# Laser Cutting Experiment of Thick Stainless Steel for Nuclear Decommissioning: Effect of Nozzle Types

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## 1. Introduction

Laser cutting technology coupled with fiber laser can be suitable dismantling tool at a nuclear decommissioning site due to the production of a small amount of secondary waste and remote controllability.[1-2] The mechanism of laser cutting technology is described that high-powered laser beam heats up the local area of steel plate over melting points. The resultant molten steel is blown outside steel plate by injecting assist gas with high speed. The high speed assist gas is generated through that high pressured gas passes through the nozzle with small diameter. Notably, the geometric configuration of the nozzle significantly influences the flow behavior of assist gas emerging from the nozzle tip, which is closely related to melt removal efficiency in the laser cutting. [3]

In this study, two types of nozzles, subsonic and supersonic nozzle [3], were used in comparatively evaluating the cutting performance with the focus on the melt removal efficiency according to variation of stand-off distance. Stand-off distance refers to distance between nozzle tip and specimen surface.

## 2. Experiment

### *2.1 Experimental Setup*

Laser cutting system associated with 6kW fiber lasers (IPG, YLS 6000) contains cutting head and 25-m-long process fiber. The high-powered laser beam is fed into cutting head through the process fiber with a core diameter of 100 m. The cutting head serves to focus the laser beam onto the specimen and discharge an assist gas with high pressure into cutting-kerf. In detail, the laser beam was focused by two optics in the cutting head, a collimation lens (f: 160mm) and parabolic focusing mirror (f: 600mm). The nozzle coupled with the cutting head is connected to the high-pressure gas pipe so that compressible air of 10.0 bar gauge pressure is introduced from the outside and injected into the specimen. The throat diameters of convergent and convergent-divergent nozzles used in the experiment were 2mm and the flow rates was about 400L/min. X-Y-Z axis stage adjusts relative motion of cutting head. The dust collector sucks dust generated in the laser cutting experiment and exhausted to the outside after passing through the filter. The throat diameters of convergent and convergent-divergent nozzles was 2mm and the flow rates was about 400L/min. The 60-mm-thick stainless steel blocks (SUS 304L) was used in the cutting experiment.

## 3. Result and Discussion

### *3.1 Effect of subsonic nozzle on cutting performance*

The cutting performance of stainless steel plate (SUS 304L) with 60 mm thickness was evaluated using subsonic nozzle. The subsonic nozzle has a convergent shape. Laser cutting was carried out from left side of specimen toward right side and its entire cutting length was 40mm for The cutting speed was initially set at 20 mm/min until 10 mm cutting, after which, 60 mm/min cutting speed was set to the reminder of 30mm cutting. Complete cutting was observed in the range of 1-mm and 3-mm stand-off distances, whereas incomplete cutting was observed in the case of 4.0 mm stand-off distance. Fig. 1 presents the incomplete laser-cut specimen using a subsonic nozzle under the condition of 4-mm stand-off distance. As shown in Fig. 1(b) and 1(c), despite sufficient provision of laser energy, kerf is not generated along the rear side of the steel block in the early stages of laser cutting. This implies that the increase of stand-off distance in the subsonic nozzle leads to the degradation of melt removal efficiency.

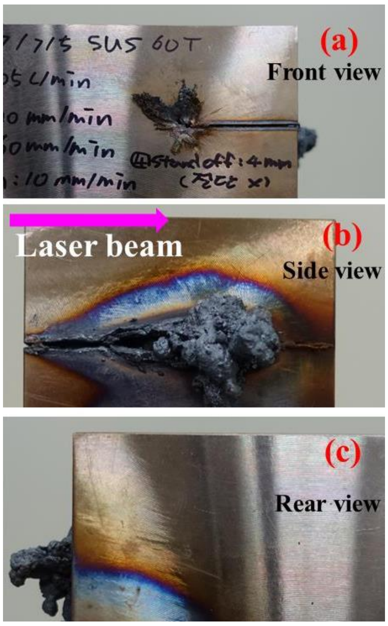


Fig. 1. Stainless steel after cutting (t=60 mm) using subsonic nozzle at 4mm standoff distance. Front face(a), Side face(b), Rear face(c).

### *3.2 Effect of supersonic nozzle on cutting performance*

For the case of supersonic nozzle (convergent-divergent shape), same experimental conditions as in the case of subsonic nozzle were employed except standoff distance. The standoff distance was steadily increased up to 15mm. Complete cutting was observed until the condition of 10mm standoff distance.

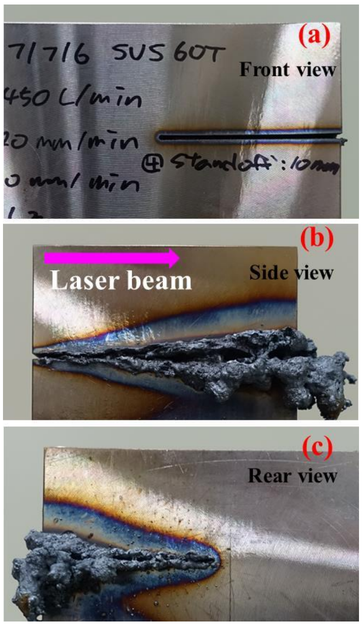


Fig. 2. Stainless steel after cutting (t=60 mm) using supersonic nozzle at 10mm standoff distance. Front face(a), Side face(b), Rear face(c).

Fig. 2 presents the specimen after laser cutting at 10mm standoff distance. It implies that supersonic nozzle is more efficient than subsonic nozzle in aspect of melt removal rate.

## 4. Conclusion

It was shown that the cutting performance according to the variation of standoff distance is influenced by geometric configuration of nozzle. In practical use, the supersonic nozzle is desirable because sufficient stand-off distance is necessary to provide easier remote operation.

## REFERENCES

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