Basic Design of the Top-mounted CRDM for a Reactor with Plate Type Fuels

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1. Introduction

A control rod drive mechanism (CRDM) is a device to control the position of a control absorber rod (CAR) in the core by using a stepping motor which is commanded by the reactor regulating system to control the reactivity during normal operation of the reactor. The top-mounted CRDM driven by the stepping motor for the new research reactor with plate type fuels is under design in KAERI. Based on the proven technology of the design, operation and maintenance for the research reactor, HANARO, the CRDM for the new reactor has been optimized by the design improvement from new experience and information [1-2]. This paper aims for the introduction of the CRDM in the process of the basic design. The major differences of the CRDM between HANARO and new reactor are compared, and the design features, structures and future works related to the new reactor's CRDM are also described.

2. Design Features

A new research reactor with plate type fuels is a pool type reactor with 5~10MW power which is open to the atmosphere. The reactivity control mechanisms of this reactor consist of four CRDMs and two second shutdown drive mechanisms (SSDMs) as shown in Fig. 1. The CRDM controls the position of the CAR in the core by using a stepping motor during normal operation. A basic design of the top-mounted CRDM has been started on the same or similar concept with that of HANARO. Therefore, many design features including the geometrical shape of components can be applicable to the new reactor's design. However, due to the differences of a fuel type and a core configuration etc., it is necessary to improve and optimize on the basis of the HANARO with the following specifications and features.

- Number of CRDM : 4
- Design lifetime: 40 years except for the CAR and CAR guide tube
- CAR travel length: 650mm
- CAR drop time for full stroke: < 3 seconds
- Neutron absorber material: Hafnium

Table 1 presents the differences in design features of the CRDM between two reactors. Among many features of the CRDM, the largest change related to the structure is the shape of the CAR and its guide structure, and their details are described in the following section.

Table 1 Differences in design features between HANARO and New Reactor

	HANARO	New Reactor
Power	30 MW	5~10 MW
CAR shape	circular, Hf	square tube, Hf
CAR stroke	700 mm	650 mm
CAR gimbal joint	2 circular joints	1 square joint
CAR guide tube	cylindrical shroud tube & flow tubes	dual square tubes
Tracks & Carriages	lower/middle/upper tracks & carriages	Same concept with optimized
Tie rod	upper/middle tie rods	tie rod with improved maintainability
CRDM drive	stepping motor driven mechanism	same mechanism with improved damping & maintainability

3. Structures

There are four CRDMs with the identical shape and function in the new reactor as shown in Figs. 1 and 2. The CRDM is composed of a CAR assembly, a CAR guide tube to protect and guide the absorber element from the turbulence of the primary cooling system flow, three tracks and carriages assembly interconnected by tie rod to transmit motion to the absorber element and a drive assembly to produce the actuation to raise and lower the CAR. The four CRDMs contain identical, interchangeable assemblies except the brackets with a slightly different shape.

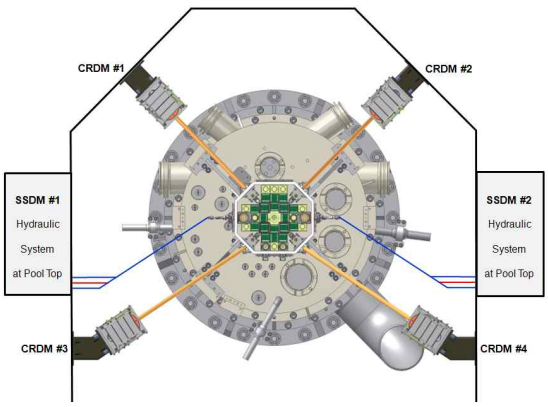

Fig. 1 Layout of the CRDMs and SSMDs.

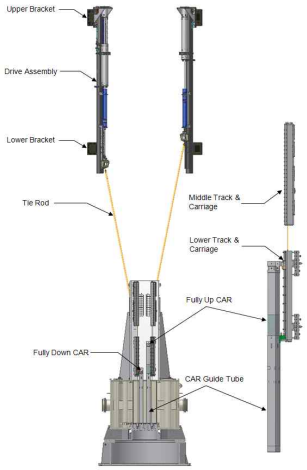

Fig. 2 Overall view of the CRDM.

3.1 CAR and CAR guide tube

The CAR and CAR guide tube as shown in Fig. 3 are the square shape, and have the greatest difference with those of HANARO, which were designed as the cylindrical shape. The CAR is a square tube with the neutron absorbing material made of Hafnium. It consists of a square bearing skirt, an absorber element, a support tube and a mounting tube. The mounting tube and support tube is connected as a gimbal joint which permits the absorber element and guidance components to be misaligned to the limit of the tolerances. The CAR guide tube is zirconium alloy dual square tubes supported coaxially with the CAR where it can absorb the flow induced forces on the exposed parts of the absorber element in the core. The lower part of the guide tube is inserted into the square slot of the grid plate, and the top end is provided with a lug which connects to a plate bolted to the bottom of the lower track assembly. When the CAR is fully inserted with the guide tube centralized in the core, the absorber element is placed between the inner and outer tube, and guided in its motion by a bearing running on the inside of the CAR guide tube.

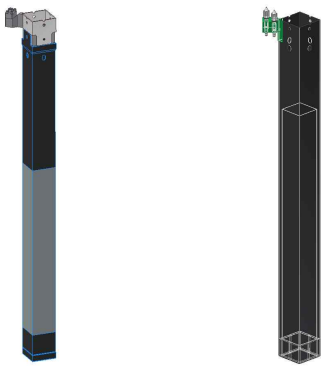

Fig. 3 Shape of the CAR and CAR guide tube.

3.2 Tracks and Carriages

The CRDM includes three sets of tracks and carriages, two mounted on the upper guide structure wall and the third on the drive assembly, and the tie rod interconnecting the carriages. The linkage formed by the carriages and the tie rod connects the absorber element to the drive assembly to effect and guide the motion of the absorber element.

3.3 Drive Assembly

The drive assembly is a driving part of the CAR movement and is attached to the top of pool liner by upper and lower brackets as shown in Fig. 2. It consists of a stepping motor, a ball screw/nut, a dry well, a hydraulic damping system, a support beam and instruments. The screw mechanism is activated by an electric stepping motor drive and contains an electromagnet to permit control rod dropping. The CAR is moved by a stepping motor turning a ball screw through the linkage of carriages and the tie rod.

4. Future Works

At present, the basic design of the CRDM in the reactor with plate type fuels was completed. The detail design for the fabrication has been carrying out along the project schedule. Also, the prototype CRDM will be fabricated and the qualification test using test rigs will be performed to verify the functionality, the drop time, the motor's stepping performance, the seismic and endurance performance.

5. Conclusions

A basic design of the top-mounted CRDM for the new reactor with the plate type fuel was performed on the basis of the HANARO's CRDM. The CAR and CAR guide tube are designed into a square tube depending on the geometrical shape of the plate type fuel and the core structure. Many components including the tracks/carriages, the tie rod and the drive assembly are designed and optimized with the improved operability and maintainability. Also, the detail design for the fabrication and the qualification test will be carried out in the future.

REFERENCES

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[2] M.H. Choi, Y.G. Cho, H. Huh, S.H. Kim and J.I. Kim, Conceptual Design of the Rectangular Control Rod Assembly, HANARO Symposium 2011, 2011.