Numerical analysis on effects of power source characteristics on arc properties in gas tungsten arc†

TSUJIMURA Yoshihiro *, TASHIRO Shinichi * and TANAKA Manabu *

KEY WORDS: (Arc) (Power source characteristic) (Arc length) (Gas tungsten arc) (Numerical analysis)

1. Introduction

Arc properties in Gas Tungsten Arc (GTA) strongly depend on welding conditions such as arc current, arc length and so on [1-3]. In GTA, the arc current and arc voltage are determined by an external characteristic of a power source and an electrical characteristic of the arc. There are two kinds of external characteristics of power sources, namely, Constant Current (CC) and Constant Voltage (CV) characteristics. The electrical characteristic of the arc depends on the arc length. In this study, dependences of the arc properties and relationships between the current and the voltage on the arc length in GTA employing power sources with the CC and the CV characteristics were analyzed. In the experiment and the numerical simulation, arc length varies time-dependently.

2. Experimental method

In the experiments, the free-burning arcs were generated between a tungsten cathode and a water-cooled copper anode in argon at atmospheric pressure. A commercial GTA torch was fixed on vibratory equipment, and an arc length varied between 2 mm and 7 mm at 10 Hz. An arc current was set to be DC 150 A with a CC characteristic. An arc voltage was set to be 13.8 V in order to make an arc current about 150 A with a CV characteristic.

3. Simulation model

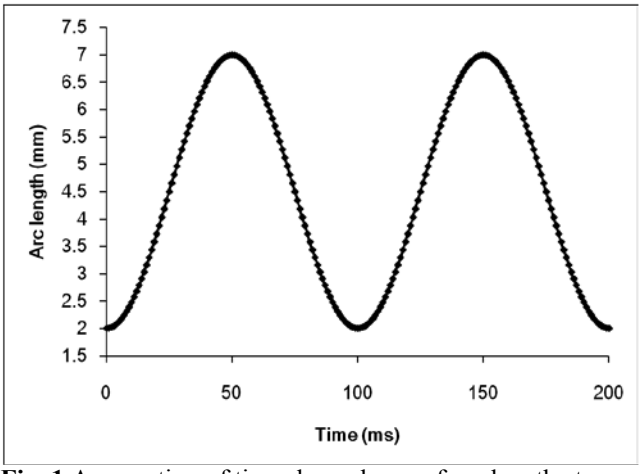

Fig. 1 Assumption of time-dependence of arc length at 10Hz

In the numerical models, the tungsten cathode, the arc plasma and the water-cooled copper anode are described relative to cylindrical coordinates, assuming rotational symmetry around the arc axis. An arc length varied between 2 mm and 7 mm at 10 Hz like **Fig. 1**. In this model, number of the mesh is constant, however, mesh size changes if arc length changes. The arc current is set to be a 150 A for a CC characteristic. The arc voltage is set to be 11.0 V for a CV characteristic. The other approximations, governing equations and boundary conditions are given in detail in our previous papers [3-5].

4. Results and Discussion

Figure 2 shows dependence of arc voltage on arc length for the CC characteristic. The experimental result of arc voltage is between 11.8 V and 15.0 V and the calculation result is between 8.3 V and 12.7 V. Although the experimental result of arc voltage is higher than the calculation result, both results decrease with decrease of arc length. **Figure 3** shows dependence of arc current on arc length for the CV characteristic. The experimental result of arc current is between 114 A and 189 V and the calculation result is between 80 A and 351 A. Although there are some difference between the experimental result and the calculation result of arc voltage, both results increase with decrease of arc length and changed circularly. In the same arc length, arc current at decreasing pattern is higher than increasing pattern. This is because the thermal problem that the temperature of the tungsten cathode changes due to change of arc current.

Figure 4 shows dependence of arc power on arc length. In experimental results, arc power is between 1776 W and 2248 W for the CC characteristic and is between 1567 W and 2615 W for the CV characteristic. In calculation results, arc power is between 1252 W and 1911 W for the CC characteristic and is between 881 W and 3869 W for the CV characteristic. With the same variation of the arc length, the arc power hardly changes for the CC characteristic, although the arc power largely changes for the CV characteristic. Furthermore, the arc power decreases with decrease of the arc length in case of the CC characteristic and the arc power increases dramatically with decrease of the arc length in case of the CV characteristic.

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* JWRI, Osaka University, Osaka, Japan

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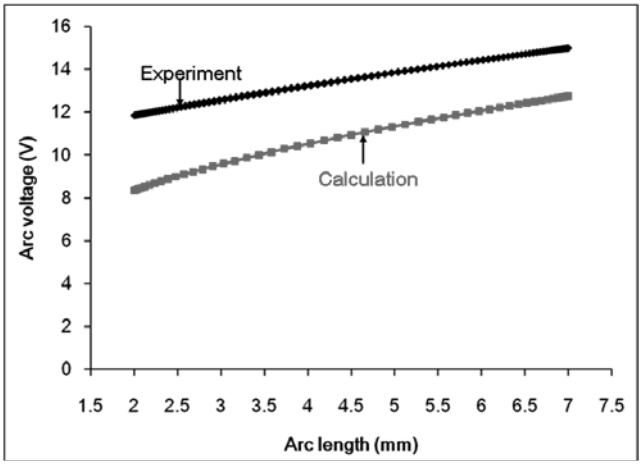


Fig. 2 Dependence of arc voltage on arc length for constant current characteristic.

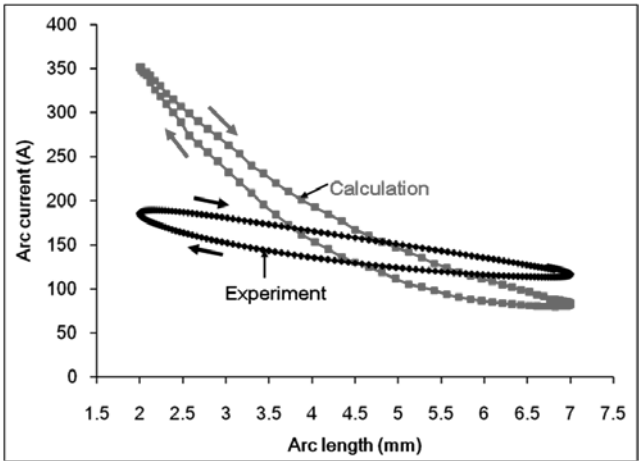
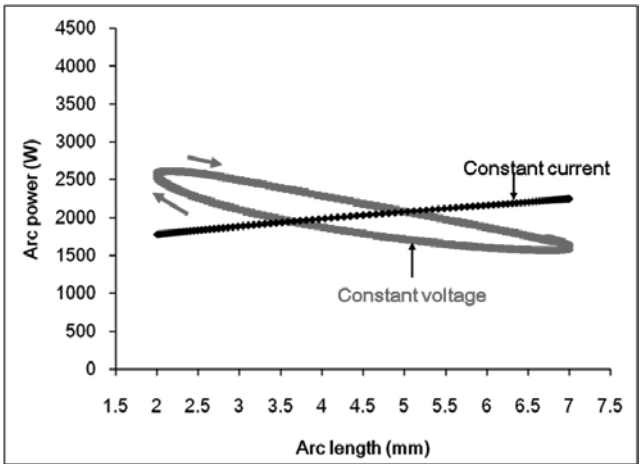
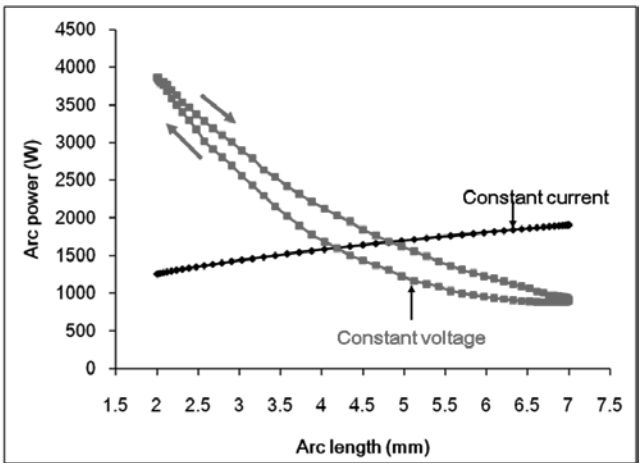


Fig. 3 Dependence of arc current on arc length for constant voltage characteristic.



i) Experimental results



ii) Calculation results

Fig. 4 Dependence of arc power on arc length.

5. Conclusions

The conclusions of this study are summarized as follows.

(1) Study of dependences of the arc properties and relationships between the current and the voltage on the arc length in GTA employing power sources with the CC and the CV characteristics were experimentally and numerically analyzed.

(2) It was found that the voltage and power of the arc decreased with decrease of the arc length in case of the CC characteristic and the current and the power of the arc increase dramatically with decrease of the arc length in case of the CV characteristic.

(3) With variation of the arc length, the arc power hardly changes for the CC characteristic, although the arc power largely changes for the CV characteristic.

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