Evaluation of Long Term Reliability of Spent Fuel Canister for Concrete Cask against Stress Corrosion Cracking

Background

Application of the concrete cask system, a kind of interim spent nuclear fuel storage, to Japan has been considered. The concrete cask system utilizes external air to cool stainless steel canister that contains spent fuel (Fig. 1). If storage facility is built on costal area similar to power plants, the canister may suffer from stress corrosion cracking (SCC) around weld as sea salt particles contained in air attach to the canister surface (Fig. 2). The period of time in which SCC occurs is limited considering a specific condition of the canister surface. Temperature on the canister surface continuously decreases depending on the decay heat of spent fuel. Cracking will not occur when the sea salt on the canister surface is dried, because corrosion does not occur without chloride solution (Fig. 3). This period of time for SCC is calculated from the decay heat curve of canister surface, temperature and humidity. In this research program, highly corrosion-resistant stainless steel was applied as a counter measure for SCC.

Objectives

- To obtain a lower limit of relative humidity and temperature for SCC initiation.
- To obtain SCC failure time for various kinds of stainless steel.
- To evaluate integrity of canister against SCC during 60 years of storage.

Principal Results

1. Conditions for SCC

SCC was initiated above 15% of relative humidity and above 25C of temperature. Considering continuous temperature decrease on canister surface depending on decay heat of spent fuel, the period of time for SCC condition on stainless steel canister is limited as shown in Fig. 4.

2. SCC failure time

Constant load test was conducted at 80℃ and 35% of relative humidity while dosing sea salt on the specimen surface. In this experiment, we defined SCC initiation time on canister surface as a failure time of specimen in which thickness is 1/10 of canister wall thickness; 2mm. While type304 stainless steel specimen ruptured at about 250 h, candidate canister materials did not fail for more than 63000 h.

3. Evaluation of long-term reliability on stainless steel canister

Relative humidity on canister surface was calculated for 60 years by utilizing hourly atmospheric temperature and humidity data and canister surface temperature obtained with model canister for decay heat test. The summated time for SCC satisfied condition is 58400 h, which is less than the SCC initiation life of 63000 h. This method is useful for evaluation of integrity of the canister.

Future Developments

The SCC initiation test is going to be continued in order to obtain longer SCC initiation life data. The evaluation method will be modified refining factors that consist of the method.

Main Researcher: Junichi Tani, Ph. D.,
Senior Research Scientist, Material Science Research Laboratory

Reference

J. Tani and M. Mayuzumi, 2009, “Stress corrosion cracking of canister materials for storage of spent fuel Vol.2, An evaluation on the possibility of SCC initiation” CRIEPI Report Q08007 (in Japanese)

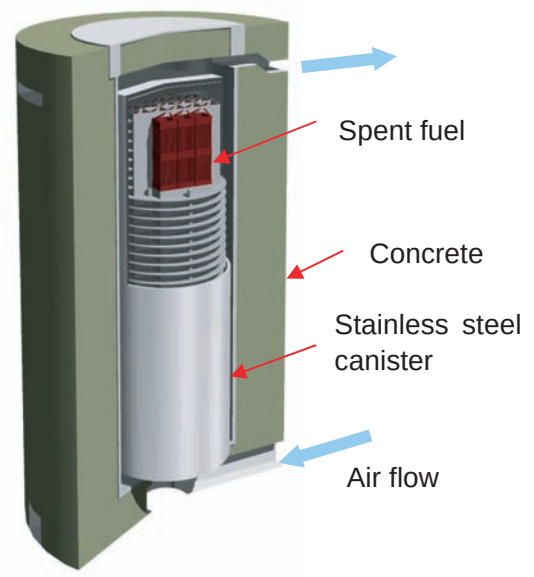

Fig.1 Structure of concrete cask

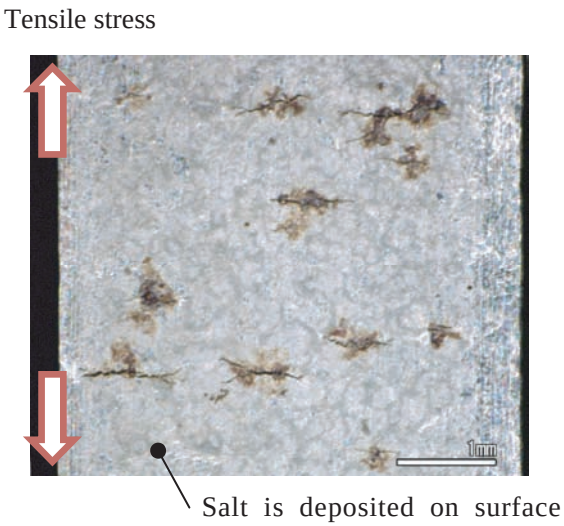

Fig.2 Example of SCC

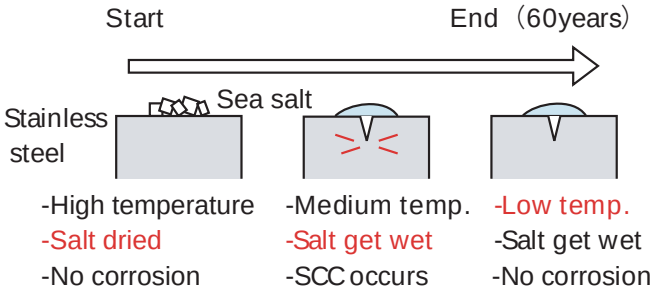

Fig.3 Changes in corrosive conditions over time.

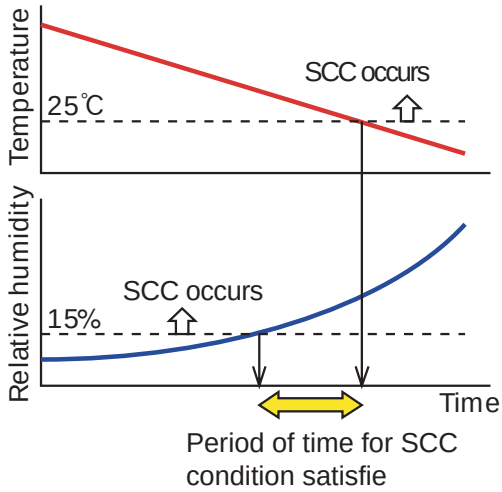

Fig.4 SCC condition and period of time for SCC