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THE DEVELOPMENT OF THE TS-69B CASK FOR TRANSPORT AND STORAGE OF SPENT NUCLEAR FUEL

Satoshi Miyamura
Toshiba Energy Systems & Solutions Corporation, Japan

Akitsugu Sonoda
Toshiba Energy Systems & Solutions Corporation, Japan

Chihiro Narazaki
Toshiba Energy Systems & Solutions Corporation, Japan

Maki Hiramoto
Toshiba Energy Systems & Solutions Corporation, Japan

Yoshitaka Doken
Toshiba Energy Systems & Solutions Corporation, Japan

Makoto Sato
Toshiba Energy Systems & Solutions Corporation, Japan

ABSTRACT

In Japan, spent nuclear fuel is stored on an interim basis until it is being reprocessed. Toshiba Energy Systems & Solutions Corp. has developed TS-69B, a dry metal cask, designed to be used for the dual purposes of transporting and storing spent fuel assembly (i.e. transfer vessels) from the nuclear power plant site to outside. One of the key features of TS-69B is its capability of loading sixty-nine (69) spent fuel assemblies, which capacity is currently the highest in Japan. Furthermore, high burn-up (i.e. 48,000 MWD/MTU for maximum) spent fuel assemblies can be stored in TS-69B. The maximum volume of decay heat to be loaded is 16 kW. Due to its high heat removal capabilities, TS-69B could be the most effective cask type with regard to storing high burnup, 9×9 BWR fuel in Japan.

In addition to the criticality prevention function, and shielding and heat removal capabilities, other features of TS-69B include its structural strength and a capability of maintaining long term integrity. In particular, in consideration of optimal fuel placement by 8×8 BWR fuel, the cask's heat removal capability was analyzed. The evaluation results indicated that the temperatures of structural members do not impact the integrity of the cask, resulting in both the temperature of the metal gasket and the fuel cladding tubes being lower than the reference design values.

INTRODUCTION

Casks for dual purposes of transport and storage must satisfy both transport and storage regulations as Japan imposes more stringent requirements compared with those in other nations. In particular, the allowable temperature for fuel cladding tubes in storage must be 270 degrees Celsius (ºC), or 200 ºC depending on a fuel type, which is substantially lower than that specified in Europe and the U.S. As a consequence, these standards place limitations on the number of fuel to be loaded and the allowable burnup temperatures.

For the TS-69B cask, Toshiba accommodated the basket materials, structure and fuel layout, and finally achieved the highest storage capacity of sixty-nine (69) spent fuel assemblies in Japan, with burnup of 48,000 MW d/t for maximum and 43,000 MW d/t for average.

Overview of the TS-69B Cask Design

The TS-69B-type is a dry metal cask for dual purposes of transport and storage, capable of storing sixty-nine (69) BWR spent nuclear fuel. The specifications of the cask are indicated in Table 1 and Figure 1. For the vessel section, forged steel is used to shield gamma (γ) – ray; epoxy resin is used to shield neutron. During storage, containment capability is ensured with two (2) lids and pressure boundaries; during transport, the tertiary lid provides the sealing capability.

The Basket Structure with Improvements on Heat Transfer

The basket is structured by double or three (3) layers, comprised of grids, neutron absorbers and heat conducting members. For grids, which reinforce the structural durability, carbon steel is used due to higher conductivity than stainless steel. For neutron absorbers, to be in place for preventing criticality events, borated aluminum is used due to high conductivity. Also, aluminum alloy plates are in place for increasing conductivity.

Furthermore, heat transfer plates are in place around the outside of the basket grid for increasing the conductivity into the vessel.

Heat Removal Performance of the TS-69B Dual Purpose Cask

Figure 2 presents the lording placement of fuel assemblies in the TS-69B cask. Figure 3 and Figure 4 present the analysis on heat removal for the cask. The temperature for the fuel cladding tubes are evaluated by (b) Radial-sectional Model. The maximum temperature for the fuel cladding tubes of the BWR fuel assembly (with zirconium liner) was 264 ºC, verifying that it is below the design temperature of 270 ºC. Likewise, the maximum temperature for the cladding tubes of the BWR fuel assembly (without zirconium liner) was 187 ºC, verifying that it is below the design temperature of 200 ºC. Other structural members also satisfy their own design temperatures.

TS-69B Licensing Status

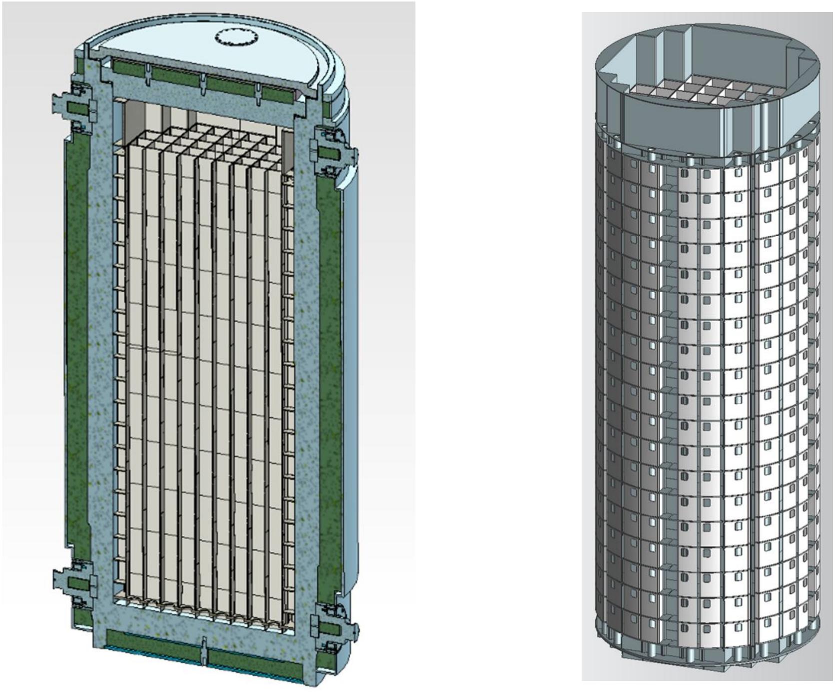
Toshiba Energy Systems & Solutions Corp. has already filed the application for the type certification of the TS-69B cask with Japan's Nuclear Regulation Authority (NRA); the NRA reviews are complete. After obtaining the type certification, the following course of action is to file the type designation application, eventually obtaining the type approval from the NRA.

CONCLUSION

The TS-69B Cask for dual purposes of transport and storage is capable of storing sixty-nine (69) BWR spent nuclear fuel. Key features of the Cask include the basket structure with high heat removal performance, its structural strength and the capability of preventing criticality events. The TS-69B Cask could be easily applied to 9×9 fuel, which is assumed to be a future move after restarting the nuclear power plants in Japan.

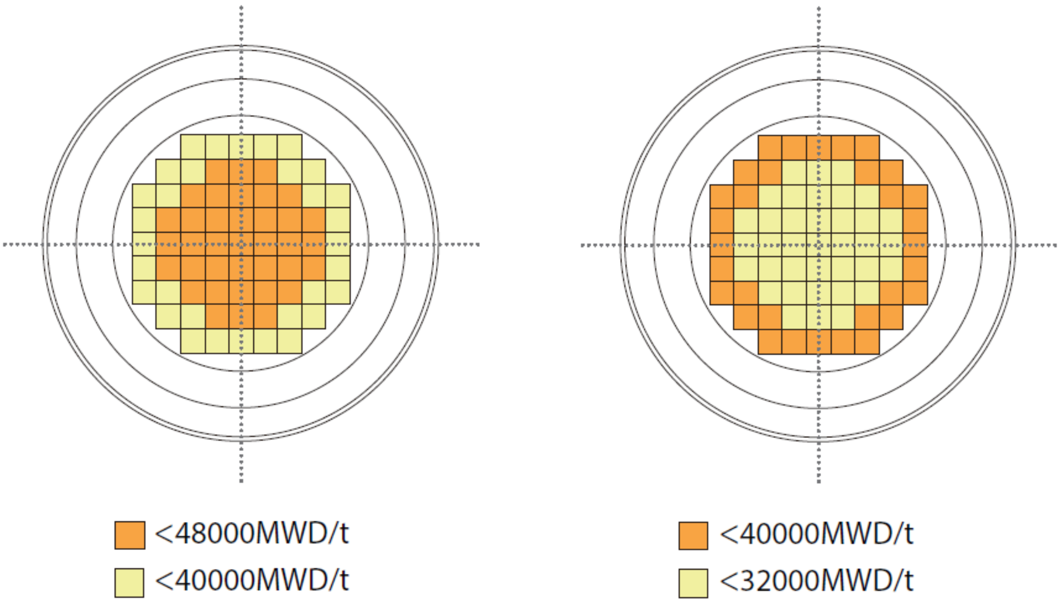
Table 1. Feature of TS-69B transport and storage cask

Fuel specification		
Fuel type	BWR 8x8 (with zirconium liner)	BWR 8x8 (without zirconium liner)
Maximum burn up	48,000 MWd/t	40,000 MWd/t
Average burn up	43,000 MWd/t	32,000 MWd/t
Minimum cooling time	17 years	24 years
Number of fuel loaded	69 assemblies	
Thermal power		
Allowable thermal power	16 kW/cask	
Design thermal power	19 kW/cask	
Dimension		
Storage condition		
Overall length	5.4 m	
Outer diameter	2.6 m	
Transport condition		
Overall length	6.7 m	
Outer diameter	3.6 m	
Weight		
Under storage	116 ton	
Under transport	130 ton	
Temperature of fuel cladding	264℃ (fuel with zirconium liner)	
	187℃ (fuel without zirconium liner)	
Dose rate	0.9 mSv/h (at surface for cask)	
	71 μSv/h (at 1m from cask)	
K_{eff} +3σ	0.39 (dry condition)	
	0.85 (wet condition)	



(a) Structure of TS-69B in storage (b) New basket for TS-69B

Figure 1. Feature of TS-69B dual purpose cask



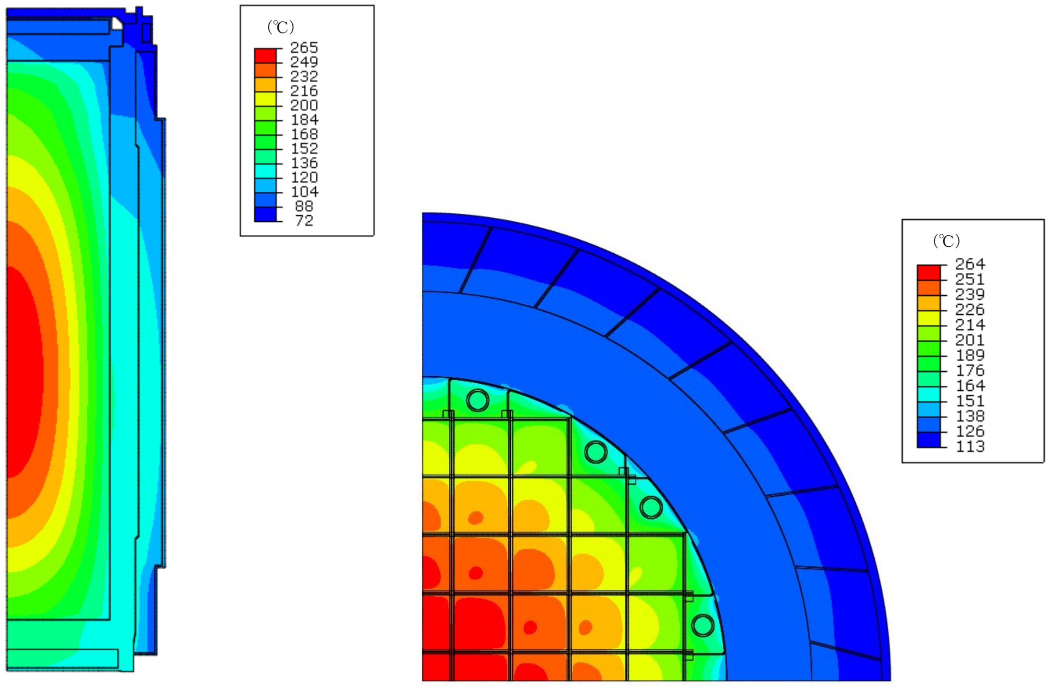
Maximum thermal power : 16.0 kW
Design thermal power : 18.9 kW

(a) 8×8 BWR fuel with zirconium liner

Maximum thermal power : 10.1 kW
Design thermal power : 11.9 kW

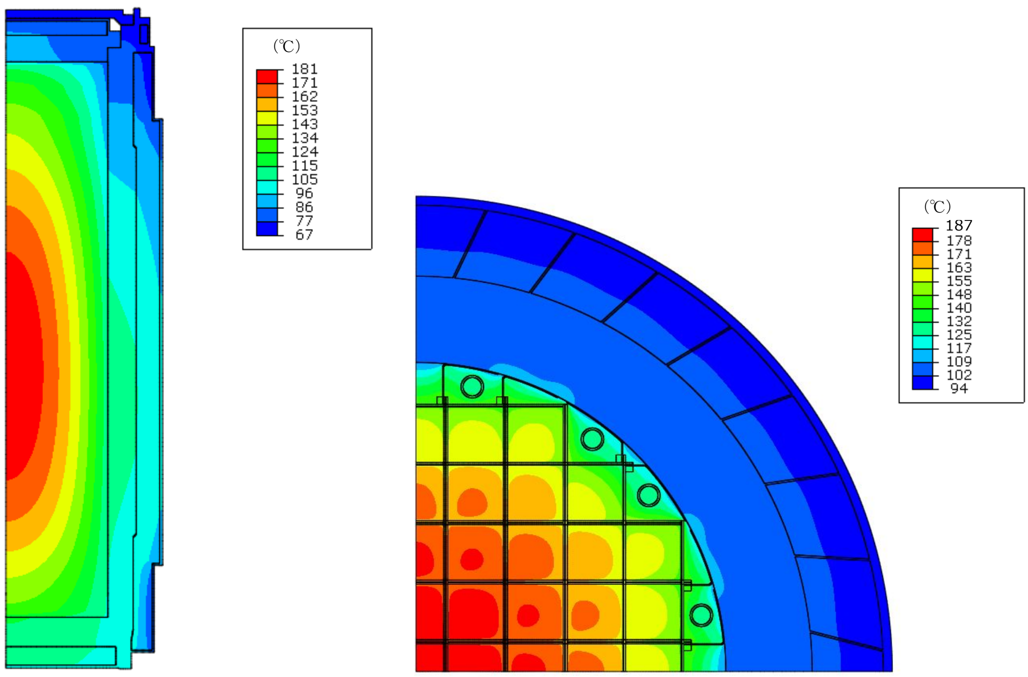
(b) 8×8 BWR fuel without zirconium liner

Figure 2. Lording placement of fuel assemblies in TS-69B cask



(a) Axisymmetric Model (b) Radial-Sectional Model

Figure 3. Result of thermal analysis (8×8 BWR fuel with zirconium liner)



(a) Axisymmetric Model (b) Radial-Sectional Model

Figure 4. Result of thermal analysis (8×8 BWR fuel without zirconium liner)