Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 10-11, 2007

Thermal analysis of the KN-12 nuclear spent fuel transfer cask

Dallsun Um,
dallsun.um@doosan.com,
BOP Design Team, Nuclear Power Plant Business Group,
Doosan Heavy Industries & Construction Co., Ltd. 555 Gwigok-Dong, Changwon, Gyeongnam 641-792, Korea

1. Introduction

Spent fuel is one of the high level radioactive materials. If it were not treated properly, it can be lethal to all lives in its neighbors. It can not be too emphasis to manage the spent fuel safely at least for several hundred of years. Currently, all of the nuclear power plants under commercial operation in South Korea are keeping their spent fuels in the water pools provided inside their buildings. However, as the operating time is going on, the amount of spent fuel in water pool in certain plant is near to its capacity. Korea Hydro and Nuclear Power Co. Ltd (KHNP) made a plan to pull out several spent fuels from the water pool at its capacity and to move them to other water pool under its capacity. One transfer cask, KN-12 was manufactured in Doosan Heavy Industries & Construction Company and supplied to KNHP for this purpose. In this paper, one thermal analysis for KN-12 was done and compared with the thermal safety test results.

2. Theoretical Calculation

In this section a simple calculation done with theories are described.

2.1 Calculation Model

Fig.1 is the cross section of KN-12 spent fuel transfer cask without impact limiters. So the cask could be assumed a hollow cylinder of inner diameter 1.2m, outer diameter 1.9m and length 4.7m. The heat source is spent fuel and its decay heat is12.6kW.

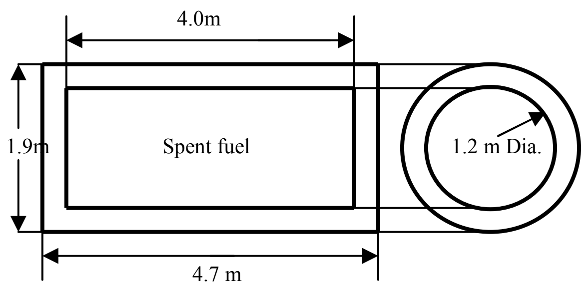

Figure 1. KN-12 Model without impact limiters.

2.2 Calculation

The calculations were done in two areas, heat conduction area (between spent fuel and cylinder) and heat transfer area (between cylinder and air in its periphery). The air temperature of the periphery of cask is assumed 27℃. Cask material is carbon steel SA-350 Grade LF3(ASME).

2.3 Calculation result

The calculation results for the model show that the highest temperature in the inner surface of cask is 127.33 ℃and the one in the outer surface of cask is 73.56 ℃.

3. Thermal analysis

3.1 Modeling

For analysis, cross section of a quarter of cylinder was taken and modeled as like Fig. 2. Different colors represent different materials in Fig. 2.

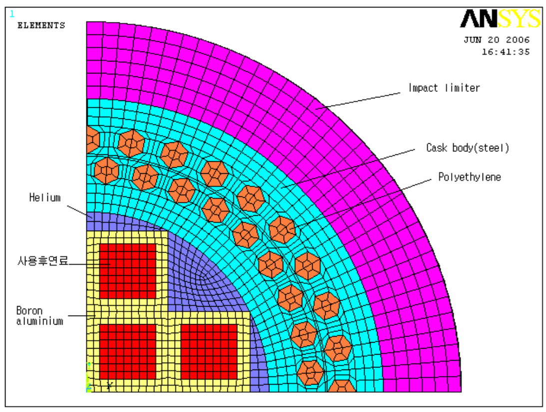

Figure2. The view of the modeling cross section

3.2 Analysis

Analysis was done with the commercial code, Fluent - 6.2. Heat transfer coefficient of $5.07\ W/(m^2 K)$ was obtained from the theoretical calculation and used in this analysis.

3.2Results

Temperature distribution of the inside and outside of cask is shown in Fig.3 and 4 respectively.

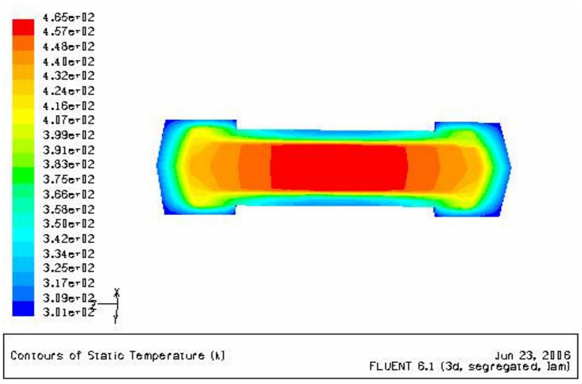

Figure 3. Temperature (Fahrenheit) distribution of the inside of cask

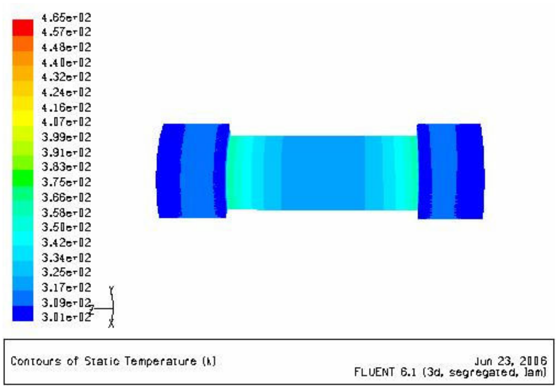

Figure 4. Temperature (Fahrenheit) distribution of the outside of cask

4. Thermal safety test

For thermal safety test, temperature measurements in cask were done with the dummy heat source which emits same amount of heat to spent fuel. Temperature measurement points are shown in Fig. 5.

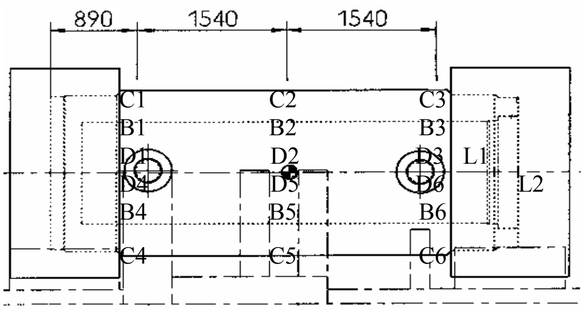

Figure 5. The temperature measurement positions on KN-12.

The highest temperature in inside of the cask is observed in D5 (176.54℃) and the one in the surface of cask is observed in C4 (83.03℃).

4. Conclusion

The comparison of the thermal analysis results and test results is shown in Table 1. The results are coincident one another in 8% of deviation.

Methods	Maximum temperature in cask (℃)	
	Inside	Outside
Analysis	190.0	90.0
Test	176.54	83.03

Table 1. Analysis result and experimental result

REFERENCES

[1] CASTOR KN-12, Spent Nuclear Fuel Transfer Cask, Safety Analysis Report, GNB-B-002/2002, Rev. 0. PT-361-G-A-R-002, Rev.0, Volume 1 & 2.
[2] M. Necati. OZISK, A. "Heat transfer", ISBN 0-07-047982-8.
[3] Structural, Thermal Analyses and Safety Test Evaluation for Dry Storage System, KAERI/CR-161/2003. 2003. 8.
[4] Structural, Thermal Analyses and Safety Test Evaluation for Dry Storage System, KAERI/CR-182/2004. 2004. 8.