A Study on the Development and Operation Technology of Joint Device for a Disposal Canister in Deep Borehole Disposal Method

Duk Woon Jung [a*], Dong Keun Cho [b], Chang soo Lee[b], Moon oh Kim [a]
[a] *Korea Nuclear Engineering & Service, 65, Myeongdal-ro, Seocho-gu, Seoul, Korea*
[b] *Korea Atomic Energy Research Institute, 989-111 Daeduk-daero, Yuseong, Daejeon*
[*] *dwjung@ kones21.com*

1. Introduction

Recently, Deep Borehole Disposal(DBD) has emerged as a promising option for the disposal of SNF (Spent Nuclear Fuel) disposal into a very deep borehole of around 3~5 km depth with the advancement of an underground excavation technology recently. [1]

The advantages of the DBD method are minimization of disposal area and possibility of radionuclides escape into a surface eco-system can be minimized [2,3].

However, For the successful disposal of SNF using the DBD method, joint device of disposal canisters has many technical issues needed to be resolved. The well-known method for the connection of disposal canisters is drilling pipes and J-Slot Joint method, But when deployment/retrieval process of canisters, joint device must be changed to a other connection device at outside. [1,4]. In addition, as the DBD method is a process performed in a very narrow space, there is difficulty in controlling the disposal canister and handling equipment, and research on the joint device to improve it is continuing.

In this study, for the more convenient and time saving than previous connection method between canisters, the concept of the joint device was derived to perform combined actions of releasing and retrieval it again without any joint or emplacement device change. In addition, a scale-down model of the joint device and disposal container were designed/manufactured for the test in a similar to the actual deep borehole disposal environment.

2. Methods and Results

2.1 Considerations and Design

For the designing of the joint device in the deployment/retrieval process, the quantity and weight of the disposal canister, the pressure and temperature gradient in the deployment zone should be considered as shown in Table 1[5].

Table 1: General considerations for DBD disposal canister

Conditions	Content
Load	Assume that 10 disposal canisters are deployed in the disposal hole with one string. 10 disposal canisters are about 50m.
Temperature	Suppose a temperature slope of 25°C/km.
Thermal stress	Design based on a maximum of 300°C.
Pressure	Calculate by strictly assuming the vertical distribution of salinity. At depths of 500 to 5,000 m, assumed to be 1.3 times the density of fresh water. At the bottom of the disposal hole assumed that ground water pressure is about 57 MPa
etc.	Assume that each disposal canister is loaded with one SNF assembly Plus7 nuclear fuel. External metal containers are designed to support only tensile loads. Basic SiC Container Dimensions - OD 344 mm, H 4700 mm, t17 mm

As shown in Fig. 1, the deployment/retrieval system consists of a connector, joint device, disposal canister, and DBD casing. The joint device is not electrically but is mechanically operated. In this study, although the actual deep borehole for disposal of spent nuclear fuel is expected to be about 400 mm in diameter at 5 km depth, a 1/4.4 scale down model was designed/manufactured for the demonstration. The weight of each disposal canister was 260 Kg. Deployment/retrieval of disposal canisters in units 10 was considered. The dimension of borehole for the demonstration test was 4 inches in diameters with 1 km depth.

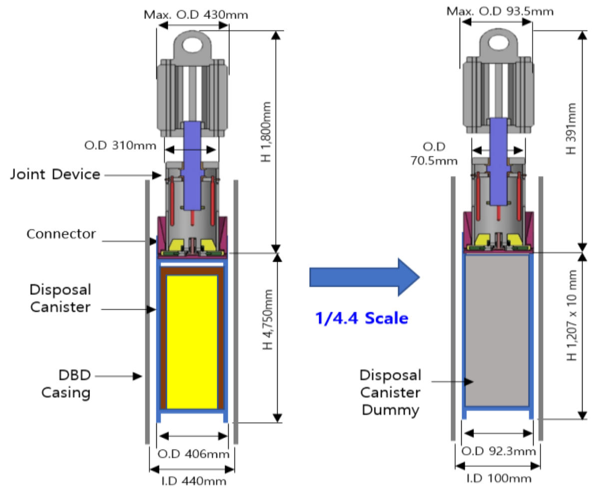

Fig. 1 Comparison of prototype and scaled down model of deployment/retrieval system

The inner structure of the deployment/retrieval system is as shown in Fig. 2, and the function of each component is as follows. ① Connector: fastened with the inner upper part of joint device ② Clamp: spring pin inserted slide clamp ③ Lock pin: fixing clamp before connect and disconnect slide clamp pressed by lifting rod ④ Lifting rod: operating connection device and supporting lifting load ⑤ Clamp pusher: retracting clamp by pushing upper part of slide clamp ⑥ Guide: minimizing of the eccentricity of joint device ⑦ Lifting lug: link to the descender on the ground.

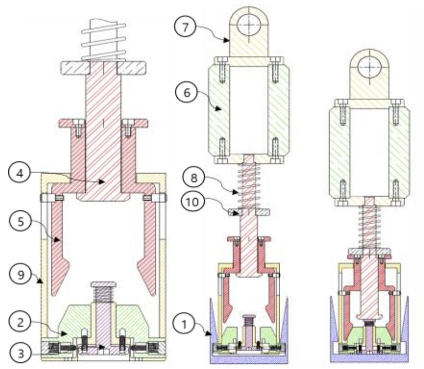

Fig. 2. Schematic drawing of the DBD joint device.

The operation procedure of the deployment/retrieval system is as represented in Fig. 3 and the joint device is only mechanically operated.

The connection mechanism of deployment/retrieval system is that four clamps inserted at the bottom of the joint device expand, and then the joint device binds with the disposal canister in the connector shoulder. The disconnection mechanism of deployment/retrieval system is that lifting bar and clamp pusher descend and push the top of slide clamp, and then clamps are retracted.

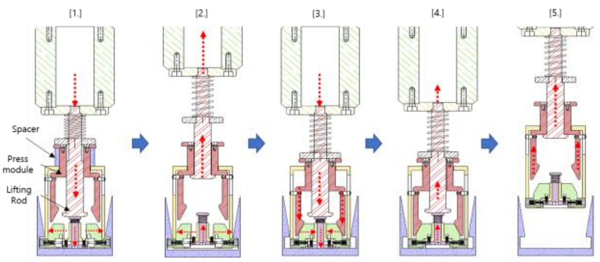

Fig. 3. Operation procedure of the DBD joint device

2.2 Manufacturing

In order to evaluate the performance of the joint device developed in this study, a 1/4.4 scale joint device was manufactured. STS 316 stainless steel was used for the joint device, and the size of joint device was 110 mm in diameter with 148 mm long. The weight of the joint device was about 8.7 kg. A lug was attached to the top of the joint device to connect with a lifting hoist. The disposal canister was made by STS304 125A Sch.20. The size of the disposal canister was 140 mm in diameter with the height of 538 mm, and the weight of the disposal canister was 10.6 kg.

Fig. 4. Testing and the assembly of the DBD joint device

In the future, using the joint device, we plan to a demonstration test in which the disposal container is deployment and retrieval in a borehole with a diameter of 4 inches and a depth of 1 km.

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3. Conclusions

The new deployment/retrieval system was developed for deep borehole disposal of spent nuclear fuels. The deployment/retrieval system has a structure in which four clamps inserted at the bottom of joint device expand and bind with disposal canister in the connector shoulder. The joint device is not electrically but is mechanically operated. For the performance test of the developed joint device, 1/4.4 scale deployment/retrieval system was designed/manufactured. The new deployment/retrieval system is feasible for the actual deployment/retrieval of the disposal canister and is expected to be used as basic data for the operation of the actual DBD in the future.

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