7th Asia-Pacific Conference on Plasma Physics, 12-17 Nov, 2023 at Port Messe Nagoya

Elucidation of arc coupling mechanism in plasma-MIG hybrid welding process through spectroscopic measurement of 3D distributions of plasma temperature and iron vapor concentration

Shinichi Tashiro[1], Kazuya Ishida[1,2], Kazufumi Nomura[1], Dongsheng Wu[1], Manabu Tanaka[1]
[1] Osaka University
[2] Morita Corporation
e-mail (speaker): tashiro.shinichi.jwri@osaka-u.ac.jp

Plasma-MIG (metal inert gas) hybrid welding is attracting attention as a method of welding thick steel and aluminium plates in a single pass. The two arcs that are formed provide a high heat flux, but their interactions can affect the weld quality. This study aims to clarify the mechanism of the arc coupling phenomena in plasma-MIG hybrid welding through the tomographic spectroscopic measurement of the 3D distributions of plasma temperature and iron vapour concentration [1,2]. The arc coupling strongly depends on the arc current waveform, so cases using both DC MIG current and pulsed MIG current were investigated for comparison. In the case of DC MIG current, the two arcs were regularly connected because a high-temperature region between two arcs with sufficient electrical conductivity was formed, retaining the current conduction between the arcs. In the case using pulsed MIG current, the two arcs were strongly connected only during the period of increase of the pulsed MIG current. Both arcs were weakly connected or disconnected at other times. The arc connection is thought to be governed by the balance between the stiffness and deflection of the two arcs. In the case using pulsed MIG current, the two arcs were not connected during the period of decrease of the pulsed MIG current, even though the pulsed MIG current was similar to that in the period of increase. In the period of increase, the MIG arc is thought to be constricted because of the thermal pinch effect, increasing the current density, which enhances the stiffness of the MIG arc and promotes the arc connection. In contrast, the pulsed MIG current density becomes lower in the period of decrease, which deflects the MIG arc backward, disconnecting the arcs. The plasma current increased by 35 A during the arc connection period, which increased the plasma arc temperature below the nozzle by 1000 K. The result implies that the arc coupling affects the distributions of the arc pressure and shear force through plasma arc acting on the keyhole inner wall, governing the keyhole stability as well as the weld pool formation process.

Acknowledgement
This work was supported by JSPS KAKENHI (Grant Number JP21K04710) and National Nature Science Foundation of China (Grant Number 52105324).

References
[1] K. Ishida *et al*, Journal of Manufacturing Processes 77, 743 (2022)
[2] D. Wu *et al*, International Journal of Heat and Mass Transfer 200, 123551 (2023)

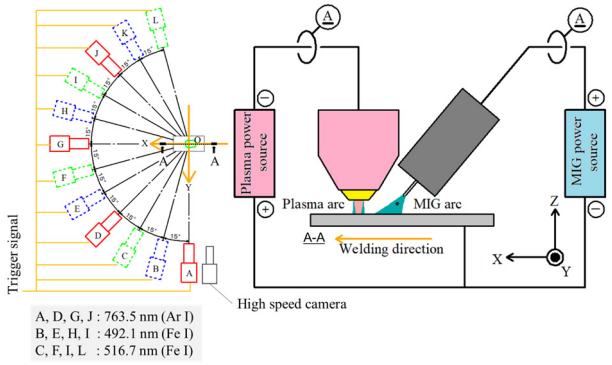
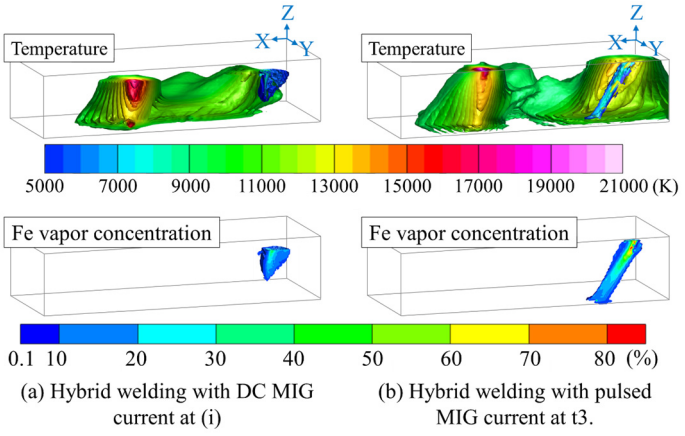


Figure 1 Schematic of the experimental setup equipped with 3D spectroscope measurement system.



(a) Hybrid welding with DC MIG current at (i)
(b) Hybrid welding with pulsed MIG current at t3.

Figure 2 3D distributions of temperature and iron vapor concentration.