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# Gas—Tungsten—Electrode (Report 4)<sup>†</sup>

## — Measurement of Cathode Temperature —

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### Abstract

*Measurement of the electrode temperature of GTA cathode has been made by the use of infrared thermometer and grooved electrode, and important phenomena concerning the emissivity of a particular surface as one of the thermal properties was discussed. The investigation reveals the effect of temperature and oxide distribution on the spectral emissivity of the electrode, in addition to the main different effect of oxides added to tungsten. This is the first of a series of experiments to be conducted to determine the effect of rare earth metal oxides on electrode temperature and emissivity and measuring the temperature distribution along the electrode axis during arcing in pure argon as shielding gas at the atmospheric pressure.*

**KEY WORDS:** (Tungsten) (Oxide Tungsten) (GTA Welding) (Nonconsumable Electrode) (Refractory Metals) (Electrode Temperature)

## 1. Introduction

From the previous study<sup>1)</sup>, it was shown that the La-oxide tungsten and Y-oxide tungsten electrodes have the more superior characteristics in arc starting characteristics, arc pressure and electrode consumption etc. compared to Th-oxide Tungsten electrodes.

Also, the electrodes activated with rare earth metal oxides observed good metallurgical stability comparing with the electrodes activated with Th-oxide<sup>2)</sup>. Moreover the stability of those oxides is not same and depending on the temperature distribution along the electrode axis. Then, to clarify the differences between all of these oxides and its effects on arc characteristics it is necessary to measure the electrode temperature.

In the first method which was previously showed and discussed in details<sup>3)</sup>, the measured curve showed an abnormal peaks which reflects the change in surface condition during arcing or due to the local concentration of oxides. The error of this measurement comes mainly from the spectral radiation emissivity, which, was assumed to be constant and have the same value as the in case of ohmically heated tungsten<sup>4,5)</sup>. But in the case of arc burning the changes of cathode surface morphology and the distribution of oxides have a very big influences on the spectral emissivity.

In this paper, the procedure and results of new temperature measurement methode of GTA cathode will be described.

## 2. Experimental Procedures

In this measuring method, electrodes 2.4 mm in diameter were machined to produce a V shape groove with the geometry shown in **Figure 1**. The groove was then filled with graphite powder under extreme pressure to avoid its loss during arcing. The graphite powder has an emissivity value of 0.97.

The temperature distribution along the electrode axis was measured using the Microrad 100 Infrared Thermometer. This type of infrared thermometer collects the infrared radiation from a target area of 0.65 mm in diameter and converts it to a temperature reading for the same target area. This system is equipped with a InSb detector. This unit has been designed as a special side looking unit which includes a filter with a wave length range of 1.8–5.0 microns. Also, the level of emissivity with a resolution of 1% can be set by using two thumb-wheels. **Figure 2** shows a schematic illustration of the experimental alignment used is this measuring method.

The measuring procedure was as follows:

The first step was to measure the temperature distribution along the electrode axis using the grooved electrodes filled with the graphite powder. The emissivity of the infrared thermometer was then set at 0.97. The temperature distribution was measured at 150 A, in pure argon at several time intervals to avoid severe melting of the tip.

<sup>†</sup> Received on May 8, 1989

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The second step was to determine the local emissivity values and their changes with time which can be attributed to the surface morphological changes or to the

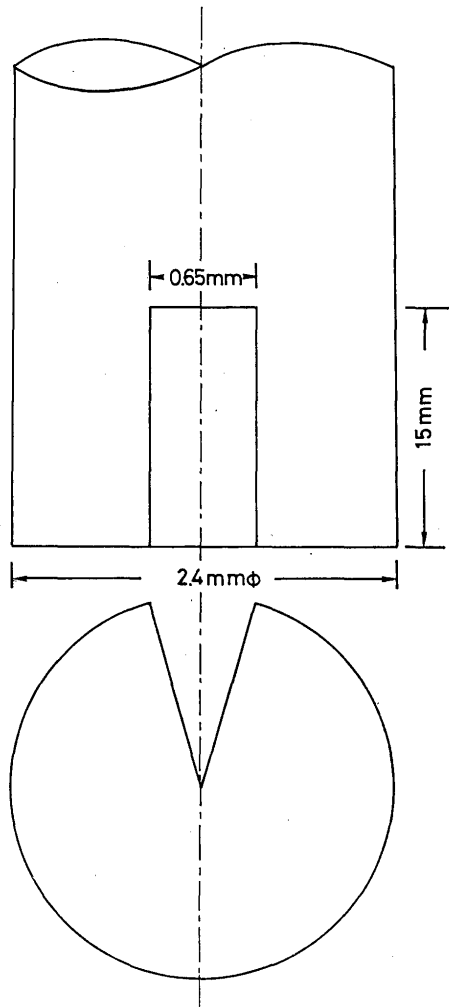


Fig. 1 Geometry of V shape grooved electrode.

oxides distribution, and their migration during arcing. Here, in order to have the same starting surface condition, electrodes were ground by means of hard grinding through No. 1500 emery papers, washed by acetone and handled with care to avoid finger prints which may affect the measuring emissivity values. With the temperature distribution measured at the first step, the local emissivity can be determined by aiming the instrument at the target and adjusting the emissivity control until the meter reading is the same as the previously measured temperature.

### 3. Results and Discussion

The actual temperature and emissivity distribution of  $W-La_2O_3$ ,  $W-CeO_2$  and  $W-ThO_2$  measured by this method has been tabulated and plotted in Table 1 and Figures 3 and 4 respectively. It is difficult to compare these results of emissivity values with those presented by earlier investigation because the conditions under which the tests were done differ in terms of (a) the pyrometer effective wave length, (b) the type of material, (c) the surface condition for emissivity measurement, and various other factors that contribute to the variation in emissivity values.

Figure 3 is a plot of the temperature vs. the distance from the electrode tip and includes all of the investigated electrodes. From this figure it is obvious that the  $W-La_2O_3$  electrode has the lowest temperature values followed by  $W-CeO_2$  and  $W-ThO_2$  respectively, which is in good agreement with the results of the first measuring method<sup>3)</sup>. However, in this method no abnormal peaks had been observed compared with the first method. The reasons for the observed peaks in the first method can be understood from Fig. 4.

Figure 4 is a plot of the spectral emissivity vs. the distance from the electrode tip. From this figure it is obvious

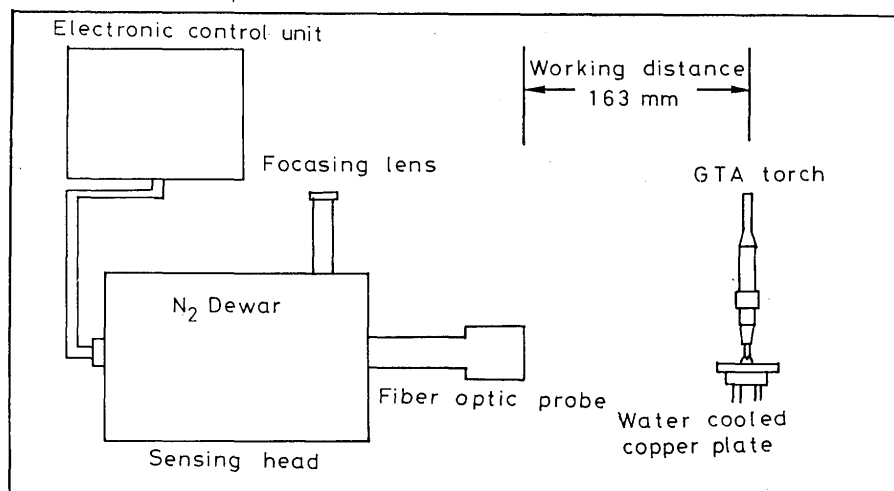
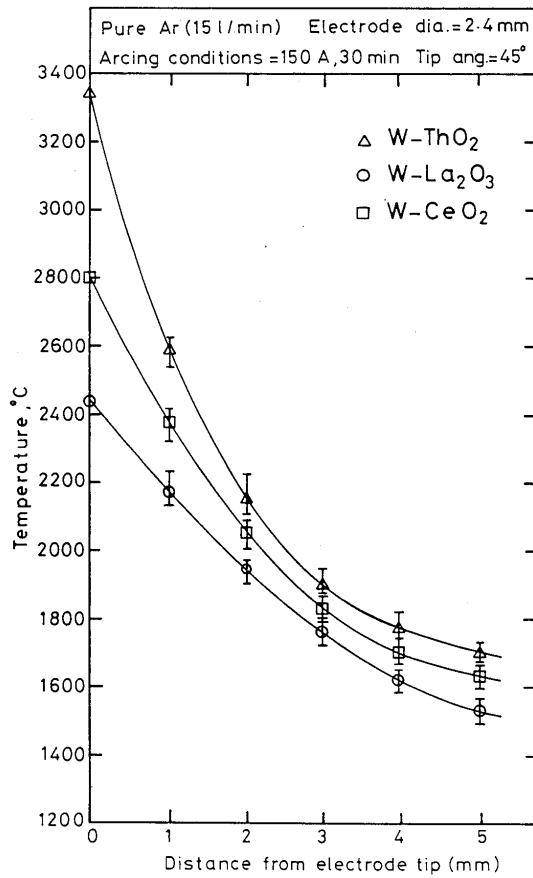


Fig. 2 Schematic illustration of the experimental alignment.

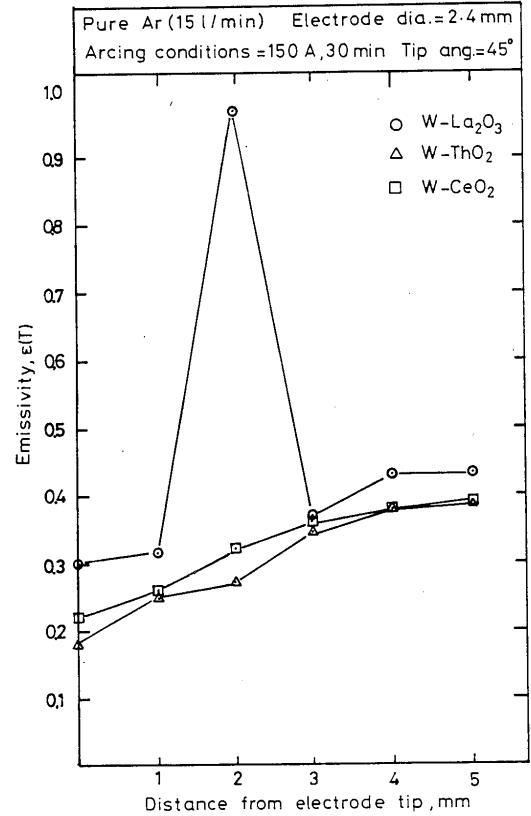
**Table 1** Temperature and emissivity values at different distances from electrode tip for several electrodes after 30 min arcing at 150 A in pure Ar.

		Tip	1 mm	2 mm	3 mm	4 mm	5 mm
W-ThO <sub>2</sub>	Temperature °C	3340	2600	2160	1920	1790	1710
	Emissivity $\varepsilon(T)$	0.18	0.25	0.27	0.34	0.38	0.38
W-CeO <sub>2</sub>	Temperature °C	2800	2400	2030	1820	1690	1620
	Emissivity $\varepsilon(T)$	0.22	0.26	0.32	0.36	0.38	0.39
W-La <sub>2</sub> O <sub>3</sub>	Temperature °C	2440	2180	1950	1750	1640	1500
	Emissivity $\varepsilon(T)$	0.30	0.33	0.97	0.37	0.43	0.43



**Fig. 3** Temperature distribution along the electrode axis.

that the location of those peaks have a higher emissivity values like in the case of W-La<sub>2</sub>O<sub>3</sub>. The sudden and local change was believed to be due to the local increase of oxide at the surface and the change of the surface conditions. However, the radiation emissivity of W-La<sub>2</sub>O<sub>3</sub> is generally higher than that of W-CeO<sub>2</sub> and W-ThO<sub>2</sub>. This result may be explain why the W-La<sub>2</sub>O<sub>3</sub> electrode has lower temperature values than the other electrodes activated with CeO<sub>2</sub> or ThO<sub>2</sub>.



**Fig. 4** Spectral emissivity distribution along the electrode axis.

It could be concluded that the measured data of temperature values at the tip lies within the range of past test results, and from the trends exhibited, this measuring method could be used fairly accurately for spectral emittance measurement of several kinds of electrodes in future.

#### 4. Conclusions

The temperature distribution and radiation emissivity

of tungsten electrodes activated with rare earth metal oxides along axis were measured and compared by using the infrared pyrometer and grooved electrodes. Tungsten electrode activated with La-oxide showed the lowest temperature values followed by tungsten electrode activated by Ce-oxide and Th-oxide in that order. Also, the W-La<sub>2</sub>O<sub>3</sub> electrode have a higher emissivity followed by W-CeO<sub>2</sub> and W-ThO<sub>2</sub> electrodes in that order.

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