Analysis of the Impact of the Gap Between the Canister and Cylinder in the COSMOS on Fuel Temperature

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1. Introduction

Korea Hydro & Nuclear Power is currently developing COSMOS (**Co**mpatible **S**torage **Mo**dule for **S**pent fuel), a SF dry storage module for dry storage of spent nuclear fuel. COSMOS secures both cost competitiveness and field efficiency compared to dry storage casks of the same capacity for storing SF. It also provides safety advantages by preventing CISCC (chloride-induced stress corrosion cracking). This advantage is achieved by arranging a cylindrical structure around the vessel to prevent direct contact between the outside air and the canister. However, since the air is located in the gap between the canister and the cylinder, it is difficult to transfer the heat generated inside the canister to the external environment, which acts as a disadvantage in terms of heat transfer performance.

In order to comprehensively evaluate the cladding temperature of the stored fuel to meet the legal safety requirements and NUREG-2215[2], it is necessary to evaluate the cladding temperature of the stored fuel. In a previous study [1], the performance of the gap thickness in removing the heat generated in the canister was analyzed, but the effect on the temperature of the spent nuclear fuel inside the canister was excluded. In this study, the goal is to analyze the effect of the gap thickness on the temperature of the spent nuclear fuel inside the 37-bundle storage canister.

2. Methods and Results

In COSMOS, the thickness of the air gap surrounding the canister is very important in influencing the heat transfer. The air gap acts as a key element in the heat transfer path and affects the heat movement within the system. In this study, we investigate how the heat transfer changes under various conditions of the air gap thickness around the canister.

In order to verify the heat transfer performance of COSMOS, a computational domain was created, and a study was conducted to verify it using a CFD (Computational Fluid Dynamics) code. Prior to performing a detailed 3D CFD analysis, the canister surface temperature was derived from the CFD analysis results of the dry storage module [1] and set as the boundary condition for the 2D canister analysis. A 2D, 1/2 symmetric, finite volume model was created for the thermal analysis of COSMOS under normal operating conditions of spent nuclear fuel, as shown in Figure 1. According to the 2D CFD results in Figure 2, as the gap thickness around the canister increases, the spent fuel temperature increases. This shows that the air gap, which acts as a barrier to heat transfer, also affects the spent fuel temperature.

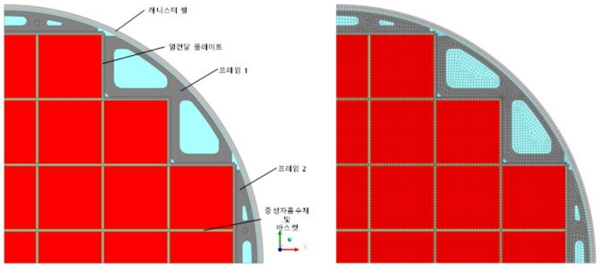

Fig. 1. Calculation Domain of Dry Storage Canister

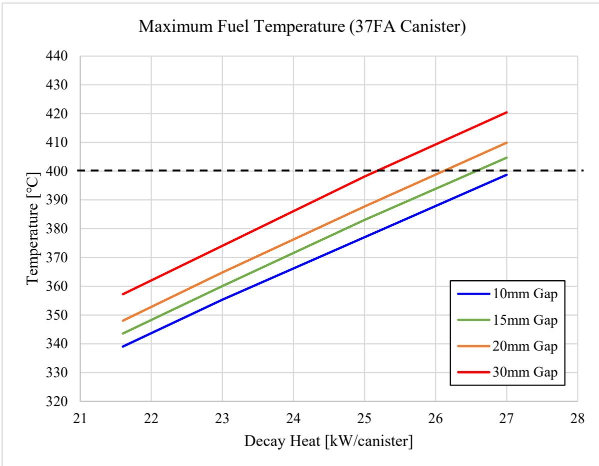

Fig. 2. Results of SF temperature in COSMOS

3. Conclusions

These findings provide important insights into the design and operation of COSMOS considering the thickness of the air gap surrounding the canister. Designing the air gap thickness around the canister to less than 15 mm can increase heat transfer efficiency and improve the safety and performance of COSMOS.

REFERENCES

[1] Taehyeon Kim, et al. "The Impact of Air Gap Thickness Around the Canister on Heat Transfer in COSMOS." Transaction of the Korean Nuclear Society Spring Meeting. 2024.

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