Transient spots on thermionic arc cathodes II. Experiment and comparison

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Abstract: *Experiments on current jump induced diffuse-spot-diffuse transitions in an HID mercury lamp were performed. The qualitative agreement between the experimental and the modelling results is quite good. It has been found that a current jump induced diffuse-spot-diffuse transition can be prevented by applying a current pulse soon after the jump that decreases the current for a short time.*

INTRODUCTION

Diffuse-spot-diffuse transitions induced by current jumps have been recently studied and reported in HID lamps [1,2]. It is the aim of this work to investigate such diffuse-spot-diffuse transitions in a 4 bar mercury HID lamp and to compare the experimental results with simulation results.

THE EXPERIMENTAL SETUP

The experiments were performed on COST-529 lamps, which are made of quartz. Such HID lamps have pure tungsten cylindrical electrodes with 500 µm diameter. Lamps filled with 5 mg of mercury (apart from 300 mbar argon filling as a buffer gas) were used, which resulted in an operating pressure of about 4 bar.
The power supply was provided by a voltage driven power amplifier MedTech Engineering FM 1295 DCU/I 750, which functioned as a current source controlled by an arbitrary waveform generator Agilent 33220A, and an analogue function generator Leader LFG–1300S.
The image of the cathode and of near cathode region was magnified 10 times and focused on a screen. The mode of arc-attachment to the cathode was diagnosed by photodiodes placed on the screen in front of the image of the cathode. The measurements were performed by a Yokogawa DL 1640 200MSs^{-1} digital oscilloscope. The lamps were operated in a vertical position.

RESULTS AND DISCUSSION

Starting at a current of 0.2 A, a diffuse-spot-diffuse transition could be induced with a current jump to values greater than about 0.9 A, which conforms to the modelling results obtained for this system. The modelling was performed within the approach described in the accompanying contribution.
Experimental results achieved for the lamp voltage and for the light intensity in front of the cathode are shown for an average lamp in fig. 1 for 0.2 A – 0.8 A and 0.2 A – 1.0 A current jumps. For the 0.2 A – 0.8 A jump the light intensity in front of the cathode increases before it stabilizes about 0.1 s after the jump. This is the expected behaviour: the cathode and arc temperatures are higher at higher currents. There is a sharp peak in the lamp voltage just after the jump, which afterwards undergoes a smooth decrease until a constant voltage of about 80 V. These results conform to the trends observed in [1, 2].

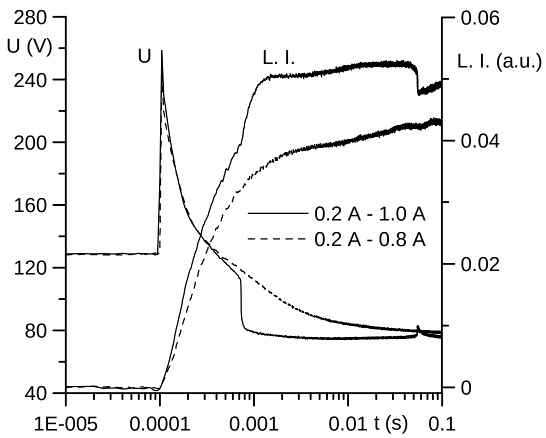

Fig. 1: Experimental results for the lamp voltage, U, light intensity in front of the cathode, L.I., for the current jumps 0.2 A – 0.8 A and 0.2 A – 1.0 A.

For the 0.2 A – 1.0 A jump there is a steep increase of the light intensity in front of the cathode at about 0.7 ms which is accompanied by a steep decrease of the lamp voltage at the same instant. About 50 ms after, the light intensity steeply decreases to a constant value, this decrease being accompanied by a small peak in the lamp voltage. These results indicate the formation of a spot about 0.7 ms after the 0.2 A – 1.0 A current jump. The spot decays after 50 ms.

In fig. 2 are shown modelling results for the near-cathode voltage drop and maximum cathode temperature obtained under the same conditions of the experimental results shown in fig. 1. The qualitative agreement between the simulations and the experiments is quite good, although our model predicts the decay of the spot about 20 ms after the current jump. It is possible that the transfer functions used in our model (see e.g. [3]) need some refinement. This is an issue that requires further investigation.

The formation of a spot in the conditions of this work can be interpreted as a result of the failure of the cathode to undergo a uniform heating as a response to an increase of the current. Therefore, in principle, a decrease of current applied shortly after the jump could aid the cathode to heat up uniformly, thus preventing the appearance of a transient spot. The experimental results shown in fig. 3 confirm this prediction. A 0.2 A – 1.0 A current jump is shown with a current pulse applied after the current jump, which results in a decrease of the current to 0.3 A during approximately 0.3 ms. The appearance of a spot is prevented.

Experiments performed in different lamps and also for different current jumps in the same lamp confirm the reproducibility of the results obtained for the prevention of the transient spot. There are experimental indications that the prevention of the spot under the conditions of this work results in a decrease of the blackening of the burner around the electrodes.

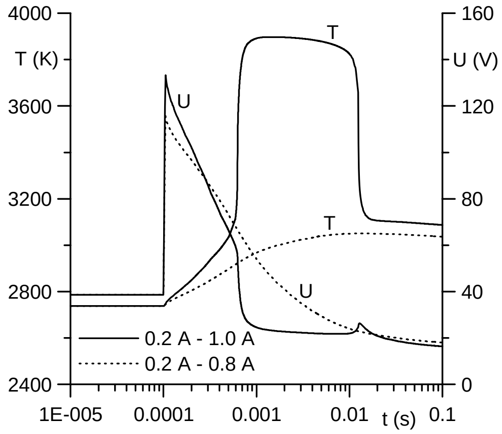

Fig. 2: Modelling results for the maximum cathode temperature and near cathode voltage drop for the current jumps 0.2 A – 0.8 A and 0.2 A – 1.0 A.

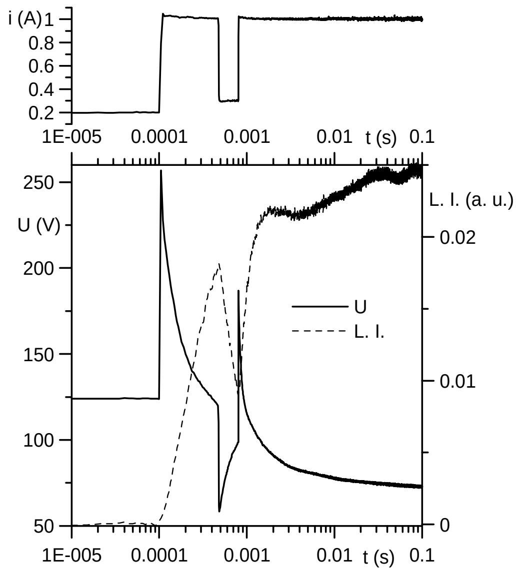

Fig. 3: The prevention of a diffuse-spot-diffuse transition in a 0.2 A – 1.0 A current jump. U: lamp voltage; i: lamp current.

Acknowledgments

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