THE MODEL OF PLASMA-ELECTRONIC TECHNOLOGY OF PRODUCING ELECTRICITY FROM ELECTRON BEAMS*

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Abstract. The article obtains the main results of the research on plasma-electronic technology for producing electricity from electronic beams, based on the electrical properties of electrons and their combination in the form of electron beams. The functional diagram of the experimental setup implementing plasma-electronic technology that proves the possibility of electricity generation by electrical installations, based on plasma-electronic technology is described.

Every electron having an electric charge - cosmological constant of $e = 1.6 \cdot 10^{-19}$ C, produces on its surface an electric field with the intensity of $10^{20}$ V/m and the energy of 511 keV. To part an electron from an atom (molecule) units of electron-volt (1.8 eV for caesium, 24 eV for helium) are needed. In one mole of 100% ionized substance, where an electron is parted from an atom within the ionic radius $r = 10^{-10}$ m, about $10^{30}$ J of electrostatic energy is concentrated; power inputs for ionizing by the electric arc ($U_D \approx 100$V) and mass transfer of ions with $10^4$ V voltage are only $10^9$ J. Directed or oscillatory motion of electrons $\text{div}(\rho \mathbf{U}) = -\partial \rho / \partial t$ forms the electromagnetic process described by Maxwell- Lorentz's equations: $\text{rot} \mathbf{E} = -\mu \partial \mathbf{H} / \partial t; \text{rot} \mathbf{H} = \rho \mathbf{U} + \gamma \mathbf{E} + \omega \mathbf{E} / \partial t$ (where $J_{ep} = \gamma$ - conductional current density vector, electric-field vector and electric conductivity of electric circuit accordingly; $J_K = \rho \mathbf{U}$ is a convection current density vector, volume density of electron beam charges and velocity vector of electron beam charges. $J_{Em} = \partial \mathbf{E} / \partial t$ - bias currents density vector, $\mu$ - magnetic and $\varepsilon$ - dielectric permeability) in the form of convection currents, conduction currents, bias currents [1,2]. Using the electrical properties of electrons it is possible to create a highly effective resource-saving pollution-free electrical power process, which surpasses modern fuelburn electrical power technology supplying about 70% of electric power [3].

Highly effective pollution-free technology of electrical power production [4,7] by means of converting the electron-plasma stream (electron beam) formed by electric arc plasmatron [5] into electric power in orthogonal field of the electric arc, anode field of the electron gun

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* Results were obtained in the framework of the state task № 72 of the Ministry of Education and Science of the Russian Federation.
and double half-wave transformation in crossed field of polarized electrode in convection current of the electron beam into electric power, that is transferred to power consumers. At the same time on the cathode of electric arc by means of electron conduction current, the cations are recombined into atoms and molecules of the working substance that is subjected to ionization in hermetic enclosure of the electric arc plasmatron. That is why there are no harmful emissions like those in fuelburn electrical power industry.

Plasma-electronic technology of producing electricity is possible due to the fact that energy of electronic beam is as square $q^2$ interacting charges in the electronic beam $W_{q\pi} = q^2 / \varepsilon r_e$, while power inputs on ionization for ionizing by the electric arc and mass transfer of electrons by anode $U_a$ field of the electron gun are proportional to the first degree charge $q_{\pi}$ $W_m = q_{\pi}(U_{\pi} + U_a)$ [1,2,6]. To make this technology not only transforming one kind of electricity into another, but also generating electric power is necessary to create working current strength not less than [6]:

$$I_p \geq \varepsilon(2\varepsilon / m_e)^{1/2}(U + U_e)^{3/2}$$

(1)

Here:
- $q_{\pi}$ - electrical charge of electronic beam;
- $\varepsilon$ - dielectric constant in a beam;
- $r_e$ - average distance between electrons in a beam;
- $m_e$ - electron mass.

The functional diagram of experimental setup for modeling processes of electricity generation from electronic beams is at the picture 1.

The experimental setup consists of: electric arc plasmatron 1, electron guns 2 with output axial anode $A_p$ (plasmatron 1 and guns 2 are not presented in details being a part of another invention); working electrodes 4 with working cavities (WC) 5, made of the first class conductor material, that gives double electric layer on WC surface; metal plates 6; dielectric 7 between plates 6 and working electrodes 4 together form the capacitors $C_{4-6}$, connected successively with the electric capacity of double electric layer on WC surface 5; decelerators 8; inductive windings $L_1, L_2$ of primary circuit of power transformer – converter (PTC) 9, winding $L_2$ consists of winding $L_u$ and $L_T$, and their relationship can be regulated; L2 and the capacitor $C_{p2}$ make resonance on operating frequency; amperemeters $A_x, A_y, A_\gamma$ measure current strength of electric arc, bias currents, conduction currents; identical inductive windings $L_3$ of secondary circuit power transformer – converter (PTC), one of these windings is connected to voltmeter $V_\gamma$, that measures the equivalent stress receiving by the setup. The other winding $L_3$ is connected to the industrial network through the LATR. This winding includes a load $R_{in}$, an amperemeter $A_c$ and a voltmeter $V_c$, that measure current strength and stress, either received from the electrical supply network or transferred to it, a cross-flow electricity meter Wh SET1A-P type, that measures the quantity of electric energy inputs from the network and outputs transferred to it, when the setup works as an electric energy generator. Plasmatron 1, electronic guns 2 and electronic beams transformers 4, 5, 6, 7, 8 placed into a vacuum chamber (VC) filled with argon with $6 \cdot 10^{-3}$ Pa discharge.

According to the functional scheme, inside the experimental setup the working substance (discharged gas) is ionized by electric arc plasmatron 1; the forming, acceleration and
modeling of an electronic beam 3 by network frequency is proceeded by means of electronic gun 2. Going through the axial working anode $A_p$ and receiving the anode $A_p$ potential $U_a$ of the electronic gun 2, laser beam passes into working cavity 5 of electrode 4, where it is subjected to compression of converging conicity on the the beam’s way to working cavity 5 under the influence of electric field of double electric layer on the working cavity surface 5, as a result charge density, beam energy and received power increases in ($d_{ex}$/$d_{max}$) times, where $d_{ex}$ and $d_{max}$ are the diameters of inlet and outlet of the working cavity 5.

Power inputs of anode field of electronic gun 3 for mass transfer of beam electrons, that form electron’s matrix, and production of electron matrix kinetic energy [1,5,6,7].

$$ W_a = q_m \cdot U_a = N_m \cdot e \cdot U_a \leftrightarrow N_m \cdot m_e \cdot v_e^2 / 2 = W_{mb} $$

(2)

Where $v_e = (2 \cdot e \cdot U_a / m_e)^{1/2}$ - the electron speed received from equation of electron motion in electric field [1]; $m_e$ - electron mass;

The quantity of electrons in radial section of a beam ($N_{mr}$); the quantity of electrons in cross-section of a beam ($N_{ml}$); the quantity of electrons in a beam matrix $N_m = N_{mr} \cdot N_{ml}$.

Electron interaction energy in matrix according to Coulomb force

$$ W_{mq} = N_m \cdot F_q \cdot r_{em} = ((N_m - 1)^2 \cdot e^2 / \varepsilon \cdot r_{em}^2) \cdot r_{em} = N_m^2 \cdot e^2 / \varepsilon \cdot r_{em}^2 $$

(3)

Where $N_m >> 1$, so $(N_m - 1)^2 = N_m^2$;

$\varepsilon = 4\pi\varepsilon_r\varepsilon_o$ - dielectric constant of medium in matrix, $\varepsilon_r$ and $\varepsilon_o$ - relative and absolute dielectric constants;

$$ r_{em} = ((l_m^2 + r_m^2) / 2) + r_j) / 2 $$ - an average distance between electrons in matrix, m;

$r_j = (e \cdot l_a / \varepsilon \cdot U_a)^{1/2}$ - an average distance between neighboring electrons in a beam, m;

$l_a$ - distance between cathode $K_g$ and outlet anode $A_p$ electron gun 2, m;

$l_m \times r_m$ - length and radius of an electron beam (electron matrix), m;

$E_a = U_a / l_a$ - gun 2 made field intensity, V/m

Electron interaction energy in a matrix according to Lorentz force [1,3]:

$$ W_{mb3} = N_m \cdot e \cdot [B_e \times U_e] \cdot r_{ij} \cdot N_{mr} = \mu \cdot N_m \cdot N_{mr} \cdot e^2 \cdot v_e^2 / 2 \cdot \pi \cdot r_{ij} $$

(4)

Where $B_e = \mu \cdot l / 2 \cdot \pi \cdot r_j$ - the induction of a magnetic field produced by i -electron moving at $U_e$ speed in neighboring $j$ - electron, Tl;

$\mu = \mu_r \cdot \mu_0$ - magnetic permeability of medium in matrix, $\mu_r$ and $\mu_0$ - relative and absolute magnetic permeability, H/m;

$I_e = e \cdot U_e / r_{ij}$ - current stress, produced by i - electron moving to neighboring $j$ - electron, A (ampere).

An electron beam is a result of dynamic equilibrium of three electric forces that at a first approximation produce an equal amount of energy. Anode field force $F_a = e \cdot E_a$ accelerates
electrons and produces kinetic energy (2). Coulomb force $\mathbf{F}_q = e \mathbf{E} / \varepsilon r_{ij}^2$ produces energy (3) and accelerates electrons in longitudinal direction of a beam. Lorentz force $\mathbf{F}_{nu} = e \mathbf{B} \times \mathbf{U}_L$ performs in radial direction of a beam and produces energy by keeping it (energy) in a beam.

To transform the energy of an electronic beam into electric circuit using double half-wave circuit, one modulates an electronic beam 3 with operating frequency of the electric network by supplying correct voltage $U_a \sin \omega t$ on to outlet anode $A_p$ of the electron gun 2. The voltage changes with frequency $\omega$ of the electrical network. Then they influence on the modulated electron beam with the crossed electric field having components $\mathbf{E}_r$ и $\mathbf{E}_l$ of operating frequency of electric network.

The radial component $\mathbf{E}_r$, compressing the electron beam 3 and holding it in such a condition with constant energy (3 and 4) in the beam, is possible to create with the help of correct combination of quadrupole electron lenses [1,5]. In this particular case, field intensity of double electric layer in working cavities (WC) 5 is used.

The longitudinal component $\mathbf{E}_l$, decelerating electrons, is made by relevant voltage on decelerating $(U_{T2})$ electron 8, taken from $L_2$. While regulating the voltage $U_a$ and $U_{T2}$, one regulates beam 3 slowing down and the amount of transmitting energy through $L_2$ to energy consumers.

Under the influence of the decelerating component of crossed electric field the kinetic energy of matrix (2) electrons transforms into tension on operating and decelerate 8 electrodes

$$U_{pT} = m_e (\vartheta_e - \vartheta_{ef})^2 / 2e,$$

Here: $\vartheta_{ef} = (2eU_{T2} / m_e)^{1/2}$ - electrons speed that enter the decelerating electrode 8;

At full stop of the beam $\vartheta_{ef} = 0$, so $U_{pT} = U_a$ from (2). $U_{pT} = U_a$

Due to the compression of the electron beam in radial section in 2-3 times, it is possible that electrode tension may increase in 4 times. The tension produces bias currents through the capacitors $C_{4,6}$, switched on in a series with the electric capacity of double electric layer and additional power $(S_{4-6} = U_{4-6}^2 \cdot \omega \cdot C_{4-6})$ transmitted through $L_1$ to the industrial network.

Full tension produced by electron matrix [7], taking into account that longitudinal $U_{ml}$
tension and radial $U_{mr}$ are orthogonal.

$$U_m = U_{ml} + (U_{ml}^2 + U_{mr}^2)^{1/2} = U_a ((1^2 + 2^2)^{1/2} + 1) = 3,2U_a$$

Convection current of electrons matrix [2]

$$I_{mq} = \rho_m \cdot \mathbf{U}_e \cdot S_{mr} = 3 \cdot e \cdot \mathbf{U}_e \cdot r_m^2 / 4 \cdot r_{ij}^3 = 0.75 \cdot N_{mr} \cdot e \cdot \mathbf{U}_e / r_{ij}$$

Where $\rho_m = 3 \cdot e / 4 \cdot \pi \cdot r_m^2$ - charge density in electrons matrix, C/m;

$S_{mr} = \pi \cdot r_m^2$ - area of radial section of matrix, m².

Convection current of matrix under the influence of crossed electric field of operating charge converts to conduction current of primary electric circuit $(L_2)$ to PTC9.

$$I_{mL} = U_m \cdot Y_{mL} = U_m (g^2 + (b_L - b_C)^2)^{1/2}$$
Where: \( g \) – active conductivity of an electric circuit (EC), cm;
\( b_L = \frac{1}{\omega L} \) - inductive conductivity of EC, cm;
\( b_C = \omega \) - capacitive susceptance of EC, cm;
\( \omega = 2\pi f \) - cyclic operating frequency of electricity network, rad/sec.

According to the first Kirchhoff's law \([2]\) and the charge conservation law \( \text{div} \mathbf{j} = -\partial p / \partial t \) \([1]\), these two currents strength in a first approximation is equal (\( I_{mg} \approx I \)), as it is a series connection of elements of the same electric circuit\([2]\).

Power produced in EC of PTC9

\[
S_{3\omega} = I_{3\omega}^2 \cdot Z_{3\omega} = I_{mg} \cdot U_m = U_m^2 \cdot Y_{3\omega}
\]

Where \( Z_{3\omega} = 1/Y_{3\omega} \) - impedance and electric conductivity of EC, accordingly;

The power spent on producing and mass transfer of electron’s matrix

\[
S_{\text{wamp}} = I_g \cdot U_g + I_{mg} \cdot U_a = 1.2 \cdot U_a \cdot I_{mg}
\]

Here \( I_g \approx (3÷4) I_{mg} \) – required current strength of plasmatron’s electric arc, A;
\( U_g = 0.05 U_a = 30 \div 50 \) B – operating electric arc voltage.

Power factor - received power (9) to supplied power (10) ratio.

\[
k_S = \frac{S_{3\omega}}{S_{\text{wamp}}} = \frac{3.2 U_a I_{mg}}{1.2 U_a I_{mg}} = 2.5 > 1
\]

Due to transformer losses, power factor for this model must be more than one, so that the presented physical model of electricity transformation from one form into another becomes current generator \( I_{3\omega} \) (8).

When generator operated under load, it is necessary to create currents resonant condition (\( I_{3\omega} = I_{C2} \)) \([2]\). This condition compensates the reactive power in an electric circuit, increasing \( \cos \varphi \) up to one, improves the form of vibration, decreasing energy losses by ultra harmonics, it also helps to reduce the operating current of an electron beam. These facts make generators more effective and with a longer service life.

The optimal load impedance for receiving maximal coefficient of efficiency – 50% with the help of this physical model of electron beam power transformation into circuit electric power for electricity consumers.

\[
Z_{\text{opt}} = U_m / I_{mg}
\]

Physical model of the process of electron beam power transformation into electricity is at the figure 1.

Under the influence of crossed electric field of operating electrodes 4 by means of double half-wave transformation, the energy of the electron beam 3 goes to electric circuit PTC9.

Having completed their work in electric circuit, the electrons go to electric arc plasmatron 1 cathode \( K_g \), where they recombine cations into atoms and molecules of working substance that is subjected to ionization with the electric arc in the hermetic enclosure of plasmatron. Being ionized and recombined for many times electrons are not destroyed and complete their functions in the electric circuit (electron is a stable particle with life period about \( 10^{20} \) years). Moreover, electrons do not spend working substance and do not produce harmful emissions like those in fuelburn electrical power industry \([3]\).
Based on this plasma-electron technology it is possible to create a highly effective electricity generator and electrodynamic engines [4,6,7,8]. They will be able to work on land, in the water, in the air and in vacuum without burning traditional fuel, without producing harmful emissions and waste, which insert a pernicious influence on personnel and environment.

Conclusion:
Basing on electron’s properties and electromagnetic parameters of beam’s charged particles and on the laws of their correlation as well as on Coulomb and Lorentz laws was created the model of plasma-electron technology for the processes of electricity production from electron beams. In some special conditions, it may be used as a basis of electricity generator design. Principal provisions of the model designed are:

1. The vast amount of electric energy generated in the ionized substance many times surpasses the amount of energy supplied on ionization of the substance and ions mass transfer; it gives an opportunity to create a highly effective technology based on working substance ionization, neutral plasma separation into charged plasma streams (cation and electron beams), on converting the beam energy into electricity and on recombining of cations into atoms (molecules) of working substance, subjected to ionization again.

Figure 1. The functional diagram of experimental setup for modeling the processes of electricity production from electron beams.
2. The ionization of working substance with the help of electric arc in its orthogonal field in anode field of the electron gun, let us have an electron beam by only one operation. The electron beam is a matrix of electrons with 3 types of energy: kinetic electron energy and the energy of electrons interaction, formed by the dynamic balance of Coulomb and Lorentz forces.

3. Electron matrix energy under influence of crossed electric field of polarized electrode transforms into electric energy transmitted to consumers net. Radial component of an electric field keeps the electron beam in the compressed condition as a result of double electric layer field strength on the surface of the working cavity (WC) of polarizing electrode, as the double electric layer field strength is by two-three orders greater than the electron beam field strength. Longitudinal component of crossed electric field decelerates electrons, transforming them into kinetic energy and energy of electron interaction of Coulomb and Lorentz forces and into field potential of a decelerating electrode. As a result of double half-wave transformation the convection current of electron matrix converts into the electric conduction current, the bias current and electron beam energy converts into relevant power of an electric circuit in current resonance condition ($I_e = I_c$).

4. Plasma-electron technology of producing electricity from electron beams gives the possibility to create a highly effective resource-saving pollution-free electrical power production.

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