

NON-EQUILIBRIUM ASPECTS OF OZONE GENERATION IN SILENT DISCHARGES

Fijalkowski S.^a and Ozonek J.^b

*a) Department of Thermodynamics and Fluid Mechanics, Lublin University of Technology,
20-618 Lublin, 38D Nadbystrzycka Str., POLAND*

*b) Institute of Environmental Protection Engineering, Lublin University of Technology,
20-618 Lublin, 38D Nadbystrzycka Str., POLAND*

Abstract. The real process of ozone synthesis depends significantly on many factors influencing the states of low-temperature plasma generated in silent discharges in the reaction environment as well as the external factors connected with electric energy supply to the ozone synthesis reactor. While forming this mathematical description, the local equilibrium postulate as well as local formulation of the second thermodynamics principle was used. The description was based on the equations on substantial balance of entropy and Gibbs equation, which were then transformed to Gibbs-Duhem equation. The mathematical description of the non-equilibrium character was formulated as a dissipation function on the basis of the relations occurring between thermodynamical impulses and generalized flows of extensive magnitudes caused by these impulses.

1. INTRODUCTION

The process of ozone electrosynthesis is irreversible and non-equilibrium. The process is accompanied by intensive dissipation of the electric current work which is caused by the phenomena occurring in microchannels (streamers), namely microdischarges, physico-chemical reactions, Joule-Lentz heat release, diffusion and thermal diffusion of the produced ozone and many others. The location of the microdischarge channels within the process space changes in time, as well as the microdischarge current in separate channels changes. Occurrence of these phenomena results in irregular distribution of ozone electrosynthesis reaction zones in the process space and heterogeneity of the temperature in the channels. The intensity of heat outflow and ozone thermal diffusion from these zones towards different directions of the process space is also diverse. The process of cooling the reaction environment is also non-equilibrium. It is worth underlining, that even in set states of reactors operation, all the mentioned partial processes run irreversibly, causing energy losses (especially driving energy loss), and they are non-equilibrium. Therefore the need of deep, detailed analysis of these phenomena.

2. CHARACTERISTIC OF THE MODELLING OBJECT

Geometry of the reaction environment scheme is shown in Figure 1, where particular numbers stand for: 1 – high-voltage electrode (instantaneous cathode – Kt), 2 – grounded electrode (instantaneous anode – An), 3 – discharge gap, 4 – solid dielectric layer, x, y, z – Cartesian coordinates depicting the discharge gap.

Gas that flows in the gap of a tubular ozonizer makes a material object of the modelling. The gas undergoes a non-equilibrium process of ozone electrosynthesis. Figure 2 presents a diagram of a control element that travels through the zone of a hypothetical microdischarge channel (streamer) at the w_{sm} velocity. Figure 3 presents a diagram of microdischarge channels distribution in the ozonizer gap.

^a Electronic address: s.fijalkowski@pollub.pl