Computational analysis of arc phenomena during GTA welding with a constricted nozzle

Kyohei Konishi[*,§], Masaya Shigeta[*], Manabu Tanaka[*], Akihisa Murata[**],
Tadasuke Murata[**] and Anthony B. Murphy[***]
[*]Joining and Welding Research Institute, Osaka University, Osaka, Japan
[**]Murata Welding Laboratory Co., Ltd, Osaka, Japan
[***]CSIRO Manufacturing Flagship, Sydney, Australia
[§]Correspondence author. Fax: +81 6 6879 8689 Email: k.konishi@jwri.osaka-u.ac.jp

INITIAL ABSTRACT

GTA welding with a constricted nozzle is one of new higher-level welding processes [Murata 2013]. In this process, an arc plasma is strongly constricted due to a gas flow control using an additional gas nozzle which is called “constricted nozzle”. This welding process overcomes disadvantages of the conventional GTA welding such as low welding speed and low welding efficiency. As a result, it achieves a welding of quite thin sheet metals which is difficult for the conventional GTA welding. However the mechanism of this improvement is difficult to be understood by experiment and is still unclear because the arc phenomena are quite complicated. We developed the computational model which uses a two-dimensional axisymmetric geometry in order to analyse the arc phenomena during the GTA welding with a constricted nozzle. The calculation is performed for a steady-state arc plasma under the assumption of a local thermodynamic equilibrium condition. The computational model calculates arc plasma, cathode and anode regions not separately but at the same time. The variables of the arc plasma such as pressure, radial and axial components of flow velocity, temperatures and electrical potential are determined numerically by solving the conservation equations of mass, momentum, energy and current with one of the Maxwell’s equations. The governing and auxiliary equations are numerically solved by SIMPLEC method [Van Doormaal 1984]. Figure 1 shows the temperature distributions with the welding current of 50 A for argon arc plasma. The shielding gas flow rate of the conventional GTA welding is 10 L/min. For the GTA welding with a constricted nozzle, the inner and outer gas flow rates are set to be 3 L/min and 7 L/min, respectively. The high temperature area is concentrated to the center part of the arc and the maximum temperature increases 1310 K due to the cooling effect of the inner gas flow when the constricted nozzle is attached. Because of the arc constriction, the heat flux to the anode surface greatly increases within the radial distance of 2.0 mm whereas it inversely decreases at the outside of the arc as shown Figure 2. Furthermore, the total heat input changes from 360.3 W to 377.9 W. It was clarified that the constricted nozzle improves heat efficiency and achieves the welding of quite thin sheet metals because it offers high energy density arc plasma by the arc constriction.

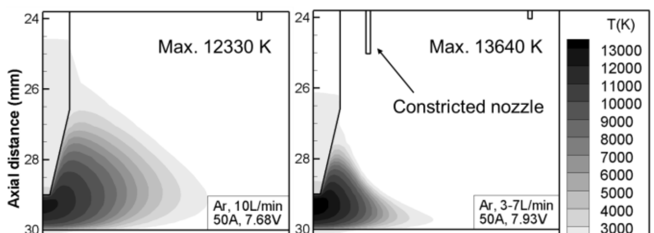

Figure 1. Temperature distributions.

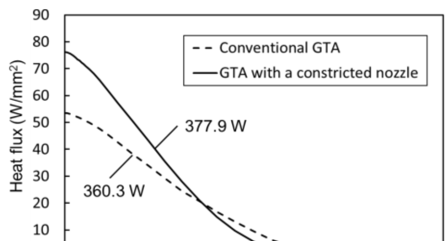

Figure 2. Heat flux distributions.

REFERENCES

Murata A., Murata T. and Tanaka M. [2013], Development and it’s practical application of GTAW automated butt welding equipment for ultra thin sheet, *J. Light Metal Welding, J. Lub. Tech.*, 51, 2, pp 56-59. (In Japanese)

Van Doormaal J.P. [1984], Enhancements of the simple method for predicting incompressible fluid flow, *Numerical Heat Transfer*, Vol. 7, No. 2, pp 147-163.