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Effect of Laser Beam Irradiation on CO_2 Gas Arc Welding†

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The laser beam is one of the best tools for heat processing, however, it is expensive and its output power is still low compared with conventional heat sources such as an arc. In contrast, arc welding is a very convenient and cheap heat source, but its ability for deep penetration or high speed welding is poor compared with the laser beam. Recently, some research works to combine conventional arc welding and laser welding have been performed. However, there are still many difficulties remaining before these heat sources can be combined effectively. This report describes a fundamental research of the effect of laser beam irradiation on conventional CO_2 gas arc welding to develop a high speed welding method for thick plates using a combination of these two heat sources.

Figure 1 shows the experimental configuration of a laser shielding gas nozzle, an assist gas nozzle and a CO_2 gas arc welding torch. The laser shielding gas nozzle was set vertically. The assist gas nozzle was set at 45 degrees inclined against the laser nozzle. The CO_2 gas arc welding torch was set at 70 degrees inclined against the laser nozzle at the opposite side to the assist gas nozzle. These are aligned along the welding direction. The effect of laser beam irradiation on the penetration depth and bead shape as a function of the distance between laser and arc under the constant conditions of laser beam and arc welding was investigated. The laser power was fixed 5 kW. The focusing point of the laser is just on the surface of the specimen. A specimen of mild steel SS41 (50x100x12t) was used and bead-on-plate welding was performed. Arc welding parameters were 25 V and 200 A (5 kW). Welding speed was 60 cm/min.

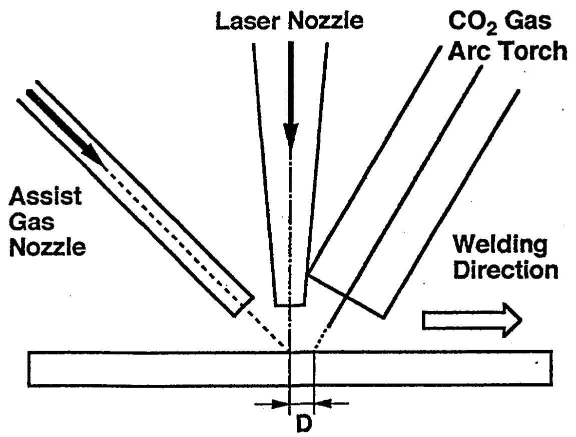

Fig.1: Experimental configuration of an assist gas nozzle, a shield gas nozzle for laser and a CO_2 gas arc welding torch.

The penetration depth and bead width changed with the flow rate of assist gas and the distance between laser and arc. **Figure 2** shows the assist gas flow rate dependency on penetration depth. Points marked ▽ and □ represent penetration depths of arc welding only and laser welding only, respectively. With increasing assist gas flow rate, the penetration depth increased and at 30 l/min showed a maximum depth. This is very similar to the dependency in the case of laser welding only. The maximum penetration depth also increased with a decrease in the distance between laser and arc. At a distance of 7 mm, penetration depth showed the maximum of 10 mm. It is thought that since the laser beam should penetrate the solidified weld after arc welding when the separation distance is large, its penetration depth inside the specimen decreases. On the other hand, since the laser beam impinges into the hot weld close to the arc when the distance is small, it can easily penetrate deeply. Therefore, the penetration depth becomes large at short distances between laser and

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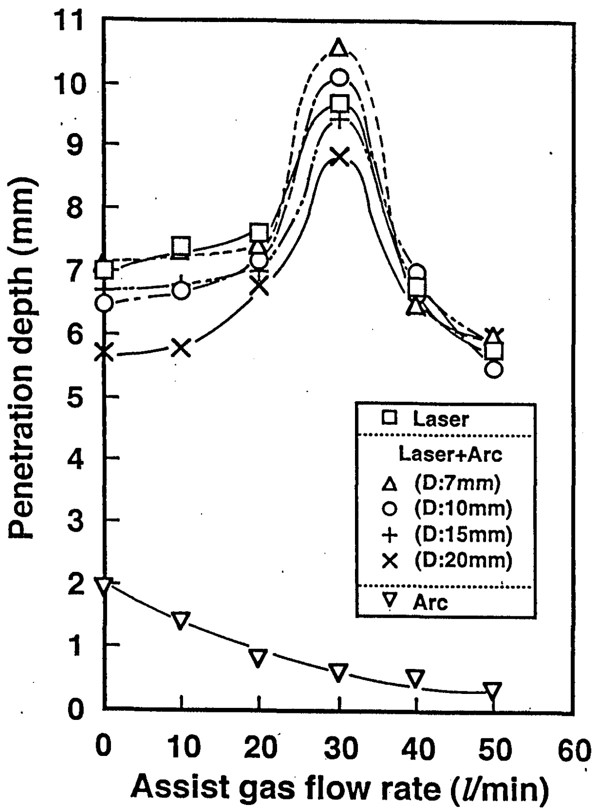

Fig.2: Penetration depth dependency on assist gas flow rate.

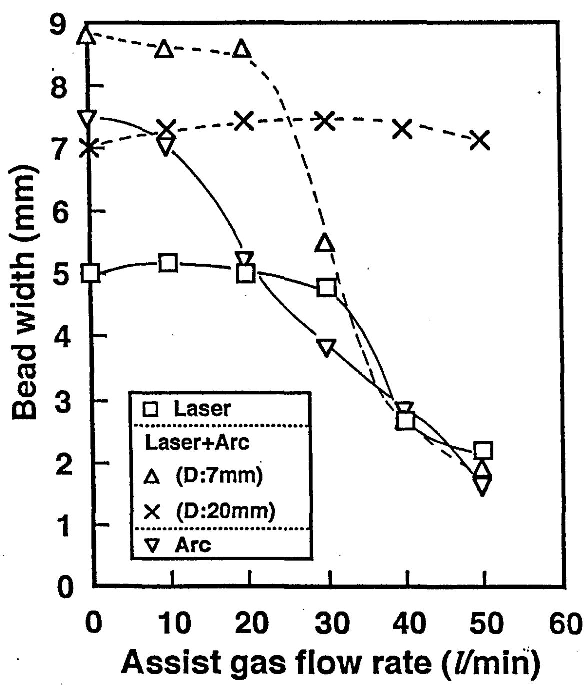

Fig.3: Bead width dependency on assist gas flow rate.

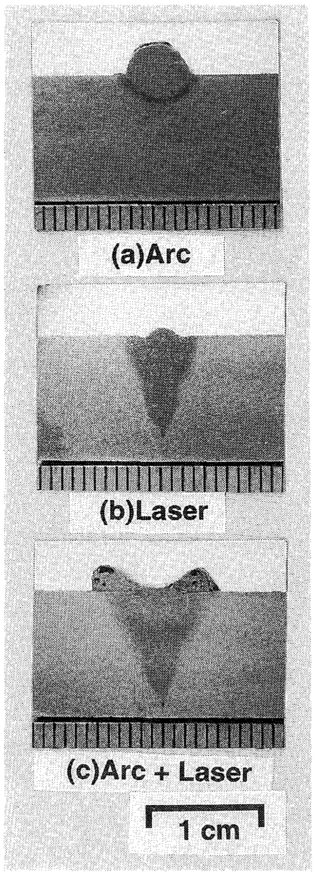

Fig.4: Typical bead shapes for (a) arc welding, (b) laser welding and (c) arc welding with laser beam.

arc. The difference is seen clearly at large distances and the low assist gas flow rates (left side of the figure). **Figure 3** shows the bead width dependency on the assist gas flow rate. With increasing the assist gas flow rate, the bead width at the surface decreased. When decreasing the distance between laser and arc, the bead width also decreased.

When the distance between the two beams is small (for example 7 mm), the heat input of arc welding affects preheating of specimen. On the other hand, when beam distance is great, the two beams act independently . In the range of this experiment, the penetration depth is governed by the laser, and the width of the bead is governed by arc welding. Optimum conditions for penetration depth are a distance of 7 mm and a gas flow rate of 30 l/min. **Figure 4** shows typical beads of (a) arc welding only, (b) laser welding only and (c) arc welding with laser beam at the optimum conditions, respectively. The shape of the bead for arc welding is shallow and wide. On the other hand, the bead of laser welding shows a deep wedge type shape. And the combination welding bead shows both the deep penetration of laser welding and the wide surface weld of arc welding.