Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 17-18, 2012

Review of the Conceptual Design for In-Vessel Fuel Handling Machines in SFR

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1. Introduction

The main in-vessel fuel handling machines in sodium cooled fast reactor(SFR) are composed of the in-vessel transfer machine(IVTM) and the rotating plug. These machines perform the function to handle fuel assemblies inside the reactor core during the refueling time. The IVTM should be able to access all areas above the reactor core and the fuel transfer port which can discharge the fuel assembly by the rotation of the rotating plug. In the 600 MWe demonstration reactor, the conceptual design of the in-vessel fuel handling machines was carried out. As shown in Fig. 1, the in-vessel fuel handling machines of the demonstration reactor are the double rotating plug type.

With reference to the given core configuration of the demonstration reactor, the arrangement design of the rotating plug was carried out by using the developed simulation program[1]. At present, the conceptual design of SFR prototype reactor which has small capacity of about 100 MWe is being started. Thus, it is necessary the economical efficiency and the reliability of the in-vessel fuel handling machines are reviewed according to the reduction of the power capacity. In this study, the preliminary design concepts of the main in-vessel fuel handling machines according to the fuel handling type are compared. Also, the design characteristics for the driving mechanism of the IVTM in the demonstration reactor and the recovery concept from the malfunction are reviewed.

2. Review for the Conceptual Design of In-Vessel Fuel Handling Machines

2.1 Comparison for the Preliminary Design Concept of In-Vessel Fuel Handling Machines

Although a double rotating plug design as shown in Fig. 2(a) in the 600 MWe demonstration reactor is selected, a single rotating plug design as shown in Fig. 2(b) in the prototype reactor of the small size has some advantages as the reference design for several reasons. First reason is cost reduction. The complexity of the double rotating plug design and the added number of components require approximately twice the amount of hardware to operate and maintain over the single rotating plug design. Second reason is space. The double rotating plug type has been found to increase the diameter of the reactor vessel greater than one meter over the single rotating plug design which has the same configuration of the reactor core. Although a double rotating plug design can use the fixed arm machine which has the reliability to the single rotating plug design of the pantograph arm type, it is predicted that the benefits of the single rotating plug are more profitable.

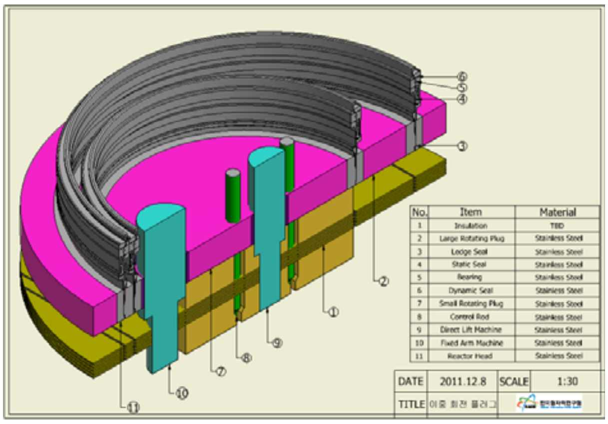
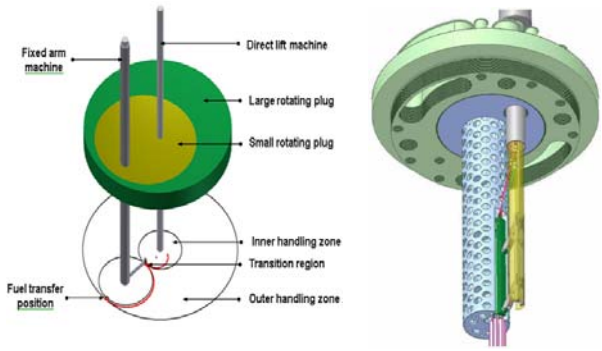


Fig. 1 In-vessel fuel handling machines of a 600 MWe demonstration reactor



(a) Double rotating plug (b) Single rotating plug

Fig. 2 In-vessel fuel handling types in SFR

2.2 Review of Driving Mechanism

Fig. 3 shows the conceptual design configuration of the fixed arm type IVTM which can be operated using four servo motors in the demonstration reactor. The mechanical parts of the IVTM submerged in sodium consist of the fixed arm, the support tube and the gripper assembly for the attachment and detachment of the fuel assembly. When the gripper assembly attached in the fixed arm is vertically lowered by the servo motor, the gripper finger is closed and contacts with the head of the fuel assembly. After that, the gripper finger is opened and connected with the head of the fuel assembly. In such a gripper mechanism, the driving forces of servo motors are transmitted to the gripper head through universal joints, and the spline shaft installed in the fixed arm is rotated and can rotate the cam spindle by using the gear. By means of the rotation of the cam spindle, the gripper finger can be open and closed. The IVTM in the demonstration reactor can be operated by the above driving mechanism and the durability at an elevated temperature should be verified because it is submerged in the elevated temperature sodium pool.

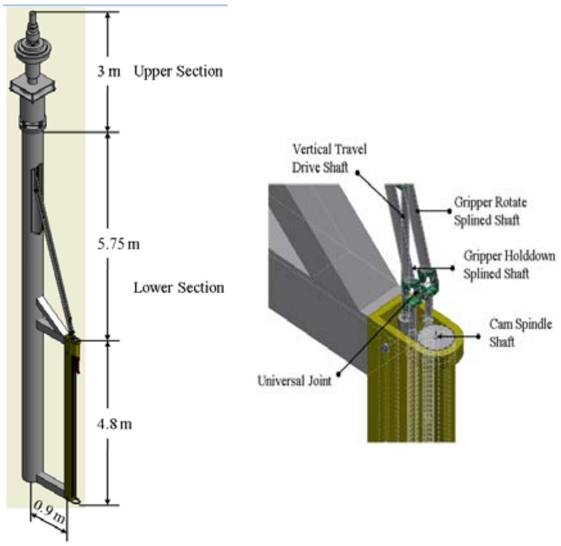


Fig. 3 Conceptual design configuration of the fixed arm type IVTM in the demonstration reactor

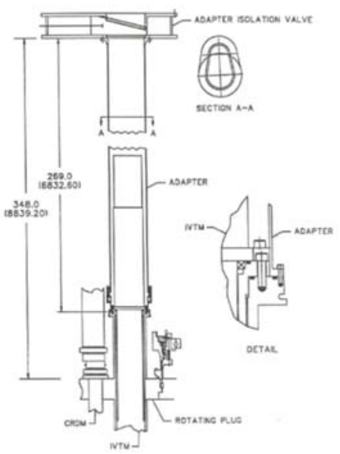


Fig. 4 Recovery concept for a single malfunction of the IVTM

2.3 Recovery from Malfunction

Fig. 4 shows the recovery concept for a single malfunction of the IVTM. In the recovery of a single malfunction of the IVTM, the allowance for unloading a gripper assembly in a designated area within the reactor, the removal of the IVTM through the penetration in the rotating plug and the installation of the new IVTM should be possible. Fig. 5 shows the recovery concept for multiple failures of the IVTM. When the recovery process is not unsuccessful or the multiple failures occur, the IVTM attaching the fuel assembly is removed through the penetration of the rotating plug. The IVTM is then enclosed in the cask above the reactor head and transferred to the fuel building for the removal of the fuel assembly[2].

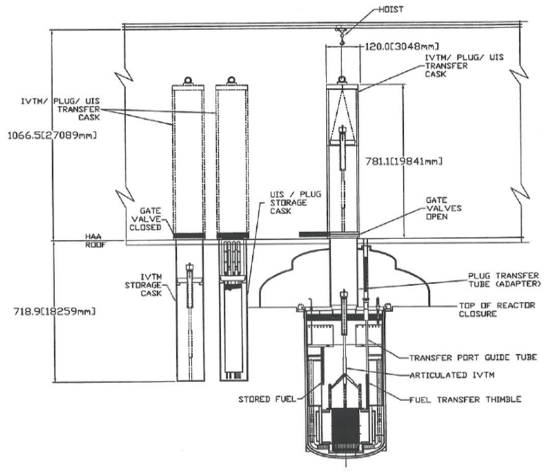


Fig. 5 Recovery concept for multiple failures of the IVTM

3. Conclusion

The review of the conceptual design for in-vessel fuel handling machines in SFR is performed. The fuel handling types of the in-vessel fuel handling machines are compared and the driving mechanism of the IVTM and the recovery concept from the malfunction are reviewed.

Acknowledgements

This study was supported by the Korean Ministry of Education, Science and Technology through its National Nuclear Technology Program.

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[1] S. H. Kim and J. B. Kim, Development of the Simulation Program for the In-Vessel Fuel Handling System of Double Rotating Plug Type, trans. of the KNS, October, 2011.
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