%) lead to

the occurrence of obvious defects in the initial welding layer (Fig. 2). We made a revision draft for the JSME code regarding concrete casks*2 including our research results in 2013. The proposal of this draft revision contributes to practical use of concrete casks in Japan.

3 Development of prototype devices for remote measurement of salt attached to canisters

The measurement of salt attached to a canister is a promising inspection method for monitoring the occurrence of SCC at the surface of the canister during storage of spent fuel. Laser-induced break down spectroscopy (LIBS) is a candidate salt measurement method, however, remote measurement is an important issue in terms of inserting the LIBS devices into the narrow

space such as the space between the canister and a concrete body. In this study, we developed a compact device comprised of optics for LIBS and a drive unit for vertical movement (Fig. 3). The performance test results showed that salt can be detected by LIBS in the narrow space when the distance from the laser device to the measurement points was around 22 m (H13004)

4 Development of a monitoring system for helium leakage from canister

We propose a monitoring system which uses the temperature difference between the top and bottom of the canister as a helium leak sensor for the canister in storage. In order to analytically evaluate the change of this temperature difference during the leakage of helium gas from the canister, an unsteady state

thermal hydraulics model has been developed which considers the change in density of helium gas (Fig. 4) (N13008).

Hereafter, we will verify the model and establish the evaluation method for sealability of the canister, so as to contribute to practical use of concrete casks in Japan.

*1 A cylindrical container made of stainless steel which contains spent nuclear fuel and is placed in a concrete cask

*2 JSME, Code for Construction of Spent Nuclear Fuel Storage Facilities (JSME FBI-2003)

[1] A. Bèziat, M. Wataru, K. Shirai et. AL., 17th International Symposium on the Packaging and Transportation of Radioactive Materials, August, 2013

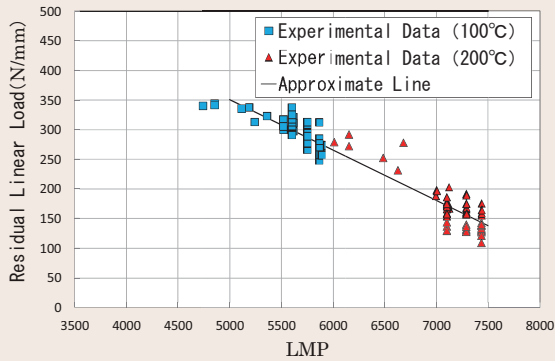


Fig. 1: Relation between residual linear load of metal gasket and LMP

This figure shows the test results with a metal gasket 6.2 mm in diameter. X axis is the LMP. The LMP is shown as follows; $LMP = T^*(C + \log(t))$ where T (K) is absolute temperature, C is material constant, t (h) is time. l_1 is assumed for C. Y axis is residual linear load of the metal gasket. Residual linear load at 100 and 200°C and the LMP have good correlation. The results with a diameter of 8.4 mm are similar. This was a combined study between CEA (France), GNS (Germany) and CRIEPI. The tests will continue for 100,000 hours and finish in 2015.

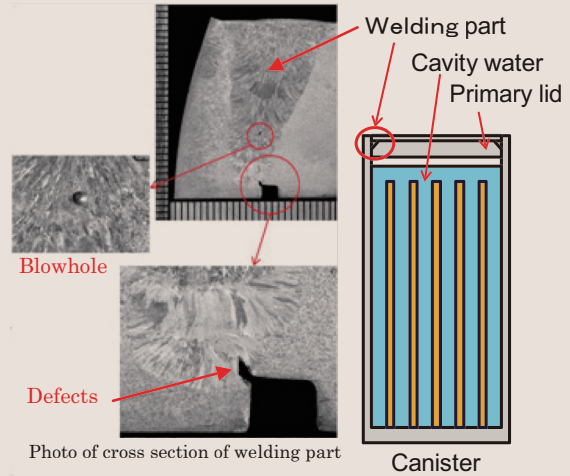


Fig. 2: Relation between residual linear load of metal gasket and LMP

The primary lid of the canister is welded under moist conditions because the cavity water is heated by the decay heat of spent nuclear fuels. We performed the welding test using a small test plate made of SUS304L (diameter: 50 cm, thickness: 12.6 mm). The defects in the initial layer of welding occur if the back shield gas decreases and oxygen gas concentration in argon gas exceeds 5%. These results show that it is necessary to enhance training of welders and inspectors regarding welding under most conditions and perform a welding procedure test using a full-scale mock-up before commencing the practical welding process. We added these results to the draft revision for the JSME code.

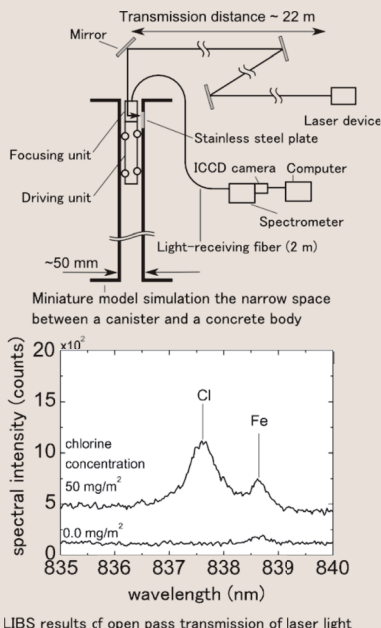


Fig. 3: Remote measurement test using a miniature model simulating the narrow space between a canister and a concrete body

The remote measurement of salt attached to canister material has been performed by inserting LIBS devices, which have laser light focusing and a light-receiving function, into a miniature model simulating the narrow space between a canister and a concrete body. The results showed that the chlorine emission spectrum was measured when the distance from laser device to the measurement points was about 22 m, and suggest that salt concentration can be measured by remote LIBS.

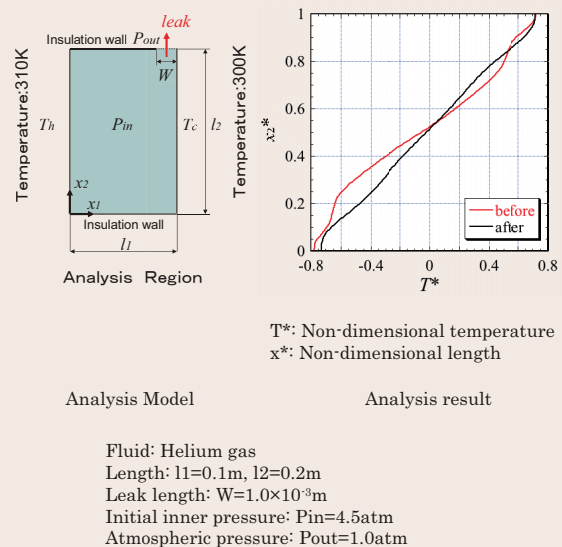


Fig. 4: Results of a helium leak analysis for cavity flow

The characteristic of the present model considers the non-conservative method of the governing equations for the compressible fluid problem. We confirmed a valid solution was obtained for the problem of helium leaks from rectangle cavities. Hereafter, we will make a 3D model to simulate the complex structure of the inner canister in order to apply this method to a real cask.