Welding Mechanism of Laser-Arc Combination High Speed Welding†

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KEY WORDS : (CO_2 Laser Welding)(MIG Arc Welding)(Combination Welding)(High Speed Welding) (Welding Mechanism)

In the previous reports[1)2)], LPLAC(Leading Path Laser-Arc Combination) high speed welding was reported for mild steel plates of up to 16mm in thickness at a welding speed of up to 5m/min using the specimens having V grooves and a leading path of laser. The effect of the laser on the arc was also investigated by the observation of welding phenomena with a high speed video camera. However, welding defects such as cracks and porosity occurred frequently, especially on thick specimens. In this report, in order to apply the LPLAC welding method to thicker plates, the effect of arc conditions on the defects in Laser-Arc Combination welding are investigated through the observation of the molten pool, laser plasma and arc plasma using a long distance microscope and a high speed video camera.

The observation system for welding phenomena is shown in **Fig.1**. A 7 kW CO_2 laser and a 10kW MIG arc welder were combined into the LPLAC welding system. Helium gas was used, both as the assist gas for the laser and the shield gas for MIG arc welding. Specimens used were mild steel plates SS400 of 16mm in thickness with a V groove. Welding speed was set at a constant speed of 5m/min. A long distance microscope was used for the observation of behavior of the molten metal, laser plasma and arc plasma in a narrow imaging area of 10mm x 10mm at the distance of 1m from the welding point. A copper vapor laser was used for illumination to suppress the intense light noise from laser and arc plasma.

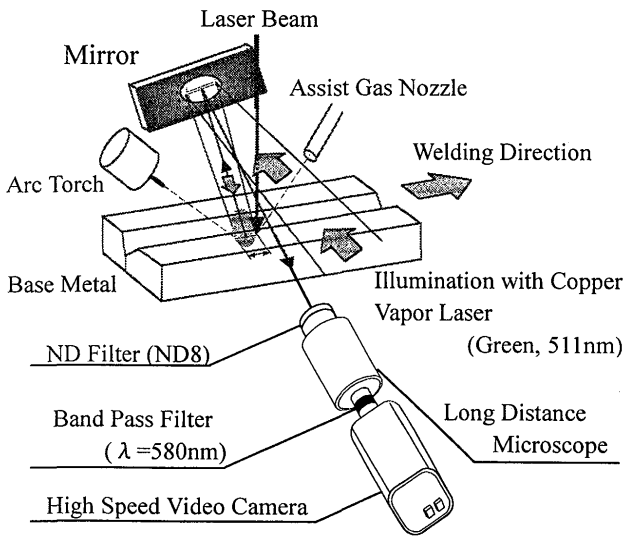

Fig.1 Experimental apparatus

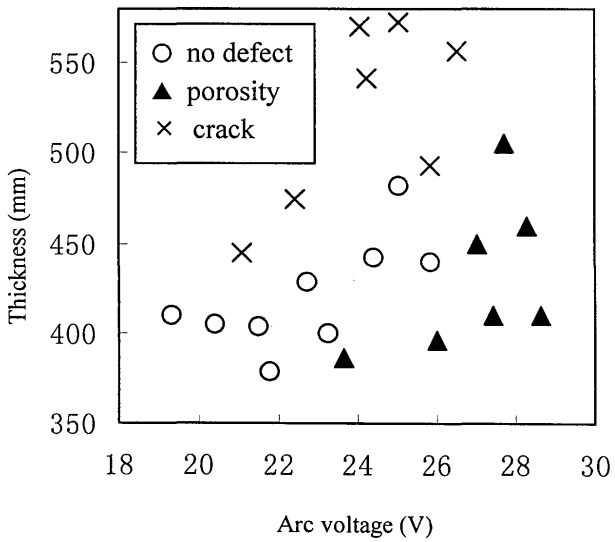

Fig.2 Arc condition dependency on welding defect

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The occurrence of welding defects was investigated for various combinations of arc voltage and current in order to identify the non-defect arc condition area in Laser-Arc Combination welding at a welding speed of 5m/min. **Figure 2** shows the porosity, crack or non-defect zone plotted for various combinations of arc voltage and current. When porosities and cracks occurred in the same specimen, they were plotted in the crack zone. It can be seen clearly that three zones of crack, porosity and sound bead area are separated according to arc voltage and current. When the arc voltage was high, porosity occurred and when the current was high, cracks occurred. These phenomena were analyzed from the welding phenomena. **Figure 3** shows arc plasmas at different arc voltages and the same arc current of 450A. When the arc voltage becomes high, droplet transfer phenomena changed from globular transfer to spray transfer. **Figure 4** shows arc plasmas and molten metals at different currents and a constant arc voltage of 26V. With increasing arc current, the amount of molten metal was increased. On the other hand, it was observed that the penetration depth became shallower with increasing arc current. It was thought that the irradiation of laser beam into the bottom part of the bead, which was the main factor of deep penetration, was suppressed by the increasing amount of molten metal caused by the high current arc. This caused the excess heat input to the upper part of the bead, inducing cracking in the bead. It was found that it is difficult for LPLAC welding to increase molten metal by increasing arc power because it also caused welding defects. Therefore, it is important to control the interaction of laser and molten metal by controlling the distance of laser and arc in accordance with increasing arc input power for further penetration depth in the LPLAC welding.

References

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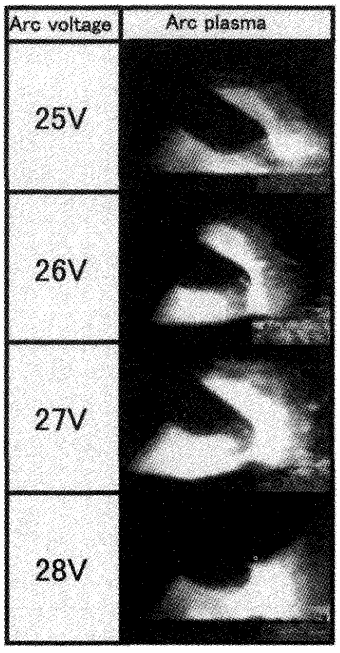

Fig.3 High speed photographs of Laser-Arc combination welding at various arc voltages
Laser power : 7kW, Arc current : 450A
Distance between laser and arc : 5.0mm, V groove

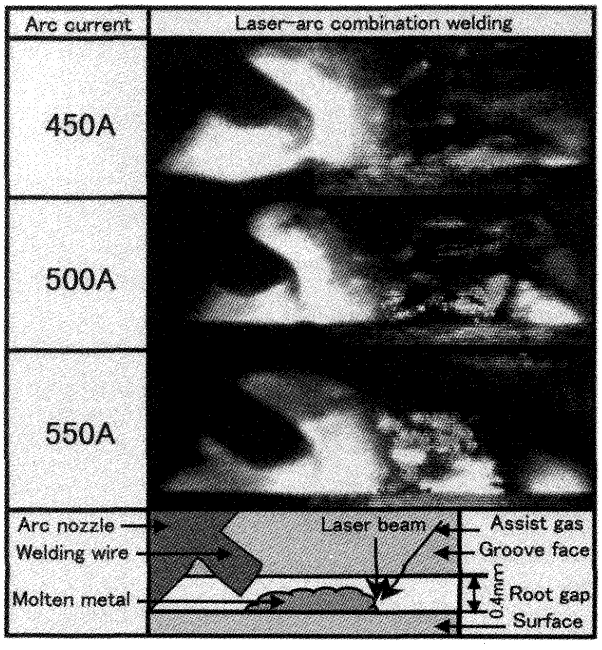

Fig.4 High speed photographs of Laser-Arc combination welding at various arc current
Laser power : 7kW, Arc voltages : 26V
Distance between laser and arc : 5.0mm, V groove