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Stabilization of Discharge Processes in Electric Fields of Electric Filters

MuzafarovSh.M.,Babaev A.G., Balitsky V.E.

TASHKENT INSTITUTE OF ENGINEERS OF IRRIGATION AND AGRICULTURE MECHANIZATION

ABSTRACT: Based on the analysis of the operating principle of existing electrostatic precipitators, the article identifies their shortcomings and identifies research areas. An analysis of the development of discharge processes in the technological gaps of electrostatic precipitators revealed that when feeding them with pulse voltage with overvoltage and high duty cycle, a streamer form of corona discharge takes place. An analysis of the transient process in the supply circuit of the technological discharge gap by a pulse voltage revealed that the stability of the discharge processes occurs at a certain frequency, determined by the parameters of the power supply circuit elements and the time of full compensation of the space charges formed in the discharge gap.

KEY WORDS: corona discharge, dust, gas treatment, overvoltage,streamer, potential plane, corona discharge, degree of gas purification.

I.INTRODUCTION

The results of theoretical studies are confirmed by experimental studies. Experimental studies determined the parameters of the electrode system "Potential plane with corona needles - a grounded plane." The best correlation of the parameters of the electrode system was determined by experimental studies of the trapping of aerosol particles from the air stream.

The problem of cleaning exhaust gases from solid and liquid aerosol particles in technological processes remains unsolved. Existing inertial dust collectors work satisfactorily when trapping particles up to 100 microns. Different types of filters capture particles by dispersion related to IV and V groups. However, they have significant aerodynamic drag, low gas cleaning performance and are equipped with replaceable filter elements. From this point of view, electrostatic precipitators are most preferred. However, existing electrostatic precipitators have a significant mass (up to 600 tons) and dimensions (dust deposition zone up to 27 m) and a low velocity of the gas to be cleaned. At the same time, electrostatic precipitators consume power up to 300 kW.

The listed disadvantages of electrostatic precipitators are a consequence of the use of a corona discharge of constant voltage in them. This type of discharge, which is independent, has such undesirable properties as the instability of the discharge current in frequency and amplitude, locking the discharge, the transition of the discharge into a spark or arc form.

To increase the efficiency of gas treatment processes, it is first necessary to ensure the stability of discharge processes. For this, it is necessary to combine independent and non-independent discharges in one discharge gap using high-voltage unipolar pulses with a constant component and amplitude above the breakdown threshold of constant voltage.

From the point of view of production use, a similar type of voltage can be obtained according to the scheme (Fig. 1). The circuit uses a generator of periodic voltage pulses, a step-up transformer and a rectification circuit with voltage multiplication. The advantage of the proposed method lies in the possibility of considering the technological discharge gap as an element of an electric circuit.

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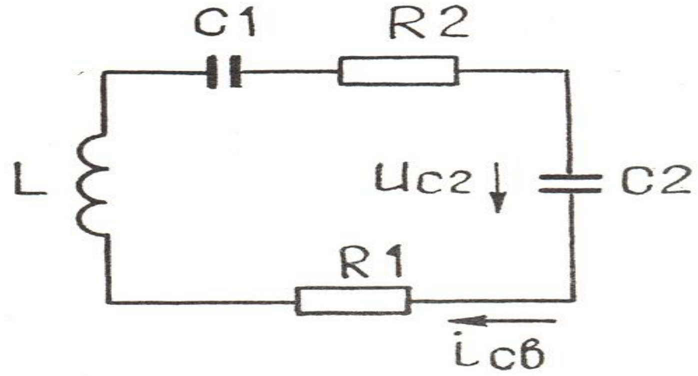


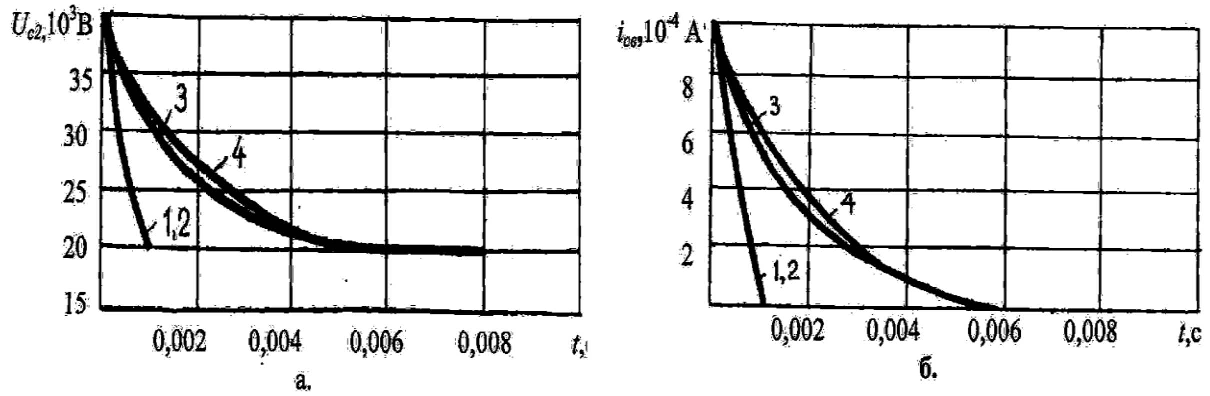
Fig. 1. The equivalent circuit of the source of high voltage pulses in the pause between pulses.

An analysis of the transient circuit in the pause between pulses was carried out by the operator method and the laws of change in current and voltage were deduced. Using the formulas obtained, a transient was calculated for various values of the parameters of the elements of the power circuit. (Fig. 2)

The laws of changing the voltage and current of the discharge gap in the pause between pulses are:

$$U_{C2.св} = [1/(p_2-p_1)]\ [(p_2U_a-i_a)p_1e^{P1t}-(p_1U_a-i_a)p_2e^{P2t}]+U_a,$$
$$i_{св} = [C/(p_2-p_1)]\ [(p_2U_a-i_a)p_1e^{P1t}-(p_1U_a-i_a)p_2e^{P2t}].$$

Fig. 2. The process of changing the voltage (a) and current in the circuit (b) of the discharge gap in the pause between



pulses:
1 - $C_1 = 10^{-10}$Ф, $C_2 = 10^{-12}$Ф; 2 - $C_1 = 10^{-9}$ Ф, $C_2 = 10^{-12}$ Ф; 3 - $C_1 = 10^{-10}$Ф, $C_2 = 10^{-11}$Ф; 4 - $C_1 = 10^{-9}$ Ф, $C_2 = 10^{-11}$Ф.

The condition for the stability of discharge processes is the condition under which in the pause between pulses there is a complete recombination of the space charges formed in the discharge gap upon application of the pulse amplitude.

It was also revealed that under the operating conditions of electrostatic precipitators and the use of pulse voltages with an overvoltage of more than 5%, a streamer form of corona discharge is observed.

Experimental studies of the characteristics of the streamer form of the corona discharge were carried out at the bench.

The experimental results confirmed the analysis of the possibility of stabilization of discharge processes and the conditions of their stability. (Fig. 3 and 4).Comparative volt-ampere characteristics of pulsed and constant voltage revealed an excess of current at pulsed voltage.

Comparative studies of the power characteristics of the two types of voltage showed a 2.6-fold excess of the power effect of impulse voltages at a frequency of 200 s-1.

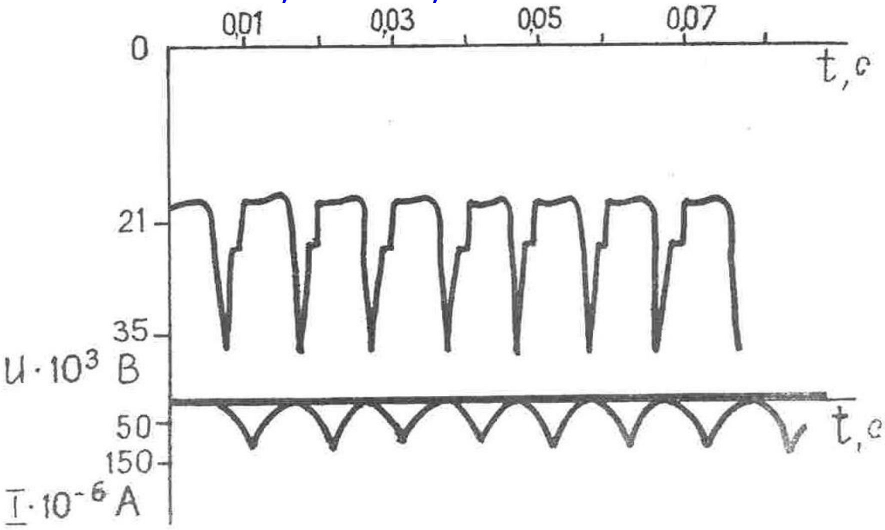


Fig. 3.Oscillograms of voltage (upper) and current (lower) streamer form of corona discharge at a frequency of 100 s-1

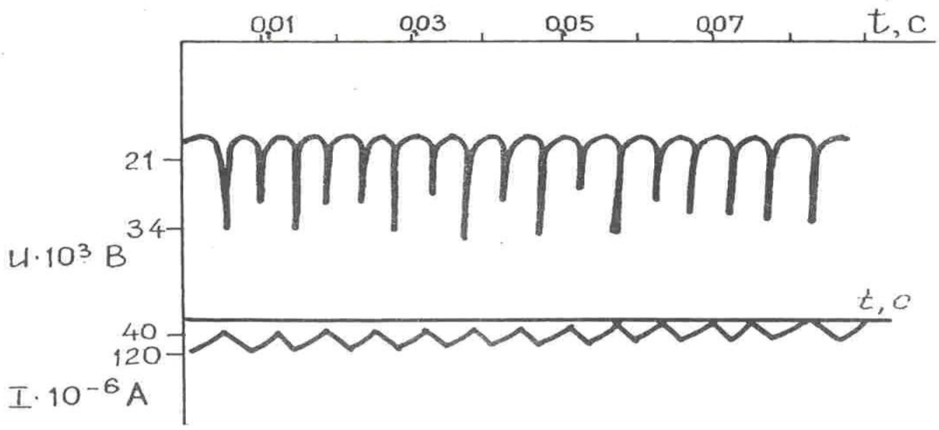


Fig. 4.Oscillograms of voltage (upper) and current (lower) of streamer form of corona discharge at a frequency of 220 s-1.

The experiment also investigated the parameters of the electrode system "Potential plane with corona needles - a grounded plane."

Combinations of parameters for interelectrode distances of 0.05 and 0.1 m were determined by the maximum discharge current.

Of these parameters of electrode systems, the most preferable are determined by the results of experimental studies of the process of trapping aerosol particles from an air stream. The studies were conducted at a bench simulating the operation of an electrostatic precipitator.

In figures 5 and 6 show traces of deposited dust on the grounded electrode of the stand, which clearly shows the mutual screening effect of the corona needles? When dust is deposited from a single needle, the trace is a perfect circle shape.

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Fig. 5. The pattern of spots of deposited dust from corona needles 25 mm long, with their staggered arrangement and the same distance between the needles in the rows and between the rows of needles.

Fig. 6. The pattern of spots of deposited dust from corona needles 20 mm long, with their corridor arrangement and the distance between the needles in rows is twice as large as the distance between the needles in rows

According to the research results, it was found that the greatest degree of dust cleaning of the air flow is observed with a needle length of 20 mm, a distance between needles in a row - 40 mm, a distance between rows of needles - 80 mm. The studies were carried out at an air flow rate of 8 m / s. The specific power of the process in this case was 33 W s / m3. Certain parameters formed the basis for the development of an electrostatic precipitator system for ginneries.

Technical and economic indicators of the electrostatic precipitator were determined by comparison with the existing electrostatic precipitator type EFVA 10-20. A significant advantage of the developed electrostatic precipitator was revealed for all compared indicators.

II. GENERAL CONCLUSIONS

1. Existing inertial dust collectors are able to capture only coarse particles, and existing electrostatic precipitators have significant dimensions with a large power consumption. For wider use of electrostatic precipitators, it is necessary to increase the efficiency of the influence of electric fields on dust particles.
2. Improving the efficiency of gas treatment can be carried out while stabilizing the discharge processes. This can be achieved by combining in one discharge gap independent and non-independent discharges, namely, using unipolar voltage pulses with a constant component and amplitude above the breakdown threshold of a constant voltage. In this case, the discharge has the streamer shape of the corona discharge.
3. An analysis of the transient process in the power supply circuit of the technological discharge gap showed that the stability of the discharge process occurs when the discharge current decreases to zero in the interval between pulses, that is, with full compensation of space charges in the technological gap. The maximum stable frequency is determined by the electrical parameters of the technological gap and the elements of the power circuit.
4. Experimental studies of discharge processes confirmed the results of a theoretical analysis on the stability of discharge processes and revealed significant advantages of the streamer shape of the corona discharge over a constant voltage discharge.

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