Feasibility Study on the Laser Cutting of Stainless Steel Pipes for Dismantling of Nuclear Power Plants

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1. Introduction

Dismantling of nuclear power plants requires the remote cutting because human access is limited to the work place having a high radiation. Laser cutting with optical fiber delivery is advantageous for remote control because not only a small laser head is placed in a work space, but also non-contact cutting does not generate reaction force [1]. In addition, laser cutting has been attractive as a cutting technique with various advantages because it generates less secondary wastes than other cutting techniques and provides reasonable maintenance with inexpensive cost. For this reason, studies on the laser cutting technology for dismantling of nuclear power plants have been actively proceeded [2-4].

Korea Atomic Energy Research Institute (KAERI) has developed the laser cutting technology aimed at the dismantling of nuclear reactors from 2015. Utilizing its own development of cutting head, the laser cutting capability of 100 mm stainless steel and carbon steel was ensured. However, the inside of the reactor contains complicated structures in the form of pipes in addition to the thick metal plate. For field application of laser cutting, it is important to cut these pipes in one direction. In this study, cutting experiment of stainless steel pipe using 10 kW fiber laser was applied to evaluate the laser cutting technology to metal pipe structure.

2. Laser cutting experiment

2.1 Experimental setup

A 10 kW fiber laser was used in the cutting experiment. The laser beam was delivered by an optical fiber and focused on the specimen through a laser cutting head attached to the X-Y-Z axis stage device. At this time, the cutting head moved along the cutting direction, and the moving speed of cutting head determined the laser cutting speed. Fig. 1 shows the view of laser cutting experiment of the stainless steel pipe. The cutting head was moved from the bottom to the top. In order to remove the melt from the cut specimen, a high pressure assist gas was injected through the 2 mm diameter nozzle at a high flow rate to the cut specimen. The compressed air of 1 MPa gauge pressure was used as an assist gas.

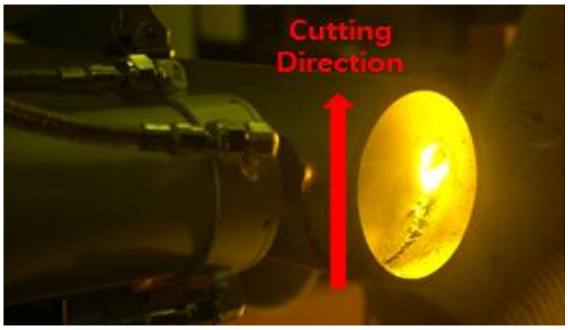

Fig. 1. View of the laser cutting experiment of stainless steel pipe.

2.2 Results and discussions

The first cutting experiment was carried out at a speed of 30, 50 and 100 mm/min for a stainless steel (SUS304L) pipe with a diameter of 90 mm and a thickness of 5.4 mm. The cutting interval for each cut line was 30 mm. The pipe was completely cut with one scan of the laser beam for all cutting speeds. Fig. 2 shows the cut pieces of the stainless steel pipe with a diameter of 90 mm and a thickness of 5.4 mm.

Fig. 2. Cut pieces of the stainless steel pipe with 90 mm diameter after laser cutting at speeds of (a) 30 mm/min, (b) 50mm/ min, (c) 100 mm/min.

The next cutting experiment was carried out at a speed of 50, 70, 100 mm/min for a stainless steel (SUS304L) pipe with a diameter of 165 mm and a thickness of 7 mm. The cutting interval for each cut line was also 30 mm. When cutting at a speed of 50 mm/min, the pipe was completely cut at one time. As shown in Fig. 3, when cutting at a speed of 70 or 100 mm/min, the pipe was incompletely separated or parts of the pipe was not cut due to the effect of the dross. Therefore, the cutting was carried out again in the opposite direction after the first cutting, and in this case, it was completely cut. Fig. 4 shows the cut pieces of the stainless steel pipe with a diameter of 165 mm and a thickness of 7 mm.

Fig. 3. View of the stainless steel pipe of 165 mm diameter after first cutting.

Fig. 4. Cut pieces of the stainless steel pipe with 165 mm diameter after laser cutting at speeds of (a) 50 mm/min, (b) 100 mm/min, (c) 70 mm/min.

3. Conclusion

In this study, the applicability of high power laser cutting technology to internal metal structures of the pipe type was evaluated with the aim of dismantling of nuclear power plants. One direction cutting of the stainless steel pipe with a 10 kW fiber laser resulted in successful cutting to a maximum diameter of 165 mm. The applicability of laser cutting technology was partially confirmed in order to dismantle internal structures of nuclear power plants. In the future, the laser cutting technology will be further evaluated through cutting experiments on various types of structures.

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REFERENCES

[1] J. S. Shin, S. Y. Oh, H. Park, S. Seon, C.-M. Chung, T.-S. Kim, L. Lee, B.-S. Choi, and J.-K. Moon, “Study on thick stainless steel cutting using a high power fiber laser for dismantling of nuclear power plants,” Abstracts of Proceedings of the Korean Radioactive Waste Society Autumn, 461-462 (2016).

[2] C. Chagnot, G. de Dinechin, and G. Canneau, “Cutting performances with new industrial continuous wave ND:YAG high power lasers: For dismantling of former nuclear workshops, the performances of recently introduced high power continuous wave ND:YAG lasers are assessed,” Nucl. Eng. Des. 240, 2604-2613 (2010).

[3] K. Tamura, R. Ishigami, and R. Yamagishi, “Laser cutting of thick steel plates and simulated steel components using a 30 kW fiber laser,” J. Nucl. Sci. Technol. 51, 916-920 (2016).

[4] K. Tamura, and R. Ishigami, “Laser cutting conditions for steel plates having a thickness of more than 100 mm using a 30 kW fiber laser for nuclear decommissioning,” Mechanical Engineering Journal 3, 15-00590 (2016).