Design Features of Fuel Transfer Mechanism for SMART-P

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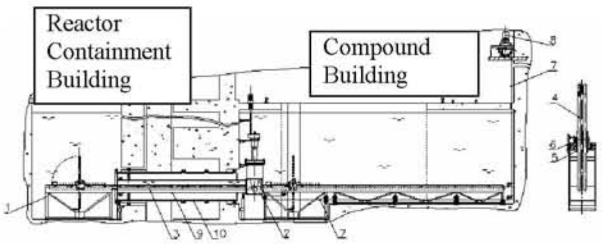
1. Introduction

The conceptual design of the fuel handling and storage system for SMART-P(System-integrated Modular Advanced ReacTor) is under development. In general, the Fuel Transfer Mechanism (FTM) is an important part of the fuel handling and storage system for a nuclear power plant. The FTM is intended to transport fuel assembly (FA) from the containment to the compound building and back through a horizontal penetration between the buildings. In this paper, the results of the conceptual design of fuel transfer mechanism for the SMART-P are described. The design features of the FTM for the SMART-P are compared for those of the KSNP (Korean Standard Nuclear Power Plant).

2. Design Features

2.1 System Components

The FTM for the SMART-P consists of two tables; one in the reactor containment building (RCB) transfer canal and the other in the compound building (CB) transfer canal. Each table has a support frame with pins attached to the tables, upender fitted with cross wheel, carriage seat for FA and electric drives as shown in Figure 1.



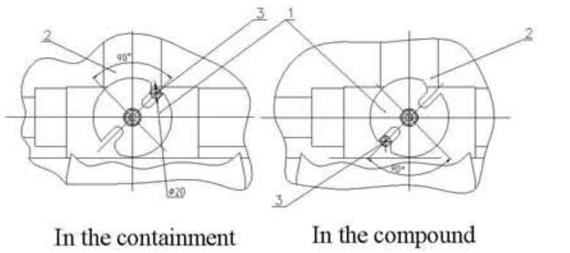
1. Table	2. Gate valve	3. Carriage
4. Carriage seat	5. Upender	6. Track
7. Rope	8. Motor	9. Guide tube
10. Leak-tight penetration		

Figure 1. Fuel transfer mechanism for SMART-P

One drive system, which moves a carriage between the upenders located in the two buildings via the guide tube of the FTM, is provided in the compound building. The guide tube connects the refueling pool in the reactor containment building to the spent fuel storage pool in the compound building. It is of sufficient diameter to allow the fuel transfer carriage to pass through it on permanently installed rails whose elevation coincide with the elevation of the rails on the upenders at either end. A central monitoring and control system for the FTM is provided in the main control room. Two cavities in a carriage are provided for containing a fuel assembly during the movement. The configuration for the cavity is designed to meet a criticality and cooling requirement. The blind flange, which installed on the end of the guide tube in the reactor compound building, is designed for retaining a pressure boundary during the plant operation. A gate valve is installed on the guide tube end in the compound building.

2.2 Drive Mechanism

The drive mechanism of the FTM is consisted of a motor, drum and rope system. A rope of individual electric drives transfers the carriage along horizontally arranged FTM carriage seat. One drive ensures carriage movement to the containment, and the other in reverse direction. Electric drives are fitted with manual doublers. The carriage moves along FTM track, lay on tables, and along the track in gate valve between the buildings. The carriage seat on upender shall be rotated into vertical or horizontal position by activation of a cross wheel fixed on the seat. When the carriage approaches the extreme position, the cross wheel on tables interacts with pins of supports and the upender automatically rotates into vertical position and is fixed at that position. When the carriage comes down from the table, the FTM carriage seat automatically turns into horizontal position. The drive mechanism of upender by using cross wheel action is shown in Figure 2.



1. Cross wheel 2. Carriage seat 3. pin

Figure 2. Mechanism of the upender rotation using cross wheel

2.3 Interlocks

The FTM includes interlocks to prevent damages upon FAs or equipments. The interlocks system has major five systems, which are composed of winch overload interlock, carriage interlock, upender rotation interlock, upender interlock and carriage rotational interlock [1]. When the RM(refueling machine) and the SFHM(spent fuel handling machine) are at their upender table, rotation of the upender is denied by the interlock system[2].

2.4 Comparison of Design Feature with FTM of KSNP

The components and arrangement for FTM compared with those of the KSNP are shown on Table 1.

Table 1. Comparison of design features between SMART-P and KSNP

Design features	SMARP-P	KSNP
Components and Arrangement . FTS table(CB/ FB) . Control console . Upender and HPU . Carrier and Cavity . Winch system.	. Drive mech. in CB . Central control . Cross wheel type . the same w/KSNP . the same w/KSNP	. Drive mech. in RCB . One unit per bldg. . Cylinder rotation type . Two cavity . Motor, Drum and Cable
Drive mechanism	. Winch system . Automatic w/ cross wheel	. Winch system . Cylinder w/ hydraulic water
Interlock system	. the same w/KSNP	. With RM and SFHM . Over/underload , etc

The arrangement of FTM table differs from that of KSNP. The electric motor drive mechanism of SMART-P is arranged in the side of compound building. This new concept, which is similar with that of the EPRI Utility Requirements Document [3], intends to enhance the maintenance for periodical inspection and operational accidents. The control system of FTM has an advanced design feature of central monitoring and control system in the main control room. It has an advantage of effective control in respect of refueling process.

The drive mechanism of the winch system is the same as that of the KSNP. However, cross wheel type upender rotation mechanism is adopted in SMART-P while the drive mechanism of upender in KSNP has a feature of the hydraulic water cylinder type. The advantage of the upender system of the SMART-P automatically operates by the activation of cross wheel. The configurations of the other component are the same as those of the KSNP.

The interlock system provided in accordance with Reference 3 prevents damages to fuel assemblies and ensures improved personnel safety. The interlock system for the KSNP does not permit the RM or the SFHM to access unless it is not vertical position, and for the FTM upender shall not to be rotated when the RM and the SFHM are located on the FTM upender position. Then, the FTM interlocks system of SMART-P share with the same design concept of the KSNP.

3. Conclusion

The brief descriptions of conceptual design features of fuel transfer mechanism for SMART-P have been presented. The design concept developed for the FTM of the SMART-P has an enhanced feature concerning the maintenance for winch system and table arrangement. The design feature of central control system has a positive effect to control and handle fuel assembly. Also, an automatic drive mechanism of upender rotation is a simple compared with the KSNP. The design for the FTM also has safety functions by providing the interlocks device.

REFERENCES

[1] ANSI/ANS 57.1, Design Requirements for Light Water Reactor Fuel Handling Systems, ANS, 1991.
[2] Safety Analysis Report for SMART-P, Rev.01, Chapter 9, KAERI, 2005
[3] EPRI Utility Requirements Document, EPRI, Vol. II, Chapter 7, 1991.