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Design Study on the Rotating Plug Size of an Advanced SFR Demonstration Plant

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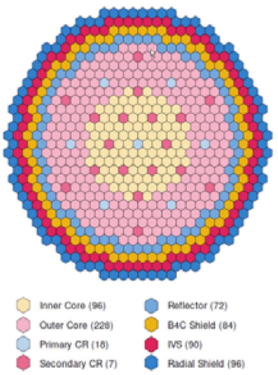
1. Introduction

The preliminary reference core of the 600 MWe SFR demonstration plant as shown in Fig. 1 is composed of 324 fuel assemblies, 25 control rods, 72 reflector assemblies, 180 shield assemblies and in-vessel storages. Fig. 1 presents the reactor core configuration and design feature[1]. As shown in this figure, the fuel assembly duct pitch and gap size are 153.87 mm and 4 mm, respectively. The determination of the rotating plug size is significant in the design of the reactor vessel because the reactor vessel size is decided from the interfaces with the rotating plugs penetrating the reactor head. The main factor affecting the rotating plug size along with the arrangement of the surrounding equipment is the position of the control rod in the reactor core. The size of the upper internal structure(UIS) can be decided by considering the distance from the reactor center to the outermost control rod[2]. In the in-vessel fuel handling concept of the double rotating plug type selected in the SFR demonstration plant, the size of the UIS and the eccentricities of rotating plugs are significant parameters for the decision of the rotating plug size.



Assembly Data	Units(mm)
Assembly duct pitch	153.87
Duct material	HT9
Duct gap	4.0
Duct wall thickness	3.7
Core size	Units(mm)
Diameter of inner core	1692
Diameter of outer core	3693
Number of inner driver	96
Number of outer driver	228
Maximum core diameter	4451.8
Control rod	Units(mm)
Distance from outermost control rod to reactor core	1399
Number of control rod	25

Fig. 1 Reactor core configuration and design feature of the 600 MWe SFR demonstration plant

2. In-Vessel Fuel Handling Concept

In the SFR demonstration plant, the in-vessel fuel handling system provides an access to any core position by means of the eccentricities of double rotating plugs located in the reactor head, a direct lift machine(DM) and a fixed arm machine(FM). The DM is situated at the center of the UIS in the small rotating plug and covers the inner handling zone of the core. The FM which covers the outer handling zone is also located on the small rotating plug. Take over positions created in the core at the start of each fuel handling movement provide the link between the two charge machines where the two handling zones overlap. The interfaces with the secondary fuel handling system are provided by a fuel transfer port suspended from the reactor head. A new assembly is deposited through the fuel transfer port from the outside of a reactor vessel, while a spent assembly is deposited to the fuel transfer port by the FM[3]. Fig. 2 shows the fuel handling principal of double rotating plugs.

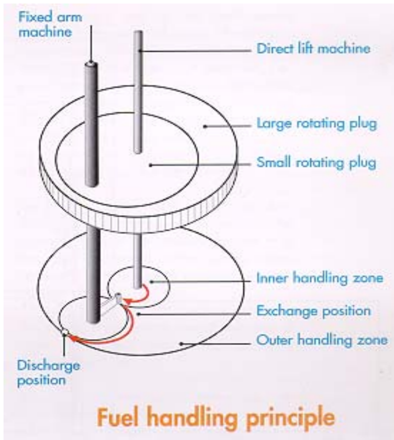


Fig. 2 Fuel handling Principal of double rotating plugs

2.1. Case study for the rotating plug size

To design the smallest size of the rotating plug in the given demonstration plant reactor core, the case study is carried out for the variation of the eccentricity. The eccentricity values of the small rotating plug(SRP) are changed 30 Cm to 50 cm, and those of large rotating plug(LRP) are 15 cm and 0 cm. Fig. 3 shows the top view of rotating plugs with the 30 cm and 15cm in the eccentricity values of the SRP and LRP, respectively. As shown in this figure, when the DM which is located in the center of the reactor core is rotated as the eccentricity value of 30 cm in the center of the SRP, the transition line with the radius of 60 cm is made. The diameter of UIS determined to consider the outermost position of the control rod is 3.1 m and the diameter of FM penetration which is located in the inside of the SRP is designed as 60 cm. By considering the distance between the UIS and FM and the flange gap of the upper part of the rotating plug, the diameters of the SRP and LRP are determined as 4.5 m and 6.0 m,

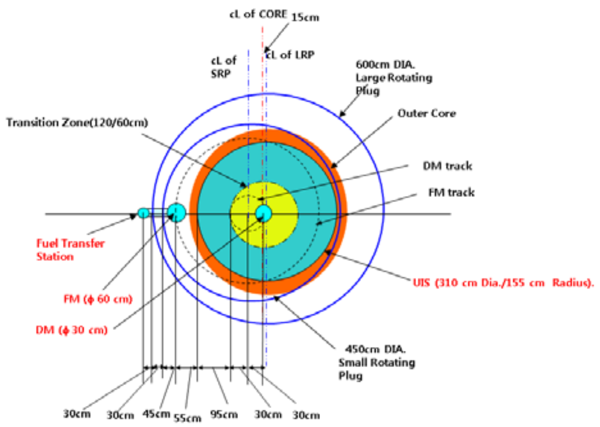


Fig. 3 Top view of rotating plugs with the 30 cm and 15cm eccentricities of the SRP and LRP, respectively

Table 1. Evaluation results for the rotating plug design

	Eccentricity of LRP, 15 cm	No Eccentricity of LRP	Design Possibility
	Diameter Of SRP and LRP	Diameter Of SRP and LRP	
Eccentricity of SRP, 30 cm	4.5/ 6.0 m	4.5/ 5.7 m	Not Ok
Eccentricity of SRP, 40 cm	4.3/ 6.0 m	4.3/ 5.7 m	Not Ok
Eccentricity of SRP, 45 cm	4.2/ 6.0 m	4.2/ 5.7 m	Ok
Eccentricity of SRP, 50 cm	4.3/ 6.0 m	4.3/ 5.7 m	Ok

respectively. From the case study for the rotating plug eccentricity, the evaluation results of the rotating plug diameter are presented in Table 1. As shown in this table, it can be seen that the diameter of the LRP is not influenced by the eccentricity values of the SRP, and is evaluated as 6 m and 5.7 m for the LRP eccentricity values of 15 cm and 0 cm, respectively.

2.2. Review for the accessibility of the fuel handling machine

The in-vessel fuel handling machine should be able to reach all positions of the reactor core and the fuel transfer port by considering the interfaces of surrounding structures. Fig. 4 shows the conceptual drawing for the accessibility evaluation of the reactor core for in-vessel fuel handling machines and double rotating plugs. The DM is located in the center of the reactor core and the FM is placed in the edge of the SRP. As shown in this figure, the point A, B and C indicate the fuel transfer positions in the transition line and the accessibility evaluation for predicting whether both FM and DM can reach these positions is carried out. From the evaluation results for the accessibility of fuel handling machines as shown in Table 1, it can be seen that FM can access the transition line to provide the link between the two charge machines in case of the SRP eccentricity values of 45 cm and 50 cm with no eccentricity of LRP. Thus, the LRP size can be designed to the smallest diameter in these two cases in the given reactor core.

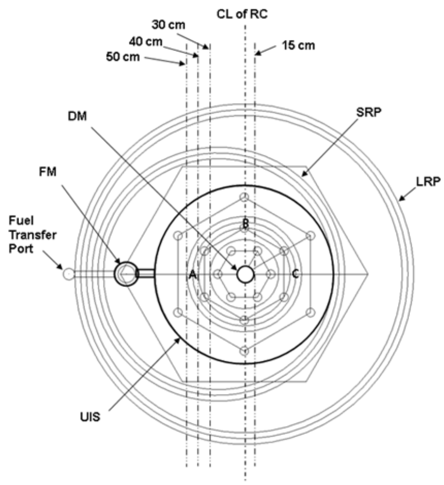


Fig. 4 Conceptual drawing for the accessibility evaluation of the reactor core for in-vessel fuel handling machines and double rotating plugs.

3. Conclusions

In the SFR demonstration plant, the in-vessel fuel handling concept is reviewed. When the arrangement of the reactor core and the position of the control rod are changed, the rotating plug size and the accessibility of the fuel handling machine are evaluated. To design the smallest size of the rotating plug in the given demonstration reactor core, the case study is carried out for the variation of the rotating plug eccentricity.

Acknowledgements

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