Development of Multi-Purpose Jig for Laser Welding

Sung-Ho Heo [a*], Jintae Hong [a],Chang-Young Joung [a], Ka-Hye Kim [a*]
[a] Neutron Utilization Technology Division, KAERI, Daedeok-daero 989-111, Yuseong-gu Daejeon
[*]*Corresponding author: hsh@kaeri.re.kr*

1. Introduction

A Nuclear Fuel Test Rig, which is designed to investigate nuclear fuel, need hundreds of detailed component assembly or welding processes. To weld small and complicate components, the laser welding process is one of the most important processes in fabricating a Nuclear Fuel Test Rig.

Joung developed an automatic Laser Welding System[1]. Hong analyzed the welding properties of Zircaloy-4 and STS 316L of the rig's material[2]. Kim[3] used a Dual Cooled Fuel Test Rig. However, the Laser Welding System is difficult to be used for welding if the parts are too small or there some interference exists.

In this study, a Multi-Purpose Jig, which is able to change the angle and fix the center of the Mother material to help the Laser welding system, is described.

2. Multi-Purpose Jig

2.1 Laser Welding System

A Laser Welding System has been developed using a fiber laser that has a better heat intensity and utilization than a resistance welding and TIG welding machine. It consists of a fiber laser source with a 3-axis servo stage, an LM guide, an index chuck, a control PC, and a welding head, as shown in Fig. 1.

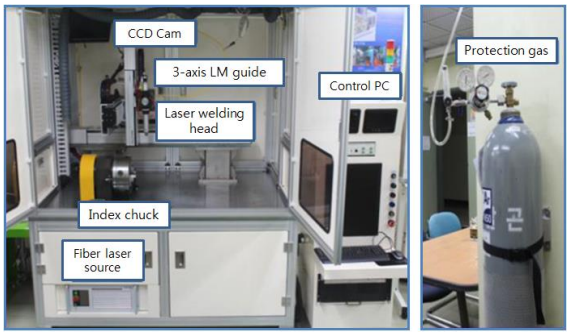

Fig. 1. Laser welding system

A fiber laser source is IPG's YLR-QCW-150/1500 AC model, which can emit a pulse wave and continuous wave mode. Pulse wave mode can emit up to 1500 watts, and continuous wave mode is able to emit up to a maximum average of 250 watts. In addition, an LM guide and index chuck are possible for manual or automatic operation to use a CNC based control program, and check the welding position and progress from the output of a CCD camera.

The welding head is connected to the fiber laser source, can be moved by the LM guide, is supplied welding protective gas, and can tilt side to side by 45 degrees of the laser emission direction in 5 degree increments.

2.2 Composition and role of Multi-Purpose Jig

A Laser Welding System using an index chuck requires a jig for supporting the other side of the part in the axial direction of the rod of butt welding. Sometimes, components interfere with another device during lap welding.

Accordingly, a Multi-Purpose Jig was developed to solve these problems, and the roles of each component are as follows.

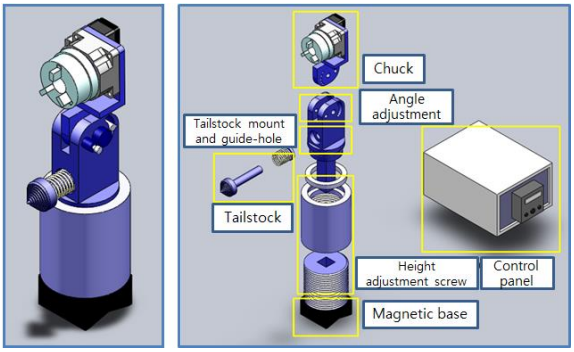

Fig. 2. Composition of Multi-Purpose Jig

The Multi-Purpose Jig uses a hollow chuck to secure a long tube-material, and the chuck is driven by a step motor that controls the direction of the rotation and speed.

A Laser Welding System was designed to adjust the angle of the welding head, but it is impossible to operate the equipment in the case of interference. Thus, the incidence angle of the laser can be controlled by changing the angle of the chuck, as shown in Fig. 3.

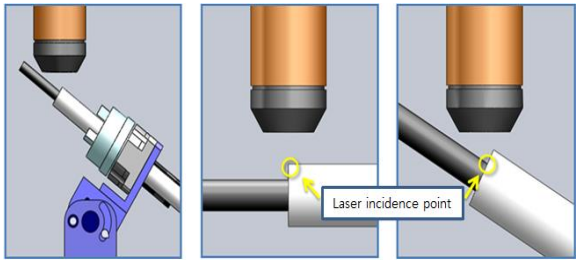

Fig. 3. Incident point and changing angle of the chuck

As shown in Fig. 4, the angle of the chuck is able to change using a clamp device of up to ±45 degrees, and can be fixed at 5 degree increments using a fixing pin.

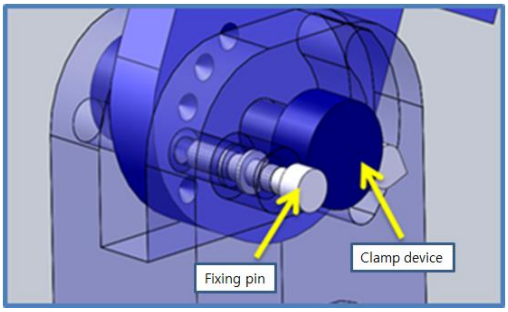

Fig. 4. Angle adjustment device

A Multi-Purpose Jig does not interfere with the system and is easy to move, because it can be attached and removed on a welding table using the magnetic base. In addition, it can be readjusted to an affordable height, as shown in Fig. 5.

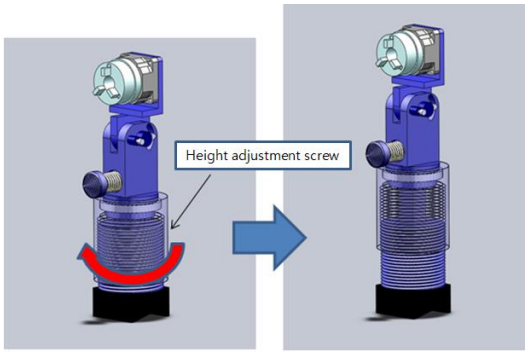

Fig. 5. Height adjustment screw

Tailstocks were also designed to support the butt welding. To increase the stability of the welding, the spring is applied to give the proper compression on the two weldments during welding.

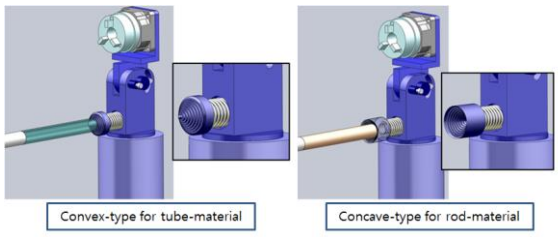

Fig. 6. Tailstock

Tailstocks have two types. One is a convex-type for the tube-material, and the other is a concave-type for the rod-material. Before using the tailstock, the calibrated center of the tailstock must be aligned with the index chuck. At first, the guide-rods are fixed on the index chuck, after the tailstock is removed from the jig. The guide-rod is then put placed in line with the guide-hole and the magnetic base should be fixed. Finally, the guide-rod is removed from the guide-hole, and the centerline alignment of the index chuck and the Multi-Purpose Jig is complete. When ready to conduct the butt welding, the tailstock needs to be assembled to the guide-hole according to the type of material.

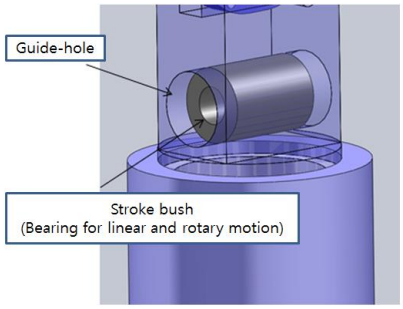

Fig. 7. Guide-hole and Stroke bush

3. Apparatus experiment

3.1 Butt welding to use the Multi-Purpose Jig

After the tailstock was installed using the guide-rod, butt welding experiments were carried out, as shown in Fig. 8. The materials used in the welding part are Zircaloy-4, and the welding conditions are 1050W, 10Hz, QCW mode, and 20L/min of He gas.

As a result, it was confirmed that there is no defect to the welded part.

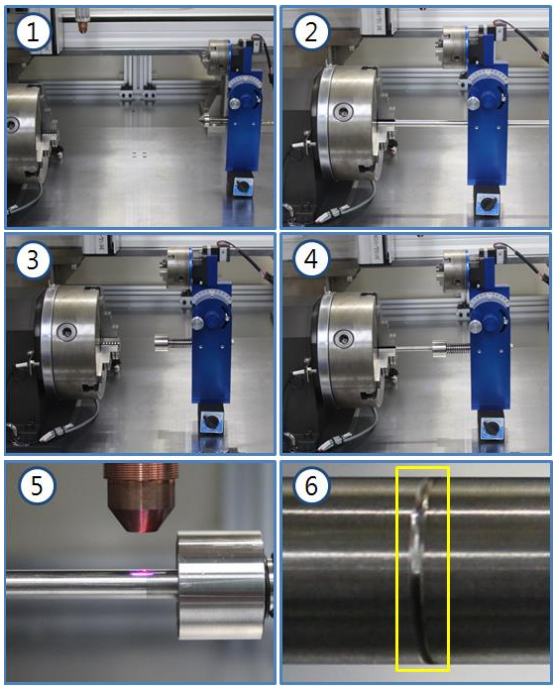

Fig. 8. Butt Welding

3.2 Lap welding to use the Multi-Purpose Jig

As shown in Fig. 9, the angle of the Multi-Purpose Jig chuck is adjusted, and lap welding is carried out. The material used in the welding is STS 316L, and the

welding conditions are 450W, 10Hz, QCW mode, and 20L/min of Ar gas.

As a result, the welding bead shows a smooth surface with a constant width, and oxidation did not appear.

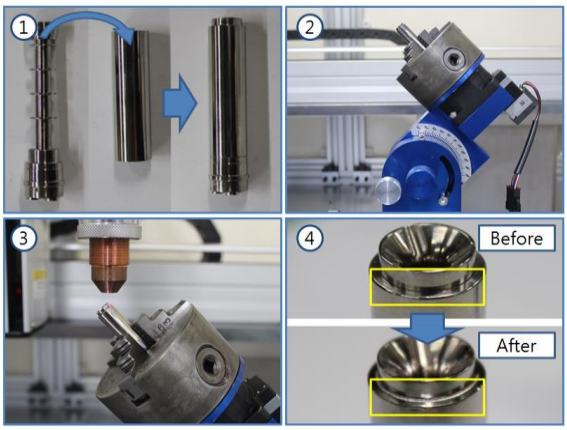

Fig. 9. Lap Welding

4. Conclusion

In this study, a Multi-Purpose Jig available in fabricating a nuclear fuel test rig was developed. Using the developed Multi-Purpose Jig, butt and lap welding experiments are currently in progress. As a result, it was confirmed that precise fixing and support are possible.

Using the developed jig, the workability and accuracy of the laser welding for small components were dramatically improved.

Acknowledgement

This work is supported by the Nuclear Research & Development Program of the National Research Foundation of Korea (NRF) grant funded by the Korean government (MEST).

REFERENCES

[1] Joung,C.Y., The Fabrication of Precision Laser Welding System for Nuclear Fuel Test Rig, KAERI/TR-5268/2013.
[2] Hong,J.T., Joung,C.Y., Kim,K.H., Heo,S.H. and Kim,H.G., Study on Fiber laser Welding Conditions for Fabrication of a Nuclear Fuel Rod, International journal of Precision Engineering and Manufacturing, VoL.15, No.4, pp.1-5.
[3] Kim,K.H., Hong,J.T., Ahn,S.H. and Joung,C.Y., Study on Conditions of Laser Welding for Manufacturing Irradiation Rig of Dual cooled Fuel, Transactions of the Korean Nuclear Society Autumn Meeting Gyongju, 2013.