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Measurement of the Radial Temperature Distribution in the Central Part of an Arc Burning Through a Polyethylene Tube

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SUMMARY

The radial temperature distributions in the central part of arcs burning through polyethylene (PE) tubes are estimated by measuring the half-width of $H\alpha$ line spectrum and using the electron density versus Stark half-width and the electron density versus temperature characteristics. Estimation is carried out for various tube inner diameters (2 and 4 mm) and dc arc currents (5, 10 and 15 A). The result shows that the temperature at the arc center is around 10,000 K, and it tends to increase as the tube inner diameter becomes narrow and/or the arc current increases.

The overall temperature distributions from the arc axis to the tube wall are obtained by combining these inner temperature distributions with outer temperature distributions which have been derived from C_2 spectra. They are found to take a form of typical two-temperature distributions of ablation stabilized arcs.

The electric field strengths of PE arcs are evaluated from the temperature distributions and the electrical conductivity versus temperature characteristics of thermally decomposed polyethylene vapor gas. The results agree well with experimental values.

Key words: Arcing in polyethylene; temperature distribution of arc discharges; ablation arcs.

1. Introduction

When a high-pressure arc discharge burns through a tube of solid polymeric material, the polymeric material is ablated quickly by the arc heat. As a result, the arcing space is filled immediately with the polymeric ablation gas. Such ablation arcs occur not only in high-intensity flash lamps but also in circuit breakers, expulsion fuses and at a ground fault point of power cable.

The ablation arc in high-intensity flash lamps has been studied for an industrial application [1-3]. It has been found that the arc is stabilized by the axial gas flow of ablation gas. Then the investigation has been carried out from a viewpoint of protection of the electrical power system [4-10]. Niemeyer has proposed that the arc in the tube is radially separated into a conductive core with high temperature and a nonconductive sheath with low temperature.

A variety of materials has been used as tubes: for example, polyvinylchloride [3]; yttrium oxide [3]; polyacetal [4]; polymethylmethacrylate [5]; alumina [5, 6]; and polytetrafluoroethylene (PTFE) [7]. Recently, the arc in a PTFE nozzle has been studied experimentally to reveal the nozzle-clogging phenomenon of the circuit breaker [8, 9], and material properties of thermally decomposed gases of nylon and boric acid have been calculated theoretically for study on arcs burning through those tubes [10].

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