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PULSED CORONA DISCHARGE GENERATED BY MARX GENERATOR

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Abstract. The pulsed plasma has a significant role in new environmental protection technologies. As a part of a pulsed corona system for pollution control applications, Marx type repetitive pulse generator was constructed and tested in arrangement with wire-plate corona reactor. We performed electrical measurements, and obtained voltage and current signals, and also power and energy delivered per pulse. Ozone formation by streamer plasma in air was chosen to monitor chemical activity of the pulsed corona discharge.

1. INTRODUCTION

Air pollution control is an important topic in today's society. One promising technique to control gaseous pollutants, such as NO*x*, SO*x* and VOCs, in exhaust gas streams, is the use of non-thermal plasmas. In non-thermal plasma, only the electrons are energized while the bulk gas is not significantly heated. Currently, the repetitively pulsed corona is one of the most promising atmospheric pressure, non-thermal plasma discharges. During electrical discharge in gas, free electrons gain energy from an imposed electric field, and during their drift they lose energy through collisions with neutral gas molecules. The collisions of energetic electrons with neutral gas molecules cause the formation of chemically active species to initiate chemical reactions, leading to the removal of gaseous pollutants. Advantages of pulsed corona treatment are: simultaneous removal of several pollutants, high destruction efficiency, no demands on temperature and pressure, insensitive to contamination, no damage from high loads, widely applicable, simply installed, compact, little service and small scale. (van Veldhuizen 2000).

Reliable, inexpensive pulsed power supplies are vital for the implementation of pulsed corona technology and they are based primarily on the capacitive energy storage and closing switches (Winands et al. 2005, Pokryvailo et al. 2006, Yan et al. 1998). A good solution for pulsed corona power supply could be a repetitive Marx generator presented in this work. In 1923, Erwin Marx patented the circuit for a high voltage generator with the fundamental principle of charging capacitors in parallel and switching the capacitors in series into a load (Marx 1923). We designed a pulsed power supply based on the same principles and used it for pulsed corona generation. Many plasma driven pollution control processes are initiated by ozone, so we measured the plasma production of ozone in the air, to analyze the plasma processing efficiency (Kuraica et al. 2008).

2. EXSPERIMENTAL SETUP

For this experiment we a constructed repetitive, three-stage Marx generator with an external trigger. It consists of three 20 nF capacitors in parallel charged via 1 kΩ resistor and four 500 μH inductivities as presented in Fig. 1. The high voltage transformer with rectifier charges capacitors to the positive charging voltage of 10-12 kV, when trigger pulse discharges the first spark gap which then in turn, due to the addition of the voltages, discharges the second spark gap. The inductors act as very high reactance due to the speed of the discharge and thus the spark gaps are fired in series. A positive output pulse is produced with a voltage which is more than three times the charge voltage i.e. ~ 40 kV. In this research we have set the repetition rate of generator at 100 pps.

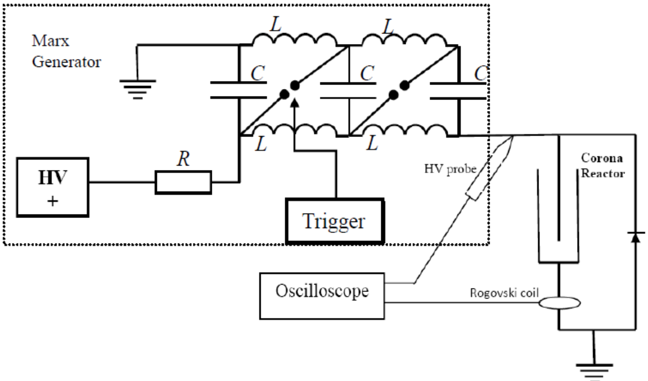

Figure 1: Schematic overview of three-stage Marx generator with corona reactor.

Wire-plate corona reactor had seven wires, 0.5 m long and 0.8 mm in diameter, placed at 4 cm distance from parallel positioned stainless steel plates. Dimensions of the reactor are 0.7 x 0.5 x 0.08 m^3. A fan has been used to provide 10-60 m^3/h air flow rate through the reactor.

For voltage measurement, a high voltage probe Tektronix P6015A (1000:1±3%) was used with a digital oscilloscope Tektronix 3032 (300 MHz, 2.5GS/s). Current measurements were performed with current transformer Pearson Electronics 3025. Probes were positioned as shown in Fig. 1.

The ozone concentration was determined using the UV absorption (Fig. 2) in the Hartley-band (230-290 nm), where the absorption of ozone is the largest. As UV source a Shimadzu deuterium lamp was used. Ocean Optics QE 65000 spectrometer (200-400 nm, resolution 0.2 nm) was used to acquire the spectra. Measuring cell with quartz windows and optical path length (*d*) of 8 cm was located after the electrode system at distance of approximately 0.5 m.

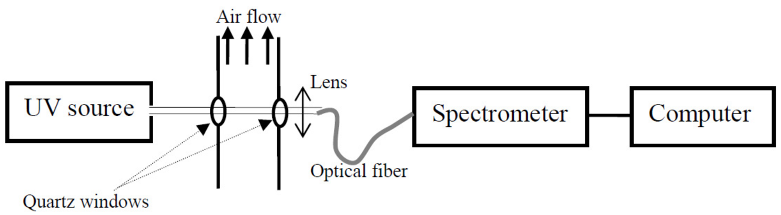

Figure 2: Shematic owerview of UV absorption technique set-up.

The ozone concentration in exhaust gas flow was determined using Lambert-Beer's law:

$$I(\lambda) = I_0(\lambda) \cdot e^{-c \cdot \sigma(\lambda) \cdot d} \quad (1)$$

in which c is the ozone concentration (molecules·m^3), $I(\lambda)$ is the absorption spectrum, $I_0(\lambda)$ is the background spectrum (gas flow without ozone) and $\sigma(\lambda)$ is the absorption cross-section (m^2) of ozone as function of wavelength (Seinfeld, 1986). Ozone concentration measured in 100 points in the range from 253 to 273 nm is presented as a function of energy density delivered to the reactor from the Marx generator. In this study the energy density has been changed by changing of flow rate.

3. EXPERIMENTAL RESULTS

The voltage and current waveforms are displayed in Fig. 3.a). Power is calculated by multiplying voltage and current waveforms. Energy is determined by integrating the power waveform. The risetime of the pulse is about 40 ns. For energy of ~1 J/pulse, the half-width of power signal is about 200 ns (See Fig. 3.b) which is of great interest for pulsed plasma efficiency (van Veldhuizen, 2000).

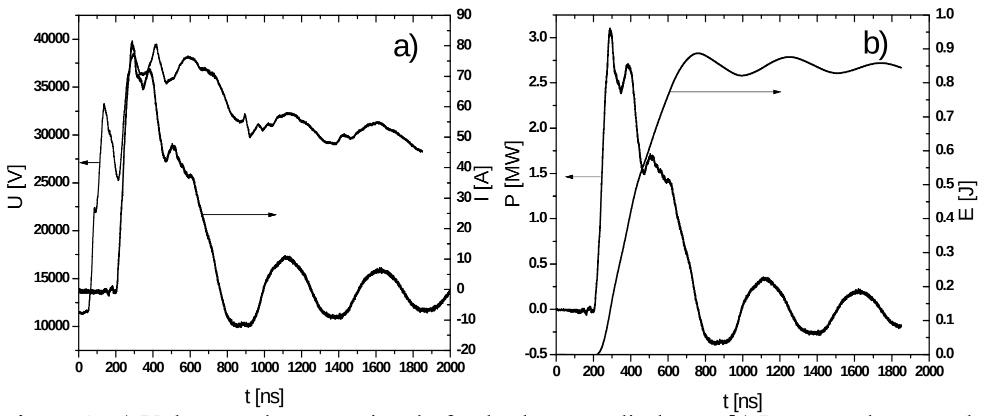

Figure 3: a) Voltage and current signal of pulsed corona discharge. **b)** Power and energy delivered to the corona reactor.

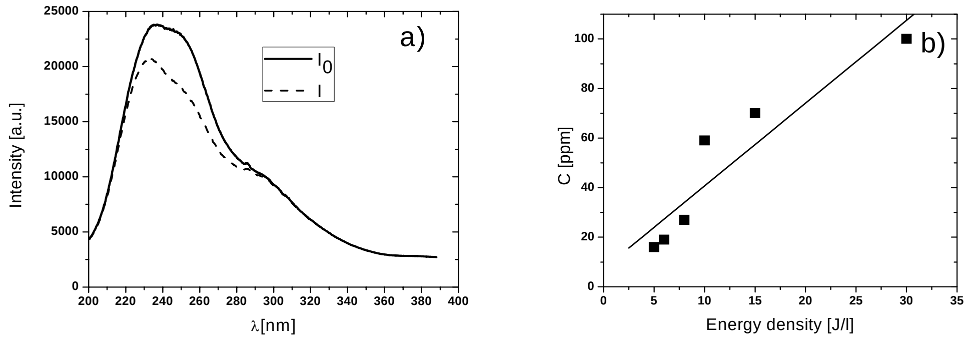

Figure 4: a) Deuterium spectrum when plasma was turned off and when it was turned on with delivered energy density of 30 J/l. **b)** Ozone concentrations for different densities of delivered energy.

Ozone production was measured as an indicator for chemical activity of pulsed corona. Analyzing Fig. 4.b) it can be concluded that the ozone concentration increases almost linearly with increase of energy density. Obtained results are in good agreement with results presented in literature (Winands et al. 2006), and show that investigated pulsed corona discharge driven by the Marx generator has a good efficiency in ozone production, so this system represents a promising plasma source for treatment of gaseous pollutants.

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