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Design Features of an OASIS-32D Metal Cask for both Transport and Storage of SNF

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1. Introduction

According to the decision of the disposal plan [1] for the high-level radioactive waste of on-site Spent Nuclear Fuel (SNF) in domestic operating nuclear power plants, the SNF management facility shall be constructed at the outside of nuclear power stations. Therefore, it is necessary that the development and the preparation of the SNF transport and storage system be initiated urgently according to the utility strategy to manage dry storage facilities within nuclear power stations.

This paper introduces design features of an OASIS-32D (Optimized And Safe Interim Storage System) metal cask for the transport and storage of the SNFs. This metal cask is designed to minimize the effect on the SNFs inside of the basket from the external impact, and to facilitate the function of heat transfer and radioactive shielding by modifying the internal structures of the cask based on the conceptual design of OASIS-32D [2]. This metal cask can be used for both transport and storage of 32 bundles of PWR fuel.

2. Design Features of an OASIS-32D

2.1 Design Considerations

The principal design parameters of the SNF metal cask for both transport and storage are fuel types, initial enrichment, discharge burnup and minimum cooling periods after core burnup. Those parameters are considered for the basic design of the SNF metal cask. The design features applied to OASIS-32D development are given in Table I.

Table I : SNF and Cask Design Parameters

Parameter	Design Features
Fuel types	ACE 7 & PLUS 7 PWR SNF (32 bundles of fuel)
Initial enrichment	Maximum 5.0 w/o (U-235)
Discharge burnup	45,000 MWD/MTU
Cooling periods	10 years
Cask Weight	~ 110 metric tons (loaded FA)

OASIS-32D has adopted critical analysis methodology which was proposed by USNRC considering a burnup credit to maximize the transport and storage capability of cask, and has reflected the information for the hoist capacity of overhead crane in most domestic operating nuclear power plants in the basic design of the cask.

2.2 Components of OASIS-32D

OASIS-32D consists of a cask body and a canister. The canister is comprised of a basket for storing the SNF and reinforcement supports for supporting the basket and releasing internal decay heat. The cask body materials surrounding the external of canister are composed of carbon steel and neutron shielding material.

2.3 Design Features of OASIS-32D

The canister as shown in Fig. 1 is a cylindrical wall that can store and transport up to 32 bundles of PWR SNF. Its lid and bottom plate are directly welded to a cylindrical shell to provide complete sealing and containing. The lid is equipped with vent and drain ports which are utilized to remove moisture and air from the canister, and backfill the canister with a specified pressure of inert gas.

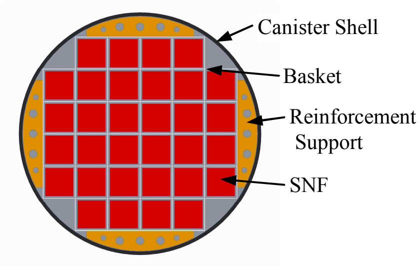

Fig. 1. Configuration of Canister

The basket is designed to accommodate the design features of fuel provided in Table I, and the basket consists of the honeycombed composite cell structures utilized to maintain subcriticality of the SNF. Each basket has sheathing plate welded to the inner wall for retaining the neutron absorbers which absorb the neutron sources generated from the SNFs. The basket is sequentially welded and assembled in order to manufacture the final basket cell structure.

The reinforcement support for holding the basket in the canister as depicted in Fig. 2 is a structure welded with constant intervals to the outer surface of the basket. In order to effectively remove decay heat generated by the SNFs, the radiant heat transfer area is enlarged by widening the attachment area between the reinforcement support and the basket. A number of flow holes are provided inside of the canister to enhance the efficiency of gas heat dissipation. A support mechanism is also designed to safely support the SNFs stored in the basket from the external impact caused by such as a drop accident.

The heat transfer pin (refer to Fig. 2) is transfers heat generated by the SNFs to the cask through the basket, the reinforcement support, and it is released into the atmosphere through the heat transfer pin embedded in the neutron shield material covered by the outer cover. The configuration of the heat transfer pin is designed by considering heat transfer efficiency and weldability. In terms of welding process, the heat transfer pins are welded to the outer wall of the cask, and then welded to the inside of the outer cover composed of several cylinders. If necessary, heat transfer pins are welded to the inside of the outer cover and then welded to the outer wall of the cask.

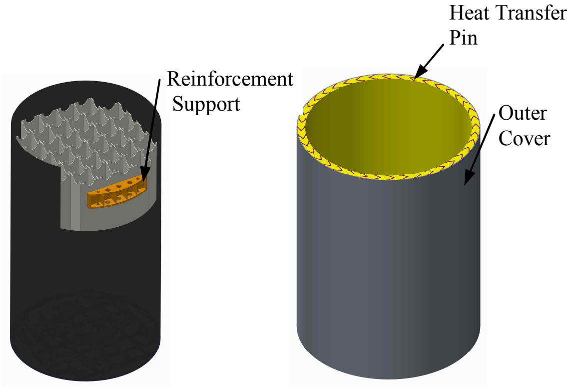

Fig. 2. Reinforcement Supports and Heat Transfer Pins

The cask body, a containment vessel with a thick wall of carbon steel effective for shielding gamma rays, consists of structural material and neutron shielding material. Those materials have sufficient thickness to satisfy the allowable radiation dose rate. The neutron shielding material installed on the outer wall of the cask is designed to facilitate the release of internal heat by providing heat transfer pins inside of the neutron shielding material.

The neutron shielding material surrounding the outside of the cask is designed to optimize circumferential and axial neutron shielding. The optimal combination to accomplish the optimized neutron shielding material is determined by factors such as thickness of shielding, combination of various composition materials, shapes and dimensions.

The upper and lower bumpers of the cask are located on the outside of the cask, and those bumpers are used as energy–absorbing components to protect the cask and its contents in case of an inadvertent drop of the cask. The bumper and the cask body are fastened with the long cap screw to the cask lid. If there is space limitation during the detailed design process, addition of a support bracket to the outer wall of the cask can be also considered.

2.4 Optimization of OASIS-32D

The development of an OASIS-32D (refer to Fig. 3) is under the detailed analysis for structure, criticality, cooling, shielding, etc. in order to optimize the overall cask configuration by improving safety and performance such as weight optimization, maximization of loading capacity, ensuring of structural integrity and maximization of thermal performance. All gaps between fuels are properly considered based on the lengths or widths of component, coefficients of thermal expansion and typical average component temperatures for the SNF metal cask design. And also, in order to improve the thermal performance, additional detailed review on the quantity, shapes and materials of the reinforcement support and the heat transfer pin will be performed.

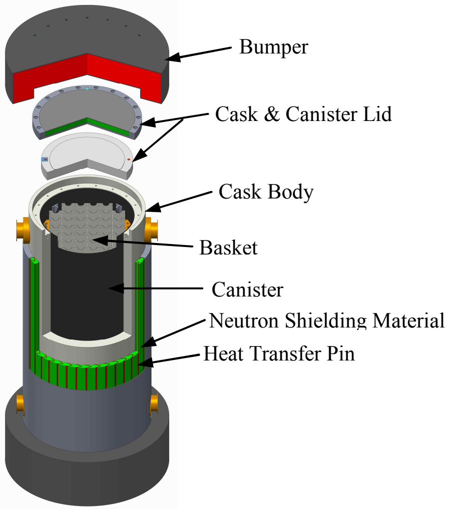

Fig. 3. Configuration of OASIS-32D

3. Conclusions

An OASIS-32D, PWR SNF metal cask for both transport and storage, is under developing by KEPCO E&C to be compatible with the hoisting load of overhead crane in domestic operating nuclear power plants to handle 32 bundles of PWR fuel. Such a large capacity of cask can reduce radiation exposure and potential risk of accidents by reducing the number of the transport and storage times of SNFs. In addition, it is expected that the OASIS-32D can enhance the utilization of dry storage facilities as well as the economic efficiency of SNF storage facilities.

REFERENCES

[1] Press release, The Office for Government Policy Coordination, 6th Atomic Energy Commission, [Determination of High-level Radioactive Waste Management Plan], July 26, 2016.

[2] K. J. Ko, et al., Development of Dual-Purpose Metal Cask (OASIS-32D) for Transport and Storage of Spent Nuclear Fuel, Korean Radioactive Waste Society Autumn Meeting, 2016.