OZONE PLANT AS SYSTEM OF COUPLED CIRCUIT

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ABSTRACT

The presented work is devoted to investigation of the physical processes proceeding in ozonators with the two-barrier discharge. The obtained results and their analysis show that it is necessary to choose frequency of the applied voltage, for effective work of the ozone plant in each concrete case, at which the maximal efficiency is provided.

Keywords: ozonators, applied voltage, maximal efficiency, power, physicochemical.

I. INTRODUCTION

As is well known, at the heart of work of the most industrial ozonators laid one or two-barrier discharges. The physicochemical processes proceeding in such discharges are sufficiently complex and completely are not investigated [1-3].

II. MAIN PART

The presented work is continuation of investigation of the physical processes proceeding in ozonators with the two-barrier discharge, stated in [4] where it has been shown, that the active power put in discharge interval, ceases to depend on the frequency of the applied voltage in the certain interval (500-900 Hz), and then decreases with frequency increasing (fig. 1).

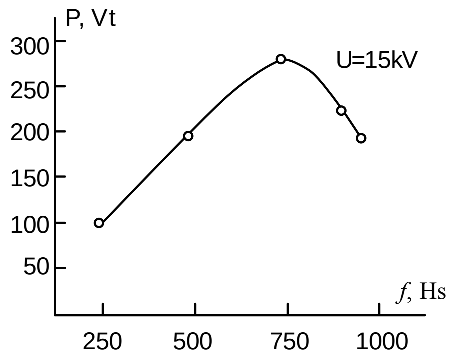

Fig. 1. Dependence of capacity including to discharge interval of ozonator on the frequency of the applied voltage.

The power was determined from volt-ampere characteristics of the discharge by the formula of

$$P = [I_{ac} - I_{ic}] \cdot U_d \qquad (1)$$

Where I_{ac} - is the average current, I_{ic} - is the current at ignition potential, U_d - is voltage of discharge burning. The discharge stops with increasing of frequency up to values exceeding 1000 Hz. This conclusion actually contradicts the design formula established in the ozonators theory to where, power increases when frequency increases.

$$P = \frac{2}{\pi}\omega U_d [C_b(U - U_d) - U_d C_d] \qquad (2)$$

Where $\omega = 2\pi f$ - is the circular frequency, U_d - is voltage of discharge burning, U - is the voltage on ozonator, C_b - is the capacity of barrier, C_d - is the capacity of discharge interval.

We shall make the full equivalent circuit ozone plant working on the basis of the two-barrier discharge in pulse regime for elucidation of the above-stated rejection of experimental results from theoretical expression (2) (fig. 2).

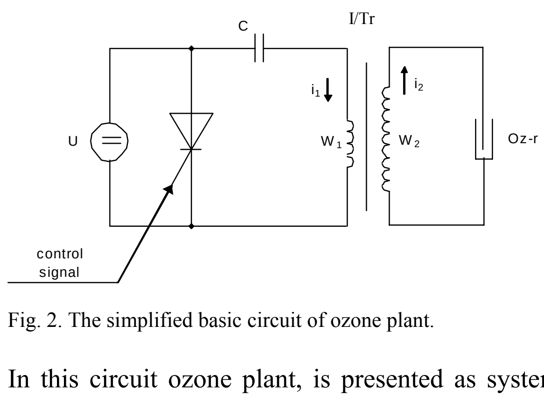

Fig. 2. The simplified basic circuit of ozone plant.

In this circuit ozone plant, is presented as system of two-coupled circuit. The supply voltage is transferred from primary circuit to secondary by means of the pulse transformer. The big role at transfer of voltage pulses from the primary circuit to secondary play leakage inductance (L_s) and magnetization (L_m). The first of this influences on the form of pulses at transfer of fast processes and formation of their forward fronts, and the second - influences at transfer of slow-reformative parts of pulses and forms their tops.

The discharge current had two half-cycles and had strongly decaying character. It can be presented in complex kind as $\dot{I}_1 = \dot{I}_{m1} e^{j\omega t}$ - for the primary and $\dot{I}_2 = \dot{I}_{m2} e^{j\omega t}$ - for the secondary circuit. $\dot{I}_1$ - is created by influence of e.m.f of the primary circuit $e_1(t)$. The electromotive force created in secondary circuit by this current equal to,

$$\dot{E}_{m12} = -\frac{M d\dot{I}_1}{dt} = -j\omega M \dot{I}_{m1} \quad (3)$$

$\dot{I}_2$ - is the current of secondary circuit, and creates the e.m.f. in the primary circuit:

$$\dot{E}_{m21} = -j\omega M \dot{I}_{m2} \quad (4)$$

Where M - is the factor of reciprocal induction: $M = \chi\sqrt{L_1 L_2}$ (χ - is the connection factor, L_1 and L_2 - are the inductance of primary and secondary circuit accordingly. $\dot{I}_{m1}$ and $\dot{I}_{m2}$ - are the complex amplitudes of currents.

Let us write down Kirkhofs equations for the given system of the coupled circuit

$$\begin{cases} \dot{I}_{m1} \cdot \dot{Z}_1 = \dot{E}_m + \dot{E}_{m21} \\ \dot{I}_{m2} \cdot \dot{Z}_2 = \dot{E}_{m12} \end{cases} \quad (5)$$

For the electromotive force $\dot{E}_{m12}$ and $\dot{E}_{m21}$ we shall obtain the formula taking into account here expressions (3) and (4)

$$\dot{I}_{m1}\left(\dot{Z}_1 + \frac{\omega^2 M^2}{\dot{Z}_2}\right) = \dot{E}_m \quad (6)$$

Where $\dot{Z}_1$ and $\dot{Z}_2$ - are the complex resistance of circuits. The equation (6) expresses the Ohm law for considered system. As seen from formula, the primary circuit includes as though the certain complex resistance:

$$\dot{Z}_{ed} = \frac{\omega^2 M^2}{\dot{Z}_2} \quad (7)$$

The reactive part of this formula, so-called brought resistance, compensates reactive resistance of the primary circuit as a result of resistance of system becomes active and, naturally, independent on the frequency. This assumption explains the independence of capacity including to the discharge on the frequency nearby resonant frequency ($\omega_0 = 750\ Гц$), observable in our experiments [4]. Obviously, thus other characteristics, in particular factor of transfer of considered system of the coupled circuits change also.

It is necessary to note, that brought resistance is the conditional concept. It allows determining the decrease of primary circuit current, as result of increase of the primary circuit resistance on magnitude of $\dot{Z}_{ed}$. Actually, not for anything resistance is not brought from one circuit to another.

The capacity absorbed on active resistance of the secondary circuit of R_2, which is composed from resistance of secondary winding of the pulse transformer, $R_{2\ w.t.}$, moreover resistance of discharge interval of active element of the ozonator changing on time, equals:

$$P_2 = I_2^2 R_2 \quad (8)$$

Where $R_2 = R_{2\ w.t.} + R_2(t)_{oz.}$

The equivalent circuit (fig. 3b) at resonance when reactive resistances vanish possesses the active resistance:

$$R_e = R_1 + Z_{.r} = R_1 + \frac{\omega^2 M^2}{R_2} \quad (9)$$

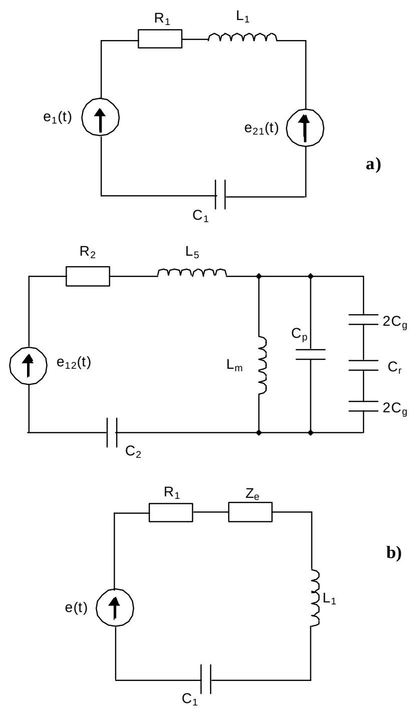

Fig. 3. Full (a) and one-planimetric (b) circuits of the ozone plant. C- is a memory capacity, $e_1(t)$ - e.m.f. of the power supply, R_1 - active resistance, L_1 - inductance of primary circuit, $e_{12}(t)$ - is the e.m.f. created by current of the primary circuit in secondary, $e_{21}(t)$ - is the e.m.f. created by current of the secondary circuit in primary, L_s - leakage inductance, L_m - inductance of magnetization of the pulse transformer, $C_п$ - stray capacitance, $C_д$ - capacitance of dielectric part, $C_г$ - capacitance of gas interval of active element of the ozonator including to the second circuit.

And capacity

$$P_e = I_1^2\left(R_1 + \frac{\omega^2 M^2}{R_2}\right) \quad (10)$$

The available active capacity including to discharge interval of the ozonator is a part of this equivalent capacity allocated on equivalent resistance of R_e:

$$P_a = aP_2 = a(P_e - P_1) = aI_1^2 R_{ed} \quad (11)$$

Where $P_1 = I_1^2 R_1$ - is the capacity spent in active resistance of primary circuit, a - is the constant. From here, it is possible to estimate the efficiency (η) of ozone plant at resonance:

$$\eta = \frac{P_a}{P_e} = \frac{aI_1^2 R_{ed}}{I_1^2 R_e} = \frac{aR_{ed}}{R_e} = a\frac{1}{1 + R_1/R_{ed.}} \quad (12)$$

As seen from formula, the efficiency of ozone plant increases with the brought resistance value. It is necessary to increase reciprocal induction factor of M and accordingly connection factor as it is directly connected to reciprocal induction factor for increase of brought resistance value. All these reasoning show necessity of creation the critical connection between the ozone plant circuits: $\chi Q = 1$, where Q - is the good quality of system.

III. CONCLUSION

Thus, the results obtained in this paper and their analysis show, that it is necessary to choose frequency of the applied voltage at which the maximal efficiency is provided for the effective work of ozone plants in each concrete case.

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