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Generation of innovative thermal plasma with diode-rectification technique

Manabu Tanaka[1], Tsugio Matsuura[2], Yuta Kugimiya[1], Hiroki Maruyama[1], and Takayuki Watanabe[1]
[1] Department of Chemical Engineering, Kyushu University, [2] Taso Arc Corp.
e-mail (speaker): mtanaka@chem-eng.kyushu-u.ac.jp

A multiphase AC arc (MPA) is attractive thermal plasma source due to its advantages such as high energy efficiency. However, electrode erosion is one of the most important issues to be resolved. Many experimental efforts to understand the electrode erosion mechanism had been reported. High-speed visualization revealed that the erosion due to droplet ejection was dominant at cathodic period, while the erosion due to metal evaporation was dominant at anodic period [1].

An innovative diode-rectified MPA (DRMPA) has been developed to overcome above-mentioned electrode issues [2]. The electrode erosion in the DRMPA with bipolar electrodes was drastically improved on the basis of the separation technique of an AC electrode into a pair of cathode and anode. However, the arc temperature field and its fluctuation in the DRMPA has not been clarified yet. The purpose of the present study is to understand the fluctuation phenomena in the DRMPA.

Schematic illustrations of the electric circuits and electrode configuration for the DRMPA and the MPA are shown in Figures 1 and 2. Each electrode in the DRMPA consists of tungsten-based cathode with 3.2 mm in diameter and copper anode with 20 mm in diameter. Six pairs of the electrodes are symmetrically arranged at the angles of 60 deg. Odd numbered cathodes are placed above the corresponding anodes, whereas even numbered anodes are placed above the cathodes. DRMPA was generated among these electrodes in argon atmosphere. Thoriated-tungsten was used as cathode material.

Arc temperature in the DRMPA was measured by a high-speed camera with appropriate band-pass filters. Transmission wavelengths were selected as 675 ± 2.5 and 795 ± 5 nm, which include line emissions form atomic argon at 675.2834 and 794.8176 nm, respectively. Frame rate and shutter speed were 10,000fps and 20 μs, respectively.

Figure 3 shows the arc behaviors of the DRMPA and the MPA. Electrodes No. 5 and 6 were in the cathodic period at 0.0 ms, while electrode No. 2 and 3 were in the anodic period. In the case of the MPA, both the cathode jet and anode jet were observed near the electrode. In the case of the DRMPA, the anode jet was not observed, while cathode jet was clearly observed. These different behaviors of the anode jet originated from the negligible anode evaporation in the case of the DRMPA.

Figure 4 shows the visualized temperature fields of the DRMPA and the MPA. These temperature distributions correspond to the high-speed snapshots in Figure 3. The results indicated that the temperature of both DRMPA and the MPA were fluctuated in the range of 7,000 K to 13,000 K. The arc temperature near the electrode was higher than 10,000 K. Contrastingly, temperature in the center of the electrode region was lower than the 10,000 K. The center temperature is sufficiently high to evaporate the refractory metals or ceramics in the limited residence time.

An innovative thermal plasma source was established with diode-rectification technique. The obtained understanding of fundamental phenomena will enable us to achieve the practical use of this thermal plasma source in industrial field.

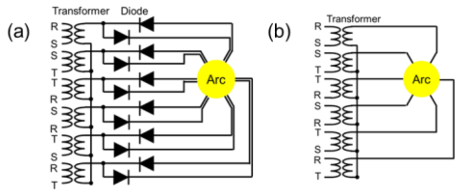

Fig. 1. Schematic electric circuits for (a) the DRMPA and (b) the conventional MPA.

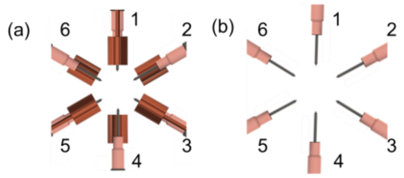

Fig. 2. Electrode configurations for the DRMPA (a) and the conventional MPA (b).

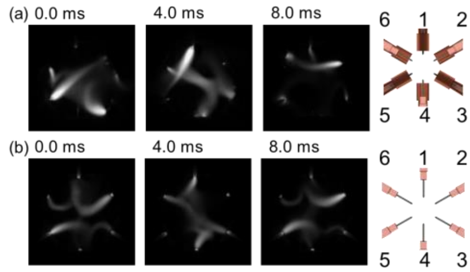

Fig. 3. High-speed snapshots of (a) the DRMPA and (b) the conventional MPA.

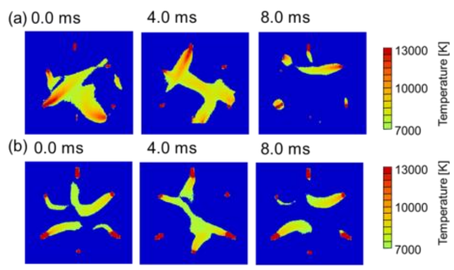

Fig. 4. Temperature distributions High-speed snapshots of (a) the DRMPA and (b) the conventional MPA.

References

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