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A Study on Dismantling of Westinghouse Type Nuclear Reactor

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1. Introduction

Recently, decommissioning of nuclear power plant has become a major issue of the public. KHNP started a research project this year to develop a methodology to dismantle nuclear reactors and internals. In this paper, we reviewed 3D design model of the reactor and suggested feasible cutting scheme.

2. Cutting of Nuclear Reactor

2.1 Removal of Internals and Nuclear Fuels from Reactor Vessel

Westinghouse type reactor vessel is connected by four nozzles, two for hot water supply and two for cold water return respectively, to the steam generators as shown in Figure 1.

The reactor closure head and the upper internal could be removed from reactor vessel when it is opened for fuel discharge. The core support barrel and the lower internal are removed from the vessel afterwards.

Removal of the reactor internals may be made using the polar crane. Spent fuels can be removed by the fuel handling machine. Fuels are transferred to the spent fuel storage facility through fuel transfer channel. Fuel transfer channel connects refueling pool and spent fuel storage pool.

In spent fuel storage pool, fuels are stored and cooled for several years for several years. Spent fuels may be used for reprocessing or permanently disposed. Reprocessing is forbidden for Korea now. Therefore, we could only store or dispose it.

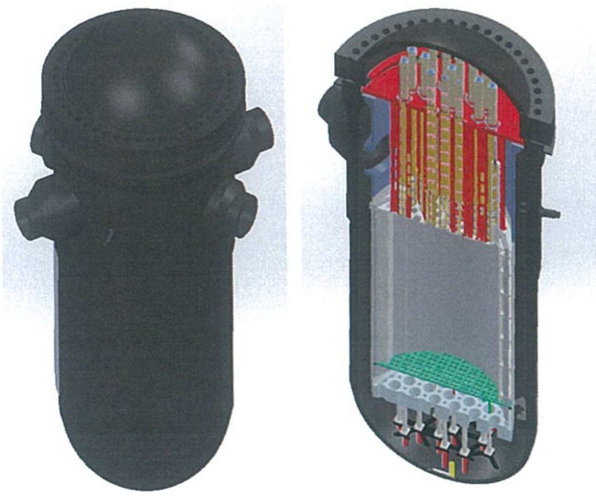
Dry storage in concrete cask may be the best economical option up to now. Spent fuels are inserted in metal canister before putting into a dry storage cask. Dry storage casks containing several metal canisters with the spent fuels in it may be located in a security controlled area for several decades.

2.2 Reactor Vessel Cutting

The reactor closure head is transferred to a prepared workshop and installed on a rotational table. Various cutting tools such as plasma torch, metal cutting saw, and water jet cutter may be used to cut it into smaller segments. The size and shape of segments of the reactor closure head is determined by requirements of waste disposal facility. The same rule also applies to the segments made by reactor vessel.

Among various cutting technologies which are applicable for segmenting the reactor closure head and the reactor vessel, plasma cutting technique is considered to be the most economical and feasible.

Fig. 1 3-D Model of Reactor Vessel and Internal



A robotic torch controller with more than three degree of freedom may be used to control the path of plasma torch. A robot with adjustable up down, rotation, and prismatic motion could reach every possible torch path in reactor vessel.

Robotic torch supports may be installed in the four lugs of the reactor vessel as shown by an arrow in Figure 2. The position of the lugs is so accurate that accuracy of the robotic may easily be obtained.

Gripper may be designed for picking up the segments of reactor vessel and closure head. Hydraulic operated gripper or magnet may be used for grasping the segments.

Plasma cutting workshop should be managed tightly to prevent proliferation of radioactive particles or gas which may be generated during cutting operation. Active ventilation system for cleaning and cooling contaminated air should be provided.

Hemispherical lower vessel as shown in Figure 2 could be transferred to another workshop with rotational table. Capsized position would be easier for further cutting. In this situation, radiation level around the hemisphere is not very high. Operation may approach it for manual cutting.

Metal box should be provided to contain segments of reactor vessel. After packaging of the reactor segments into the box, radiation at the surface of the box should be detected and registered. Operators handling the box should pay attention to minimize radiation exposure during transportation.

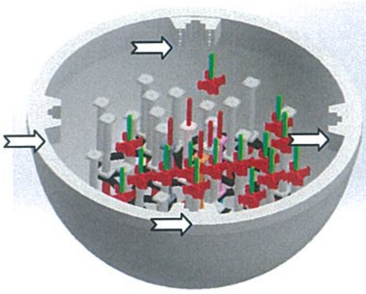


Fig.2 Four Lugs in Reactor Vessel for Robot Install

2.3 Reactor Internal Cutting

Figure 3 shows the reactor internals of Westinghouse type reactor. The upper internal is difficult to cut with plasma torch because of its limited effective cutting range. However, lower internal may be segmented with plasma because its shape is similar to a barrel with limited thickness. Inside of lower internal is vacant. Nuclear fuels are located vertically inside here during hot operation.

The upper and lower internal could be separated. For removing of the fuel, the upper internal is lifted and moved from top of the lower internal. Afterwards, fuel handling crane could access top of the spent fuel.

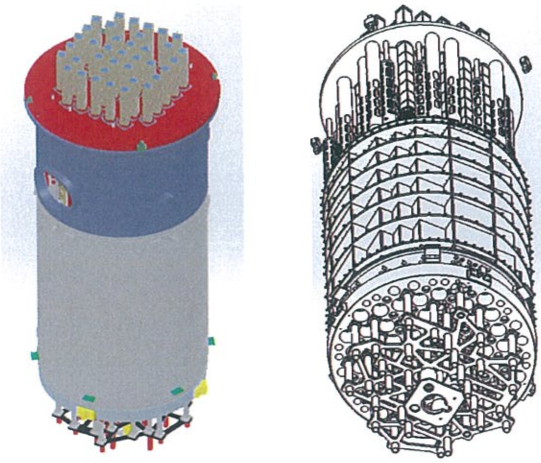


Fig.3 Reactor Internal

The upper internal may be segmented by an electric wire cutter, a circular saw, and a band saw. The electric wire cutter is the easiest method for application. However, it is very slow. Circular saw is fast, but sometimes dangerous and difficult to change the saw blade. Band saw would be a best feasible tool for this case of upper internal cutting.

Plasma cutting is fast and maintenance free. However, it generates large volume of radioactively contaminated air. As in cutting of reactor vessel, air tight ventilation and cleaning system is also necessary for segmenting the reactor internal by plasma torch.

The ventilation system covering reactor vessel could also be used for cutting of the reactor internal. Before cutting the reactor vessel, the reactor internals could be removed and transported to a separate storage area. After the cutting of the reactor vessel is completed, the reactor internals could be moved into the ventilation system.

Robotic tool for guiding plasma torch may be effective for remote operation to avoid radiation exposure of the cutting operators. Radiation level at the surface of the internals is expected to be relatively high considering its several decades of hot environment.

Another method for segmenting lower internal is to disassemble the baffle and the former by removing the baffle former bolts as shown in Figure 4. The heads of baffle former bolts may be removed by milling cutter. Baffle and former plates could be separated after removing the baffle former bolts. Disassembled baffle and former plates should be cut further to maximize packing into a waste container.

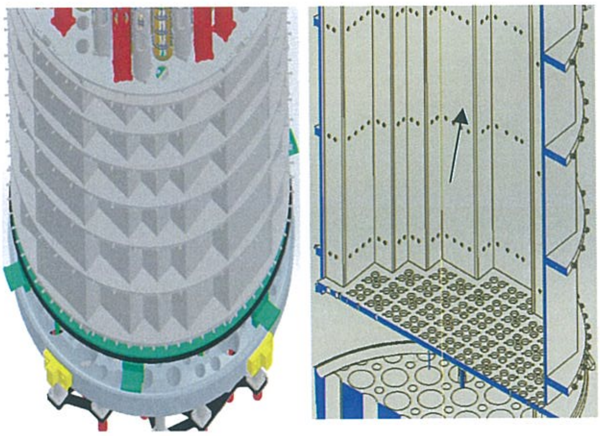


Fig.4 Baffle Former Bolts

3. Conclusions

Using 3-D CAD model of Westinghouse type nuclear reactor and its internals, we reviewed possible options for disposal.

Among various options of dismantling the nuclear reactor, plasma cutting was selected to be the best feasible and economical method.

The upper internals could be segmented by using a band saw. It is relatively fast, and easily maintained. For cutting the lower internals, plasma torch was chosen to be the best efficient tool.

Disassembling the baffle and the former plate by removing the baffle former bolts was also recommended for minimizing storage volume.

When using plasma torch for cutting the reactor vessel and its internal, installation of a ventilation system for preventing pollution of atmosphere was recommended.

For minimizing radiation exposure during the cutting operation, remotely controlled robotic tool was recommended to be used.