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The impact of Air Gap Thickness Around the Canister on Heat Transfer in COSMOS

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1. Introduction

Korea Hydro & Nuclear Power is currently developing the SF Dry Storage Module, COSMOS (**Co**mpatible **S**torage **Mo**dule for **S**pent fuel), for the dry storage of spent nuclear fuel. COSMOS ensures both cost competitiveness and site efficiency compared to dry storage casks of the same capacity for storing SF. Additionally, it offers safety advantages by preventing CISCC (Chloride-induced Stress Corrosion Cracking) through the placement of cylindrical structures around the canisters, thus avoiding direct contact between external air and the canisters. However, the air gap between the canisters and the cylinders acts as a disadvantage in terms of heat transfer performance, as it facilitates the transfer of heat generated within the canisters to the external environment. Therefore, this study aims to analyze the impact of air gap thickness around the canisters on heat transfer by adjusting the air gap thickness in various ways.

For a comprehensive evaluation meeting legal safety requirement and NUREG-2215[1], it is necessary to assess the temperature of the cladding of the stored fuel. However, since the canister design for storing the 37-assembly fuel currently under development in COSMOS is not yet complete, the analysis focused on the influence of heat transfer based on the surface temperature of the canisters.

2. Methods and Results

The thickness of the air gap surrounding canisters in COSMOS is crucial in influencing heat transfer. The air gap serves as a key element in the pathway of heat transfer, affecting the movement of heat within the system. This study investigates how heat transfer varies under various conditions of air gap thickness around the canisters.

To validate the thermal transfer performance of the COSMOS, a calculation domain was generated, and this research was conducted to verify it using Computational Fluid Dynamics (CFD) codes. A 3D, 1/2 symmetric, finite volume model was created for the thermal analysis of the COSMOS under normal operating conditions of spent nuclear fuel. The schematic representation of this model is shown in Figure 1 and calculation results are shown in Figure 2. According to results, as the thickness of the air gap around the canisters increases, there is a tendency for heat transfer efficiency to decrease. This is attributed to the air gap acting as a barrier to heat transfer. Additionally, it was observed that beyond a certain threshold of air gap thickness, the rate of increase in heat transfer diminishes gradually.

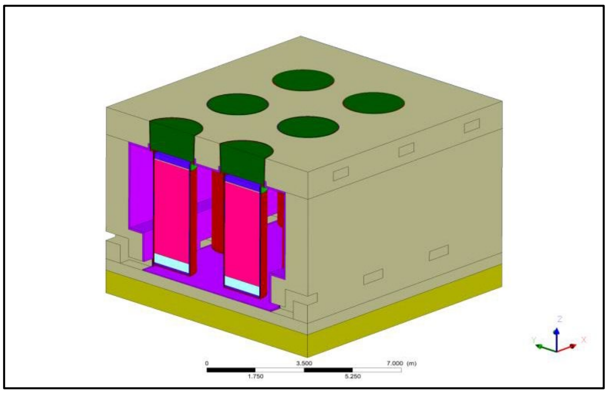

Fig. 1. Calculation Domain of Dry Storage Module

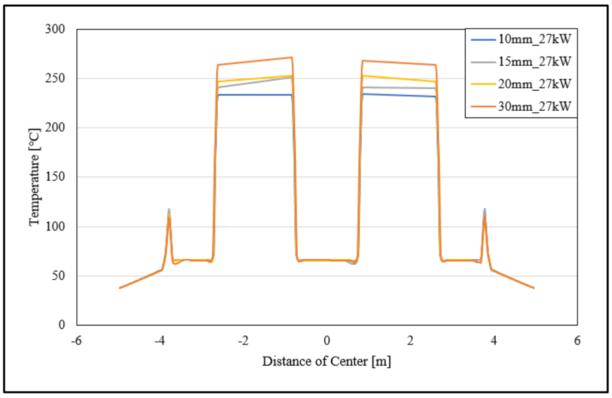

Fig. 2. Calculation results of temperature profile in COSMOS

3. Conclusions

Through comparison, differences in heat transfer were observed under varying thicknesses of the air gap surrounding the canisters. Particularly, when the air gap thickness was thinner, higher heat transfer rates were observed, leading to increased heat transfer efficiency. Conversely, thicker air gap thickness resulted in decreased heat transfer rates.

These findings provide important insights for the design and operation of COSMOS by considering the thickness of the air gap surrounding the canisters. Proper adjustment of the air gap thickness around the canisters can enhance heat transfer efficiency and improve the safety and performance of COSMOS.

REFERENCES

[1] "NUREG-2215, "Standard Review Plan for Spent Fuel Dry Storage Systems and Facilities", U.S. Nuclear Regulatory Commission, 2020.