Some Problems on Laser Plasma Control with Argon Assist Gas†

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Laser beams have been widely used for very convenient tools in material heat processing, especially in welding field. However, laser beams produce laser plasma by its high energy density. This plasma prevents laser beams from transmitting to materials. This paper describes some problems on the suppression of this laser plasma by argon assist gas. Effect of flow rate of assist gas on the amount of laser plasma and penetration depth are reported.

Figure 1 shows an experimental setup. Laser beam impinges perpendicularly to the work piece of SM 41 steel. Argon assist gas blows an irradiated point of laser beam on material surface with an angle of θ_n from behind of laser beam. A diameter of nozzle ϕ_n is 3 mm, and a height of nozzle from surface h_n is 10 mm. Flow rate of assist gas is varied from 4 l/min – 30 l/min.

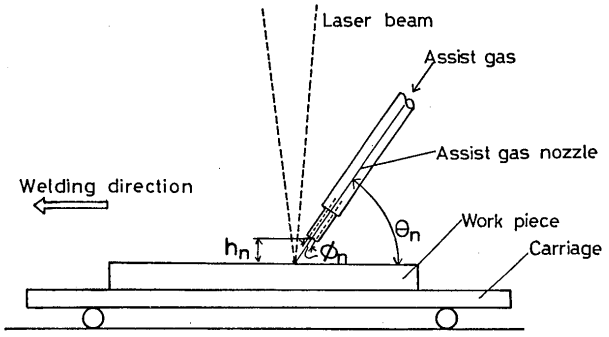

Fig. 1 Experimental setup.

Figure 2 shows a dependence of penetration depth h_p on gas flow rate at a power W_b of 5 kW and welding speed v_b of 600 mm/min. When the flow rate is low, the penetration depth is rather shallow compared with that on no assist gas condition (that is, in air) of about 4 mm. However, it rapidly increases with gas flow rate and exceeds the penetration depth in air over a flow rate of 8 l/min, and reaches a level of about 1.5 times deeper penetration depth than that without assist gas. Then, it gradually decreases with gas flow rate.

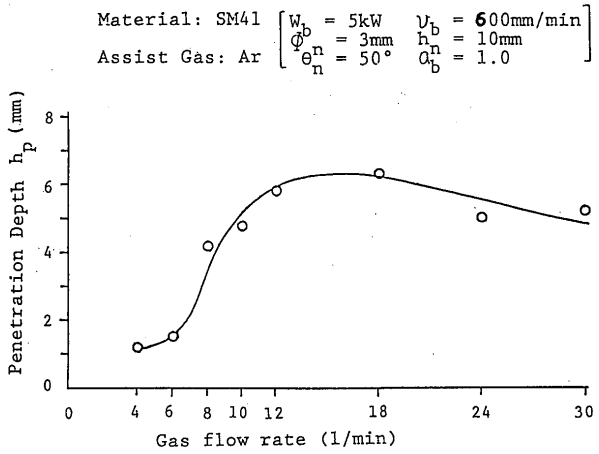

Fig. 2 Dependence of penetration depth on gas flow rate.

Material: SM 41
Assist gas: Ar

W_b = 5kW v_b = 600mm/min ϕ_N = 3.0mm
h_N = 10mm θ_N = 50°

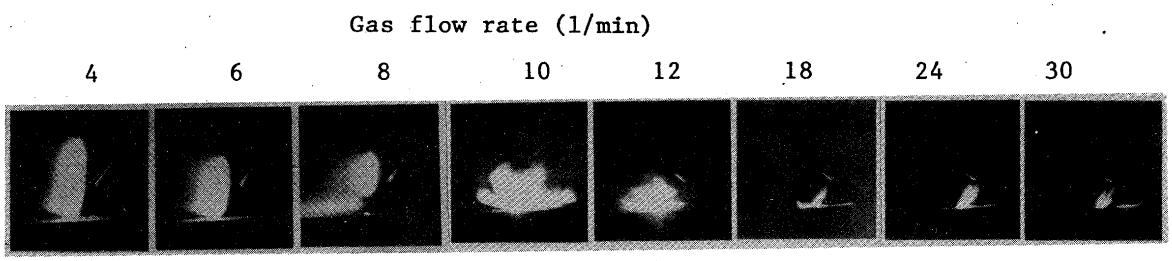

Fig. 3 Laser plasmas in various flow rates of assist gas.

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Material: SM 41
Assist gas: Ar

W_b = 8kW v_b = 1m/min ϕ_N = 3.0mm
h_N = 10mm θ_N = 65° α_b = 1.0

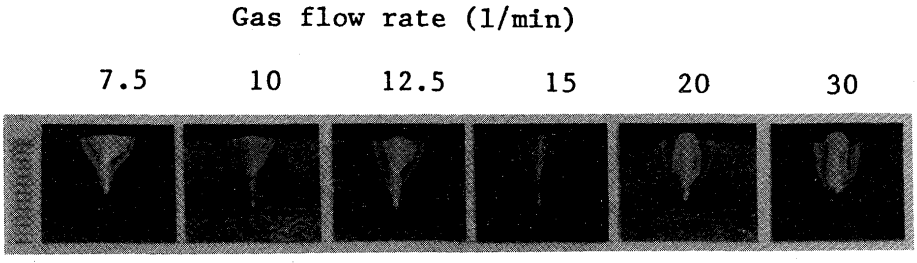

Fig. 4 Bead crosssections of various flow rates of assist gas.

Figure 3 shows typical phogographs of laser plasma in each gas flow rate. At low gas flow rate, laser plasma is produced more violently than that in air. This corresponds very much with shallow penetration depth in Fig. 2. The amount of laser plasma decreases with increasing gas flow rate. Over 12 l/min, the amount of laser plasma seems to be almost reduced by assist gas. This corresponds with the deep penetration depth in Fig. 2. Because the assist gas of low flow rate rather increases laser plasma, the penetration depth decreases compared with that in air. Proper gas flow rate can blow away laser plasma, however, further high flow rate cannot decrease laser plasma no more.

Figure 4 shows bead crosssections in various gas flow rate in 8 kW and 1 m/min. Below a flow rate of 15 l/min, bead crosssections show wine-cup shape. Over 15 l/min, they become rather round shape. This shows the change of effect of assist gas. When the flow rate is low, assist gas cannot blow away the laser plasma effectively. Because the ionization potential of argon gas is lower than air, much amount of laser plasma is produced. This causes too shallow penetration depth in Fig. 2. With increasing gas flow rate, assist gas blows away the laser plasma effectively. The penetration depth increases with gas flow rate. However, too high a flow rate of assist gas affects the molten metal flow and the shape of beam hole. It is shown in the change of shape of bead crosssections. At high flow rate, assist gas blows away molten metal directly. Therefore, assist gas cannot increase penetration depth no more.