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Development of core sampling technique for ITER Type B radwaste

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1. Introduction

Type B radwaste (intermediate level and long lived radioactive waste) imported from ITER vacuum vessel are to be treated and stored in the basement of the hot cell building. The Type B radwaste treatment process is composed of a buffer storage, cutting, sampling/tritium measurement, tritium removal, characterization, pre-packaging, inspection/decontamination, storage etc.

The cut slices of Type B radwaste components (Fig. 1) generated from the cutting process undergo the sampling process before and after the tritium removal process. The purpose of a sampling is to obtain small pieces of samples in order to investigate the tritium content and concentration of Type B radwaste. However, because Type B radwaste components are metallic (stainless steel, copper alloy, tungsten, beryllium) and bulk (~ 1 m or more in size and ~ 100 mm or more in thickness), there are several difficulties in sampling. In addition, sampling has to be carried out without use of any liquid coolant to avoid the spread of contamination. As one of the sampling techniques, core sampling is suggested in this study.

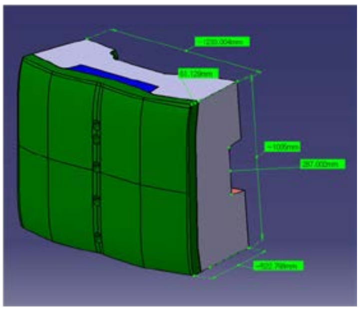

Fig. 1. An example of ITER Type B radwaste – Blanket module of Tokamak vacuum vessel

2. Core sampling

Core sampling is to take core samples from metallic thick materials by a core drilling method. The target materials are stainless steel and copper alloy which have a thickness of less than 50 mm. In order to carry out core sampling successfully, a broach cutter (Fig. 2) as a core drill bit and a vertical machining center are used.

In the core sampling, a considerable amount of cutting chips are generated, which caused interference with the tool and workpiece. Thus, it is necessary to remove the cutting chips completely during drilling. The step drilling procedure in which the cutting chips could be removed was newly established as shown in Fig. 3.

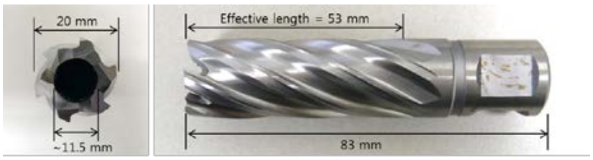

Fig. 2. Broach cutter used in core sampling

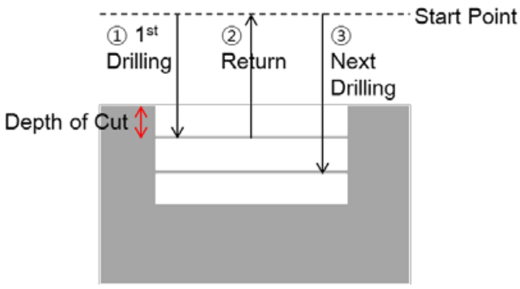

Fig. 3. Core sampling procedure (Step drilling)

Detailed procedure is as follows;
1. Drill to depth(depth of cut) at feed rate
2. Return to start position at traverse speed
3. Remove cutting chips using compressed air
4. Move to drilled depth at traverse speed and drill to next step at feed rate
5. Repeat (2-4)

The produced cutting chips can be removed by compressed air while the core drill bit returns to the starting position

3. Experiment

3.1 Sampling

Core sampling experiments for SS316L and CuCrZr materials which have 50 mm thickness, respectively, were conducted under dry condition. Compressed air at 6 bar was provided continuously during drilling to remove the cutting chips and reduce cutting temperature. Experimental conditions are presented in Table 1.

Table I: Sampling conditions of core sampling

	SS316L	CuCrZr
Spindle speed (rpm)	150	150
Feed rate (mm/min)	5	5
Traverse speed (mm/min)	150	150
Depth of cut (mm)	0.5	1.0
Start point (mm)	7	7

Fig.4. shows the obtained SS316L and CuCrZr core samples of 50 mm in length. The total machining times were approximately 65 min for SS316L and 38 min for CuCrZr.

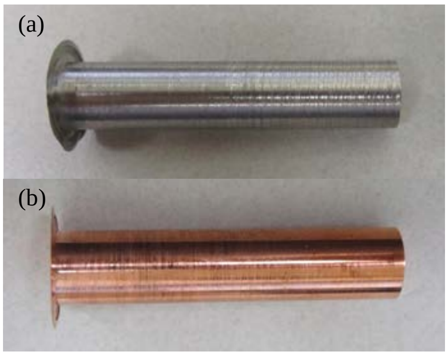

Fig. 4. Core sample: (a) SS316L (b) CuCrZr

3.2 Measurement of Temperature Variation

The goal of sampling is to take samples without tritium loss. Since tritium release is generally affected by temperature, it is essential to know the temperature distribution into the core sample during the sampling process. In order to measure the temperature of the core sample center, a K-type thermocouple, 3.4 mm in diameter, was used. Based on the fact that tritium is concentrated near the surface of Type B radwaste, a thermocouple was embedded 5 mm below the surface in the center of the core sample, as shown in Fig. 5. Experiments were conducted to a 30 mm depth and the temperature values were recorded in real time.

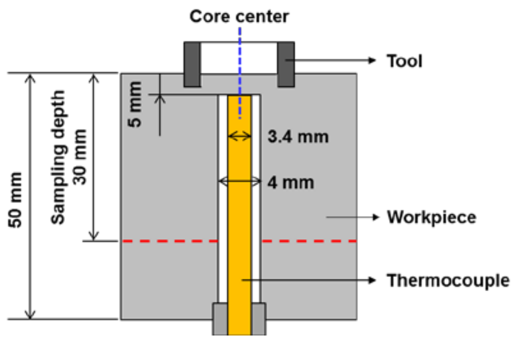

Fig. 5. Experimental setup for core sample temperature measurement

Fig. 6 shows the measured core sample temperature for SS316L. The maximum temperature was 44.5 ºC, which was an approximately 20 ºC increase compared with the initial temperature of 25 ºC. Therefore, it can be concluded that the core sample surface of SUS316L does not undergo severe temperature variation during the core sampling. Fig. 7 shows the measured core center temperature for CuCrZr. The maximum temperature was 32.8 ºC, which was an approximately 8 ºC increase compared with the initial temperature. There was a subtle difference within 4 ºC in peak temperature after a 5 mm depth sampling.

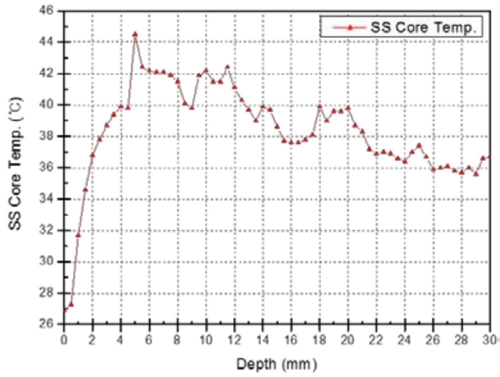

Fig. 6. Temperature variation measured at the center of core sample during drilling for SS316L core sample

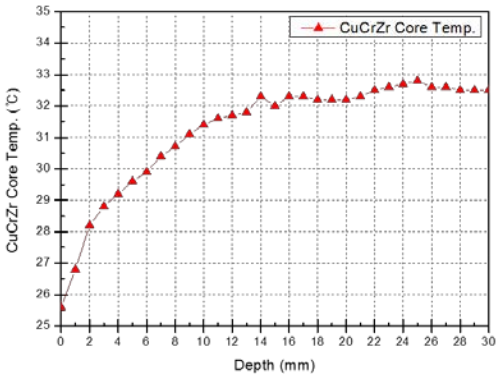

Fig. 7. Temperature variation measured at the center of core sample during drilling for CuCrZr core sample

4. Conclusions

Core sampling, which is a candidate sampling technique to be applied to ITER hot cell, is available for a non-thick (less than 50 mm) metal without the use of a coolant. The materials used in the experiment were SS316L and CuCrZr in order to simulate ITER Type B radwaste. In a core sampling, substantial secondary wastes from the cutting chips will be unavoidably produced. Thus, a core sampling machine will have to be equipped with a disposal system such as suction equipment. Core sampling is considered an unfavorable method for tool wear compared to conventional drilling. Hence, the wear state and machinability of the tool will be evaluated.

REFERENCES

[1] D. Torcy et. al. Technical specification of Type B radwaste processing and treatment equipment development, EGVZ3J(ITER Document), 08 Jul. 2015.