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# Experimental observation of cleaning action of cathode spots in AC TIG welding of aluminum plates<sup>†</sup>

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**KEY WORDS:** (AC TIG welding) (Cathode spots) (Aluminum) (Oxide layer)

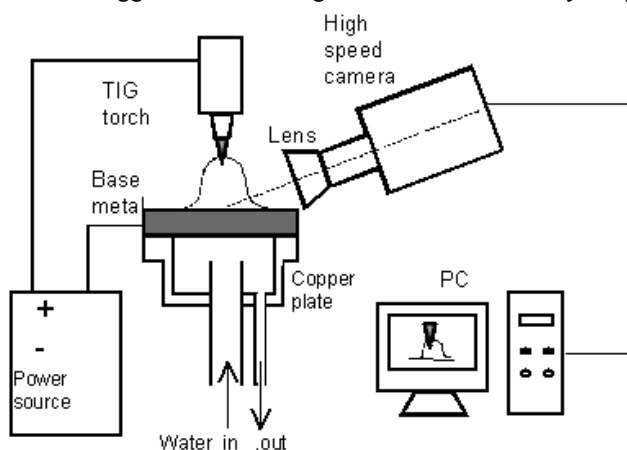
## 1. Introduction

Since it is necessary to remove the the oxide layer on aluminum for realizing high quality weld joint in arc welding of aluminum plates, AC TIG welding is generally employed. In duration of EP (Electrode Positive) in AC TIG welding, the oxide layer is removed by the cleaning action of cathode spots. In this study, the cleaning action of cathode spots on the oxide layer in AC TIG welding of the aluminum was experimentally observed with a high speed video camera and the cleaning rates of the oxide layer and velocities of cathode spots were evaluated.

## 2. Experimental procedure

Fig. 1 shows a schematic illustration of the experimental setup which consist of a TIG torch, an AC power source (DAIHEN: DA300P), a water cooled copper electrode, an aluminum plate as a base metal (A1050, 10mm thickness), high speed video cameras (SHIMAZU: HPV-1 and NAC: GX1), a PC for image processing and a data logger (KEYENCE: NR-200). The tungsten electrode with added 2%  $\text{La}_2\text{O}_3$  with the diameter of 3.2mm and the conical angle of 60 degrees was employed. The electrode gap was 5mm. An arc current was set to be AC 250A (frequency of 70Hz). The length of EP to that of a cycle was 0.3. Shielding gas was argon and introduced at the flow rate of 15l/min. The wave form of the current was recorded with the data logger. The cleaning zone of the oxide layer by

the aluminum plate was recorded with GX1 at frame rate of 40,000fps for 1s from the arc ignition. On the other hand, traces of cathode spots were recorded with HPV-1 at frame rate of 500,000fps for 200  $\mu\text{s}$ .



cathode spots on Fig. 1 Experimental setup.

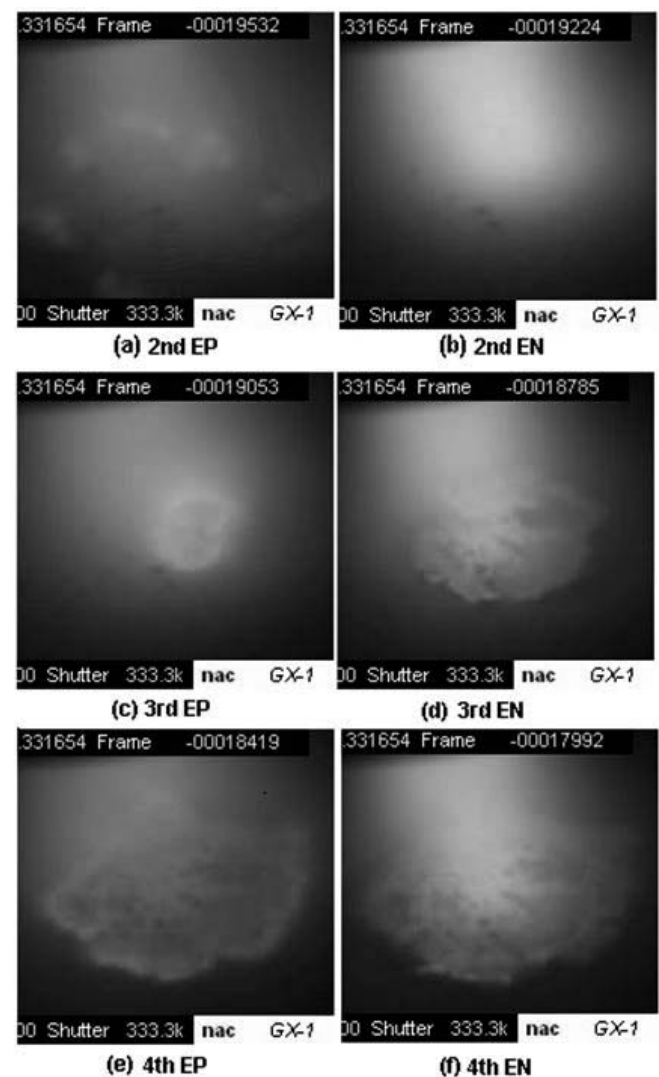


Fig. 2 Time variation of cleaning zone.

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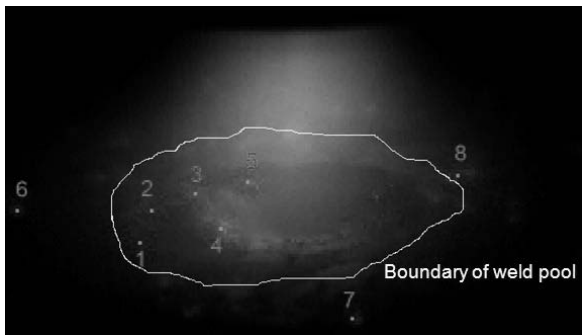


Fig. 3 Distribution of cathode spots.

### 3. Results and Discussion

Figure 2 shows cleaning zone of the oxide layer by cathode spots in 4 cycles from the arc ignition recorded with GX1. In EP of the second cycle, although cathode spots appeared on the oxide layer, cleaning of the oxide layer didn't occur. In EP of the third cycle, the oxide layer in the region near the arc axis was removed by cathode spots. After that, a large number of cathode spots occurred on the edge of the cleaning zone and the cleaning zone was expanded outward due to the cleaning action. From this observation, it was found that cleaning rate of the oxide layer was approximately  $180\text{cm}^2/\text{s}$ . A cleaning rate of  $10\text{cm}^2/\text{s}$  was reported in the case of stainless steel cathode in low pressure [1]. As a reason for the difference, it is considered that although the thickness of the oxide layer formed on the aluminum plate was an order of  $10\text{nm}$  [2], that of the stainless steel was an order of  $\mu\text{m}$ .

Figure 3 shows distribution of cathode spots recorded with HPV-1. The cathode spots mark as positions 1~8 in Fig. 3 were traced and their velocities were calculated. The cathode spots at positions 1~5, positions 6 and 7 and position 8 were on the weld pool, the oxide layer and the boundary of the weld pool, respectively.

Figure 4 shows trace of each cathode spot for the same duration. It was seen that distances of traces of the cathode spots on the weld pool where the oxide layer was already removed were larger than those on the oxide layer.

Figure 5 and Table 1 show time variations of cathode spot velocities and their averaged velocities, respectively. As a result, it was found that cathode spots moved slowly on the oxide layer and their averaged velocity was an order of  $10\text{m/s}$ . On the other hand, cathode spots near the center of the weld pool, where the oxide layer had been mostly removed, moved at high speed and their averaged velocity reached an order of  $100\text{ m/s}$ . Furthermore, the velocity greatly changed depending on the position of the cathode spot and exceeded  $1\text{ km/s}$  at the maximum.

### 4. Conclusions

Conclusions are summarized as follows.

- (1) The cleaning rate of the oxide layer was approximately  $180\text{cm}^2/\text{s}$
- (2) The cathode spots moved slowly on the oxide layer and their averaged velocity was an order of  $10\text{m/s}$ .
- (3) The cathode spots near the center of the weld pool, where the oxide layer had been mostly removed,

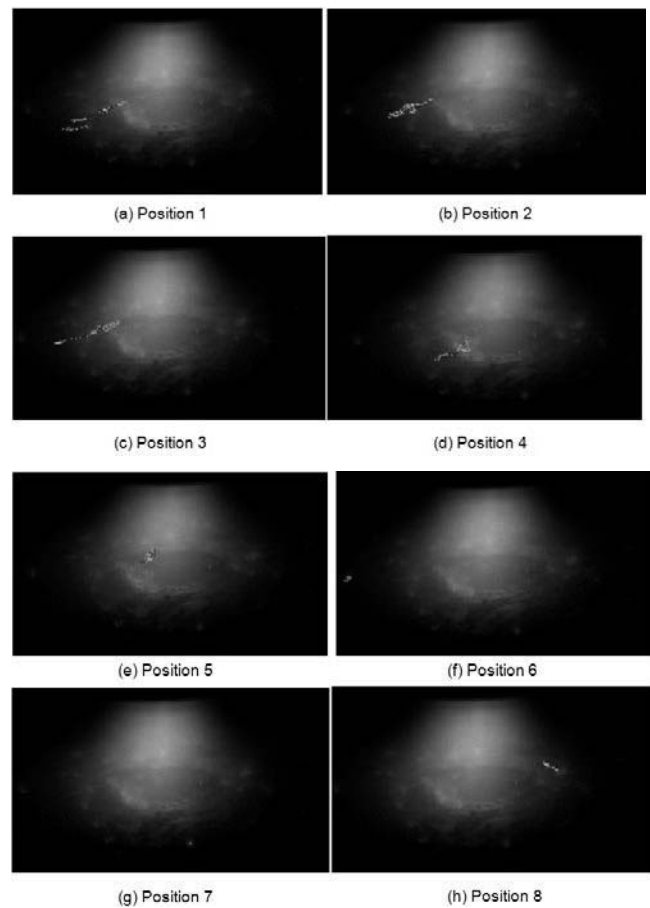


Fig. 4 Traces of cathode spots

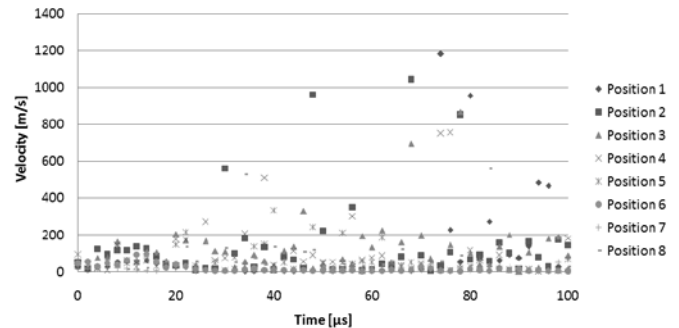


Fig. 5 Time variation of cathode spot velocities

Table 1 Averaged velocities of cathode spots

Position1	Position2	Position3	Position4
122.5m/s	122.5m/s	128.7m/s	113.9m/s
Position5	Position6	Position7	Position8
83.3m/s	14.0m/s	7.9m/s	56.4m/s

moved at high speed and their averaged velocity reached an order of  $100\text{ m/s}$ .

- (4) The velocity greatly changed depending on the position of the cathode spot and exceeded  $1\text{ km/s}$  at the maximum.

### References

- [1] K. Takeda et. al.: Material Transactions, 7 (1997) pp. 636.
- [2] M. S. Hunter, P. Fowle: Journal of the Electrochemical Society 103 (1956) pp. 482.