Applicability of Laser Cutting and Decontamination Technologies for Remote Decommissioning Work – 16115

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ABSTRACT

Recently, various cutting and decontamination technologies for remote decommissioning works have been developed and applied. One of the technologies is a laser technology which has good capabilities for such kinds of works. Remote controllability is one of advantages of a laser system. Because in general the laser head is light and compact compared to the other types of cutting and decontamination tools, the head can be easily handled by remote operation equipment such as manipulators, and thus it gives an effective and flexible remote work. As the other examples of the advantages, there are no parts of a laser system necessary to be replaced so frequently like blades of mechanical methods and also, it does not generate secondary waste so much like contaminated water generated from waterjet methods.

Additionally, recent laser technology development has increased laser output power which makes it possible to be able to cut thick steel plate more smoothly and speedy, and width of laser irradiation which makes it possible to perform an efficient surface decontamination work.

This paper will provide outline of the remote laser cutting system and decontamination system developed by IHI Corporation (IHI) and how those technologies are effective in various kinds of remote decommissioning works.

INTRODUCTION

In recent years, a laser technology has been applied to a wider industrial field due to the appearance of the laser equipment which has higher output power and longer operating life. That has also attracted attention as one of applicable technologies to various kinds of remote works in nuclear D&D facilities. The major reason is that a laser cutting and decontamination method has the following advantages compared to other alternative methods such as mechanical and waterjet methods:

1) High Cutting and Decontamination Performance

It is possible for a laser method to cut thick metal plate quickly at one time. Mechanical methods usually needs several times cutting for thick metal plate. Also, a laser method performs decontamination works more quickly than mechanical methods in most cases. One of the reason is a maintenance frequency of equipment can be reduced in case of using a laser method because a laser head does not have consumable parts to be replaced so frequently, like a blade of mechanical tool.

2) Less Secondary Waste

In case of a waterjet method, a great deal of liquid waste is generated as a secondary waste. A laser method only generates small amount of fume and spatter, which are relatively easy to be collected and treated.

3) Remote Controllability

In case of mechanical methods, remote-controlled equipment is required to have an enough capacity to resist reaction forces from a target. On the other hand, a laser method creates no reaction force during cutting and decontamination operations. That allows remote-controlled equipment to be smaller and have lower capacity. In addition, a laser head which is handled by remote-controlled equipment during operations is generally much smaller than mechanical end-effectors. Consequently, those advantages for a laser method provide flexible and precise remote operations.

DESCRIPTION

Development of Remote Laser Cutting System

The remote laser cutting system that is applicable to the high radiation environment was developed in 2008-2013. Safety, robustness, ease, flexibility and efficiency were considered in a preferential manner for the development to optimize the system to be used for various remote operations in high-radiation environment. This system has been already applied and operated to dismantle highly-contaminated waste structures in an actual hot cell.

Fig.1 shows an overview of the remote laser cutting system which mainly consists of laser head, optical fiber, laser oscillator, cooling water unit and assist gas supply unit. The laser head, the optical fiber and the hoses for cooling water, which are placed in the high radiation environment, have a capacity to resist 10^6 Gy absorbed doses.

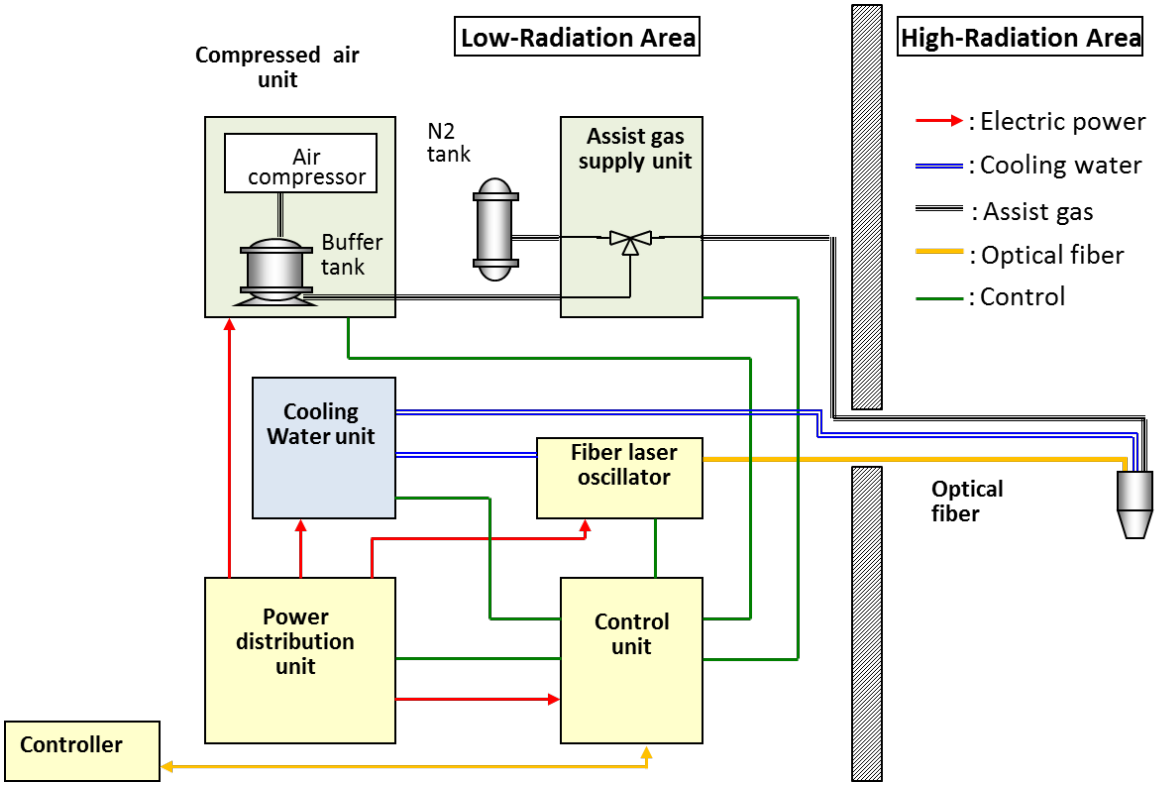


Fig.1 Remote Laser Cutting System Overview

The laser head for this system is unitized and reduced in size and weight as much as possible. Additionally the front area closed to the nozzle of the laser head is designed to be slimmer. Those customizations allow the laser head to reach narrow area and provide clear visibilities around the head. As a result, easy and flexible remote operations and maintenance works for the laser head are provided.

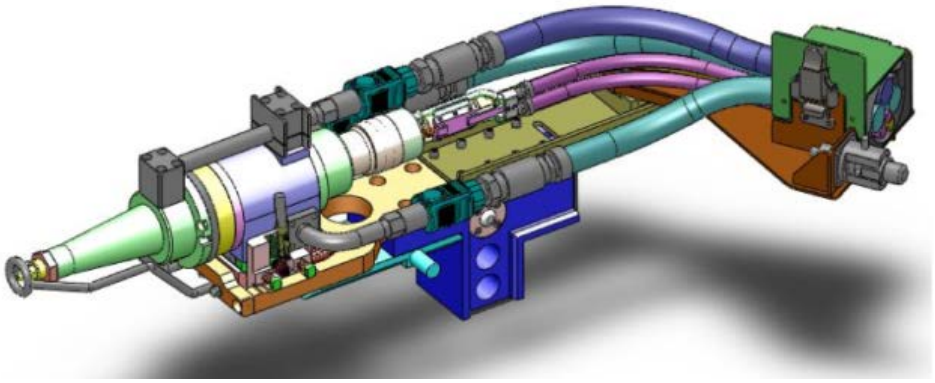


Fig.2 Laser Head

The remote laser cutting system has the originally-developed safety interlock system to protect the objects not allowed to be cut around the laser head. This safety interlock system watches interference between the laser irradiation model and the protected object models in the 3D-CAD virtual space in real time during laser cutting operation.

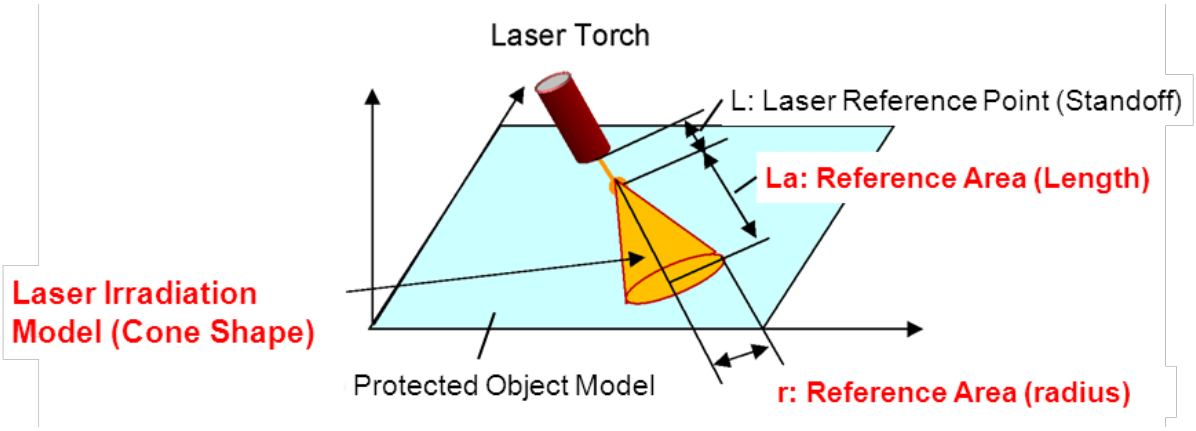
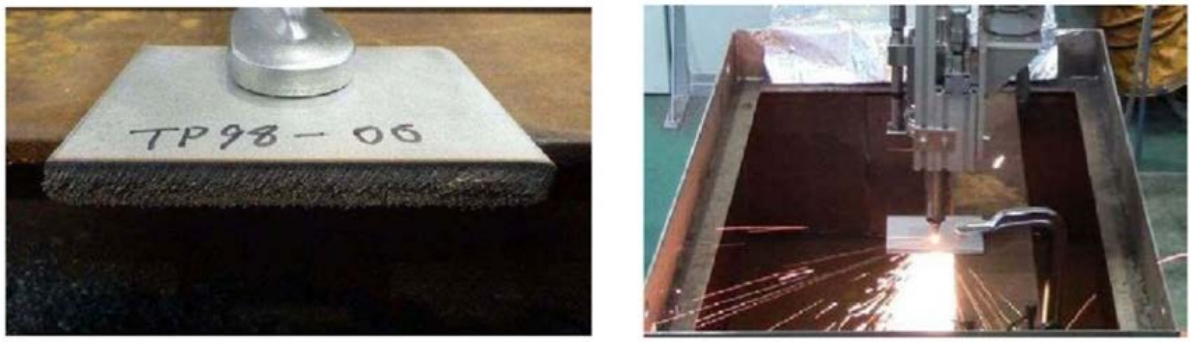
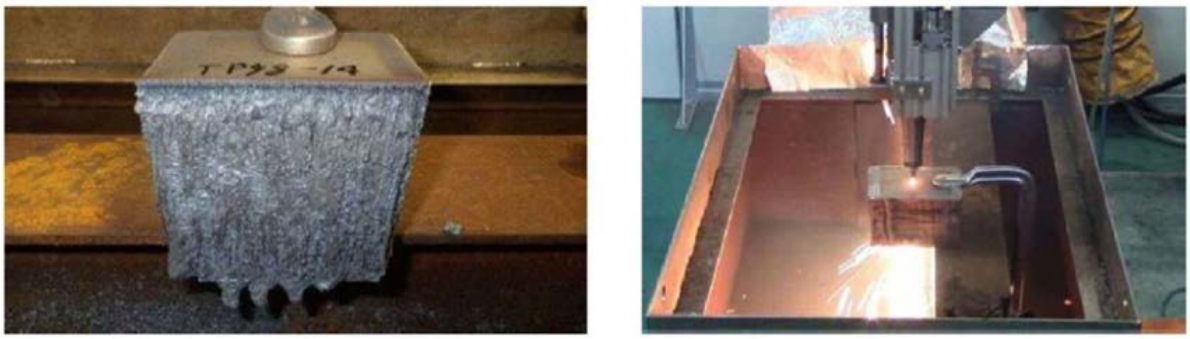


Fig.3 Concept of Safety Interlock System for Laser Irradiation

A high-power (~10kW) laser is applied to the remote laser cutting system. Basically, a higher-power laser provides cutting work to various kinds of metal materials more smoothly and speedily compared to a lower-power laser. Fig.4 shows the examples of the laser cutting for stainless steel plates using this system.



(Laser Power: 3kW, Cutting Speed: 500 mm/min)



(Laser Power: 9kW, Cutting Speed: 30 mm/min)

Fig.4 Examples of Laser Cutting for Stainless Steel Plates

Development of Remote Laser Decontamination System

The remote laser decontamination system is applied to remote decontamination works for contaminated surface of targets by using manipulator. This system consists of a laser irradiation system and a waste collection system as shown in Fig.5.

For the remote decontamination operation, at first the hood mounted on the laser head is pushed to a target surface at right angle and proper pushing force. After that, the laser irradiation starts to clean a contaminated surface and collects stripped particles in the hood through the suction hose. The laser head is moved parallel to the

target surface with keeping proper pushing force range and angle of the laser head during the operation.

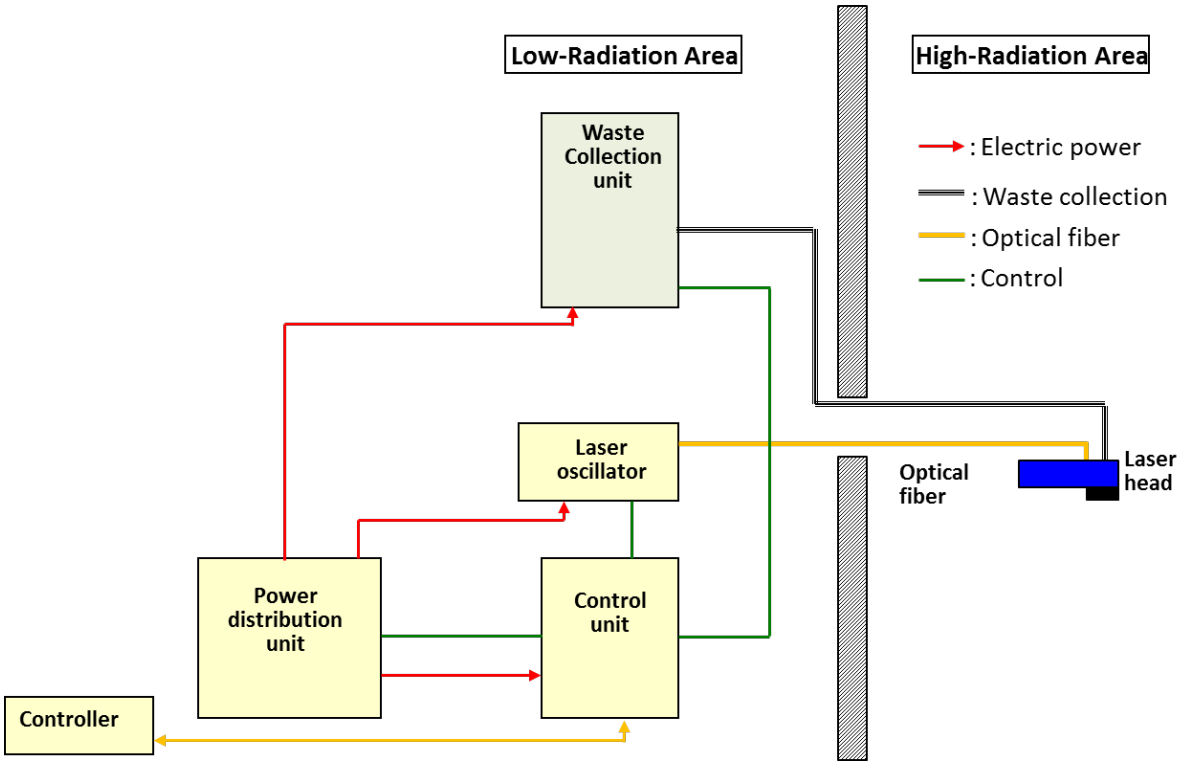


Fig.5 Remote Laser Decontamination System Overview

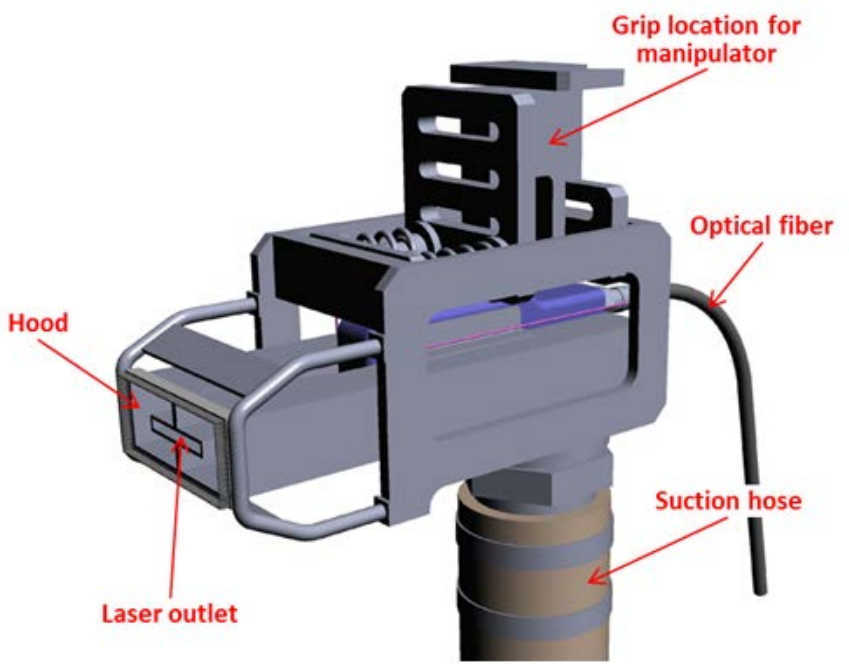


Fig. 6 Laser Head for Remote Laser Decontamination System

Laserclear®, developed by IHI Inspection & Instrumentation Co., Ltd., is applied as the laser beam irradiation equipment in the remote laser decontamination system. Laserclear® is used as the effective equipment to cleaning various metal surfaces such as paint and rust stripping. It has been applied to automobile, airline, semiconductor and other various industries. Laserclear® has two major advantage points. First is that the light and compact laser head can be handled very easily. Second is that the cleaning operation is performed effectively with 100 mm width of laser irradiation by using less than only 100W electric powers.

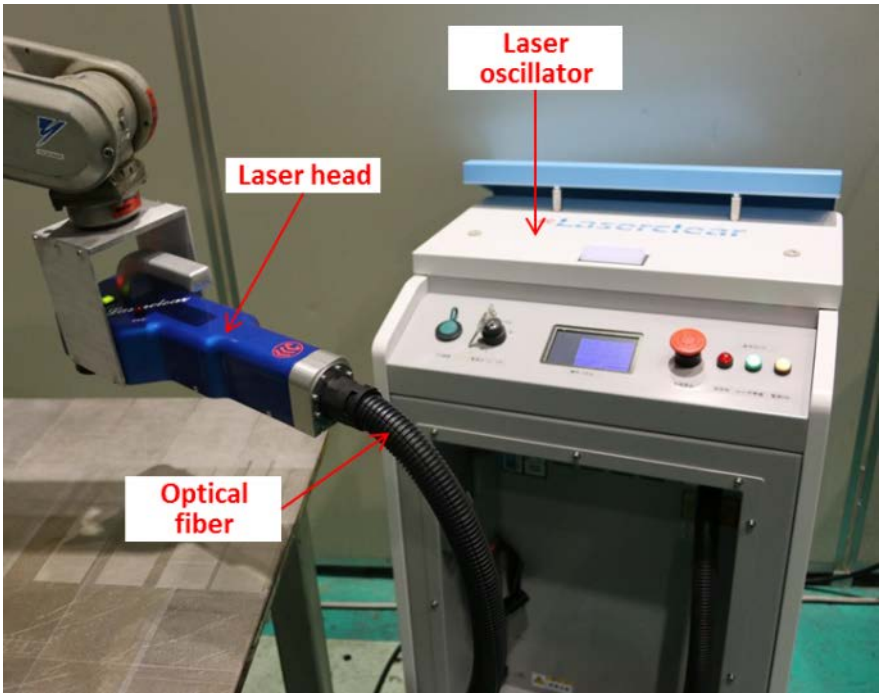
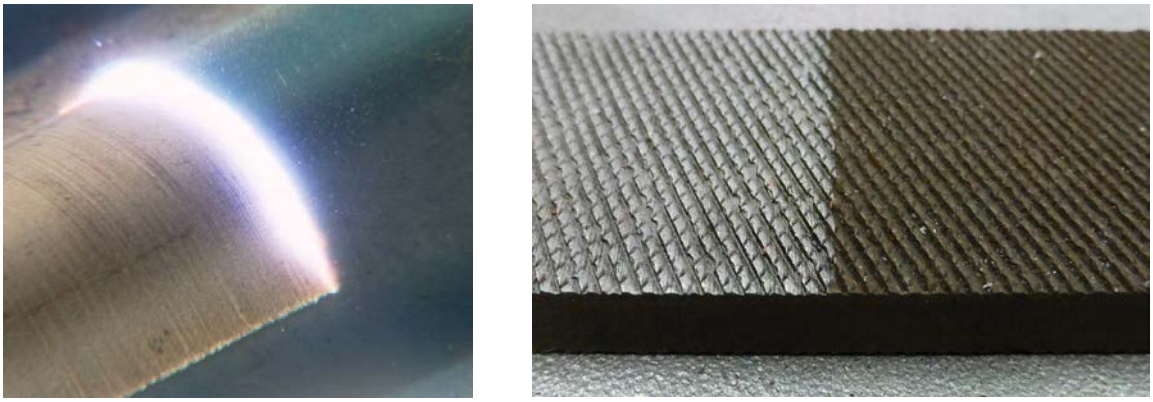


Fig. 7 LaserClear®



(Left: Paint stripping, Right: Rust stripping)

Fig. 8 Examples of Metal Surface Decontamination using LaserClear®

DISCUSSION

In order to expand applicable range of the remote laser cutting and decontamination system, further development plans are considered as next steps.

One of the most advantage points of laser cutting method is to provide very efficient cutting operation for metal materials. In recent years, the technologies for laser oscillator has been rapidly progressed and the capacity of laser output power has become higher and higher. To apply such a laser oscillator which has higher laser output power to the current remote laser cutting system should be able to provide more speedy cutting work for thicker metal materials.

It is preferable for the remote laser decontamination system to increase its work-efficiency. The current Laserclear® applied to the remote laser decontamination system was designed under a concept “light and compact” to provide easy handling for the laser head. However, speedy and efficient work is required in most cases of decontamination projects in D&D sites. Therefore, it is planned that the Laserclear® will be improved to have higher laser output power and wider laser irradiation range in order to increase its work-efficiency.

CONCLUSIONS

The remote laser cutting and decontamination systems developed by IHI have an enough capability to be applied to various kinds of cutting and decontamination works in high radiation environment. Compact, contactless and efficient laser system is one of the most appropriate systems for remote operations. With a rapid progress of laser technologies, those systems will be continuously improved to expand their applicable ranges.