Development of the Simulation Program for the In-Vessel Fuel Handling System of Double Rotating Plug Type

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1. Introduction

In-vessel fuel handling machines are the main equipments of the in-vessel fuel handling system, which can move the core assembly inside the reactor vessel along with the rotating plug during refueling. The in-vessel fuel handling machines for an advanced sodium cooled fast reactor(SFR) demonstration plant are composed of a direct lift machine(DM) and a fixed arm machine(FM). These machines should be able to access all areas above the reactor core by means of the rotating combination of double rotating plugs. Thus, in the in-vessel fuel handling system of the double rotating plug type, it is necessary to decide the rotating plug size and evaluate the accessibility of in-vessel fuel handling machines in given core configuration. In this study, the simulation program based on LABVIEW which can effectively perform the arrangement design of the in-vessel fuel handling system and simulate the rotating plug motion was developed. Fig. 1 shows the flow chart of the simulation program.

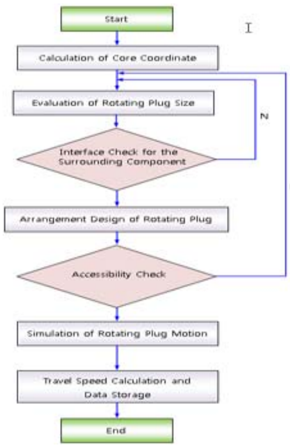

Fig. 1 Flow chart of the simulation program

2. Arrangement Design of the In-Vessel Fuel Handling System

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, the DM and the 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(SRP). 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[1]. Fig. 2 shows the fuel handling principal of double rotating plugs.

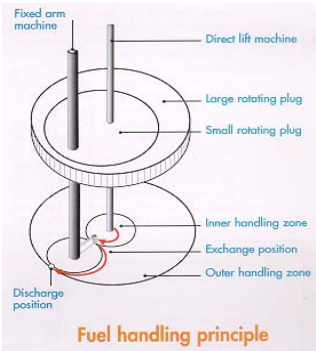

Fig. 2 Fuel handling principal of an advanced SFR demonstration reactor

2.1 Calculation of the Rotating Plug Size

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 component 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. Fig. 3 shows the evaluation results of the rotating plug size calculated by the simulation program in case the eccentricity value of the SRP is 48 cm with no eccentricity of the large rotating plug(LRP).

2.2 Accessibility Check of the Fuel Handling Machine

The in-vessel fuel handling machines can access to all areas inside the core and the fuel transfer port by considering the interfaces above the core. The accessibility check of in-vessel fuel handling machines is evaluated to three types such as the accessible region of the DM, the transition region and the accessible region of the FM. Fig. 4 shows the evaluation results of the accessibility check calculated by the simulation program. The left side figure shows the position coordinate of core assemblies automatically generated by the core assembly duct size and the right side figure presents the region where in-vessel fuel handling machines can reach. As shown in this figure, total 12 core assemblies indicated in red points are located in the transition region. In this region, inner core assemblies transferred by the DM can move to the outer core in another time by using the FM. From the evaluation results by the program, it can be seen that in-vessel transfer machines can access all positions inside the core in above given design condition.

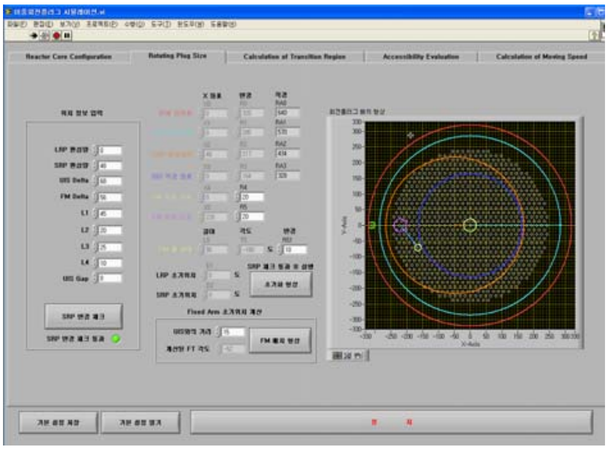

Fig. 3 Calculation results of the rotating plug size

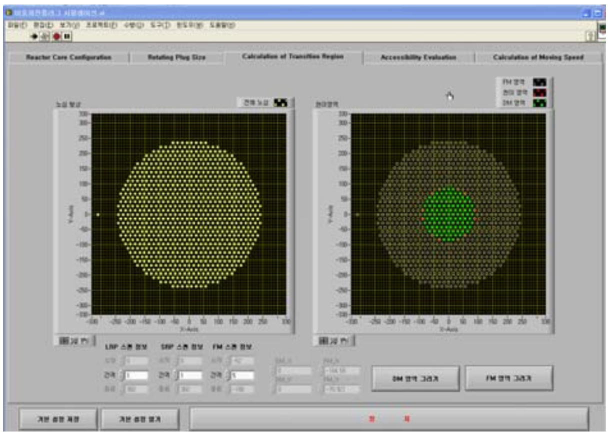

Fig. 4 Evaluation results of the accessibility check calculated by the simulation program

3. Simulation

When the inner core assembly shifts from the inner core to the fuel transfer station, it can move in twice handling, but the outer core assembly can directly move into the the fuel transfer port. For this moving mechanism, rotation angles of double rotating plugs and moving tracks of the DM and FM are simulated. Fig. 5 presents the simulation process for the in-vessel fuel handling system. In this program, the moving position and travel speed of core assemblies during the refueling period can be evaluated.

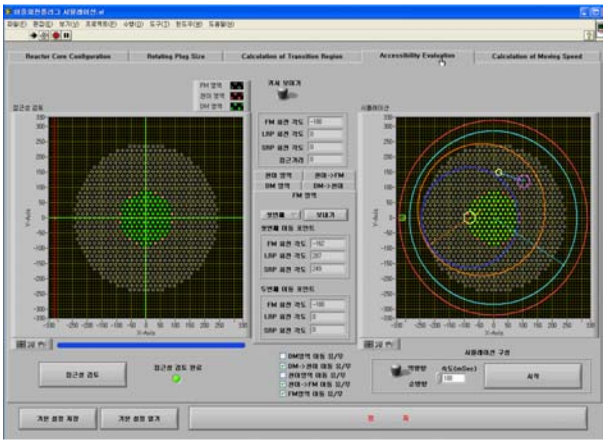

Fig. 5 Simulation process for the in-vessel fuel handling system.

4. Conclusion

Through the development of the simulation program for in-vessel fuel handling system of the double rotating plug type, the arrangement design of the in-vessel fuel handling system can be effectively performed. Also, by means of the simulation of the moving mechanism, the moving positions and the travel speed of core assemblies during refueling period can be predicted.

Acknowledgements

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