INFLUENCE OF ELECTRODE SHAPE ON HEAT DISSIPATION CAUSED BY ELECTRICAL ARC ACROSS THE METAL ELECTRODES

Aytug FONT[1]; Ozcan KALENDERLI[2]
[1,2]Istanbul Technical University

CEEC-TAC1 , The Central and Eastern European Committee for Thermal Analysis and Calorimetry 2011

ABSTRACT

The electrical arc is a luminous, noisy and hot electrical discharge. One of the physical properties of the arc is heat dissipation. The arc leads to large scale of temperature due to joule heating.

In this study, influence of using electrode shape on heat dissipation of the electrical arc is investigated experimentally and the test results are presented. Besides, the paper describes the laboratory work including formation of electrical arc and measurements of arc properties such those arc temperature, arc voltage and current.

Different shapes of the electrodes such as sphere, plane, and rod electrodes are used for the experiment setup. Different voltage levels are applied to the electrodes to obtain arc**.** Temperature of the arc plasma column and the electrode surface are measured by infrared thermometer for each electrode shape and configuration to obtain the characteristics of both column temperature and surface temperature with respect to arcing voltage and current. Also the tests are repeated for the electrodes having different surface areas under fixed voltages to obtain relation between the electrode surface and the heat dissipation.

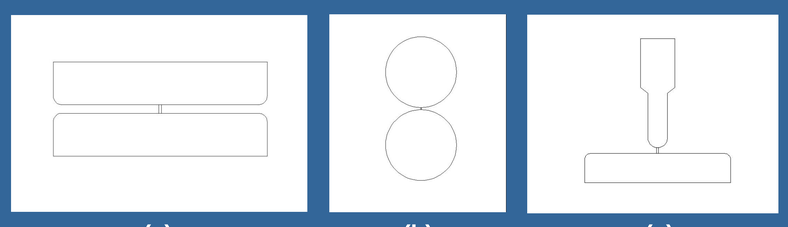
After the experiments, heat analysis of the system is performed by using the finite element method. The system having different electrodes is simulated with program Finite element method based programme.

All the results are given graphically in the paper. Consecutively, from studies on heat dissipation of the arc it is found that area of electrode surface is dominant on this effect.

CONTACT

AYTUG FONT
ISTANBUL TECHNICAL UNIVERSITY
e-mail: font@itu.edu.tr
Phone: 0555 481 10 66
Website: http://web.itu.edu.tr/font/

MODELING



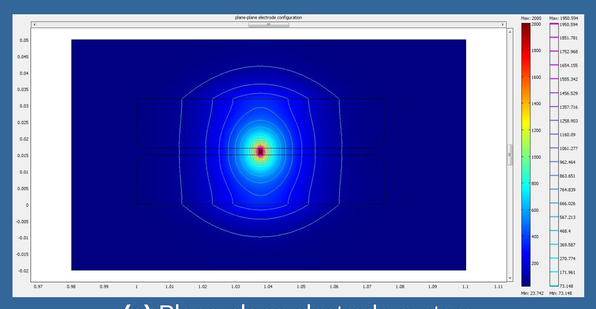
(a) **(b)** **(c)**

Figure 1: Electrode systems used for simulations: (a) Plane-plane, (b) Sphere-sphere, and (c) Rod-plane electrode systems.

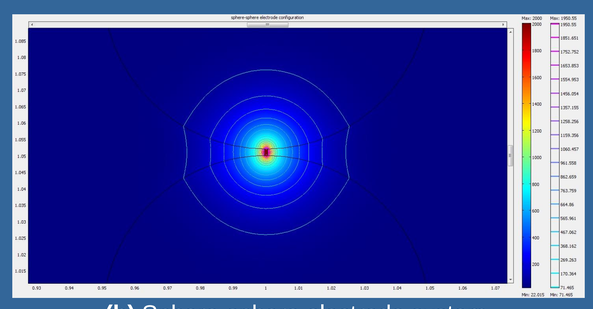
Table 1: Model parameters.

Subdomain	Unit	Air	Arc plasma	Zinc electrodes
Thermal conductivity (k)	W/(m·K)	0.0257	429	116
Density (rho)	kg/m^3	1.205	10500	7140
Heat capacity at constant pressure (C)	J/(kg·K)	1006	235	390

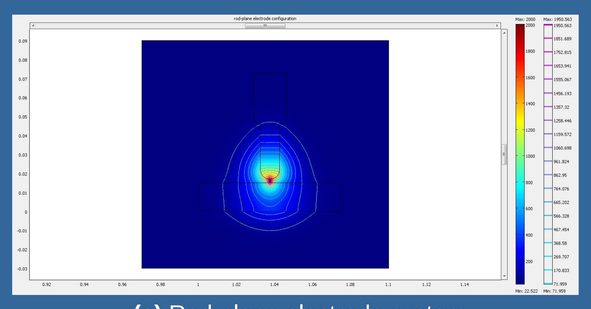
SIMULATIONS



(a) Plane-plane electrode system



(b) Sphere-sphere electrode system

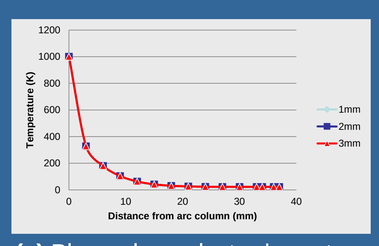


(c) Rod-plane electrode system

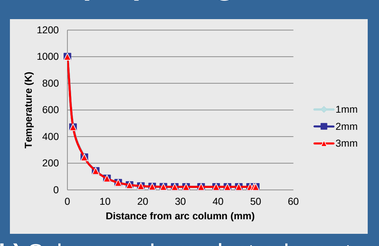
Figure 2: Temperature distributions at the electrode systems.

RESULTS

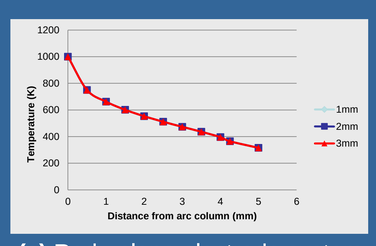
Gap Spacing Effect



(a) Plane-plane electrode system



(b) Sphere –sphere electrode system



(c) Rod –plane electrode system

Figure 3: Temperature distributions along the electrodes for different gap spacings

Electrode Shape Effect

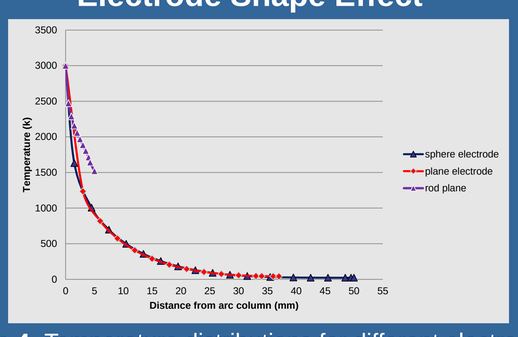
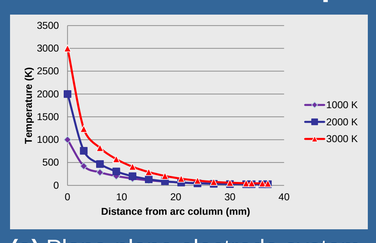
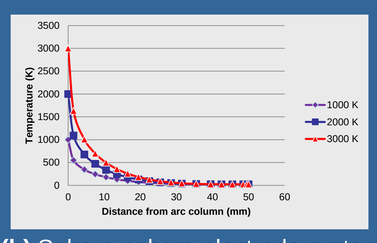


Figure 4: Temperature distributions for different electrodes.

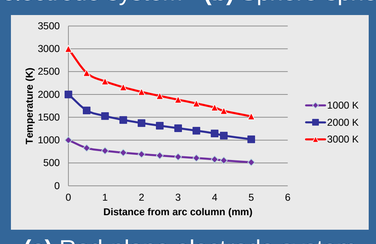
Arc Temperature Effect



(a) Plane-plane electrode system



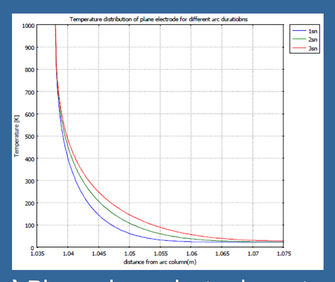
(b) Sphere-sphere electrode system



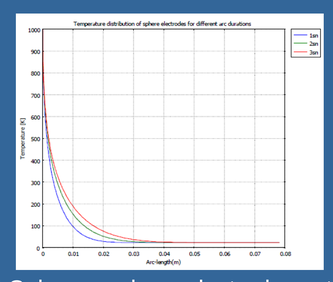
(c) Rod-plane electrode system

Figure 5: Electrode temperature dissipation with respect to arc column temperature.

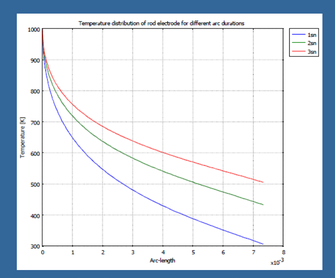
Arc Duration Effect



(a) Plane-plane electrode system



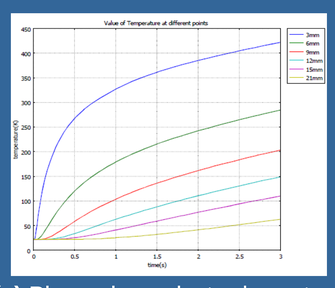
(b) Sphere –sphere electrode system



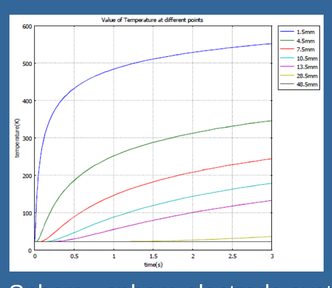
(c) Rod-plane electrode system

Figure 6: Temperature distributions of the electrodes for various arc durations.

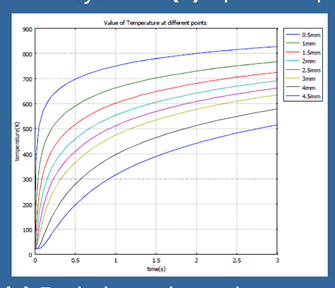
Effect of Distance From Arc Column



(a) Plane-plane electrode system



(b) Sphere –sphere electrode system



(c) Rod-plane electrode system

Figure 7: The value of temperature at different points on the electrode surface.

CONCLUSIONS

- For smaller air gaps, change of gap spacing has no effect on temperature distribution.
- Temperature along the electrode surface very depend on temperature of the arc plasma.
- Each electrode shape has its own thermal characteristics and distributions.
- Temperature on the electrode surface is getting higher when the duration of the arc increases.
- For the further points on the electrode surface temperature changes slowly.