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ELECTROMAGNETIC PUSHKA MODEL TO CREATE RECOMMENDATIONS AND SUGGESTIONS

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Abstract:
The thesis demonstrates model structure of the electromagnetic canon, it’s working process and physic procedures in it’s elements.

Keywords: Capacity, capability, electric key, power, unpower, electr source.

Introduction

Currently, the improvement of modern weapons and the creation of new weapons are one of the pressing issues. One of the modern weapons in this regard is the electromagnetic gun. To analyze the structure and principle of operation of the electromagnetic gun, it is appropriate to use the electromagnetic gun model shown in Figure 1.

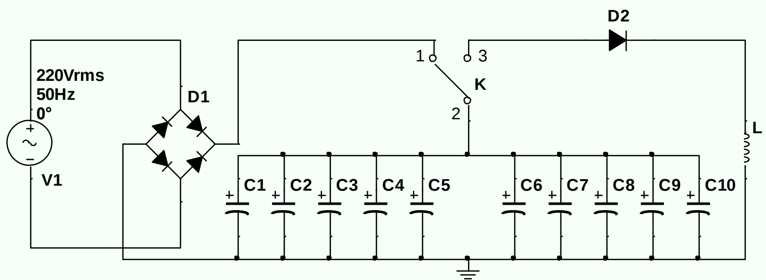

Figure 1. The principle scheme of the electromagnetic gun

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The device is connected to a variable 220 V voltage source V1 and consists of the following elements: a single-phase two-wave diode rectifier D $_1$, a capacitor C, an inductive coil L, a diode D $_2$, and a recloser switch K. The principle of operation of this circuit is as follows: in the initial state, contacts 1-2 of the recloser K are connected, which charges the capacitor C, generating electric field energy, the expression of which is determined as follows:
known as the capacitor charging current

$$i_c = C\frac{du_c}{dt} (1)$$

both sides of expression (1), $u_c$separating the variables, and integrating, we obtain

$$\int i_c u_c\, dt = C\int u_c\, du_c (2)$$

or $$W_c = C\frac{U^2}{2} \qquad (3)$$

Expression (3) shows that the electric field energy stored in a capacitor is proportional to the magnitude of the capacitance and the square of the voltage applied to it. To obtain the required capacitance, it is necessary to connect the capacitors in parallel. Figure 2 shows the parallel connection of capacitors

Figure 2. Parallel connection of capacitors

When the repeater K is switched to the 2-3 state, the capacitor is connected to the inductor L through the diode D $_2$ and the capacitor is discharged, the electric field energy stored in the capacitor generates magnetic field energy, the expression of which is determined as follows:
It is known that the self-induction electric force in an inductive coil is equal to

$$e_L = L\frac{di}{dt} (4)$$

both sides of expression (4), $i$separating the variables and integrating, we obtain

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$$\int i\, e_L\, dt = L \int i\, di (5)$$

or

$$W_L = L \frac{I^2}{2} (6)$$

Expression (6) shows that the energy stored in the magnetic field of an inductive coil is proportional to the inductance of the coil and the square of the current flowing through it.

Figure 3 shows the design of an L-shaped induction coil.

Figure 3. Design of an L-shaped induction coil

shown in Figure 1 is as follows: in the initial state, the contacts 1-2 of the switch K are connected, in which case the capacitor C is charged and $W_c = C\frac{U^2}{2}$ generates electric field energy, then as a result of switching the switch K to state 2-3, the capacitor C is discharged through the diode D $_2$ and the inductive coil L $W_L = L\frac{I^2}{2}$, creating a magnetic field, which leads to the appearance of a magnetic flux F around the coil, which forces the metal projectile inside the tube outward.

We will analyze the physical processes occurring in the circuit elements shown in Figure 1. For this, we will use the equivalent circuit of the contacts 2-3 of the switch K in Figure 1 in the switching state. The equivalent circuit of a capacitor with a capacity C whose charge is not equal to zero, connected in series with a resistor r and an inductance L is shown in Figure 4. The direct resistance of the diode D $_2$ is not taken into account in the circuit because it is small. r is the active resistance of the inductive coil.

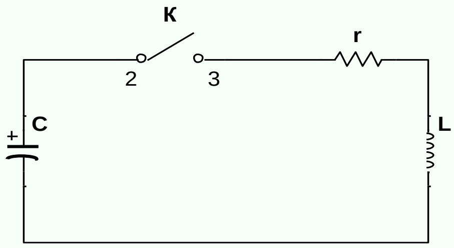

Figure 4. Equivalent circuit with r, S, L elements

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From the resulting equivalent circuit, the differential equation of the circuit, based on Kirchhoff's second law, is written as follows:

$$L\frac{di}{dt}+ri+u_c\text{=0 (7)}$$

here $i=\frac{dq}{dt}=C\frac{du_c}{dt}$(8)

If we put the value of the current in expression (8) into equation (7), we get

$$\frac{d^2u_c}{dt^2}+\frac{r}{L}\frac{du_c}{dt}+\frac{1}{LC}u_c=0(9)$$

To solve the resulting expression (9), we construct its characteristic equation

$$p^2+\frac{r}{L}p+\frac{1}{LC}=0(10)$$

These are the roots of the equation

$$p_{1,2}=-{}^{r}/_{2L}\pm\sqrt{{}^{r^2}/_{L^2}-{}^{1}/_{LC}}\ (11)$$

$_0$ when the switch K is in the 2-3 state, i.e. closed , must be aperiodically discharged to zero. The aperiodic solution of the homogeneous equation (9) must have real roots of the characteristic equation (10), i.e.

$${}^{r^2}/_{4L^2}>{}^{1}/_{LC}$$

or

$$r>2\sqrt{{}^{L}/_{C}}(12)$$

This resistance is called the critical resistance of the circuit, at its minimum value the free process has an aperiodic characteristic:

$$r_{kp}=2\sqrt{{}^{L}/_{C}}(13)$$

The condition must be met for the roots p $_1$ and p $_2$ of the characteristic equation to be real and distinct .$r>r_{кр}$

The free component of the discharge voltage of the equivalent capacitor shown in Fig. 4 (9) is determined in the form of a sheep for different roots of the equation [1]

$$u_{C.эр}=A_1e^{p_1t}+A_2e^{p_2t}\ (14)$$

Here, A $_1$ and A $_2$ are continuous integration, they are determined from the initial condition, r $_1$ and r $_2$ are the roots of the characteristic equation with real and different values given in the expression (11).

For the free-form process to be time-varying, the roots must be negative.

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The free current generator in the corresponding circuit according to expression (8) is determined as follows:

$$i_{эр} = C\frac{du_{Cэр}}{dt} = C(A_1p_1e^{p_1t} + A_2p_2e^{p_2t})(15)$$

When the capacitor is discharged, the current and voltage in the circuit are equal to zero, therefore their transient values are equal to their free constituents:$u_{C.эр} = u_c$; $i = i_{эр.}$

the initial conditions $u_c(0) = u_0$ ва $i(0) = 0$. If we put the initial conditions into expressions (14) and (15), then we obtain

$$U_0 = A_1 + A_2; \; 0 = A_1p_1 + A_2p_2$$

from these expressions

$$A_1 = \frac{p_2U_0}{p_2 - p_1}; \quad A_2 = -\frac{p_1U_0}{p_2 - p_1}$$

At these values of constant integration, the voltage in the circuit (14) and the current in the circuit (15) are equal

$$u_c = u_{C.эр} = \frac{U_0}{p_2-p_1}(p_2e^{p_1t} - p_1e^{p_2t});(16)$$

$$i = i_{эр.} = \frac{U_0Cp_2p_1}{p_2 - p_1}(e^{p_1t} - e^{p_2t}) \qquad (17)$$

$p_2p_1$since the product of the roots is equal to the free letter of the characteristic equation, that is, $p_2p_1 = {}^1/_{LC}$the last expression (17) will have the following form

$$i = \frac{U_0p_2p_1}{L(p_2-p_1)}(e^{p_1t} - e^{p_2t})(18)$$

The time variation of the voltage in the inductive coil is determined by the following expression

$$u_L = u_{Lэр} = \frac{Ldi}{dt} = \frac{U_0}{p_2-p_1}(e^{p_1t} - e^{p_2t})(19)$$

The currents and voltages in capacitive and inductive elements consist of two exponential components. Figure 5 u_c, u_L, ishows the graphs of the changes in parameters over time.

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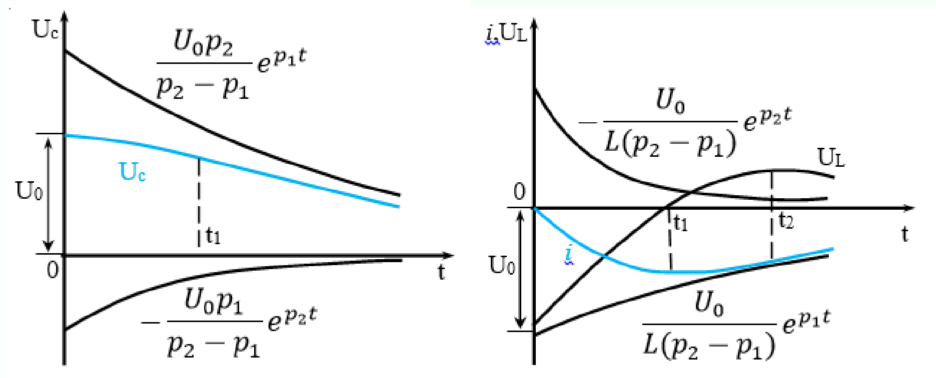

a b

Figure 5. u_c, u_L, i**Graphs of changes in parameters over time**

5 *a* , b that the voltage in the capacitor $u_c$decreases monotonically from the $i$initial value, $U_0$and the current increases from zero, reaches its maximum value, and then decreases.

The maximum value of the current in the equivalent circuit and the voltage across the capacitor shown in the graph occur at time t 1. This time t $\frac{di}{dt}$1 can be determined by setting the derivative equal to zero.

The voltage across an inductive element at t=0 is equal to the current and $u_r = ri$voltage, and therefore u_c ва $u_L$equal in absolute value. At the beginning of the process, the voltage $u_L$decreases in absolute value, crosses the abscissa axis at the maximum value of the current, has a maximum positive value, and then decreases to zero.

u_LThe maximum value and the point of curvature of the current shown on the graph $i$occur at time t 2. This is determined by setting the derivative of time t $\frac{du_L}{dt}$2 to zero.

In conclusion, it should be said that from the analysis of the derived expression (11), it can be seen that an Lincrease in the inductance of the coil leads to a decrease in the absolute value of the roots of the characteristic equation p 1 and p 2 , which leads to an increase in the current in the equivalent circuit shown in Figure 4 and an increase in the discharge time of the capacitance. The smaller the coil, the$L$ Inductance accelerates the increase in current in the circuit and the discharge of capacitance. In addition, in an electromagnetic gun, it is necessary to use a high-power power supply to create a strong electromagnetic field.

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