A Study on the Temperature Correlation between a Surface of Dry Storage Canister and Spent Fuel Clad – 16446

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ABSTRACT

Analysis of temperature correlation between dry canister surface and spent fuel cladding is performed in this study. The result shows that the spent fuel cladding temperature is possibly estimated using canister surface temperature in normal condition and the result of estimation is depended on analysis model. Two analysis models are designed by using a hypothetical spent fuel model and thermal analysis for the models is performed by using CFX(v11.0) code.

INTRODUCTION

Nuclear power plants (NPPs) have been operating over 30 years in Republic of Korea and the temporary storage capacity for spent fuels is expected to be full in few years. Furthermore, Decision making process to build a permanent disposal facility has been delayed. Even if the decision had been made, it would take several decades to begin operation of the disposal facility. Therefore, dry storage system has been considered as an interim storage system to manage spent fuels in Korea. Currently, thermal analysis using CFD is expected for licensing of a dry storage facility and it can be possible that the method of analysis may be used in field of inspection. Therefore, preliminary thermal analysis was performed to confirm possibility of using temperature correlation between canister surface and SF cladding surface for inspection.

Models and Assumptions

The hypothetical spent fuel model was chosen following the Korea Atomic Energy Research Institute (KAERI) result, "Selection of Korea Standard Spent Fuel(KSSF) and Source term for design of deep geological repository"(2006). The cross section area of KSSF is square of 2.14 cm and decay heat capacity of KSSF, which was cooled in spent fuel storage pool for during 10 years, is 938.8 Watt.

It is assumed that the (arranged) pitches of KSSF are equal and the stored KSSF in each canister are 24 EA and 32 EA respectively. The two commercialized canisters of Holtec Inc. for 24 EA and 32 EA were referred to determine the diameter of the canister for SF and gas between KSSF assemblies was calculated as 2.85 cm and 1.19 cm by using Newton Method.

KSSF assembly is a modeled as a homogeneous rectangular because configurations and supporting structures of spent fuel assembly are highly complicated and it is assumed that the canister is filled with helium gas and the supporting lattice for spent fuel assembly is stainless steel.

The calculation model describes a quarter of the canister. The model consists of 633,918 numbers of element and 1444,382 numbers of node. And convection, conduction and radiation are considered. Using CFX code, maximum 1,000 numbers of iterations were performed and temperatures at random points are monitored in order to confirm convergence.

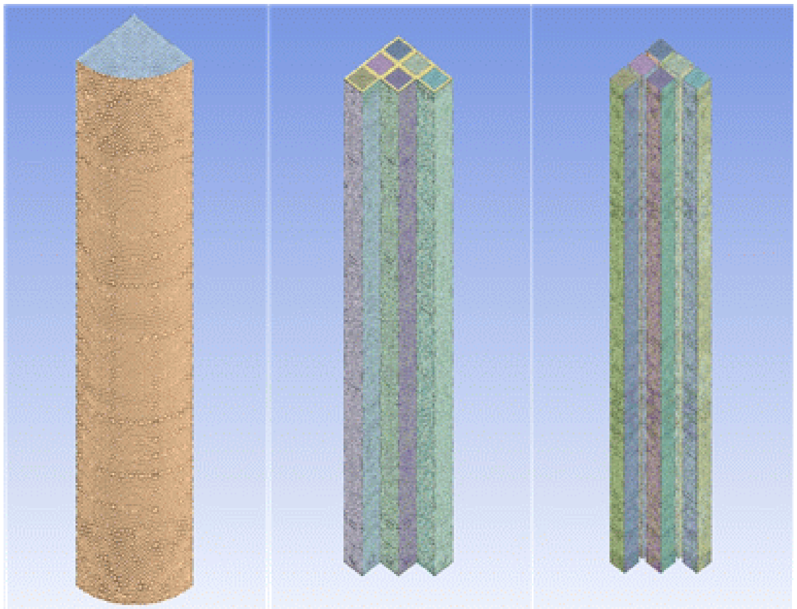


Figure 1. Model mesh for 24 storage canister

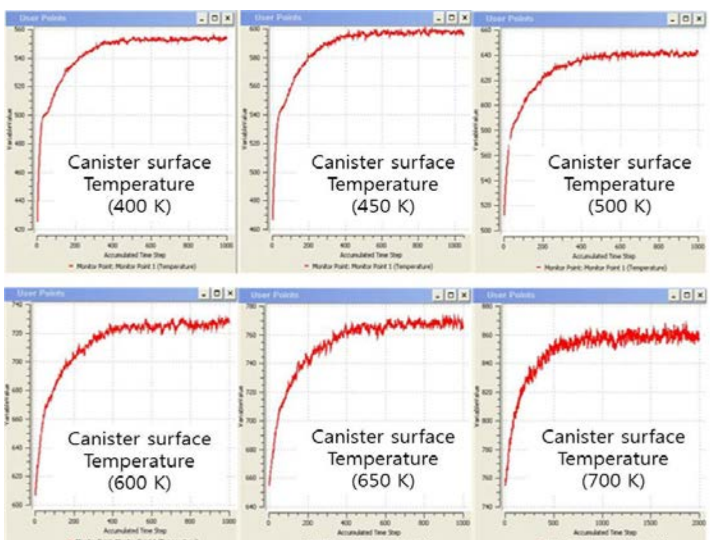


Figure 2. Monitoring of Convergence

Analysis Results

Based on variations of wall temperature of the canister, cladding temperatures were calculated. The requirement of NUREG-1536 and ISG-11 limits clad temperatures below 400^{o}C in steady-state conditions and below 570^{o}C in short period of accidents. According to the limited temperatures, the canister surface temperatures were calculated as below 293^{o}C and 494^{o}C for 24-PWR canister and below 191^{o}C and 440^{o}C for 32-PWR canister respectively.

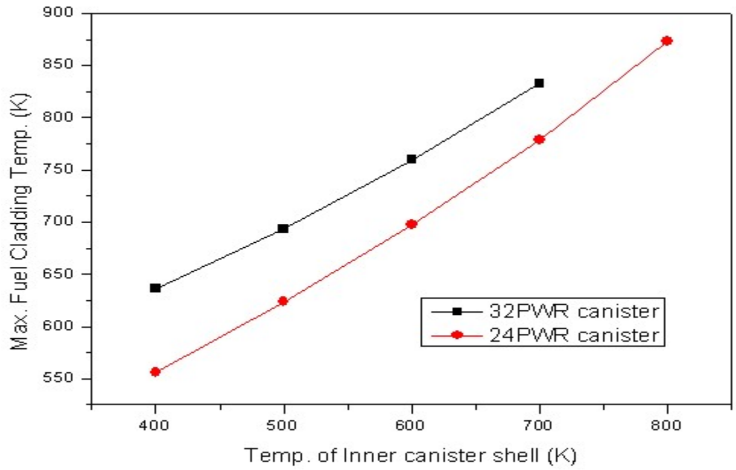
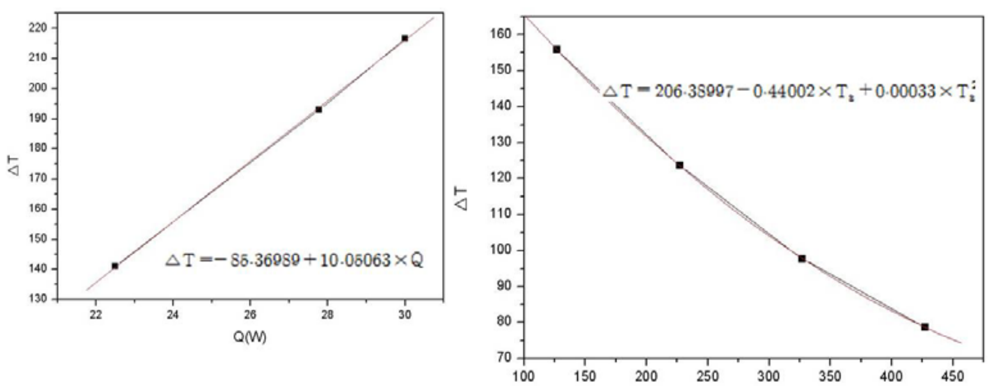


Figure 3. Results of calculation

CONCLUSIONS

The result shows that the maximum cladding temperature and wall temperature have some constant correlation. Using the correlation a linear regression equation was suggested and it is tested with some data from other analysis and examination. Accuracy of the equation was over 96% within the wall temperature from 127^{o}C to 427^{o}C with heat capacity from 22.5 kW to 30 kW.



$$T_{max} = 0.00033 \times T_s^2 + 0.55998 \times T_s + 10.05063 \times Q - 19.12303$$

Figure 4. The max. clad temp. eq. and relation between Q, T(clad) and T(canister surface)

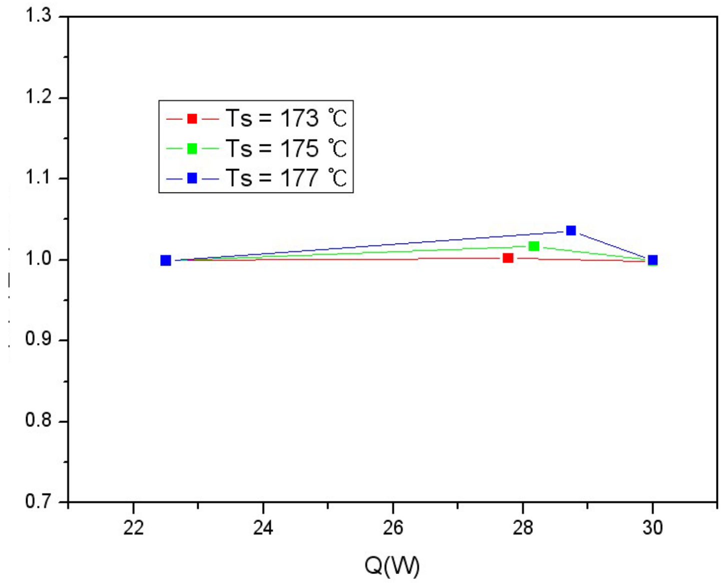


Figure 5. Error rate regarding Q

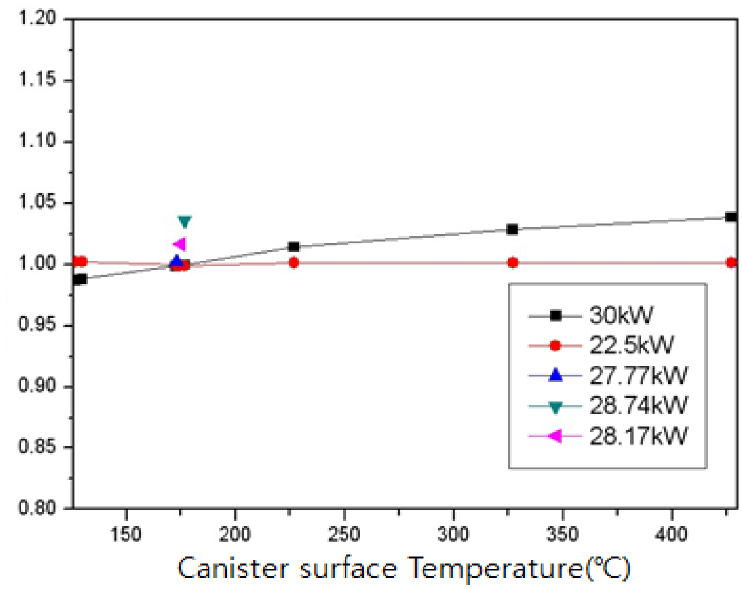


Figure 6. Error rate regarding surface temp. of canister

This study is performed to show the possibility, that the maximum temperature of spent fuel cladding could be predicted with the wall temperature of the canister. Although dry storage facility for spent fuel assembly is not operated in Korea, these results will be contributed to in-service inspection methodology for a dry storage facility.

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