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Development of Procedures for Dismantling Tanks Used in NPP

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1. Introduction

Tanks of various uses and types are used in nuclear power plants, and are expected to be classified as a large amount of waste when nuclear power plants are dismantled. In general, storage tanks are bulky and require cutting and disassembly because they occupy a significant volume during processing, disposal, and storage.

Since there is a possibility of releasing airborne radioactive materials in the process of dismantling a tank used in a nuclear power plant, it is necessary to minimize secondary contamination and exposure to workers. Therefore, NILEPLANT Co., Ltd. evaluated the thermal cutting technology under various conditions based on previous research, and sought the optimal conditions suitable for cutting SUS304.

The previous study tested three thermal cutting technologies: Oxy-fuel(oxygen-acetylene) cutting, Plasma cutting, and TIG cutting. Through each thermal cutting technique, the cutting speed according to the thickness of SUS304, the amount of molten scattering products generated, the amount of dust generation, and the NOx concentration were evaluated. Based on the evaluation results of each cutting technology, the optimal cutting conditions for stainless steel were derived. In addition, a simulated tank cutting test procedure was prepared including jigsaw cutting, which is mechanical cutting to minimize radioactive air emissions [1,2].

In this study, a simulated cutting test was conducted to dismantle a radioactively contaminated tank based on the optimal cutting conditions for stainless steel derived from thermal cutting technologies evaluation. When tanks are cut using high-temperature cutting technology, a special cutting procedure has been established that includes not only tanks with the possibility of generating trans-uranium airborne radioactive materials such as plutonium, but also tanks without airborne generation.

2. Methods and Results

In this study, airborne radiation amounts were indirectly evaluated based on the NOx concentration generated during the cutting process because a tank that was not contaminated with radioactive materials was used. In addition, an exhaust line was installed in the manhole to exhaust NOx generated during the cutting process, and an exhaust fan and damper were installed at the rear end of the line to conduct the experiment.

Mechanical cutting with a jigsaw is very slow compared to thermal cutting, but since airborne radioactive materials does not occur even without the use of an exhaust fan, an experiment was conducted to cut the structural connection during final dismantling.

2.1 Simulated Cutting target tank

A vertical cylindrical tank discarded after use in the general industry was selected to simulate cutting, as it is similar to the shape mainly used in the nuclear power plant.

The thickness of SUS304 constituting the tank is 4 tons, and the overall size is ø2,400mm in diameter, 2,430mm in height, and the internal capacity is 10m^3.

Fig. 1. Simulated cutting target tank.

2.2 Tank Simulated Cutting Condition

Each thermal cutting test condition was performed according to internal test procedures[2].

The cutting length was 60cm, and the NOx generated in the direction of the worker's breathing during the cutting process was measured as the maximum value.

The jigsaw cut the stainless steel using a commercially available saw blade, and the cutting length was cut based on 2cm to cut only the structural connection. At this time, the NOx concentration was measured in the same way as plasma cutting.

The thermal cutting technologies for simulated tank cutting used plasma based on the experimental results. The plasma cutter used in the simulated cutting test was used as a portable device for easy movement and storage. The size of the cut specimen was set to 30x30cm, 40x40cm, 50x50cm, and 60x60cm for the cutting length.

In order to indirectly measure the amount of airborne radioactive materials generated by the NOx concentration generated in the direction of the operator according to the gas discharge inside the tank, the NOx concentration and the wind volume at the front of the damper were measured. The capacity of the exhaust fan used in the test was 9,000m^3/hr, and the degree of opening of the damper was set to 100%, 50%, 25%, and 12.5%. The cutting length was 2m and plasma was used.

Fig. 2. An exhaust pipe installed in the manhole(left) and a hot wire anemometer installed in front of the damper, and NOx measuring device(right)

2.3 Tank Simulated Cutting Result

Fig. 3. Marking of the cutting area before the experiment(left) and sealing after cutting(right)

2.3.1 Cutting speed for each cutting technologies

For the cutting speed by thermal cutting technologies, plasma was the fastest, and in the case of a jigsaw for cutting structural connections, it was only 0.34% compared to the cutting speed of a plasma cutter .

2.3.2 NOx measurement results for each cutting technologies

In the Nox generation measurement result, mechanical cutting with the jigsaw did not generate measurable Nox, while plasma cutting generated the lowest among the thermal cutting technologies.

2.3.3 Tank Simulated Cutting Result

As a result of the test, 30×30cm was the slowest, and there was little change in cutting speed when it was 40×40cm or more. Therefore, considering the weight and ease of handling of the cut fragments, it was confirmed that about 40×40 cm was the most suitable cutting size.

2.3.4 NOx and Air Volume Measurement Results According to Exhaust Air Volume

The air volume increase rate at the end of the test compared to the air volume at the start of the test significantly decreased from 2.02 to 1.37 times as the opening degree of the damper decreased. This means that the negative pressure inside the tank is greatly reduced as the size of the cutting opening increases as the damper opening decreases.

When the damper is open 100%, the maximum NOx concentration in the worker's environment is 3ppm, which is considered to be the most desirable exhaust condition when designing the tank cutting process. Therefore, in order to guarantee the safety of the cutting operator during the tank cutting process, the capacity of the exhaust fan should be 1000 times or more of the tank volume per hour. Under these conditions, it is judged that continuous cutting can be performed up to a length of about 2 m without sealing the cut.

3. Conclusions

In order to establish a procedure for dismantling radioactively contaminated tanks that are generated in large quantities during the decommissioning of nuclear power plants, a plan for a simulated tank cutting experiment was prepared by deriving optimal cutting conditions for stainless steel through prior research based on thermal cutting technologies. Based on the simulated cutting test procedure, a simulated cutting test was conducted to establish a dismantling procedure for tanks with the possibility of generating radioactive airborne as well as general tanks, and the following conclusions were obtained.

For basic cutting, excluding structural connections, the speed is the fastest, and plasma that has been confirmed to generate low NOx in proportion to the speed is suitable.

Since the exhaust system is removed during the final dismantling of the tank, mechanical cutting without airborne generation is suitable to minimize the generation of radioactive airborne. However, special mechanical cutting techniques must be developed to improve the cutting speed.

It is most desirable in terms of cutting speed and ease of handling of the cut specimen to perform the cutting design with the size of the cut specimen as 40×40cm.

Since most of the NOx components generated during the plasma cutting process are removed by the exhaust fan, the capacity of the exhaust fan should be sufficient to remove the radioactive airborne and minimize the inhalation of the radioactive airborne by the operator during the cutting process.

In order to guarantee the safety of cutting workers from radioactive airborne during the tank cutting process, the capacity of the exhaust fan must be 1,000 times the tank volume per hour or more.

Based on the results of this test, a commercial process design report for the decommissioning of radioactively contaminated tanks was prepared, and it is expected that it can be effectively used in the dismantling of nuclear power plants in the future.

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