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MEASUREMENT OF THE VELOCITY OF THE PLASMA JET APPEARING FROM A WALL STABILIZED ARC

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Abstract. In this paper we report results of argon plasma jet velocity measurements. The jet is formed at atmospheric pressure.

1. INTRODUCTION

High temperature plasma jets are used for various material productions and processing, for example for synthesis of new materials, cutting and welding, plasma sintering (Spores and Pfender 1989), producing carbon nanotubes (Hahn et al. 2004), plasma-aided metallurgy, industrial plasma chemistry, hardening and nitriding of steels (Belevtsev et al. 2006), or material transformation such as melting, vaporization, and also applications in nanomaterial fabrication (Kim and Kim 2019). In this experiment, an argon plasma jet was produced by using a modified wall stabilized electric arc. For the application of plasma jets, some parameters, such as plasma temperature and jet velocity, are very important. Here we report the plasma jet velocity measured at atmospheric pressure.

2. CURRENT PULSE SOURCE

The basic plasma source is an atmospheric pressure wall stabilized arc (Nikolić et al. 2004). The arc channel, 5 mm in diameter and 70 mm in length, is formed by six copper discs, 7.1 mm in thickness. The discs are separated by 0.5 mm thick Teflon gaskets and were cooled by water. Pure argon is introduced into the arc channel through holes in tungsten electrodes with a flow rate of 3 l/min. The wall stabilized arc is usually used with closed ends behind the electrodes in direct current (DC) regime, with a current of 30 A. This current provides a plasma with electron temperatures between 10000 and 11000 K and electron densities of a few times 10^{16} cm^{-3} (Djurović et al. 1997, 2002). In that case, the plasma column is formed between the electrodes. For the purpose of this experiment, the end behind the hollow anode is opened and high current pulses are applied. During the pulses, a two cm long plasma jet appeared on the open side of the wall stabilized arc (Ćirišan et al. 2006). The block scheme is given in Fig. 1a. A DC current source is connected to the arc via a diode, in order to protect the DC power supply from high current pulses. High current pulses, with a current maximum of 180 A, are obtained from the civil AC network of 220 V by using an appropriate high current switch and a trigger unit. Every 16^{th} of the 50 Hz cycle was used to produce a high current pulse. The current intensity (Fig. 1b) was controlled by a current limiting resistor. In that case, the repetition rate of high current pulses was 3.13 Hz. The electron temperature in the plasma jet varied between 9400K and 10200 K during the plasma life (Ćirišan et al. 2006). The current pulses were controlled by means of a Rogowski coil and a digital oscilloscope.

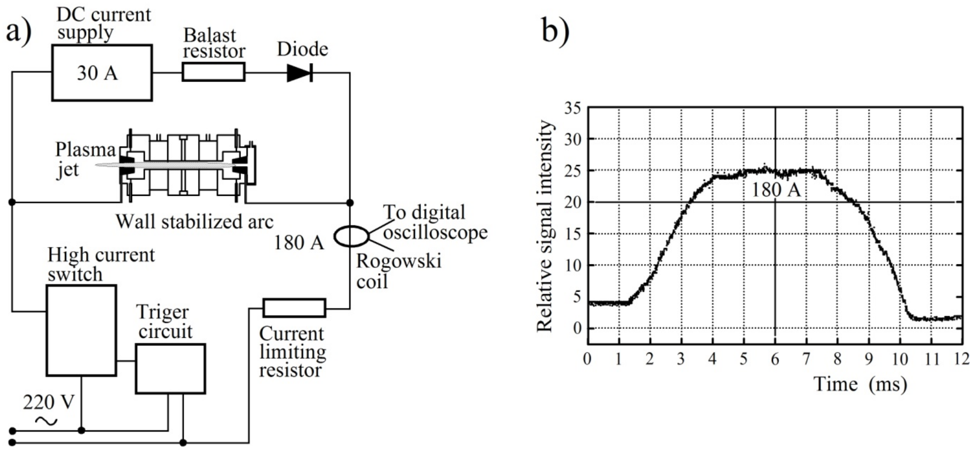

Figure 1: a) Block scheme of the electrical circuit and b) High current pulse.

3. JET VELOCITY MEASUREMENTS

For jet velocity measurements, the optical system shown in Fig 2 was assembled. Optical signals are led to the digital oscilloscope through an optical fiber and a photomultiplier. The signals are taken at two positions with a distance of 1 cm between them. Precise positioning of the end of the optical fiber is performed by using a movable table.

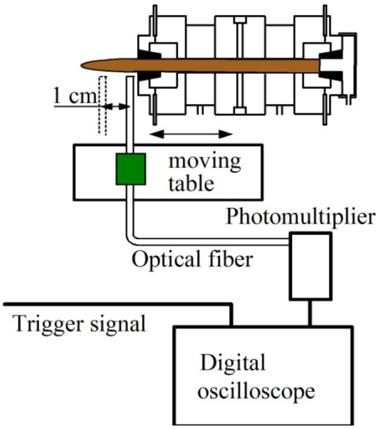

Figure 2: Optical system for velocity measurements.

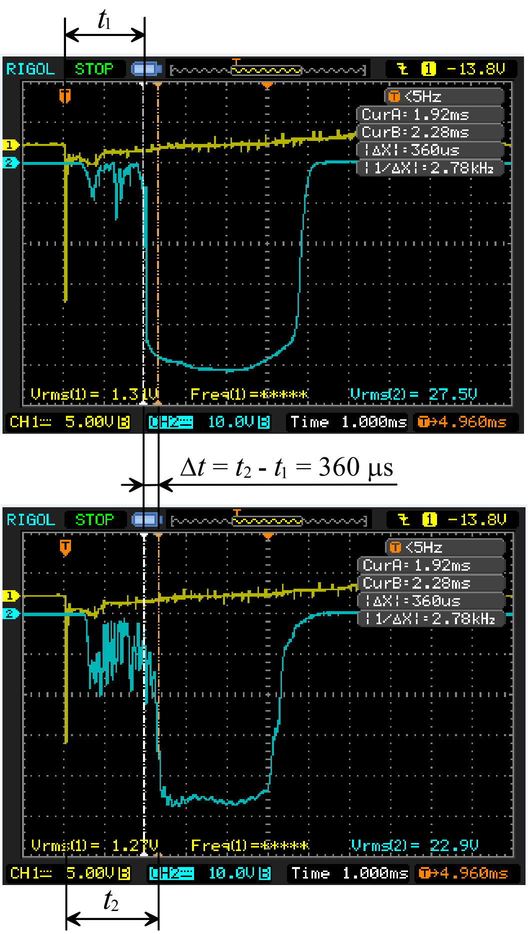

Figure 3: Optical signals from the digital oscilloscope.

Figure 3 shows the shape of the signals received from the optical fiber. The first signal is obtained when the optical fiber is positioned closer to the anode, while the second one is obtained when the optical fiber is positioned 1cm further from the anode. From the first signal it can be seen that the life time of the plasma jet outside of the plasma channel is about 4 ms.

The time difference between the beginning of the rise of the signal in the first and the second position of the optical fiber, $\Delta t = t_2 - t_1 = 360$ μs, is the time for which the front of the plasma jet passes the distance $\Delta s = 1$cm. The times t_1 and t_2 are measured relative to the trigger signal. The trigger signal is obtained by the Rogowski coil which is positioned in the high pulsed current circuit (Fig. 1a). This signal gives the information on the start of the high current pulse. Based on these data, the calculated velocity of plasma jet propagation is $v = \Delta s/\Delta t = 27.78$ m/s = 100 km/h. The estimated experimental error is around 10%.

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References

Belevtsev A. A., Chinnov V. F., Isakaev E. Kh., 2006, *Plasma Sources Sci. Technol.*, **15**, 450-457.

Ćirišan M., Djurović S., Mijatović Z., Vujičić B., Kobilarov R., 2006, *J. Res. Phys.*, **30**, 95-102.

Djurović S., Mijatović Z., Kobilarov R., Konjević N., 1997, *J. Quant. Spectrosc. Radiat. Transfer*, **57**, 695-701.

Djurović S., Nikolić D., Mijatović Z., Kobilarov R., Konjević N., 2002, *Plasma Sources Sci. Technol.*, **11**, 95-99.

Hahn J., Han J. H., Yoo J-E., Jung H.Y., Suh J.S., 2004, *Carbon*, **42**, 877-883.

Kim K. S., Kim T. H., 2019, *J. Appl. Phys.*, **125**, 070901 p. 1-26.

Nikolić D., Djurović S., Mijatović Z., Kobilarov R., Vujičić B., Ćirišan M., 2004, *J. Quant. Spectrosc. Radiat. Transfer*, **86**, 285-298.

Spores R., Pfender E., 1989, *Surf. Coat. Technol.*, **37**, 251-270.