Repeat WEDM to reduce the effect of the Recast layer and reduce the surface roughness.

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1. Introduction

When evaluating the mechanical properties of a material, a sample requires accurate dimensions and surface condition. In order to satisfy the dimensions, the sample is machined using Computer Numerical Control (CNC) machining, and surface treatment is performed after mechanical machining. When analyzing irradiated samples from a nuclear reactor, samples for mechanical property evaluation must be processed under hot lab conditions. However, for the machining of the irradiated material, it is necessary to prevent radiation of the test space and the researcher, so there are many restrictions. In particular, the use of limited processing equipment is required. Wire electric discharge machining (WEDM) is a machining method using CNC and is used in many industrial fields that require precision machining. This processing method minimizes sample damage during radioactive sample machining, thereby minimizing radioactive waste generation and contamination of space.

WEDM generates an arc during processing, melting or evaporating a localized area of the sample. The arc melting process forms a thin layer on the sample surface despite the sophisticated processing of WEDM. The thin layer consists of a recast layer called the white layer (WL) and the heat affected zone (HAZ). This layer has high hardness and acts as a crack-initiated point when evaluating mechanical properties. Thickness of the layer is controlled by the conditions of EDM.

In this research, samples were machined under three different EDM conditions. For each EDM condition, surface topology and chemical composition analysis by using SEM and EDS technique. In addition, the hardness of WL and HAZ for each specimen was analyzed through indentation analysis.

2. Experiment

2.1 Wire-EDM machining

Stainless 316 was machinated in the order of 1st and 2nd processing after main cut processing using Excetek's V400G Wire-EDM. AC arc method was applied to minimize sample damage. Detailed EDM conditions of as-received (AR), Main Cut (MC), 1st Trim Cut (TC1), and 2nd Trim Cut (TC2) shows in Table 1. After surface processing, samples were rinsed with a rust remover for 10 seconds to remove rust while preventing surface damage.

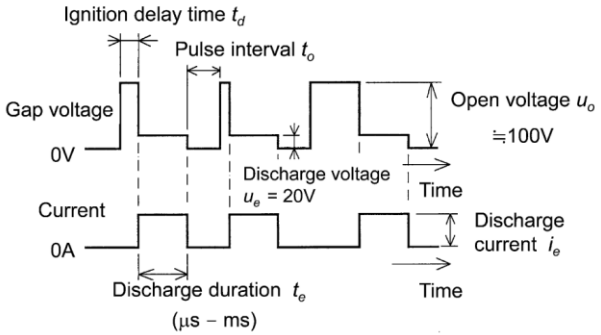

Fig 1. Voltage and current waveforms.

Table 1. EDM process parameters used for wire-EDM machining.

	Gap voltage	Servo voltage	On time	Off time	Arc on time	Arc off time
AR	-	-	-	-	-	-
MC	6	38	15	8	7	8
TC1	13	43	2	11	2	11
TC2	9	40	2	10	2	10

2.2 Surface roughness analysis

In order to analyze the surface roughness of the sample by cutting conditions. 3D profile was measured by Keyence VHX-6000 microscopy, and the image of the surface was analyzed using SEM.

2.3 Oxidation analysis

To analyze the degree of surface oxidation by re-melting, the surface oxidation degree was analyzed through EDS analysis.

2.4 Hardness measurement

In order to analyze the effects of WL and HAZ layer of the sample, Hardness test was performed by Vickers hardness tester and compared with the as-received stainless 316.

3. Results

The sample surface is improved with repeated cutting sequence. The surface brightness of each sample was changed in the order of MC, TC1, and TC2, and it was confirmed that the surface roughness was improved through the repeated processing sequence. For the above reasons, it can be seen that the MC sample shows a rough and dark surface, while the TC2 shows a bright and shiny finish surface. The measuring result shows 20 μm, 12 μm and 3 μm respectively.

The surface oxygen concentration that measured by EDS also shows a tendency to decrease according to the repeated machining process. In addition, the hardness increased in proportion to the thickness of the oxide layer.

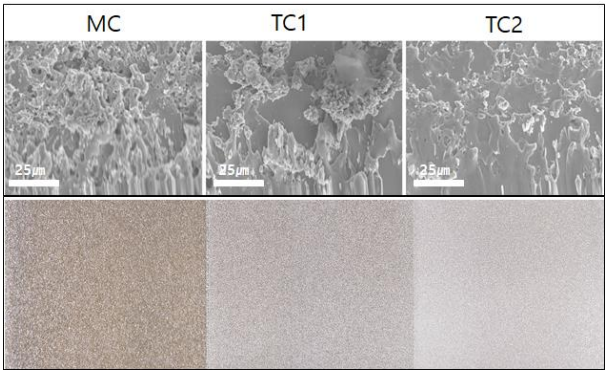

Fig 2. WEDM cutting surface by cutting sequence.

Table 2. Surface analysis on wire-EDM cutting.

	AS	TM	TC1	TC2
Hardness(HV)	164.44	300.32	250.2	186.6
Oxide(at%)	1.3	18.40	7.63	5.45
Roughness(㎛)	-	20	12	3

4. Conclusions

This analysis confirmed that repeated WEDM machining was effective for surface modification. While the initial Vickers hardness of the SS316 was about 164 HV, the hardness of the initial WEDM machined surface increased to 300 HV. This introduces an error in the strength of the radioactive specimen. The surface of the sample was modified through the second and third machining. It was confirmed that the third machined specimen reached about 186 HV, similar to the initial sample.

Through future experiments, the 4th and 5th machining conditions will be set additionally, and the appropriate WEDM conditions will be set to configure additional conditions for analyzing radioactive samples without mechanical processing.

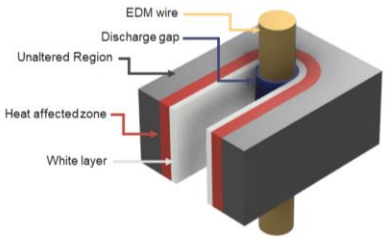

Fig 3. Schematic of the Wire-EDM process.

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