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Performance Test of the Remote Operation Light Ablation Decontamination System

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1. Introduction

Laser induced ablation studies of various materials are the topics in the laser-matter interaction. By virtue of the attainable high energies, lasers are excellent tools to induce a photoelectric response from metallic substrates. Contamination control has been a major concern for the nuclear electric power industry in recent years, but despite the positive steps taken to address the issue, important safety concern still remains. Laser ablation was shown to be potentially superior to all other methods [1]. It is known that when laser intensity is high enough, especially in the case of high power short pulse laser, laser energy absorption occurs rapidly and only in a very thin layer on the target surface. The thin layer is thus instantaneously evaporated and removed. However, investigations into the properties of laser ablation decontamination and its possible application to nuclear facilities are still only in their early stages. In this paper, we used the light ablation decontamination system operated remotely by computer. The system was designed and fabricated by KAERI. The objective of the study is to investigate the performance of the system. Especially, the result of the decontamination test was presented.

2. Methods and Results

2.1 Laser irradiation

A Q-switched Nd:YAG laser (Quantel Co. Model: Brilliant b) with a third harmonic generation was employed. The pulse energy determined from the energy meter was 153 mJ/pulse at 355 nm. The repetition rate was 10 Hz and pulse duration was 5 ns. Laser beam was transported by articulate arm optics. Decontamination performance tests to the three dimensional specimen and wall shape specimen were also performed.

2.2 Specimen Preparation

The rectangular type aluminum specimens (100 mm x 100 mm X 1mm) were polished with abrasive paper and washed with water and ethyl alcohol. The experimental specimens were prepared as follows: Two kinds of solution [$Co(NH_4)_2(SO_4)_2$ and $EuCl_3$] were dropped onto the surface aluminum specimen by injection, respectively. The specimens were dried in a shadow place at room temperature. The contaminated specimens were moved into the electric furnace and they were heated at 600 ^{0}C for 4 hours. The oxide layer formed on the aluminum surface during the heating was analyzed by XRD.

2.3 Remote operation system

Fig. 1 shows the photograph of the remote operation light ablation decontamination system. The system consisted of laser generation equipment, beam transfer equipment, laser nozzle, control panel, computer and translation system. The system could move in a three dimension and the laser torch was rotated within 90^o range. The maximum translation speed was 8 mm/sec and maximum rotation speed was 14^o/sec. The distance between the sample and the laser torch was 6 cm.

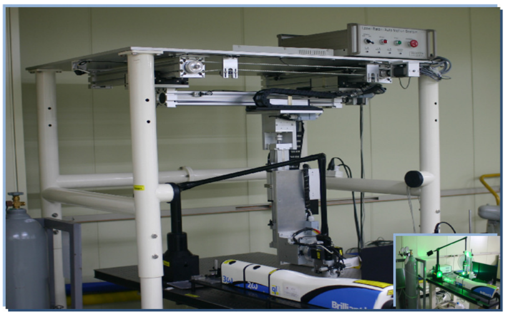

Fig. 1. Fabricated remote operation laser decontamination system.

2.4 Remote control system

Fig. 2 shows the input parameter window for the operation of the fabricated remote laser decontamination system. The window consists of axis communication port (X, Y, Z and rotation), laser distance measuring communication port (left and right), jog mode, axis input mode, speed input window, automatic input parameter window, widow for showing the measured laser torch speed and the torch sensor activation window.

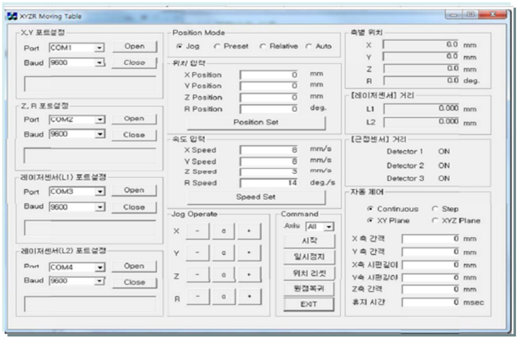

Fig. 2. Input parameter window for the operation of the fabricated remote laser decontamination system.

2.5 Test results

Fig. 3 shows the photograph of the aluminum specimen irradiated with string type laser beam. It is shown that decontamination efficiency is increased with the decrease of the sweeping speed. Although not shown vividly, the contaminants on the aluminum surface were satisfactorily removed when the sweeping speed was 0.1 mm/sec.

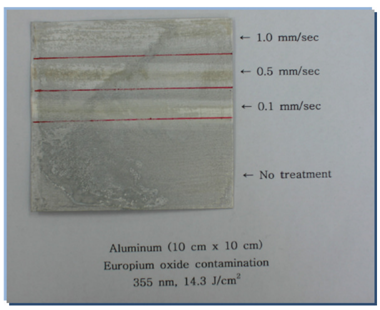

Fig. 3. Photograph showing the effect of sweeping Speed of laser beam on the removal of oxide layer.

Fig. 4 shows the photograph of aluminum specimen irradiated with string type laser beam. Aluminum surface was covered with cobalt oxide layer. As the increase of the number of application times, the removal portion of contaminants on the surface was also increased. The color of the surface, however, turned into dark gray as a result of a long contact time.

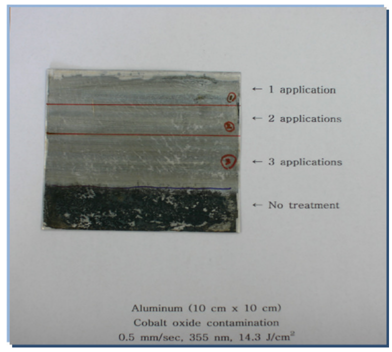

Fig. 4. Photograph showing the effect of the number of application time on the removal of oxide layer.

3. Conclusion

The application of remote operation Q-switched Nd:YAG laser system is important to the decontamination of high radiation field area such as the internal of hot cells. From the test results, we found that the system operated properly for the decontamination of rectangular type specimen. The decontamination system also showed good performance on the wall surface and three dimensional shape specimens. The upgrade of the system which is more elaborate and has a simple configuration is under consideration.

Acknowledgement

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REFERENCES

[1] K. Imasaki, " Laser ablation cleaning of nuclear facilities", Report of the Institute for Laser Technology, Osaka, Japan(1999).