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A Study on Number Concentration Distribution of Aerosol Generated During Metal Laser Cutting

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1. Introduction

Decommissioning a nuclear power plant, radioactively contaminated metal structures must be dismantled and cut to a disposable size. Therefore, the cutting process is essential when decommissioning metal structures [1]. Among various metal cutting methods, thermal cutting method is mainly used because of its high cutting speed compared to other cutting methods. However, thermal cutting method generates more aerosols compared to other cutting methods when cutting metal [2]. When decommissioning NPPs, the cutting object can be released radioactive aerosol, because it can be contaminated with radioactive. Therefore, in this study, in order to protect the workers from the radioactive aerosol when the NPPs decommissioning, the characteristics of the aerosol generated in various thermal cutting conditions are evaluated.

2. Methods and Results

2.1 Laser Cutting Process

The cutting method was the laser cutting method among thermal cutting methods. The laser cutting tool used TRUMPF's Disk laser. The pulse wavelength of the laser is 1064 nm.

STS304 of 20mm thick plate was used for cutting objects. The inlet of air from the outside was blocked, and the cutting object was cut in a chamber under atmospheric pressure.

The cutting conditions are shown in Table 1. The laser stand-off distance is 1mm and the defocus distance is -10mm when cutting. Also, gas type used is N_2. Based on cutting condition #1, the cutting was operated by changing the laser power, gas pressure, and cutting speed.

Metal cutting started at the edge of the plate. The cutting operation is cut at the start cutting speed up to the cut length of 20 mm and then the other 20 mm is cut at the end cutting speed.

Table 1 Cutting Condition

No.	Laser Power [kw]	Gas Pressure [bar]	Start Cutting Speed [mm/s]	End Cutting Speed [mm/s]
#1	8	15	2	5
#2	8	15		9
#3	8	8		5
#4	4	15		5

2.2 Measurement of aerosol characterization

Aerosols are measured during metal cutting. A sampling pipe is installed in the chamber to sample some parts of the aerosol generated by cutting. The aerosol is sampled at a location 355 mm horizontally along the x-axis from the cutting position. The sampled aerosol is delivered to a high-resolution aerosol measuring instrument (Dekati®, HR-ELPI+) at a flow rate of 10 lpm through an isokinetic sampler probe in the sampling pipe. HR-ELPI+ measures the number concentration of aerosols in the range of aerodynamic diameters from 6 nm to 10 μm in real-time from the sampled aerosol. The aerodynamic diameter range being measured is a range that can affect the worker through inhalation. The safety of the working environment is evaluated through the aerosol number concentration within the range.

3. Results

Aerosols that were generated until the end of the metal cutting were measured. The cutting object was clean cutting at 40 mm and measured until the time when the aerosol number concentration gradually decreased. From the measured aerosol data, the number concentration distribution according to the aero dynamic diameter was shown in Fig 1.

CMAD (Count Median Aerodynamic Diameter) was calculated through the Aerodynamic diameter distribution. CMAD is the 50% cumulative aerodynamic diameter in the cumulative distribution of number concentrations.

3.1 Aerosol Distribution

For the four cutting conditions in Table 1, the number concentration distribution in the 6 nm-10um aerodynamic diameter range is shown in Fig. 1. Most of the aerosol distribution generated during laser cutting were less than 1 μm. And except for cutting condition 3, in the cases of conditions 1, 2, and 4, the distribution have peaks at 0.1 μm or less. Their distributions were multi-modal, which follows the general trend of aerosols generated during cutting[3].

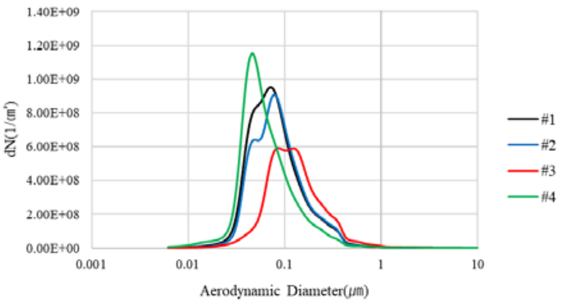

Fig. 1. Aerodynamic diameter distribution of aerosol by cutting conditions

3.2 CMAD Calculation

The median aerodynamic diameter increases when the cutting speed increases, the gas pressure decreases and when the laser power increases(Fig 2). These results were similar to those of previous studies operated with the same cutting method [4, 5].

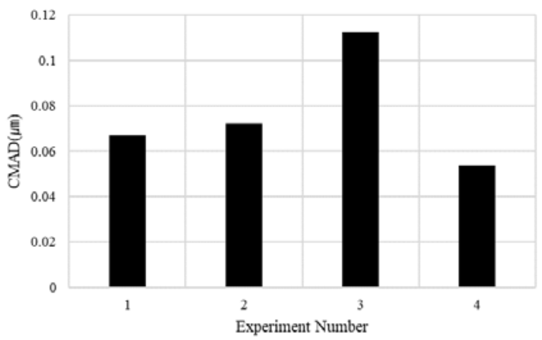

Fig. 2. CMAD by cutting condition number

4. Conclusions

In this study, the aerosol distribution generated during laser metal cutting was evaluated. Aerosol diameter distributions were compared with cutting conditions.

As a result, the gas pressure had the greatest influence on the generation of aerosols. More than 90% of the aerosols generated are distributed in the range of 1 μm or less. In addition, it was confirmed that the peak of the aerosol distribution shown at 0.1 μm or less.

Aerosol for 1 μm or less is the range in which the worker can deposit in the respiratory tract through breathing. Therefore, it is necessary to prepare for the protection of workers from the environment in which fine particles of 1 μm or less are generated during laser metal cutting.

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