Transactions of the Korean Nuclear Society Autumn Meeting
Pyeongchang, Korea, October 30-31, 2014

Conceptual Study on Dismantling of CANDU Nuclear Reactor

Woo-Tae Jeong* and Sang-Guk Lee
KHNP-CRI, 70, Yuseongdaero 1312, Daejeon, Korea, 305-343
**Corresponding author: wtjeong@khnp.co.kr*

1. Introduction

As a central research institute of KHNP, we started a project for developing a dismantling methodology of the nuclear reactor early this year to prepare for the decommissioning of the plant. In this paper, we reviewed 3D design model of the CANDU type reactor and suggested feasible cutting scheme.

2. Cutting of CANDU Nuclear Reactor

2.1 Removal of Fuel Channels from CANDU Reactor

CANDU reactor is called calandria assembly. Figure 1 shows the calandria assembly of CANDU nuclear power plant. KHNP owns four CANDU reactors in Korea. Nuclear fuel bundles (1) are inserted in fuel tubes. Calandria vessel (2) is the shell of CANDU reactor. Adjustable rods (3) control reactivity of the fuel bundle. Fueling machine (8) installs new fuels and removes consumed fuels [1].

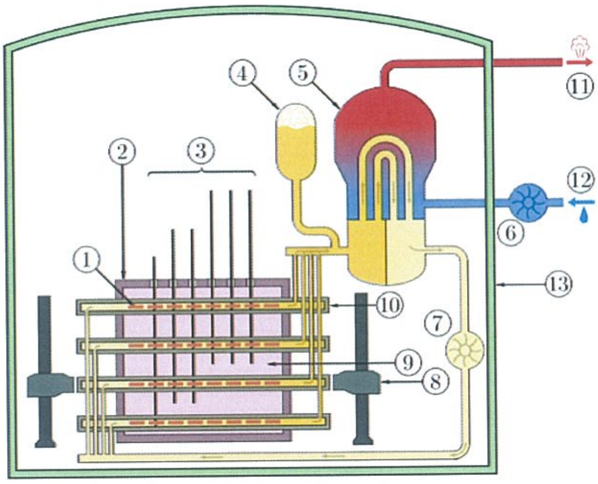

Fig. 1 CANDU Nuclear Power Plant

Calandria vessel is not a pressure boundary of CANDU reactor. Therefore, thickness of the calandria vessel is relatively thin compared to that of PWR reactor. The tube containing fuel bundles are called the fuel channel. Fuel channels become pressure boundary of the CANDU reactor.

When the decision to decommission the CANDU nuclear power plant is made, all fuels should be removed from the fuel channels. Removed fuels are transferred to the spent fuel storage pool.

It will take several years to lower radiation level around CANDU reactor. Fuel channels could be removed from the calandria assembly. The disassembled fuel channels could easily be segmented by a circular saw. The segmented fuel channels are inserted in a storage canister for future disposal.

Fuel channel cutting machine should be made not to release radioactively contaminated dust into air. Fuel channels are very close to fuels. We expect the material composing the fuel channel to be highly activated.

Adjustable rods could also be disassembled from the calandria assembly. Those rods could also be segmented by a cutting machine.

Cutting of fuel channels and adjustable rods could easily be made by a rod cutting machine. Various jigs could also be made to simplify cutting of the rods.

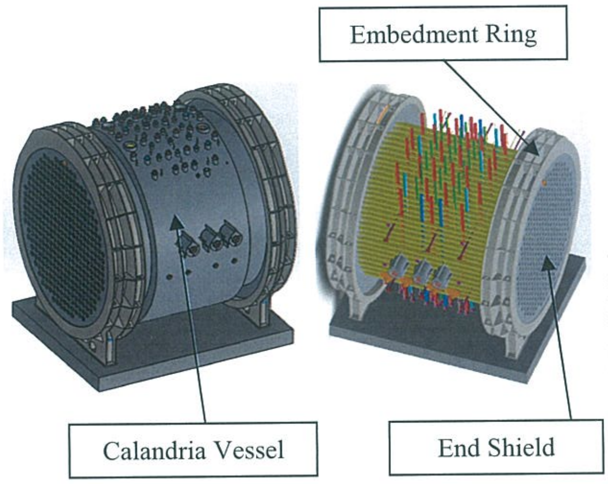

Fig. 2 3-D Model of CANDU Reactor

Cutting by a circular saw would be the most economical method. Application of a band saw may be possible for cutting in the shortest duration.

Figure 2 shows 3-D model of CANDU reactor. Horizontal tubes connecting the left and the right circular plate are the fuel channels.

Vertical rods crossing fuel channels are the adjustable rods. In the calandria vessel outside of the fuel channels is filled with heavy water moderator.

2.2 Calandria Vessel Cutting

Calandria assembly is consisted of the calandria vessel, the embedment ring, and the end shield as shown in Figure 2. Two embedment rings are attached to each end. Cutting of the calandria vessel is relatively easy compared to that of PWR reactor vessel. Plasma torch may be used for cutting the vessel.

To prevent contamination of air in the containment vessel, the surrounding of the reactor could be encapsulated.

Rather than making air tight envelope of the reactor area, a band saw may be used. It is quick, and creates less air pollutant.

After removal of all fuel channels from CANDU reactor, we expect that radiation level at around the calandria vessel is not very high.

If radiation level is not very high, an air tight envelope is not necessary for plasma cutting. Operators could approach the calandria vessel for further cutting without much radiation exposure.

2.3 Cutting of End Shields

Cross sectional view of *CANDU* reactor in Figure 3 shows that the end shields on both ends of the calandria assembly is directly contacting reactor coolant. Therefore, we could easily assume that it is relatively high in radiation around the end shields. Two end shields could be transported to some place where radiation is tightly managed. Dust or debris created during cutting of the end shields should be managed to prevent contamination.

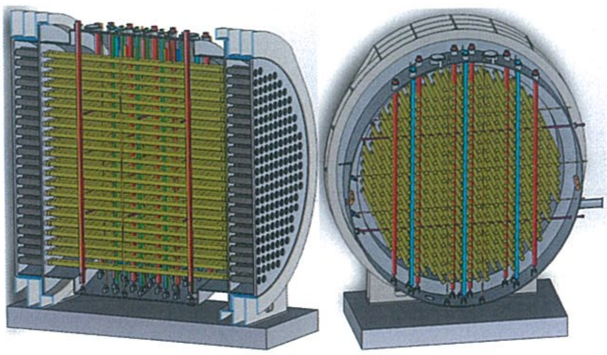

Fig. 3 Cross Sectional View of CANDU Reactor

Cutting of the end shields could be made with various means such as band saw, plasma torch, mechanical circular saw, contact arc metal cutting (CAMC), and arc saw etc. Non-contacting cutting method such as plasma cutting is easier to apply robotic technology. Plasma torch is not heavy and relatively free of maintenance. Robotic tools with longer reach for plasma cutting could be made because of small payload.

Choice of cutting method would be dependent on radiation level that operators might have during cutting. If radiation level is not very high and operators can reach the end shields, manual cutting with plasma torch will be considered as the best choice.

Robotic cutting should be considered when radiation hazard at the cutting workshop is severe. Even though robotic cutting is very expensive, safety of human operators should be considered first.

2.4 Cutting of Embedment Ring

The embedment rings is attached on both sides of calandria vessel. The embedment rings are attached to a bottom plate. This embedment rings are similar to brackets fixed on a base plate. They hold and support the calandria vessel and the end shields.

This ring shaped structure does not contact with reactor coolant. There, we could assume that the material of the rings is not highly radiation activated.

If our assumption is correct, various industrial cutting method or tools could be selected for the segmentation.

3. Conclusions

The structure of CANDU nuclear reactor, the calandria assembly was reviewed using 3-D CAD model for future decommissioning.

Through the schematic diagram of CANDU nuclear power plant, we identified the differences between PWR and CANDU reactor assembly.

Method of dismantling the fuel channels from the calandria assembly was suggested. Custom made cutter is recommended to cut all the fuel channels.

The calandria vessel is recommended to be cut by band saw or plasma torch. After removal of the fuel channels, it was assumed that radiation level near the calandria vessel is not very high.

For cutting of the end shields, various methods such as band saw, plasma torch, CAMC could be used. The choice of a specific method is largely dependent on radiological environment.

Finally, method of cutting the embedment rings is considered. As we assume that operators could cut the rings without much radiation exposure, various industrial cutting methods are suggested to be applied.

From the above reviews, we could conclude that decommissioning of CANDU reactor is relatively easy compared to that of PWR reactor. Technologies developed from PWR reactor decommissioning could be applied to CANDU reactor dismantling.

REFERENCES

[1] Wikipedia, The free encyclopedia