Numerical Analysis of Molten Metal Convection during Gas Metal Arc Welding using Three-dimensional Incompressible SPH Method

Hisaya Komen*, Masaya Shigeta† and Manabu Tanaka†

* Joining and Welding Research Institute (JWRI)
Osaka University
11-1 Mihogaoka, Ibaraki, Osaka, Japan
e-mail: h.komen@jwri.osaka-u.ac.jp

†Joining and Welding Research Institute (JWRI)
Osaka University
11-1 Mihogaoka, Ibaraki, Osaka, Japan
e-mail: shigeta@jwri.osaka-u.ac.jp
tanaka@jwri.osaka-u.ac.jp

ABSTRACT

Arc welding process is a joining process in which a base metal is melted by high-temperature arc plasma generated between electrodes. In this study, formation and detachment of molten metal droplets in a GMA (Gas Metal Arc) welding [1] were simulated using an incompressible SPH (Smoothed Particle Hydrodynamics) method [2, 3] to determine parameters of a droplet such as the transfer frequency, velocity and temperature for the weld pool convection model. As a result of the simulation, formation, growth and detachment of molten metal droplets occur repeatedly at the tip of the wire, approximately 10 droplets were transferred during 0.1s. Averaged diameter, velocity of the droplets and averaged the length of liquid columns quantitatively agreed with those of a projected transfer observed in an experiment of MAG (Metal Active Gas) welding using 80%Ar+20%CO_2 mixture gas. Using the parameters obtained by the wire model, weld pool convection and bead formation in a GMA welding were simulated with an incompressible SPH method. The results showed that the simulated weld pool and reinforcement agreed with those observed in actual GMA welding. The details of the convection phenomena were clarified by ensemble average processing. Dynamic changes of the velocity field of a weld pool were investigated for one cycle from one metal droplet transfer to the next metal droplet transfer. From these ensemble averaged results, it was formed that the droplet transfer affected the velocity field of the weld pool in only small region within about 5 mm in the radial direction from the center of the heat source and 3mm in the depth direction.

REFERENCES

[1] K. Nomura, K. Kataoka, K. Miura, Y. Hirata and T. Kishi "Tomographic spectroscopic observation of argon and metal vapor behavior in MIG arc welding", *Welding in the World*, Vol.60, No.1, 117-125, (2016).

[2] M. Shigeta, M. Ito, S. Izawa and Y. Fukunishi, "Three-dimensional simulation of a flow in an arc weld pool by SPH method", *The International Symposium on Visualization in Joining & Welding Science through Advanced Measurements and Simulation*, 9-10 & CD-ROM, (2010).

[3] M. Ito, Y. Nishio, S. Izawa, Y. Fukunishi and M. Shigeta, "Numerical Simulation of Joining Process in a TIG Welding System Using Incompressible SPH Method", *Quarterly Journal of the Japan Welding Society*, Vol. 33, No. 2, 34s-38s, (2015).