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An evaluation on the cutting technologies for decommissioning of the tube bundles in the RPV of NPPs

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ABSTRACT

This paper is to evaluate an optimal cutting technology of the tube bundles in the reactor pressure vessel of nuclear power plants. Characteristics of the tube bundles were analyzed and alternative cutting technologies of the tube bundles were evaluated. The optimal cutting technology of the tube bundles was suggested.

1. Introduction

Decommissioning of the reactor pressure vessel (whereafter 'RPV') in nuclear power plants (whereafter 'NPPs') is an important step for decommissioning of the major components in NPPs (IAEA, 1999; IAEA, 2008). Of decommissioning of the RPV, decommissioning of the tube bundles in the RPV is a critical activity. Because the tube bundles in the RPV of NPPs consist of a lot of tubes, cutting activities of the tube bundles are very difficult and have a great impact on decommissioning of the RPV.

In this paper, based on characteristics of the tube bundles, alternative technologies of cutting the tube bundles in the RPV have been analyzed. An optimal cutting technology of the tube bundles in the RPV has been evaluated.

2. Physical characteristics of the tube bundles in the RPV

The tube bundles in the RPV as shown in Table 1 are composed of control rod drive mechanism (whereafter 'CRDM') control rod housing 40, control rod guide tube 29, upper measurement tube 4, upper support tube 4, instrument nozzle 36, and instrument guide tube 36.

CRDM control rod housing as presented in Fig. 1 is welded by penetration tube on reactor head to make a move control rod in the RPV and to extract the signal lines from inserted measurements. Because the penetration tube is welded, in the first place, the outer parts of reactor vessel head have to be cut and stored into a container. The penetration tube is 60 mm in diameter, 10 mm in thickness, the length of its cut is 1300–1700 mm, and the weight of its cut is 150–190 kg.

Number of control rod guide tube, upper measurement tube, and upper support tube is 37. The shape of these tubes is shown in Fig. 2. To dismantle the assembly of upper internal structures and store those into a container, those have to be cut by the same size. The pipes are 140 mm in diameter and 10 mm in thickness. The faces to be cut are ①, ②, ③, and ④ as shown in Fig. 2. If the cut length of pipe is 1050 mm, the weight of cut pipe is 37 kg and the cut length of pipe is 1600 mm, the weight of cut pipe is 54 kg.

Fig. 3 shows that instrument nozzle is fixed within core support structure and connected with instrument guide tube. The instrument nozzle is 88 mm in diameter, 1420 mm in length. If the instrument nozzle is cut like ① as presented in Fig. 3, its weight is 50 kg.

The instrument guide tube is provided in Fig. 4. The instrument guide tube is welded through the floor of semi-sphere RPV. If this is dismantled, the outer projecting parts from reactor floor could be

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Table 1
Configuration of the tube bundles in the RPV.

Items	Number
CRDM (control rod drive mechanism) control rod housing	40
Control rod guide tube	29
Upper measurement tube	4
Upper support tube	4
Instrument nozzle	36
Instrument guide tube	36

cut. The cut part is 40 mm in diameter, 450–700 mm in length, and weighs 5–8 kg.

3. Considerations of cutting technologies for the tube bundles

To choose an optimal technology of cutting the tube bundles in the reactor pressure vessel, the commercial cutting technologies as shown in Fig. 5, hydraulic cutter, circular saw, and band saw cutting technology were considered. In addition to these technologies, abrasive waterjet, plasma arc cutter, and laser cutter are not considered because requirement of technologies is to move nozzle along the face of pipes.

4. Evaluation of cutting technologies for the tube bundles

4.1. Comparison of cutting technologies

Requirements of cut are 40–140 mm in diameter, 10 mm in thickness and materials are Inconel SB-167, ASTM A213 Type 304, ASTM A193 Gr.B8M, and Inconel SB-168.

Parameters for comparison of the cutting technologies as presented in Table 2 are cutting speed, auxiliary system requirements, costs, waste generation, payload requirements, and volume requirements. Parameters of costs are cutting system, manipulation and viewing, contamination control, and consumable. Parameters of waste generation are airborne radioactivity, liquid waste, and solid waste.

4.2. Evaluation of cutting technologies

Table 2 shows that parameter of cutting speed is not meaningful for considerations because cutting speed has little influence on cutting activities. Because three technologies is mechanical cutting, all technologies require ventilation and are the same costs. Of three technologies, only hydraulic cutter does not generate the second waste and consumes a little cost because it do not use blade. Considering parameter of the second waste aspect,

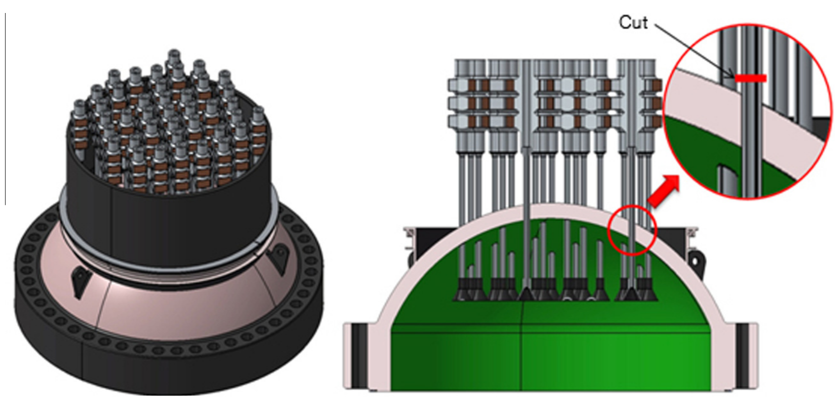

Fig. 1. The tube bundles in the RPV.

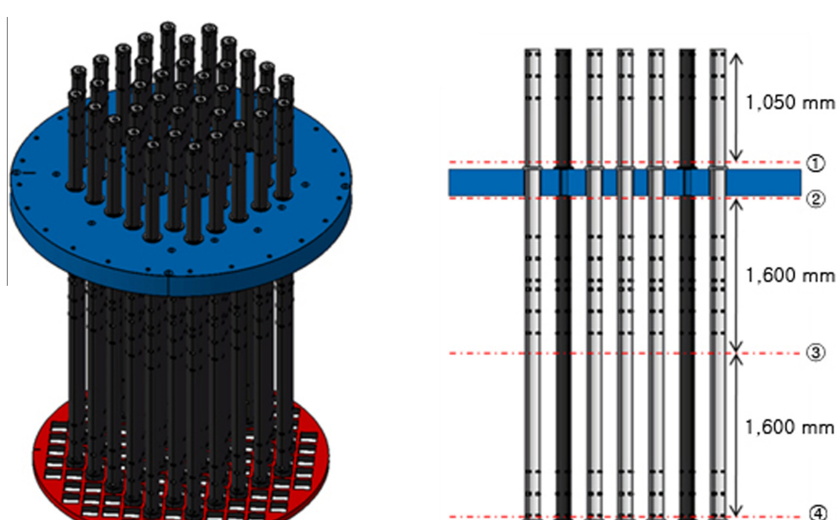

Fig. 2. The tube bundles and cut points of upper internals in the RPV.