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Development of Integrated Head Assembly Design for the Operating OPR1000

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1. Introduction

This paper outlines the Integrated Head Assembly (IHA) type applicable to the operating OPR1000 as an effort to reduce refueling steps as well as radiation exposure of the operating personnel.

Recently, IHA and Simplified Head Assembly (SHA) have been developed for the reactor head area structure in the worldwide nuclear power plants. Each IHA/SHA type has its own characteristics according to the plant owner's request and the supplier's design. A need for developing IHA is well recognized for the operating OPR1000.

2. Design Concept

The necessity of the IHA development is based on the EPRI URD [1] and KURD [2] recommendation that an integrated head disassembly capability should be provided which enables the entire head package and all related components (e.g., control rod drive mechanisms, insulation, cooling ducts, cable tray, etc.) to be lifted as a single unit by the reactor building crane.

2.1 Basic Design

Main components in the reactor head area consist of reactor head lifting structure, CEDM cooling fans/ducts, missile shield and Head Area Cable Tray (HACT). It takes a long time and many refueling steps when they are assembled and disassembled during refueling outage. Reactor head area structure is shown on the Figure 1.

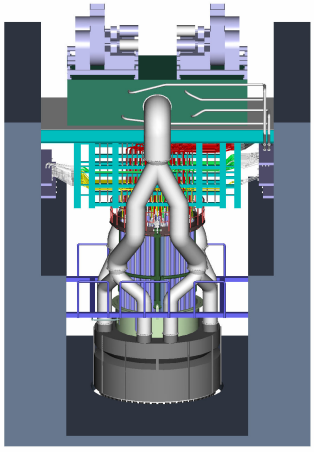

Figure 1. Reactor Head Area Structure of OPR1000

An IHA type has a lifting capability of the reactor head components by simplifying those components as a single unit. The IHA has been designed to perform the function as follows:

- lifting the reactor head
- supporting the reactor head area components
- providing the CEDM cooling air path
- absorbing the seismic loads
- shielding the missile

The IHA is designed considering Multiple Stud Tensioner (MST) which has been applied mainly to the operating OPR1000. The installation locations of the seismic support and the influence on Reactor Containment Fan Cooler (RCFC) were also reviewed considering the relevant structures.

CEDM AHU is the CEDM cooling system that exhausts cooling air from the cooling coils & pipes to the containment building. Classified design effects for the IHA are shown in the Table 1.

Table 1. Classified Design Effects for the IHA

No.	Component	Reuse	Replace	Add.
1	Cooling ducts/supports		△	
2	Head lift rig		△	
3	Skirt assembly		△	
4	HACT		△	
5	Cooling unit		△	
6	Head vent pipe	▲		
7	CEDM power, RSPT I,II, ALMS/LPMS cables		△	
8	CEDM cooling fans		△	
9	Missile shield		△	
10	RDP		△	
11	Seismic support			○
12	Integrated platform or Cable bridge			○

Considering the MST applicability, IHA diameter is restrained within 151.5in. equal to the outer diameter of the existing reactor head lifting rig. To avoid the interference with the MST inside, IHA outer is designed to eliminate the protruding parts or connections. In case of using Single Stud Tensioner (SST), the shape of the IHA might be changed.

In the operating OPR1000, the seismic support system was not used in order to absorb the seismic loads of reactor head lifting structure and CEDM. The IHA needs the seismic restraints between IHA and refueling pool wall. After reviewing the seismic support embedment location on the refueling pool wall, the

optimal locations was selected for the seismic restraint support.

CEDM cooling air temperature at the cooling fan outlet is expected to increase about 20°F~50°F when removing AHU. The influence on the RCFC capability as a result of the increased outlet temperature was also considered.

2.2 Structural Analysis

Modal and spectral analyses [3, 4] for the IHA were performed to verify the dynamic characteristics and the structural integrity for the structure. The head lifting and the seismic loading condition were used for analysis. Also evaluation for the interface structure, RCS and reactor internals, has been performed under the seismic loading condition.

2.3 3-D Simulation

3-D simulation was performed to establish the optimal operating process. The process includes disassembling /assembling of the RV head and the IHA in the refueling outage duration. The sequence of disassembling is as follows: disconnect IHA related cables ⇒ disconnect RCGVS flange ⇒ disconnect HJTC cables ⇒ remove and store IP ⇒ remove seismic restraint ⇒ remove RV flange insulation ⇒ install MST ⇒ remove RV stud ⇒ remove MST ⇒ install alignment pins ⇒ lift IHA ⇒ move and store IHA.

2.4 Economic Evaluation

The economic parameters including the reduction of refueling outage duration, the reduction of radiation exposure per outage and the remaining outage times during plant lifetime were evaluated into economic benefit amounts. It was also considered the cost-of-living adjustments and discount rate for economic evaluation.

3. Developed Design

The IHA has been developed as a reactor head lifting structure that combined with reactor head lifting frame, CEDM cooling system, IHA seismic support system and IHA cable support system for the operating OPR1000. Developed IHA model is shown on the Figure 2.

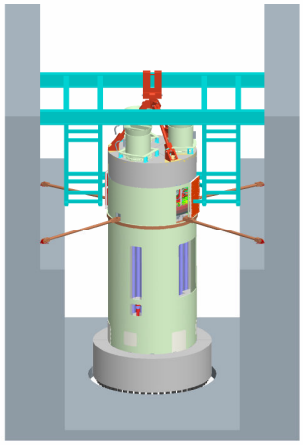

Figure 2. Developed Integrated Head Assembly Model

CEDM cooling fans are installed on the IHA top and seismic supports are added in the middle of the IHA. The CEDM cooing fans draw the cooling air through CEDM coil and RV closure head, which is induced from the IHA outside by air inlet opening. When the cooling air flows inside the IHA, the cooling air path is provided between the baffle and the cooling shroud. Also integrated platform is provided for the IHA outside cable routing.

The refueling outage duration is expected to be reduced by 4.5 days as a result of simplifying CEDM cooling duct, missile shield and HACT.

4. Conclusions

Judged from the recent oversea trend and domestic project in Kori-1 for simplifying reactor head lifting structure, the compatible IHA model for the operating OPR1000 was developed herein. The IHA is expected to greatly improve the plant operation ratio and economical efficiency as well as the reduction of radiation exposure and the usage of containment building.

REFERENCES

[1] EPRI, “Advanced Light Water Reactor Utility Requirement Document”, Rev.07, 1995.
[2] KHNP, “Korean Utility Requirements Document”, Rev.01, 2002.
[3] NUREG-0800, Section 3.7.2, “Seismic System Analysis”, US Nuclear Regulatory Commission, Rev.1, 1981.
[4] ANSYS Release 10 User‘s Manual, ANSYS Inc., 2005.