Development of FBR Fuel Shipping Cask for Post-Irradiated Examination

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INTRODUCTION

Power Reactor and Nuclear Fuel Development Corporation will be performing the post-irradiated examination of fuel subassemblies irradiated in the Japanese first prototype FBR "MONJU", in order to confirm the integrity of the fuels and to verify design methods and so on. Therefore, the development of a shipping cask to transport the fuels from "MONJU" to the examination facility in "O-arai Engineering Center" was required and was completed in October 1994.

This paper describes the details of the development process from the design to the fabrication of the casks.

DESIGN REQUIREMENTS

Because the FBR fuels have generally high specific power, high burnup, and high source intensity per unit length, the higher capacity for heat removal and shielding is required for the cask compared to one used for light water reactor (LWR) fuels. In additon to these requirements, the fuel pin temperature during transportation is required to be kept below the irradiating temperature in the reactor, and the weight of the cask including contents is required to be less than 46 tons, which was determined from the weight limitation of a bridge on the transportation route. On the other hand, two types of loading were required at the "MONJU" site; one is a wet-type loading in the pool, another is a dry-type loading in the environment of helium atomosphere.

The typical design requirements are shown bellow;

(1) Kinds of Contents
- core fuel subassemblies
- blanket fuel subassemblies
- control rods etc.

(2) Type of Package: BM(F)
(3) Number of Contents: 1 – 3
(4) Type of Loading: top loading
(5) Loading Environment: water or helium
(6) Weight: max. 46 tons
(7) Cooling System: natural convection heat transfer of air
(8) Transportation: by ship and trailer
(9) Temperature of fuel pins: below irradiating temperature in reactor

OUTLINE OF CASK

As shown in Fig. 1, the body is consisted of three cylindrical shells made of stainless steel, and three fuels inserted in the cans are contained in the cask. The cask has a length of 6.2 m, a outside diameter of 2.2 m and a weight of 46 tons including contents.

The cask is provided with machined rings made of lead between the inner and the intermediate shells for gamma ray shielding and the mixed water and ethyleneglycol between the intermediate and the outer shells for neutron shielding.

The upper portion of the cask has smaller diameter than the middle portion, in order to reduce the weight. The middle portion of the outer shell was constructed with a thicker plate than the edge portions, according to the distribution of gamma ray intensity of FBR fuels.

The circumferential fins are welded to the outer shell in order to obtain good heat removal. Shock absorbers are provided for the top and bottom of the cask in order to reduce the impact under accident conditions.

DEVELOPMENT PROCESS

The development work was started in 1987, and the fabrication of two casks were completed in 1994. Table 1 shows the summary of the development schedule.

Table 1. Development Process of FBR Fuel Shipping Cask.

Item \ Year	1987	1988	1989	1990	1991	1992	1993	1994
Design	o———	———	———o					
Verification Test			o———	———	———o			
Safety Analysis & Review by Authority					o———	———	———o	
Fabrication							o———	———o

The details of development are mentioned below.

Design

The structure of the cask was determined so as to meet the special requirements mentioned above, in addition to design requirements of the regulations. Most of the design work was in the reduction of weight and in consideration of the two ways of loading.

Verification Test

The drop tests and thermal test were performed by using models in order to verify the integrity of the cask under accident test conditions and to confirm the validity of design methods adopted. We carried out successively the following four drop tests by using the half-scale model.

- 9 m horizontal drop test
- 9 m vertical drop test turning lid downward
- 1 m punch drop test onto lid
- 1 m punch drop test onto body in horizontal position

It was confirmed that the structural and leaktightness integrities of the cask were maintained under drop tests.

The fire accident thermal test for the full-scale model of the upper portion was done by using a large furnace.
The results demonstrated that the leaktightness integrity of the cask was maintained under the fire test condition, and the maximum temperature of the lid and vent valve was confirmed to be lower than the heat-resisting temperature of rubber O-ring.

Safety Analysis

The safety analysis was performed based on the design work and the results of verification tests.
The structural and thermal analyses were done using FEM programs, and the structural integrity was evaluated in accordance with stress criteria based on the maximum shear stress theory.

The containment calculations were performed by using evaluation procedures specified in ANSI N14. 5-1987. The dose rates at all portions of the cask were evaluated, and the subcriticality analysis was performed using SCALE code in order to confirm to satisfy the requirements of the regulations.
After the safety analysis report was reviewed by our Competent Authority, the design certificate was given in March 1993.

Fabrication

We started the fabrication of casks in March 1993. After final tests and inspections such as thermal test, pressure test, and leak inspection, two casks were completed in October 1994.

CONCLUSION

We have developed the new type of cask to transport FBR fuels, which are very different from LWR fuels since 1987 and fabricated two casks in 1994. Hereafter, we plan to perform handling tests at the fuel handling facility at FBR "MONJU" and the post-irradiated examination facility (FMF) in "O-arai Engineering Center" before actual shippments.

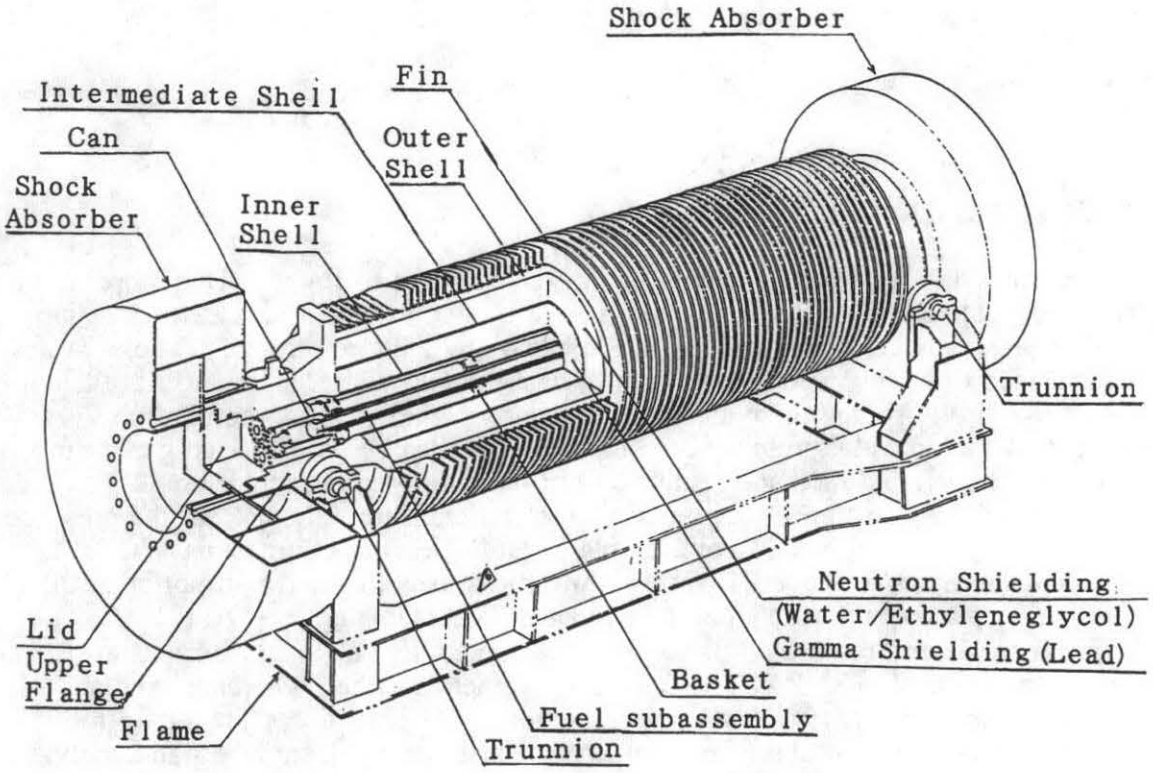

Figure 1. Outline of FBR Shipping Cask for PIE