Demonstration of Laser Cutting System for Tube Specimen

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1. Introduction

The irradiated tube specimens are required to inspect mechanical behavior of the irradiated structural materials for the assessment of dry storage of the spent nuclear fuel. The fabrication technique of the tube specimen was developed to machine the mechanical testing specimen from the irradiated fuel cladding and components using the wire cut EDM(electric discharge machine) [1]. The oxide layer removal system was also developed because the oxide layer on the surface of the irradiated fuel cladding and components interrupted the applying the electric current during the processing. However, it was found that the mechanical testing data of the irradiated specimens with removal of oxide layer was less reliable than the specimens with oxide layer [1].

The laser cutting system using Nd:YAG with fiber optic beam delivery has great potential in material processing applications of the irradiated fuel cladding and components due to non-contact process. Thus, the oxide layer doesn't interrupt the fabrication process during the laser cutting system.

In the present study, the laser cutting system was designed to fabricate the mechanical testing specimens from the unirradiated fuel cladding with and without oxide. The feasibility of the laser cutting system was demonstrated for the fabrication of various types of unirradiated specimens.

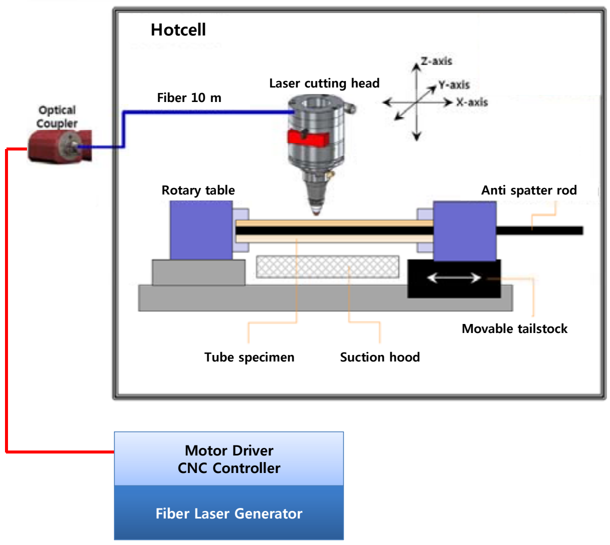

Fig. 1. Concept design of the laser cutting machine for fabrication of irradiated tube specimens in hotcell.

2. Methods and Results

Laser cutting system could be useful tools for material processing such as cutting in radioactive environment due to non-contact nature, ease in handling and the laser cutting process is most advantageous, offering the narrow kerf width and heat affected zone by using small beam spot diameter [2]. The laser cutting system using Nd:YAG with fiber optic beam delivery was modified to fabricate the tube specimens from the unirradiated fuel cladding.

2.1 Design of Laser Cutting Machine

The commercial laser beam machine, model ALC-6000 of ATI, was selected and designed for the demonstration of the laser cutting system to evaluate the performance of the laser cutting for the fabrication of the tube specimens.

The following requirements were considered for the design of the laser cutting machine as shown in Fig. 1. The installation of the electrical parts of the machine in hotcell was minimized to reduce the degradation by irradiation effect. The suction hood was applied to prevent the spread of secondary waste generated by laser cutting and assist gas during the cutting process. The rotary table and movable tailstock were proposed to control the alignment, which is required to fabricate the tube specimen precisely, of the irradiated specimen. It was observed that this method would need to be modified for the precise positioning of the irradiated cladding using the manipulator in the hotcell. The cable and connection parts of the machine as shown in Fig. 2 will be modified for the maintenance.

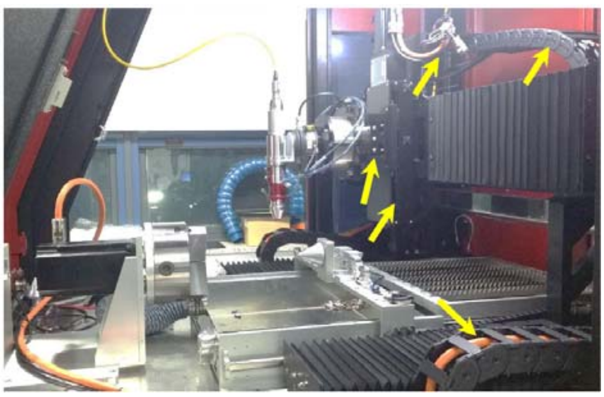

Fig. 2. Modification parts to prevent the contamination during the operation of the laser cutting machine in the hotcell.

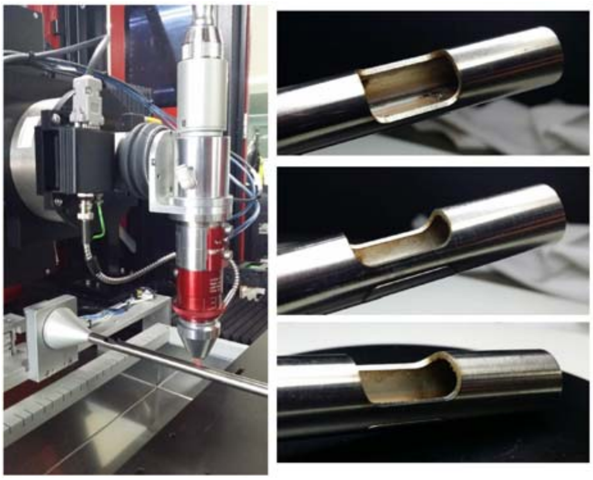

Fig. 3. Demonstration of performance of the laser cutting machine using the stainless steel tube.

Fig. 4. Fabricated specimens from the unirradiated fuel claddings by using the laser cutting machine.

2.2 Demonstration of the new laser cutting machine

In the present study, laser cutting system using the Nd:YAG laser with the peak power of 500W was introduced to fabricate the tension testing specimens from the unirradiated fuel cladding with and without oxide layer on the surface. Figure 3 shows the result of the demonstration of the laser cutting machine to evaluate the performance of the laser cutting process with the stainless steel tube for the fabrication of the longitudinal tensile specimens.

The Photographs of the tensile specimens in longitudinal directions fabricated from the unirradiated fuel cladding were shown in Fig. 4. It was found that the specimens could be successfully cut with or without the oxide layer on the surface of the specimens. Figure 5 and 6 showed that it would need much higher cutting speed than with the present level of laser cutting rate to achieve the acceptable cutting quality of the specimen.

Dimensions of specimens fabricated by the laser cutting system would be compared with the design values to evaluate the agreement with an accuracy of gauge sections.

Fig. 5. Cutting details of the fabricated specimen with thick oxide by using the laser cutting machine.

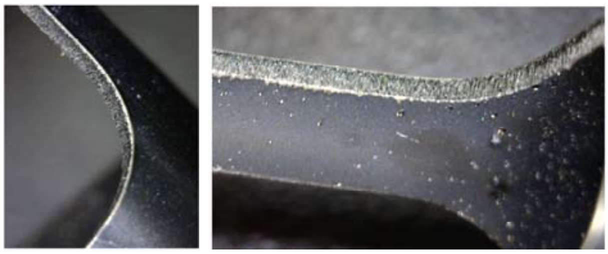

Fig. 6. Cutting details of the fabricated specimen with thin oxide by using the laser cutting machine.

3. Conclusions

Laser beam machining system was designed and mechanical testing specimens from the unirradiated fuel cladding were successfully fabricated. The effect of surface oxide layer was also investigated for machining process of the zirlo fuel cladding and it was found that laser beam machining could be a useful tool to fabricate the specimens with surface oxide layer. Based on the feasibility studies and demonstration, the design of the laser cutting machine for fully or partially automatic and remotely operable system will be proposed and made. This technique will be modified and developed for the fabrication of various types of irradiated specimens in the hotcell.

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