Development of an FBR Spent Fuel Cask for Post-Irradiation Examination

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INTRODUCTION

Japanese first prototype FBR "MONJU" is being constructed by Power Reactor and Nuclear Fuel Development Corporation (PNC). After a few cycles of it's 100 % power operation, several irradiated fuel assemblies will be transported to the PIE facility for the examinations to confirm their integrity and performance. The PIE facility will be constructed at PNC's O-arai Engineering Center (OEC) and the fuel will be transported by sea. No existing cask can accomodate "MONJU" fuel since some are short in length and some are too heavy. So, it is necessary to develop a new cask which can transport fuel irradiated in "MONJU" to the PIE facility. This paper describes a work pertaining to the development of the PIE cask.

DESIGN

(Additional Requirements)

There are a lot of requirements for packagings by the regulations. In additions to these requirements, there are some additional requirements in case of the PIE cask. First of all the cask weight should be less than 45 tons. This requirement is based on the tolerance of the bridges on the cask route. Since a high γ-ray shielding capacity is also required, it is very difficult to find out the condition with which both requirements are satisfied. Secondly, the surface temperature of any fuel pin should be kept below 450℃ during transportation. The coolant inlet temperature of "MONJU" is 450℃ , this requirement is based on the thought that fuels and materials properties can be kept unchanged during transportation, as far as temperature won't be higher than irradiation temperature. It may be thought as a conservative requirement although it is required from the point of PIE results evaluation. Any change in properties during transportation makes the evaluation very difficult, so, no change would be welcome. Thirdly, wet and dry, two ways of loading is required. One is for a fuel assembly canned with water, the other is for a specially designed inner container. This is required to save the cost of the development. All these requirements should be satisfied with the design work.

(General Description)

The cask is approximately 5.5 m is length, 1.6 m in diameter and 45 tons in weight. It is transported with shock absorbers and a transport cradle attached. Fuels are transported horizontally. The impact by the cask drop is absorbed by shock absorbers and circumferential fins are provided on the cask surface for heat removal. Main shielding materials are lead and water for γ-ray and neutron respectively. Stainless steel as a structural material and water as a coolant also provide additional shielding. A basket placed in an inner tube determines the positions of assemblies so that no movement can be happened.
A body lid, a vent valve and a drain valve are the containment boundary. Four trunnions on an upper side of the body and two on a lower side are provided for lifting up the cask sideway or vertically. The cask is usually handled vertically at sites and transported horizontally. A specially designed inner container with a containment mechanism will be used if the inert gas atomosphere is requested. Schematic of the PIE cask is shown in Fig. 1.

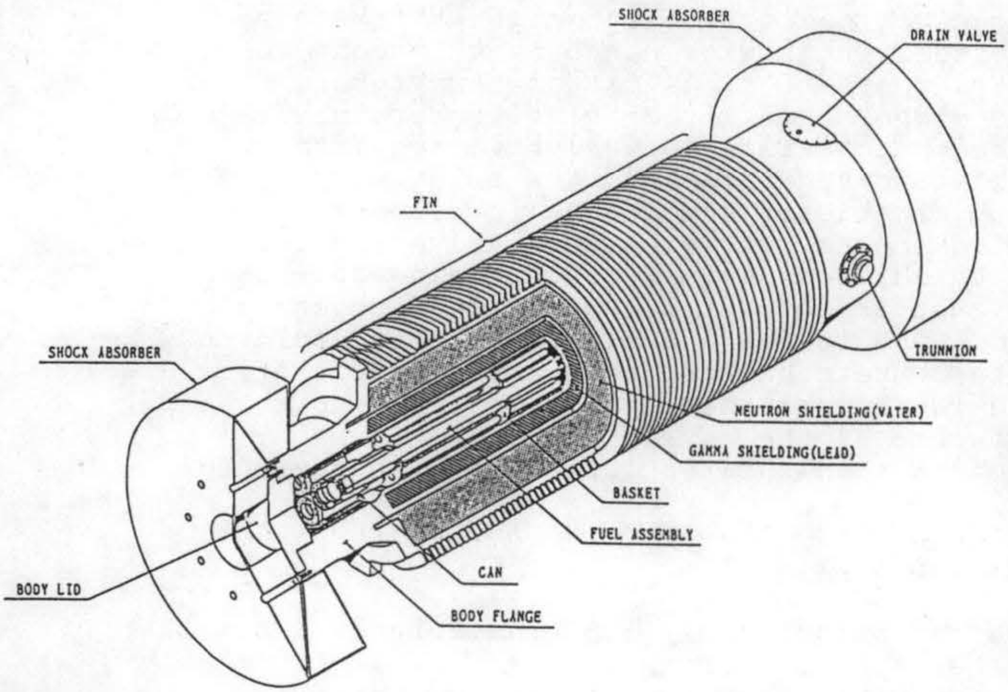


Fig.1 SCHEMATIC OF THE PIE CASK FOR PROTOTYPE LMFBR 'MONJU'

(Specification)

structure;

The PIE cask consists of three stainless steel shells with lead and water between them as shielding materials. A body flange and a body lid are a single forged stainless steel.

Heat removal;

Stainless steel, water and lead can provide good heat removal capability. The decay heat produced by a fuel assembly is conducted to an inner tube through water. The heat is then conducted to the surface of the cask through lead, water and stainless steel between them. Finally the heat is removed from circumferential fins which are provided on the surface of the cask. This mechanism of heat removal is very simple and reliable.

Containment mechanism;

A body lid, a drain valve and a vent valve provide containment boundaries. Rubber O-rings are used to achieve good seals for each boundary. In case of dry-type loading, a specially designed inner tube is welded and a leak check is conducted by using Helium gas.

Shielding capability;

Lead is selected as a γ-ray shield and water as a neutron shield. Stainless steel as a structural material and water as a coolant are also employed as shielding materials so that total weight of the cask is reduced as much as possible.

Criticality;

No special neutron absorber is required to keep off the criticality.

Main specifications are listed in Table 1.

Table-1 Main Specifications

Type of package	:	B (M)
Weight (t)	:	~45
Length (mm)	:	5450
Outer diameter (mm)	:	1585
Fuel type	:	PuO_2-UO_2
Reactor type	:	FBR, ATR
Number of assemblies	:	1~3, 1
Gamma shield	:	Lead, Stainless steel
Neutron shield	:	Water
Cooling system	:	Natural convection of air
Type of loading	:	Top loading
Transport	:	Ship, Trailer
Special requirements	:	• Surface temp. of Monju fuel pins should be kept below 450°C • Alternative way of loading (dry and wet)

WORKS REMAINED

Overview of the development of the PIE cask is summarized in Fig. 2 and schedule is shown in Fig. 3. The followings remain to be done;

Fig. 2 Flow diagram of the development

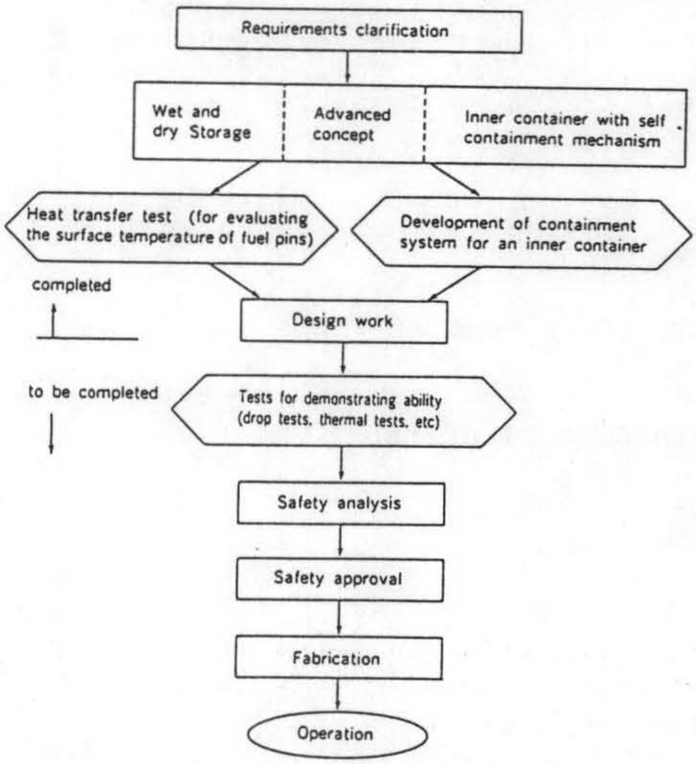
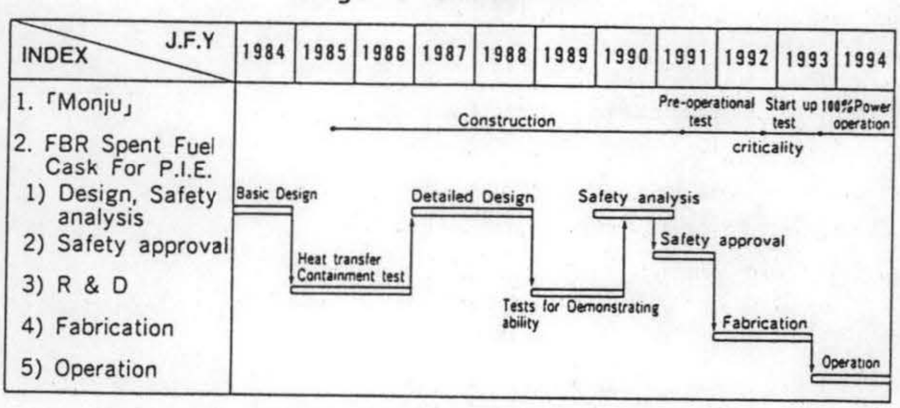


Fig. 3 Schedule



J.F.Y(Japanese Fiscal Year)

(Detailed design of the cask)

Detailed dimensions of the cask will be determined and final calculations for structural analysis, shielding capabilities and heat removal will be conducted.

(Tests for demonstrating abilities)

Drop tests using half scale models, fire test and full scale model test of a specially designed inner container are planned and will be conducted. Some handlig tests of the specially designed inner container will be also conducted.

(Safety analysis, Safety approval)

A Safety analysis report will be prepared based on the design work and the results of tests for demonstrating abilities. Then the application for approval of package designs will be made and the fabrication will be started after the approval. The cask is scheduled to be used in 1994.

CONCLUSION

The development of the PIE cask which tranports Japanese first prototype FBR "MONJU" fuel to the PIE facility is reviewed. Most of the design work has been completed and it shows that one through three fuel assemblies canned with water or one fuel assembly encapsulated in a specially designed container can be transported. The works are to be continued and the cask is scheduled to be used in 1994.