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Design Characteristics of Pantograph Type In-Vessel Fuel Handling System in SFR

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1. Introduction

The pantograph type in-vessel fuel handling system in a sodium cooled fast reactor (SFR), which requires installation space for the slot in the upper internal structure attached under the rotating plug, is composed of an in-vessel transfer machine (IVTM), a single rotating plug, in-vessel storage, and a fuel transfer port (FTP). The pantograph type IVTM can exchange fuel assemblies through a slot, the design requirement of which should be essentially considered in the design of the in-vessel fuel handling system. In addition, the spent fuel assemblies temporarily stored in the in-vessel storage of the reactor vessel are removed to the outside of the reactor vessel through the FTP. The fuel transfer basket is then provided in the FTP, and a fuel transfer is performed by using it. In this study, the design characteristics for a pantograph type in-vessel fuel handling system are reviewed, and the preconceptual designs are studied.

2. Design Review for the Pantograph Type In-Vessel Fuel Handling System

2.1 Design Review of UIS Slot

A pantograph type IVTM is used with a single rotating plug. In the upper internal structure(UIS) welded under the rotating plug, a slot for the movement of the pantograph arm is required. The slot should be designed to avoid interference with the control rod arrangement of the reactor core, the width of which can be calculated from the pitch size of the core assembly duct. Fig. 1 shows the slot configuration designed for the UIS in the ABTR [1]. The slot width can be designed by considering the configuration of the gripper guide structure. Fig. 2 shows a conceptual drawing of the gripper guide structure of the IVTM. As shown in this figure, the gripper frame has the maximum width in the gripper mechanism.

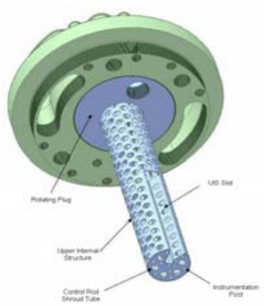


Fig. 1 Rotating plug and UIS in the ABTR

Thus, it is important to decide the slot width considering the size of the gripper frame, which can be designed to be about 1.5 times the core assembly duct pitch.

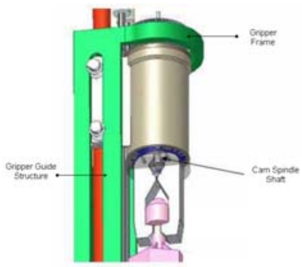
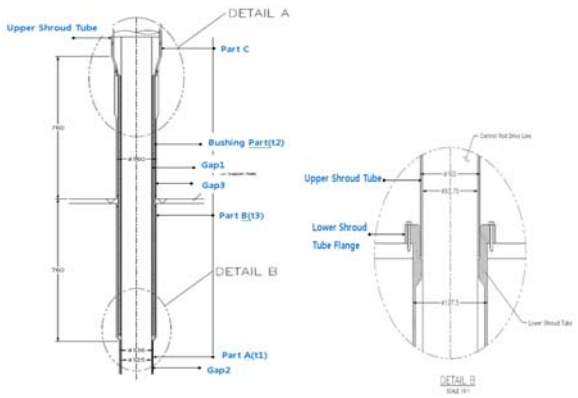


Fig. 2 Gripper guide structure of the IVTM in the ABTR

2.2 Design Review of the Control Rod Shroud Tube

In the inside of the UIS, control rod shroud tubes, which are required to move vertically the control rods and many posts for the installation of the instrument sensor, are installed. In particular, the shroud tube should avoid interference with the slot for the IVTM, and have the installation space of the driving mechanism including the sealing above the reactor head. Thus, to check the interference for the slot, it is necessary to evaluate the size of the control rod shroud tube by considering the size of the control rod drive line. Figs. 3 (a) and (b) present conceptual drawings of the upper and the lower shroud tube for a control rod, respectively. As shown in these figures, the diameter of the control rod shroud tube varies with the height. The upper shroud tube as shown in Fig. 3 (a) has the maximum diameter in the upper part, and the lower shroud tube as shown in Fig. 3 (b) has the maximum diameter in the flange part.



(a) Upper shroud tube (b) Lower shroud tube

Fig. 3 Conceptual drawing of the upper and the lower shroud tubes for the control rod in the case study of a prototype reactor

2.3 Interference Check of the Pantograph Type In-Vessel Fuel Handling System

Fig. 4 shows the configuration of the IVTM and UIS in the ABTR. The pantograph type IVTM as shown in this figure goes through the UIS slot to catch the core assemblies. The guide tube, which is fixed to the arm, is used to hold down the adjacent fuel assemblies and spread them slightly allowing the fuel assembly to be easily accessed without disturbing the adjacent assemblies. This is accepted by lowering the entire IVTM. Fig. 5 shows the arrangement design of the slot and control rod shroud tube in the case study of the prototype reactor. In the design of the pantograph type in-vessel fuel handling system shown in this figure, the UIS slot and control rod shroud tube should be designed to avoid interference, which should be considered by many case studies in the design of a reactor core.

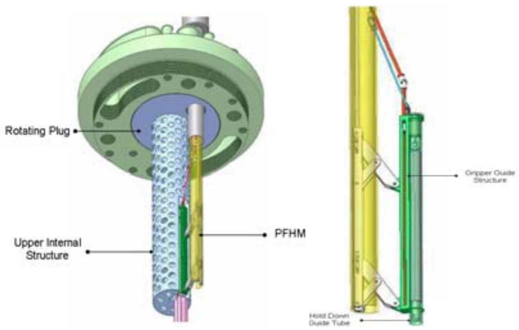


Fig. 4 IVTM and UIS in the ABTR

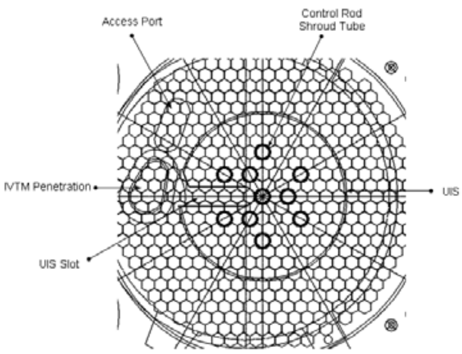
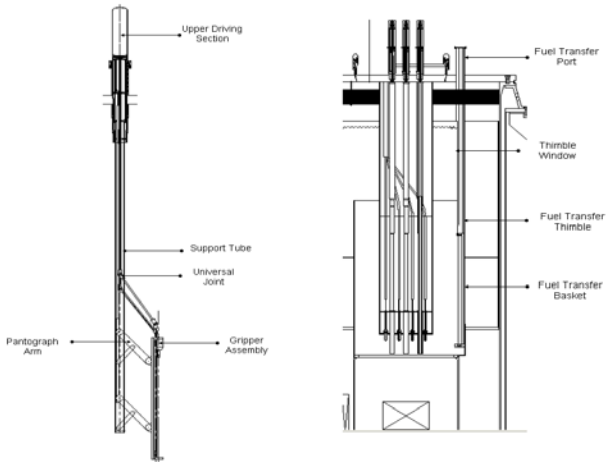


Fig. 5 Arrangement design of the slot and control rod shroud tube in the case study of the prototype reactor

3. Design Characteristics of the IVTM

The pantograph type IVTM operates using three major components such as an upper section, a support tube, and a pantograph arm including the gripper assembly. The IVTM has six motions: support tube rotation, pantograph travel, gripper travel, gripper rotation, gripper locking, and hold down travel. It can be positioned over any core assembly in the core by a combination of rotating the IVTM, extending or retracting the pantograph arm, or rotating the rotating plug. Fig. 6 (a) shows the preconceptual design of the IVTM in the case study of a prototype reactor.



(a) IVTM (b) FTP

Fig. 6 Preconceptual designs of the IVTM and the FTP in the case study of a prototype reactor

4. Design Characteristics of the FTP

A transfer of core assemblies into and out of the reactor vessel is accomplished with a straight push-pull type device operating through a fixed port in the reactor head. Fig. 6 (b) shows the preconceptual design of the FTP in the case study of a prototype reactor. The FTP is provided for the temporary parking of the fuel transfer basket while core assemblies are being transferred into and out of the basket using the IVTM.

5. Conclusion

The review of the design characteristics for a pantograph type in-vessel fuel handling system in SFR is performed and the preconceptual designs for the refueling components such as the IVTM, upper internal structure and the FTP are studied.

Acknowledgements

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REFERENCES

[1] ANL, Advanced Burner Test Reactor Preconceptual Design Report, ANL-ABR-1, 2006.