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Observation of arc phenomena in plasma GMA welding process*

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This paper presents characteristics of ionized gas metal arc processing which consists of a torch, a welding wire, shielding gases and two power sources. One of power sources ionizes the shielding gases before feeding into the arc region and another stably produces the arc with melting wire electrode. The degree of ionization in the shielding gas is well regulated by the primary power source, and then the secondary power source is able to control the arc devotedly, including the production and detachment of molten droplet at tip of the wire electrode. It is concluded that the ionized gas metal arc can make a stable processing of welding without spatters and fumes in comparison with the conventional gas metal arc processing. Furthermore, it is suggested that the ionized gas metal arc is very useful for not only welding but also thermal spraying for producing a fine coating of metal surface.

Key Words: Plasma, GMA welding, Plasma MIG, Clean and welding

1. Introduction

Gas metal arc (GMA) processing has been the most dominant welding processes in various industries of automotive, steel making, shipbuilding, bridges, building construction, pipelines, chemical plant, power generation, etc because this processing has the advantages of very high productivity and low equipment cost. However, spatters and fumes are markedly appeared during the gas metal arc welding and then are not good for the factory environment and human health.

In the gas metal arc process, the arc current and the arc voltage are chiefly assumed to be a control parameter, and the material transport to the base material are controlled so that a proper joint part is efficiently formed. On the other hand, it can catch the shielding gas with a strong recognition as a mere protection gas as another control parameter of the gas metal arc process. Electric arcs are the base of the gas metal arc processing and are usually ignited in gases at room temperature in atmospheric pressure for the welding. All gases at room temperature are excellent electrical insulators and then a sufficient number of charged particles such electrons and ions have to be generated in order to make gases electrically conducting. To ionize the gases is primarily necessary for such a gaseous discharge but needs large values of energy. Moreover, it is guessed that the heat source characteristic of the arc can be greatly changed if the shielding gas is ionized before feeding into the arc region in advance and the degree of ionization is controlled in the gas metal arc process where argon, helium, hydrogen, nitrogen, oxygen, carbon dioxide, and those mixed gases are used as a shielding gas. That is, it is thought that the flexibility of the arc heat source control improves greatly.

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Authors performed the development of advanced plasma GMA welding process. In this report, the welding arc phenomenon is described.

2. Experimental procedure

2.1 Experimental set up for plasma GMA welding

Fig. 1 and 2 show the device composition and the torch structure of the ionized gas metal arc process. The power source for the inverter control type DC pulse arc was used for gas metal

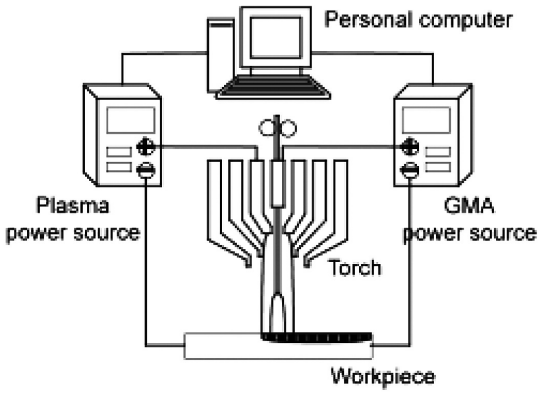

Fig. 1 Schematic diagram of plasma GMA process

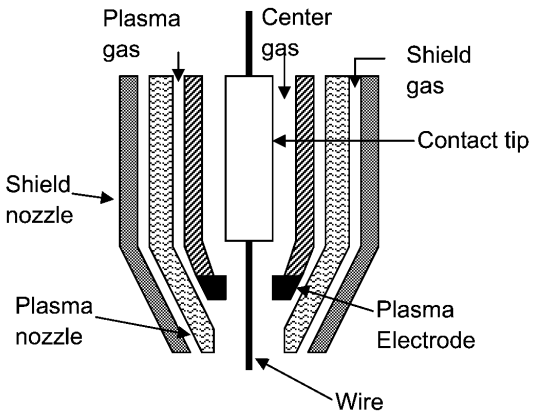

Fig. 2 Schematic diagram of plasma GMA torch.

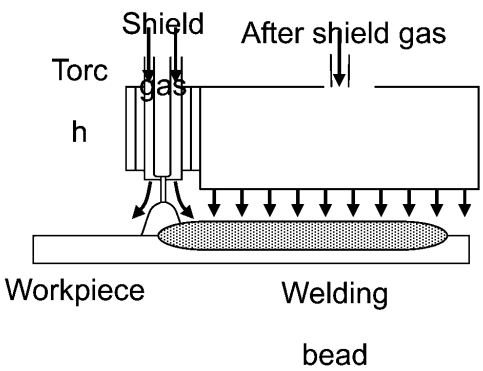

Fig. 3 Schematic diagram of after shielding device

Fig. 4 Temperature measurement system by two color pyromety method

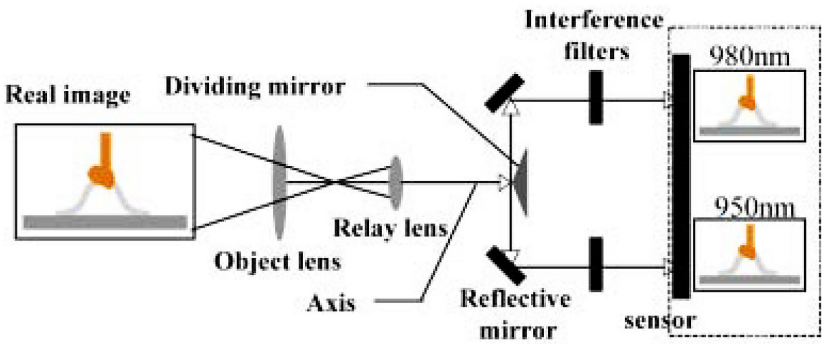

Fig. 5 Schematic illustration of high-speed temperature measurement system by two color temperature measurement.

arc, and the inverter control type DC power was used for the generation of ionized gas (recorded at the following as plasma). Pure Ar (10l/min) was supplied to both the center gas and the plasma gas, and Ar+2.5%CO_2 (15l/min) was supplied to a shielding gas as shown in Fig. 3. The mild steel plate of thickness 6.0mm was selected to the base metal, and the solid wires (YGW15 corresponding) of 1.2mm in diameter were selected to the welding wire. It was 10mm as for the distance between the nozzle point and the base metal, and It was 20cm/min as for the welding speed, and they were kept constant. We used the shielding device shown in Fig. 3 to protect the surface of the bead after from the atmosphere. After shielding gas is pure Ar (25l/min). A bead on plate was welded, and the welding arc phenomenon was observed with a high-speed digital camera. We used a high-speed digital video camera. And we took pictures of the infrared region with a high-speed digital video camera. And we carried out the temperature measurement of weld pool in plasma GMA welding by two color pyrometry.

2.2 Experimental set up for temperature measurement

Two color temperature measurement is utilized to obtain the temperature of an object. The object is photographed by high speed camera during arc welding. Two wave lengths (950nm and 980) in the infrared range are selected from the thermal radiation emitted from the object by using an imaging spectroscope, and the temperature is obtained from the intensity ratio of the two wave of radiation. A schematic illustration and a photograph of high-speed temperature measurement system by two color temperature measurement are shown in Fig. 4 and 5, respectively. The image of the object formed by the object lens is divided to two identical images with the branch mirror (Photron, Multi-Spectral-Imager). These images pass through the interference filters (950nm, 980nm) and are detected with the sensor (Photron, FASTCAM-512PCI) as the images at wavelengths of 950nm and 980nm, respectively.

3. Result and discussion

It reports that the swing of wire edge was able to be controlled with the plasma shield gas under a pure argon atmosphere. However, it became the result of bead appearance that the width of the bead shown in Fig. 3 was narrow and the weld reinforcefent is high. On the other hand, the width of the bead was wider, the height of the weld reinforcement was lower than that of doing under a pure argon atmosphere as shown in Fig. 3 when putting, and experimenting on Ar+2.5%CO_2, and the improvement of the wettability was seen. Then, it was nearly a temperature on the melting point to have measured the temperature of the weld pool respectively both. In addition, we measured amount of oxygen in weld pool. The result is that 26ppm in pure argon atmosphere and 52ppm in Ar+2.5%CO_2. Oxygen changes the small amount contained in the weld metal

Fig. 6 A weld bead appearance and cross section of plasma GMA welding with pure srgon.

Fig. 7 A weld bead appearance and cross section of plasma GMA welding Ar + 2.5%CO_2.

surface tension in a temperature near the melting point of iron. Fig. 8 shows that the temperature of the weld pool is almost equal to the melting point of iron immediately after the arc disappeared.

4. Conclusions

The conclusions in this paper are summarized as follows.

[1] The temperature of the weld pool is almost equal to the melting point of iron immediately after the arc extinction.

[2] Small amount of oxygen contained in the weld metal changes the surface tension in a temperature near the melting point of iron. Then, it gives the influence to the wetting character of the weld bead.

Acknowledgements

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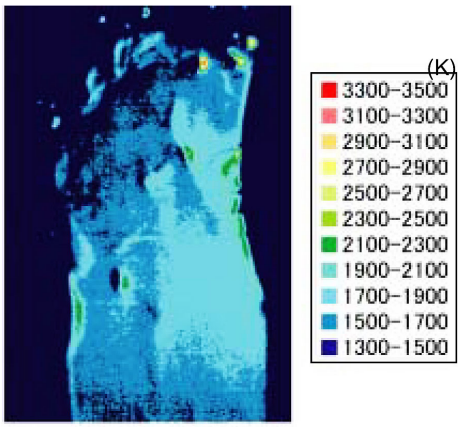

Fig. 8 Temperature distribution chart of weld pool.

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