Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 10-11, 2007

Design Review of In-Vessel Transfer System in SFR

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1. Introduction

The design concept of IVTS(In-Vessel Transfer System) has used the various types in Sodium-Cooled Fast Reactor and the new concept which gives priority to the economy and simplicity is developing through the world. The representative types of IVTS are plug-in/plug-out type which draw the IVTM(In-Vessel Transfer Machine) from the reactor in the end of refueling time, A frame type, and rotating plug type. The plug-in/plug-out type draw the upper internal structure from the reactor during refueling and use after inserting IVTM at the same position. A frame type is designed to the inclined structure for IVTM in reactor vessel, which can move the core assemblies from the inside to the outside of the reactor vessel through the inclined fuel transfer hole. The characteristics of A frame type is that the structure of IVTM is large and complex and the part of IVTM is installed in the containment dome. There are Phenix, Superphenix and SAFR in such type. The design concept of IVTS for the most extensive use is rotating plug type, which can fix IVTM in reactor vessel during operation. In such type, the refueling time of the core assemblies is short and the operator is safe for radioactivity exposure[1].

2. In-Vessel Transfer System

The function of the IVTS(In-Vessel Transfer System) is to refuel the core assemblies inside the reactor. The IVTS consists of IVTM, the rotating plug, in-vessel storage, fuel transfer station and the fuel transfer port. In-vessel storage is prepared for the temporary storage of the spent core assemblies to remove the decay heat and it is located at the outermost layer of the core. The fuel transfer station is a temporary waiting station for new or spent core assemblies before moving to IVS or cask. Also, the fuel transfer port is plugged and sealed during reactor operation. For refueling, this plug is unfastened and opened for the exchange between the new fuel assembly and spent fuel assembly ducts. The IVTM and rotating plug are the main components of IVTS. The IVTM, operating in conjunction with the rotating plug, commences the repetitive refueling cycle by removing a spent fuel assembly duct from the core and placing the assembly in an empty in-vessel storage position for eighteen months storage. The IVTM is used to handle fuel assembly ducts, control rods, reactor components in the sodium-filled core of the reactor. The machine is designed in two parts. The upper part is basically an electrically driven gear box for operating the in-vessel section lower part. The lower part is positioned vertically from the rotating plug and extends into the reactor. The machine can be rotated and pick the core assembly ducts up after positioning the grapple over the required fuel assembly duct. The rotating plug drive is an electromechanical system in which electrical power to the motor of the plug drive is controlled to rotate and position the reactor rotating plug and IVTM during refueling[2].

3. Interface Consideration of In-Vessel Structure

The rotating plug and IVTM supported to the rector head restrict the position for in-vessel structure and occupy the importance space. The main design requirements considering the space distribution and the size of interface components are as follows[3].

1. Reactor core size
2. Arrangement of CRD(Control Rod Drive)
3. Instrument ports
4. Support structure of UIS(Upper Internal Structure)
5. Rotating plug type

4. Design Review of Fuel Handling Type

As the thermal power of the reactor is increased, the size of reactor core become larger, which have the size of IVTS and the fuel handling type changed.

The fuel handling type of IVTS concept for the rotating plug type was reviewed by the interface consideration of in-vessel structure for the reactor core size in KALIMER-600 as shown in Fig. 1. The rotating plug type was reviewed for two types in KALIMER-600 as shown in Figs. 2 to 3.

One is one rotating plug type and the other is two rotating plug type. One rotating plug type with pantograph arm is the design concept of IVTS in KALIMER-150 as shown in Fig. 4. It has the advantage for the simple structure as a whole and the size of rotating plug reduced, but the structural review is necessary for the pantograph arm and mechanism in the large scale IVTS[4].

Two rotating plug type is required to two IVTM in fuel handling of the reactor vessel inside. The core assemblies for the inner core should be handled twice to move from the reactor core to the fuel transfer station as shown in Fig.

5. This reduces the simplicity of the fuel handling and increase the refueling time, but the structure of IVTM is simple and has the structural stability.

Acknowledgements

This work has been carried out under the Nuclear R&D Program by MOST in Korea.

REFERENCES

[1] KALIMER Plug-in/Plug-out IVTM design study final report, IG78A-1, GE Nuclear Energy, 1997.
[2] KALIMER-600 preliminary conceptual design report, KAERI/TR-2784/2004.
[3] S.H. Kim, "Design Requirements for KALIMER Reactor Refueling System," KALIMER/MS 440-DR-01 rev. 0/2000, KAERI, 2000.
[4] S.H. Kim, Y. S. Joo, J. H. Lee, "Examination on the marginal length for the pantograph arm of In-Vessel Transfer Machine in KALIMER-600", KNS, May 2003.

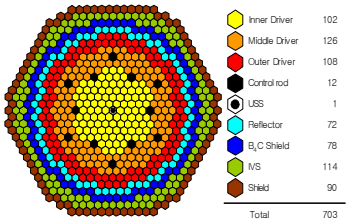

Fig. 1 Core configuration for breakeven core in KALIMER-600

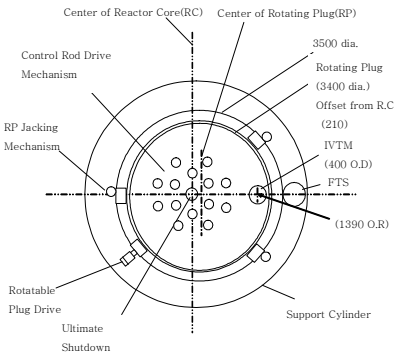

Fig. 2 Conceptual design of one rotating plug type IVTS in KALIMER-600

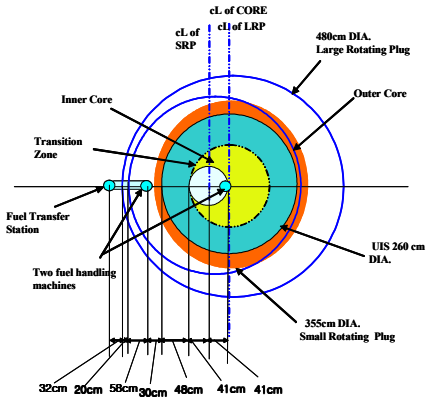

Fig. 3 Conceptual design of two rotating plug type IVTS in KALIMER-600

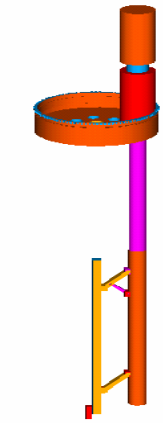

Fig. 4 3D model for one rotating plug type IVTS

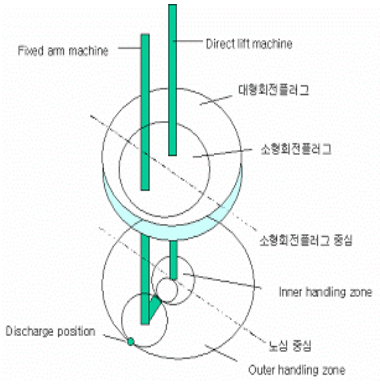

Fig. 5 Conceptual diagram for two rotating plug type IVTS