ELECTRICAL ENGINEERING

EXPLANATION OF ELECTRIC CURRENT IN MILITARY VEHICLES ACCORDING TO THE LAWS OF PHYSICAL AND MATHEMATICS

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ОБЪЯСНЕНИЕ ЭЛЕКТРИЧЕСКОГО ТОКА В ВОЕННЫХ ТРАНСПОРТНЫХ СРЕДСТВАХ ПО ЗАКОНАМ ФИЗИКО-МАТЕМАТИКИ

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ABSTRACT

This article discusses one of the problematic issues of our time, the problem of diagnosing the electrical equipment of machines serving in the military sphere, using the laws of physics and mathematics and finding its solution through a differential equation.

АННОТАЦИЯ

В данной статье рассматривается один из проблемных вопросов современности, задача диагностирования электрооборудования машин, несущих службу в военной сфере, с использованием законов физики и математики и нахождение ее решения через дифференциальное уравнение.

Keywords: generator, rotor, technical service, electrical circuit, differential equation, electrical equipment.

Ключевые слова: генератор, ротор, техническое обслуживание, электрическая цепь, дифференциальное уравнение, электрооборудование.

Today, diagnosis of electrical equipment of military combat vehicles remains one of the important and problematic issues. One of the most correct ways to solve this problem is to use the laws of physics and mathematics.

On January 28, 2022, the Decree of the President of the Republic of Uzbekistan No. 60, Annex 1, Section 7, Purpose 90, "On further improvement of the combat readiness and training of the troops of the Ministry of Defense and the training material and technical base" fully explained. At the same time, in his speeches, our honorable president, the Supreme Commander-in-Chief of the Armed Forces, Sh. Mirziyoyev has been and is saying that mathematics plays a key role in the development of all sciences, and that if young people learn mathematics and physics well, they will be able to acquire any profession without difficulty [1].

At the opening ceremony of the new building of the Institute of Mathematics named after V.I. Romanovsky of the Academy of Sciences of the Republic of Uzbekistan, our Honorable President, Supreme Commander-in-Chief of the Armed Forces Sh. Mirziyoyev remembered the words of a great academician and said: "Any scientific work will remain as thought without mathematics." Therefore, it is important to remember that mathematics and physics have a special role in solving world problems [2].

One of the most global problems of the 21st century is energy and ecology. There is such an energy that no matter what kind of energy it is, it will definitely turn into this energy again. It is characterized by ease of obtaining electricity, environmental cleanliness, and ease of use. In our country, this energy is being studied scientifically and practically by our scientists. The electrification of railways in our republic, the increase of underground, the construction of new power plants, and the commissioning of joint solar power plants with foreign countries are clear examples of this. The urgency of the matter is that in the leading transport and technical universities operating in our republic, in scientific research institutes, attention to the use of electrical equipment installed in cars and its diagnostics lags far behind developed countries. For example, although today's military combat vehicles are driven by internal combustion engines, 80-90% of the entire work process is due to electricity. The main source of internal combustion engines is petroleum products. By 2050, the demand for oil products on the surface of the earth will be very high and at the same time it will decrease sharply, experts have repeatedly emphasized. That is why the world's largest companies maintain the position of oil products for their own benefit. When petroleum products CO_2 and H_2O are burned and incompletely burned, CO exhaust gases

are released, destroying the entire ecology, and 21% of the oxygen in the atmosphere is shared by humans and animals, as well as the rest of the world. These changes are causing the temperature on our planet to rise. Therefore, we must fully equip the cars of the future only with electrical equipment!

Although several presidential decrees have been issued to ensure the widespread development of electric energy in all sectors, the projects of maintenance fleets of electric vehicles have not yet been standardized. For this reason, service stations that service internal combustion engines are used. The operation process of electrical equipment of cars is so complicated that people do not perceive it through their senses: sight, hearing and smell. Only these processes are detected indirectly through special devices, tools or modern electronic sensors. The purpose of the research is to diagnose electrical equipment installed on all combat vehicles using universal mini electronic devices. E-108 (Fig. 1) [9] and EO-214 (Fig. 2) [9], which are currently used in diagnostics, are useful models that are no less useful than devices installed in special machines. We need to train the electrical equipment installed in combat vehicles with the help of scientifically based laws of physics and mathematical apparatus, approaching the limit of human knowledge [3].

Figure 1. E-108 battery tester

Figure 2. E-214 diagnostic tool

It's no secret that the diagnostic work of military combat vehicles in foreign countries is ahead of us. This is also shown by the devices listed above that are currently in use.

Currently, electrical equipment is mainly taught through brief instructions from the designer, based on information in technical documents. This leads to stereotyped uniformity and negatively affects the scientific thinking of the learner (cadet).

The object of the research is electrical equipment installed on military combat vehicles, and its subject is the laws of physics and mathematical apparatus. The main source of electricity in military vehicles is a generator. The battery acts as a source of electricity when the generator is underpowered or not working at all. If a current-carrying conductor is introduced into a permanent magnetic field, the magnetic (vector) lines of force starting at (N) north and ending at (S) south create an electric current in the conductor (Fig. 3) [7], [8].

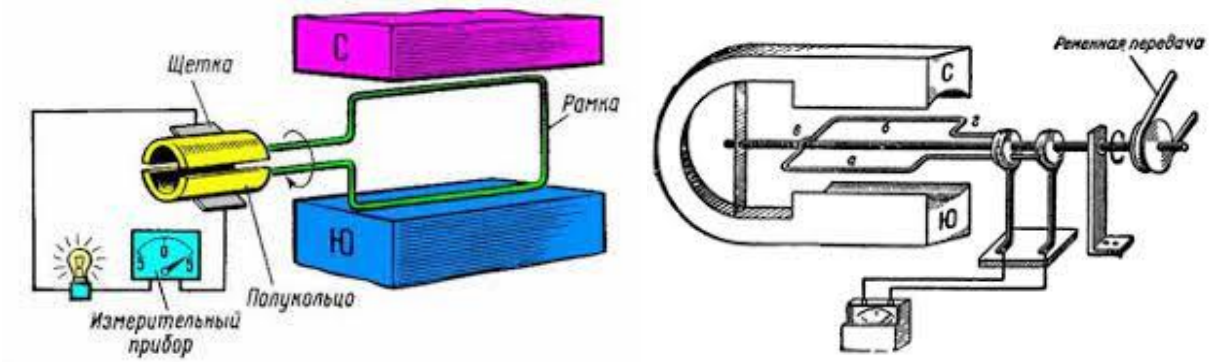

Figure 3. Generation of electric current

The mechanical device that rotates the rotor of modern generators is the reason for the classification of the generator. Generators: divided into heat generators, the hydroelectric, wind, etc. In an internal combustion engine (since the combustion process is inside the engine), the mechanical energy (primary engine) generated by the belt is fed to a generator (secondary engine), and this energy is usually produced by a single or three-phase synchronous generator (due to magnetoelectric phenomenon) creates an electromotive force [4]. The rotation speed of the shaft is expressed by the formula

$$n_v = \frac{60\,f}{p} \qquad (1).$$

In this case, n_v – the speed of rotation of the shaft (when revolutions are expressed in minutes in mechanics, the main unit of time is multiplied by 60 converted from rotaion/second to rotation/min), f - the vibration of electric energy $50Gs$, and p - is a pair of poles. Since combat vehicles are three-phase, one phase is formed in the part of the circle divided into three parts from every 120^0 ($\frac{2\pi}{3}$).

Since the magnet is cast on the shaft, the speeds of the shaft and the magnet are the same: $\vartheta_v = \vartheta_m$. Therefore, generators producing such current are called synchronous generators. The word "generator" means an exciter. The rotation speed of the shaft of three-phase generators is equal to $n_v = 1000\frac{\text{ayl}}{\text{min}}$, and three current sources with the same period, energy, frequency, but different phases by 120^0 are formed.

$$\varepsilon_A = \varepsilon_0 \sin \omega t,$$

$$\varepsilon_B = \varepsilon_0 \sin(\omega t \pm \frac{2\pi}{3}),$$

$$\varepsilon_A = \varepsilon_0 \sin(\omega t \pm \frac{4\pi}{3}) \quad (2)$$

$$\varepsilon = \frac{d\Phi}{dt} = -L\frac{dI}{dt} \quad (3)$$

EMF is the change of magnetic flux with time, the first-order time derivative of the magnetic flux produces an electric current, and (3) formula is a first-order differential equation, the alternating current circuit consists only of an inductive coil the connection between voltage (U_L) and current solves the problems of electrical safety through a very simple mathematical expression. These problems are reflected in vector diagrams or sinusoidal graphs [5].

It's no secret that inductive coils or capacitors keep current in the circuit for a long time, even if it is disconnected from the source. The reason is that current and voltage are different in phase.

The purpose of this information is to solve current and future problems. When applying Kirchhoff's I and II laws for a complex branched electric circuit, it is important that the only way to evaluate the electric circuit is to construct a system of linear mathematical equations. When calculating such equations, experts use Gauss or Kramer methods only when the number of unknowns and the number of equations are equal. The number of equations when evaluating an electric circuit is determined by the formula $У = Ш + Т - 1$. Here $У$ - indicates the number of equations to be constructed, $Ш$ - the number of grids, $Т$ - the number of nodes in the electric circuit. Of course, electrical circuits are often branched, and the coefficients of the unknowns are not integers or natural numbers, but are often in the form of decimal fractions. This makes it difficult to solve the system of equations. For this reason, due to the large number of equations (three or more) and the fact that the coefficients of the unknowns are not whole or natural, we calculate the system of equations using programmed micro calculators based on standard programs.

The role of the differential equations section of mathematics in evaluating electric circuits is incomparable. Let's consider the following as an example.

1) Given a simple unbranched electrical circuit (Fig. 4).

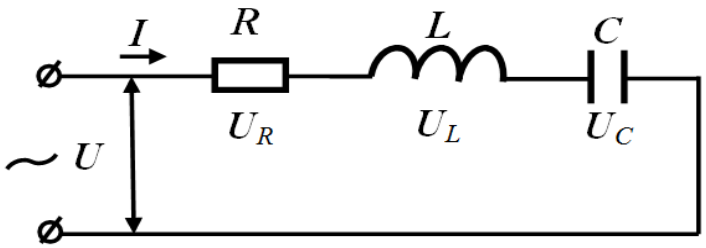

Figure 4. A simple electrical circuit

Let's apply Kirchhoff's II law for a closed electric circuit:

$$U = U_R + U_L + U_C = \\ = I \cdot R + L \cdot \frac{di}{dt} + \frac{1}{C}\int idt = U_n \sin \omega t \quad (4)$$

The complete solution of the equation (4), i.e., the solution of the differential equation with linear constant coefficients, can be solved only in one way. The solution consists of the following sum:

$$i_{ts} = i_{sh} + \tilde{i} \quad (5)$$

i_{ts} - total solution, i_{sh} - solving the homogeneous part of the differential equation and $\tilde{i}$ - particular solution of the differential equation.

2) We solve the first-order differential equation for the electric circuit below (Figure 5).

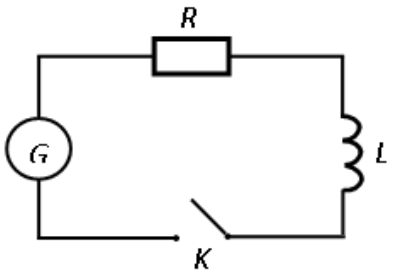

Figure 5. Simple electrical circuit

$$L\frac{di}{dt}+R\cdot i=E_0\cos\omega t$$

$$L\frac{di}{dt}+R\cdot i=0$$

$$L\frac{di}{dt}=-R\cdot i$$

$$\frac{di}{dt}=-\frac{R}{L}\cdot i$$

$$\frac{di}{i}=-\frac{R}{L}dt$$

$$\ln i=\ln e^{-\frac{R}{L}t}+\ln C$$

$$\ln i=\ln C\cdot e^{-\frac{R}{L}t}\Rightarrow i(t)=C\cdot e^{-\frac{R}{L}t}$$

$$\bar{i}=A\cdot\cos\omega t+B\cdot\sin\omega t$$

$$\frac{di}{dt}=-A\cdot\omega\cdot\sin\omega t+B\cdot\omega\cdot\cos\omega t$$

$$L\cdot\left(-A\cdot\omega\cdot\sin\omega t+B\cdot\omega\cdot\cos\omega t\right)+R\cdot\left(A\cdot\cos\omega t+B\cdot\sin\omega t\right)=E_0\cdot\cos\omega t$$

$$\begin{cases}B\cdot L\cdot\omega+R\cdot A=E_0\\-A\cdot L\cdot\omega+R\cdot B=0\end{cases}\Rightarrow\begin{cases}A=\dfrac{R\cdot B}{L\cdot\omega}\\B=\dfrac{E_0\cdot L\cdot\omega}{L^2\cdot\omega^2+R^2}\end{cases}\Rightarrow\begin{cases}A=\dfrac{E_0\cdot R}{L^2\cdot\omega^2+R^2}\\B=\dfrac{E_0\cdot L\cdot\omega}{L^2\cdot\omega^2+R^2}\end{cases}$$

$$i(t)=C\cdot e^{-\frac{R}{L}t}+\frac{E_0\cdot R}{L^2\cdot\omega^2+R^2}\cos\omega t+\frac{E_0\cdot L\cdot\omega}{L^2\cdot\omega^2+R^2}\sin\omega t$$

$$t=0\Rightarrow\ 0=C+\frac{E_0\cdot R}{L^2\cdot\omega^2+R^2}\Rightarrow C=-\frac{E_0\cdot R}{L^2\cdot\omega^2+R^2}$$

$$i(t)=-\frac{E_0\cdot R}{L^2\cdot\omega^2+R^2}\cdot e^{-\frac{R}{L}t}+\frac{E_0\cdot R}{L^2\cdot\omega^2+R^2}\cos\omega t+\frac{E_0\cdot L\cdot\omega}{L^2\cdot\omega^2+R^2}\sin\omega t=$$

$$=\frac{E_0}{L^2\cdot\omega^2+R^2}\left(-R\cdot e^{-\frac{R}{L}t}+R\cdot\cos\omega t+L\cdot\omega\cdot\sin\omega t\right).$$

3) We solve the following complex differential equation for an electric circuit (Figure 6).

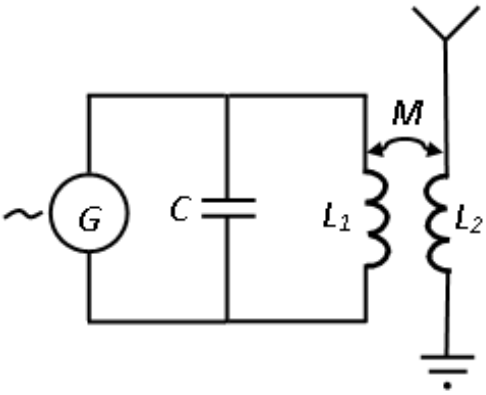

Figure 6. Simple electrical circuit

$$\begin{cases} u_1 = L_1 \dfrac{di_1}{dt} + M \dfrac{di_2}{dt} \\ u_2 = L_2 \dfrac{di_2}{dt} \end{cases}$$

$$u_L + u_C = E \;\; E = 0$$

$$L\frac{di}{dt} + \frac{1}{C}\int idt = 0$$

$$\frac{di}{dt} + \frac{1}{LC}\int idt = 0$$

$$\frac{d^2 i}{dt^2} + \frac{1}{LC}\frac{d}{dt}\int idt = 0$$

$$\frac{d^2 i}{dt^2} + \frac{1}{LC} i = 0$$

$$i(t) = e^{\lambda t}$$

$$\lambda^2 + \omega_0^2 = 0,\ \omega_0 = \frac{1}{\sqrt{LC}},$$

$\lambda = \alpha + \beta j$ - complex number is the solution of the characteristic equation, $i(t) = e^{\alpha t}\left(a\cos\omega t + b\sin\omega t\right)$, where $\alpha = 0$.

$$i(t) = e^0\left(a\cos\frac{1}{\sqrt{LC}}t + b\sin\frac{1}{\sqrt{LC}}t\right)$$

$$= \sqrt{a^2+b^2}\left(\frac{a}{\sqrt{a^2+b^2}}\cos\frac{1}{\sqrt{LC}}t + \frac{b}{\sqrt{a^2+b^2}}\sin\frac{1}{\sqrt{LC}}t\right) =$$

$$= A\left(\cos\varphi\cos\frac{1}{\sqrt{LC}}t + \sin\varphi\sin\frac{1}{\sqrt{LC}}t\right) = A\cos\left(\omega_0 t - \varphi\right),$$

where $A = \sqrt{a^2+b^2}$ is amplitude.

The abstraction of electric current indicates the importance of using a set of complex numbers in approaching the limits of human knowledge. This theory amazes any scientific researcher and calls for scientific research. Therefore, the issue of updating existing diagnostic structures requires a new era and new research in this field.

To sum up, it is not a secret to anyone that today the diagnostic systems of the electrical equipment of military vehicles do not meet the requirements of the time. Our main task now is to improve the existing diagnostic tools and create devices that meet the requirements of the time. The results of the current research show that there is a need for a new device. Therefore, we are working on creating a useful diagnostic model.

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