Underwater Laser Cutting Experiment of Stainless Steel Plate Using Supersonic Conical Nozzle for Nuclear Decommissioning

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1. Introduction

Laser cutting technology is based on the concept that local area of specimen is melted by incident high-powered laser beam and simultaneously auxiliary gas with high speed is discharged to remove the resultant melts. Cutting is accomplished along the path of the kerf generated through the removal of the resultant melts. Unlike other cutting tools, laser cutting technology has a distinguishable mark: the production of a small amount of debris. This mark meets significant decommissioning requirement. Furthermore, the use of optical fiber for the purpose of transmitting high-powered laser beam enhances remote controllability. Laser cutting technology coupled with fiber laser can be suitable dismantling tool at a nuclear decommissioning site. [1]

Dismantling works at underwater environment can contribute to the significant reduction of nuclear contaminants spreading outward the atmosphere. [2] However, laser cutting in underwater environment tends to be more difficult than in atmosphere environment because of higher absorption rate of laser beam by water, significant reduction of thermal conductivity, the possibility of water penetration into laser cutting head, and so on. In this study, we have investigated cutting performance of stainless steel plate with 30~50mm thickness in underwater environment.

2. Experiment

2.1 Experimental Setup

Underwater laser cutting system contains 6kW fiber lasers (IPG, YLS 6000, 1070 nm), laser cutting head, and water-filled tank. The high-powered laser beam is fed into laser cutting head via 25-m-long optical process fiber. The cutting head consist of a few of optics to effectively focus laser beam toward the specimen: collimation lens (f: 160mm), parabolic focusing mirror (f: 600mm), reflection mirror, widows. The end part of cutting head is connected to the high-pressure gas pipe to introduce compressible air of 10.0 bar gauge pressure. The supplied compressible air and focused laser beam are coaxially passed through the nozzle with small diameter. The throat diameters of supersonic nozzle used in the experiment was 3mm and the flow rates were about 860L/min. The stainless steel block (SUS 304L) was immersed in the water tank.

3. Result and Discussion

The underwater cutting experiment of stainless steel plate (SUS 304L) with 50mm thickness was carried out using conical supersonic nozzle. The supersonic conical nozzle has a convergent-divergent shape. Fig. 1 presents the underwater laser cutting scene of 50-mm-thick stainless steel.

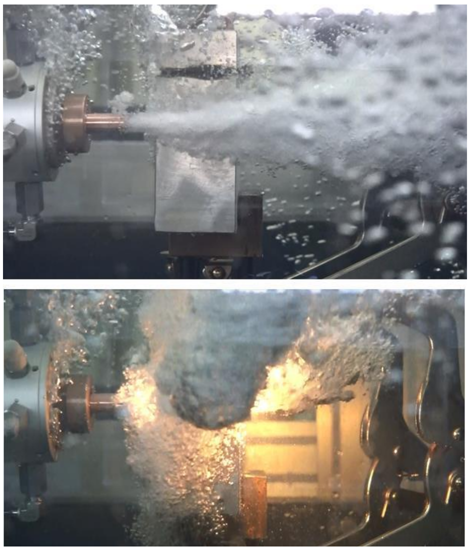

Fig. 1. Underwater laser cutting of stainless steel plate.

The cutting head is initially placed initially in the atmosphere, and then it is submerged into water tank according to relative motion X-Y-Z axis stage in order to cutting the immersed specimen. The entire cutting length was 40mm. The underwater cutting speed was initially set at 5 mm/min until after 10mm had been cut, after which, the cutting speed was increased to 20 mm/min until 30mm had been cut.

The stand-off distance was sequentially increased from 7.5mm, 10mm, up to 13 mm. The stand-off distance refers to the distance between the nozzle tip and the top surface of the steel plate. Fig. 2 shows the front, rear views of stainless steel after underwater cutting.

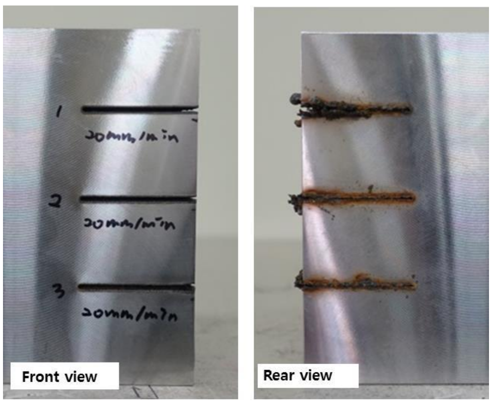

Fig. 2. Underwater laser cutting of 50-mm-thick stainless steel. Stand-off distance (1) 7.5mm, (2) 10mm, (3) 13mm.

4. Conclusion

We observed that it is possible to completely cut a 50-mm-thick stainless steel plate in the underwater environment under the condition of over 7.5mm stand-off distance.

REFERENCES

[1] K. Tamura, R. Ishigami, and R. Yamagishi, “Laser cutting of thick steel plates and simulated steel components using a 30 kW fiber laser”, Journal of Nuclear Science and Technology, 53, 916-920 (2016).

[2] D Paul Hilton and Ali Khan, “New developments in laser cutting for nuclear decommissioning”, WM2014 Conference Proceeding, Phoenix (2014).