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Design Study and Animation on an Integrated In-Vessel Fuel Handling and Inspection System in a SFR

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1. Introduction

The fuel handling system includes several major components including the rotating plug, in-vessel fuel handling machine, storage rack, cask transporter as shown in Fig. 1. The in-vessel fuel handling machine provides access to any core position by means of the eccentric rotating plugs supported in the reactor head[1].

The reactor core and mechanical components which make up the primary circuit coolant are fully immersed in sodium, with the core being up to several meters below the sodium surface. Examination of the internal structure is therefore a difficult task. For example, visual techniques are impossible because of the opacity of liquid metal, and a lowering of the sodium level is impractical once a reactor is operational. In this study, the concept of an integrated fuel handling and inspection machine was suggested to enhance the effectiveness and application of an in-vessel fuel handling machine, and the alternative concept of a specially designed indexing machine has been reviewed and compared. Also, the concept of an integrated in-vessel fuel handling and inspection system was made as a 3D computer graphic animation which is easy to understand the driving characteristics to inform of the design result and verify the design adequacy through the technical consultation of the expert.

2. Design Study of an Integrated In-Vessel Fuel Handling and Inspection System

For the components below the sodium level, the normal in-service inspection approach is based on the continuous monitoring, the dimensional gauging and the under sodium viewing. The dimensional gauging is a simple and effective method for checking the integrity of the reactor internal structures below the sodium level. In this approach, a gauging probe is used for indexing the core barrel and other specially provided gauging points on in-vessel components, thus verifying the structural integrity of components. The under-sodium viewing system consists of several ultrasonic scanning transducers, which can be used in the imaging mode for mapping the under-sodium components, or in the sweeping mode to identify the presence of obstacles.

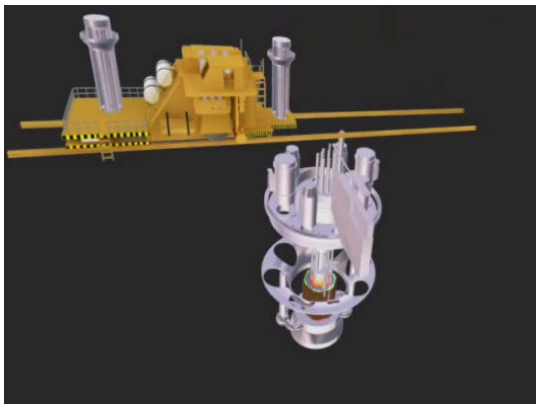

Fig. 1 The concept of the fuel handling system during refueling.

The integrated fuel handling and inspection concept can reduce the period of the reactor internal inspection during the refueling time owing to performing a dimensional gauging and under sodium viewing integratedly using the in-vessel fuel handling machine. The reactor internal inspection required during the refueling time can be simplified by using the fuel handling machine. Fig. 2 shows a schematic for the preliminary concept of an integrated fuel handling and inspection machine. The inspection probe for the dimensional gauging and the ultrasonic sensors for under sodium viewing are installed on the fixed arm of the in vessel fuel handling machine[2].

However, due to the use of two rotating plug concept and a compact in-vessel layout in KALIMER-600, accessing various locations inside reactor vessel is not possible with an integrated in-vessel fuel handling and inspection machine[3]. To resolve such difficulty, a specially designed indexing mechanism, namely in-vessel inspection machine need to be consider as an alternative design. The advantages of such a mechanism is that can have 1) multiple degrees of a freedom mobility to provide a dexterous accessibility to a large area, 2) a slim structure to fit in to tight in-vessel spaces, and 3) a high structural rigidity to render an adequate indexing accuracy. But this mechanism has disadvantages as it should be inserted in the entry provision of the reactor head during a refueling period and additionally

manufactured for an extra inspection machine. Fig. 3 shows a schematic for the concept of an in-vessel inspection machine.

3. Animation of an Integrated In-Vessel Fuel Handling and Inspection System

In the animation of an integrated in-vessel fuel handling and inspection system, the driving mechanism is described in detail and the concept of the insertion and extraction of the fuel assembly at a reactor core is explained as shown in Fig. 4. Also, the integrated concept of an in-vessel fuel handling and inspection machine is described. The detailed computer graphic modeling was made by using the 3D Max software. The shading effect of the 3D configuration for an integrated in-vessel fuel handling system in KALIMER-600 was proceed and enhanced the quality of the image synthesis using the texture mapping. To explain the driving mechanism of the in-vessel fuel handling mechanism, the operating process of the driving axes for an in-vessel fuel handling machine, the universal joints and the gripper were connected by the wire parameter[4].

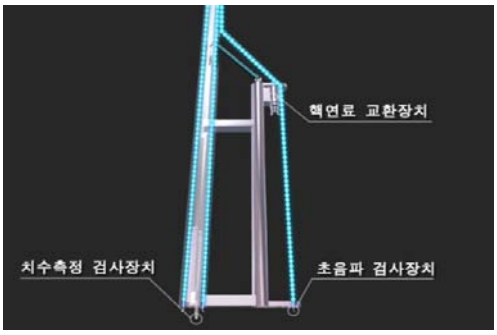

Fig. 2 A schematic for the preliminary concept of the integrated fuel handling and inspection machine.

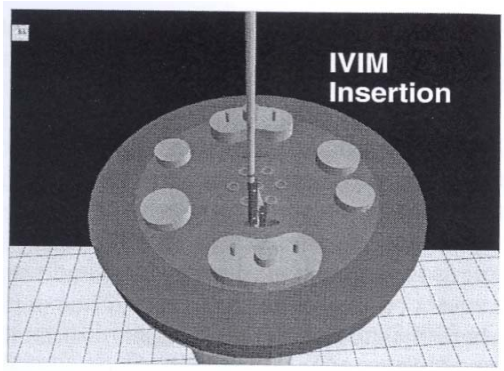

Fig. 3 A schematic for the concept of an in-vessel inspection machine.

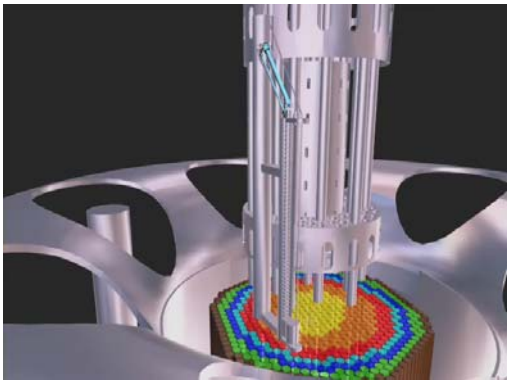

Fig. 4 The concept of the insertion and extraction of the fuel assembly at a reactor core

4. Conclusions

The verification for a deformation of reactor core structures is necessary during a refueling time and an inspection for the main parts of the other reactor internal structures is required in a SFR. The functions of the fuel handling and the inspection for the reactor internal structure were integrated by a unification approach. An integrated fuel handling and inspection concept was reviewed to enhance the effectiveness and application of an in–vessel fuel handling machine, and the concept of a specially designed indexing mechanism, namely an in-vessel inspection machine has been reviewed and compared. Also, the 3D computer graphic animation for the concept of an integrated in-vessel fuel handling and inspection system was made to review the design validity.

Acknowledgements

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