Title	Numerical analysis the influence of arc shape on metal transfer process
Author(s)	Kadota, Keiji; Hirata, Yoshinori
Citation	Transactions of JWRI. 2010, 39(2), p. 199-200
Version Type	VoR
URL	https://doi.org/10.18910/10031
rights	
Note	

Numerical analysis the influence of arc shape on metal transfer process†

KADOTA Keiji*, HIRATA Yoshinori **

KEY WORDS: (Metal transfer model) (Arc discharge model) (Unified model) (Fe-vapor) (Electro-magnetic force) (Shielding gas)

1. Introduction

In GMAW(gas shielded metal arc welding), a metal transfer process dominates arc stability and affects weld quality. The quantitative analysis of the metal transfer process is needed to control the process.

In a metal transfer process, an electro-magnetic force strongly acts molten droplets. The action of electro-magnetic force vary with arc shapes which are not fixed. During a metal transfer process, the arc shape is also changing as electrode shape is changing. Moreover, the arc shapes are changed by the plasma properties. In GMAW, metal vapor evaporates from a weld pool and metal drops, and run into arc plasma. The metal vapor makes the arc shape contracted because electrical conductivity and radiation loss increase[1].

In this report, we calculated the time-change of arc plasma together with a metal transfer process with/out metal vapor. Therefore, the unified model, which consists of metal transfer model and arc discharge model, was constructed.

2. Assumptions and boundary conditions

Metal transfer and arc discharge are assumed as axisymmetric phenomena around the wire axis. The calculation model is constructed as cylindrical coordinate model under following assumptions.

(1) A wire melting rate equals a wire feed rate. The boundary between the solid region and the molten region in electrode wire is fixed. A molten wire is flowing out from the boundary at a constant rate. In other words, molten droplets hang down on the boundary and grow at the wire feed rate.

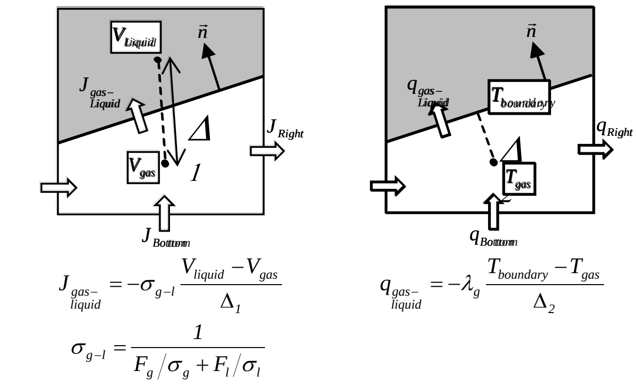
(2) The temperature on the surface of the molten wire is 2500K. In a solid region, the surface temperature is below melting point and dropping with distance from molten region. In addition, the physical properties of an electrode wire are uniform.

(3) LTE(local thermal equilibrium) approximation is applied to the arc discharge model. Arc plasma can be treated as viscous fluid with electro-magnetic properties under LTE condition.

(4) The polarity is DCEP(direct current electrode positive). The current density on a cathode surface is determined by Gaussian distribution.

As shown in **Fig. 1**, the cells near a droplet surface have a boundary between molten drop and arc plasma inside themselves because a rectangular grid is used in this model. The boundary is determined by PLIC(piecewise linear interface calculation)[2] used in the VOF(volume of fluid)[3] method when electrical conduction and heat conduction on the boundary is calculated.

The other boundary condition is illustrated in **Fig. 2**.



(a) Electrical conduction (b) Thermal conduction

Fig. 1 Electrical and Thermal conduction inside boundary cell

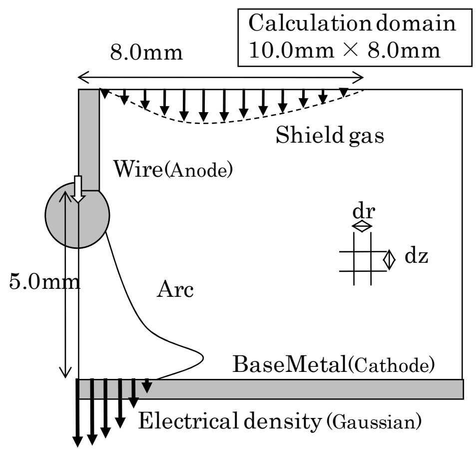


Fig. 2 Calculation domain

† Received on 30 September 2010
* Graduate School, Osaka University, Suita, Japan
** Division of Materials and Manufacturing Science, Graduate School of Engineering, Osaka University, Japan

Transactions of JWRI is published by Joining and Welding Research Institute, Osaka University, Ibaraki, Osaka 567-0047, Japan

Table 1 Welding condition

Welding current	250A
Shielding Gas	100%Ar 90%Ar+10%Fe
Gas nozzle (inside diameter)	ϕ16mm
Welding wire	ϕ1.2mm (mild steel)

3. Result and discussion

The time-change of the metal transfer process and the arc discharge in two types of shielding gas was calculated. The calculation conditions are described in **Table 1**. The calculation results of the temperature distribution and current density distribution are shown for 100%Ar in **Fig. 3** and for 90%Ar+10%Fe-vapor in **Fig. 4**.

As seen in Fig.3 and Fig.4, the metal transfer mode is spray transfer at 250A in both gas types. Arc length becomes short and arc shape becomes small as the metal drop is growing. The electro-magnetic force near the tip of drop becomes stronger because the current density is increased by contraction of the arc. As a result, the metal drop grows down slimly. Fig. 3 shows that the arc temperature in 100%Ar is very high. Arc temperature near the drop tip is heated over 25000K. On the other hand, the arc temperature is lower in the whole and the arc shape contracts when the shielding gas is Ar gas containing 10%Fe.

As previously explained, this is caused by the rise of electrical conductivity and radiation loss. As the arc contracts, the metal drop in 90%Ar+10%Fe is a little slimmer than that in 100%Ar.

4. Conclusions

The conclusions of this paper are described as follows.

(1) The interrelated influence between metal transfer and arc discharge is represented by a unified model. The arc contracts as the metal drop is growing. The metal drop grows slimly as the arc is contracting.

(2) The addition of 10%Fe into Ar prompts contraction of the arc and makes the metal drop slim.

References

[1] S. Tashiro, M. Tanaka, K. Nakata, T. Iwao, F. Koshiishi, K. Suzuki and K. Yamazaki: Plasma properties of helium gas tungsten arc with metal vapour, Sci. Technol. Weld. Joining 12 (2007), pp.202–207

[2] Kothe,D.B.,Rider,W.J.,Mosso,S.J.,Brock,J.S. : Volume tracking of interfaces having surface tension in two and three dimensions, AIAA 96-0859,(1996)

[3] Hirt,C.W., Nichols,B.D.: Volume of Fluid（VOF）Method of the Dynamics of Free Boundaries, J. Computational Phy.,Vol.39,No.1, (1981)pp.201-225

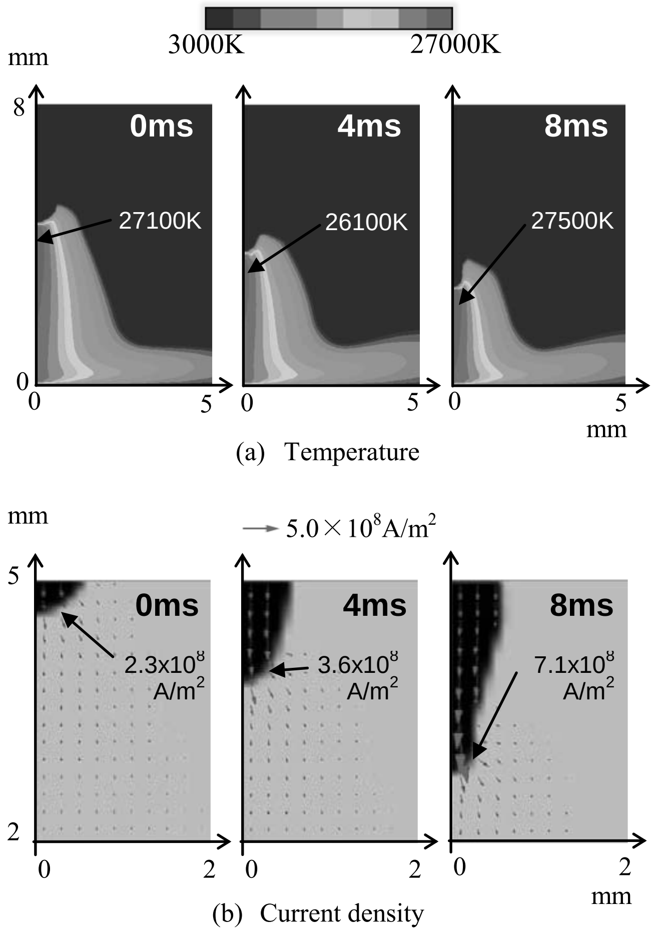


Fig. 3 The time-change of the arc temperature and current density distribution in 100%Ar

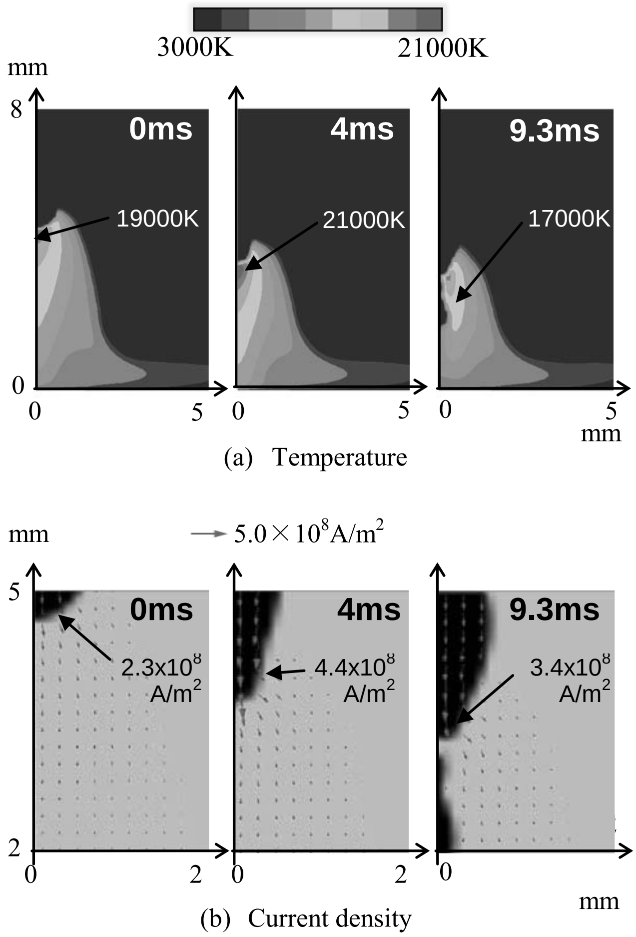


Fig. 4 The time-change of the arc temperature and current density distribution in 90%Ar+10%Fe