ASPECTS REGARDING THE INFLUENCE OF THE PARAMETERS R,L ON THE ELECTROMAGNETIC PROCESSES FROM THE ALTERNATIVE CURRENT CIRCUITS

POPESCU CRISTINEL, *„Constantin Brâncuşi" University of Tg-Jiu, Romania*
COZMA VASILE, *„Constantin Brâncuşi" University of Tg-Jiu, Romania*

Abstract : Given the fact that, in the electrical installations for producing transmission and distribution electricity, predominate and together with them, the resistance coil and capacitor as circuit elements,it is required a detailed analysis of them. The paper aims to highlight the influence of the parameters R, L on alternative electrical current circuits.

Keywords: current, resistance, circuit, electrical

1.INTRODUCION

The analisys of the alternative current circuits is more complicated than the analisys of continuous current circuits , due to the particular characteristics of the electromagnetic phenomena occurring in alternative current electric circuits.These particularities are are determined by the variation of magnetic and electric fields , coupled with current and voltage variation . Starting from these premises,we can say that the electromagnetic processes from the alternative current circuits can be described with the help of the basic parameters R , L and C.

For the analisys of the alternative current circuits is is necessary to establish the effective value of the size which is going to be determinated and the initial phase or phase difference to an another size, basic allowable .

In the analysis of the alternative current circuits it is necessary to use mathematical operations (addition , multiplication , derivation , integration) with sinewaves sizes and a significant amount of transformation of trigonometric functions . Inside these mathematical operations it is working with the current values of these parameters when using the basic laws of electrical circuits .

Due to the large simplicity , intuitive nature and ease of calculation the quantities we are interested in is it applied graphic method. By this method, the sinusoidal sizes are graphically represented by sinusoidals. To simplify the analysis of the alternative current circuits it is being used the phasor diagrams method. By this method, each size sine plot as rotating phasor (phasor radial) . Phasor module , according to the scale of representation is equal to the amplitude of the sinusoidal function . The phasor rotates around his origin with constant angular velocity corresponding to its pulse function .

Figure 1.a is represented by phasors , sinusoidal size [1] :

$$e = E_m \sin(\omega t + \Psi_e)$$

If at the moment t=0, the phasor $\underline{OM}$, with his size equal to E_m, makes the angle Ψ_e with the Ox axis, at the time t > 0 this angle is $(\omega t + \Psi_e)$. The projection of this angle on the Oy axis is[1]:

$$OM_y = E_m \cos\left[90^0 - \left(\omega t + \Psi_e\right)\right] = E_m \sin\left(\omega t + \Psi_e\right) = e$$

meaning that in any moment , this projection represents the actual value of the electromotive tension. Consequently, by its rotation , the $\underline{OM}$ phasor represents the variation in time of the electromotive tension. By an analogous procedure, are represented ,by the phasors ,all other sinusoidal sizes.

It admits that the rotating phasor to be represented in the position that it has at the time t=0 and it is called the image phasor of the sinusoidal size. In figure 1.*b* the sizes $u = U_m \sin(\omega t + \Psi_u)$ and $i = I_m \sin(\omega t + \Psi_i)$ are represented be phasors at the time. If two sizes sinusoidal pulsation **u** and **i** is identical , the two phasors rotate with the same angular velocity **Ω** .

Their mutual position , determined by the difference of the phases $\varphi = \Psi_u - \Psi_i$ does not change. This allows them to be considered as immobile modules phasors with modules equals to the actual value of the sinusoidal sizes .

Their arrangement in the xy plane is determined by the initial phase of one of the phasors conceivable base (for example, current phasor) and phase difference $\varphi = \Psi_u - \Psi_i$ (Figure 1. c) .

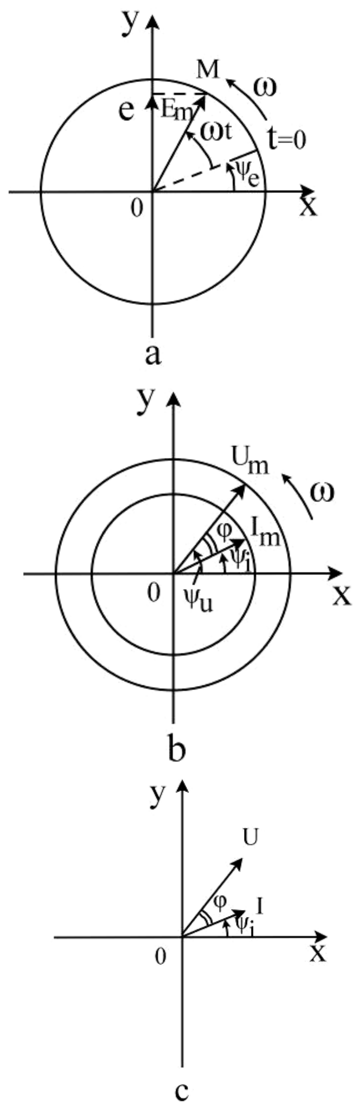

Fig.1. *a* Representation of phasors of the function: $e=E_m \cdot \sin(\omega t+\Psi_e)$

Fig.1. *b* Representation of phasors at the time t=0 phase angle

Fig.1. *c* Representation of momentary of current and voltage

The ensemble of the phasors representing the sinusoidal sizes that characterizes the practice of electrical circuit is called a phase diagram . It reflects the ratio between the amplitudes and sinusoidal sizes phases of acting on the circuit. In constructing the diagram , it is used that one of the phasors is allowed as basic . At the series connection of the elements , the core is the current phasor and at the circuits with elements connected in parallel the core is the voltage phasor.

2. LINEAR ELECTRIC ALTERNATIVE CURRENT CIRCUITS ANALISYS WITH ACTIVE RESISTANCE

If by the circuit with active resistance R (ideal resistor) sinusoidal current form $i = I_m \sin\omega t$ flows ,the active power loss in the circuit is determined according to Ohm 's law [1] :

$$u_R = R \cdot i = RI_m \sin\omega t = U_m \sin\omega t \quad (1.1)$$

From the expressions for the instantaneous values of current and voltage is observed that they are identical initial phase ($\psi_u = \psi_i = 0$), meaning that the phase difference between them is zero ($\varphi = \Psi_u - \Psi_i = 0$) .

In Figure 2 are plotted sinusoids current and voltage . They simultaneously reach their maximum and minimum values . From equation (1.1) it follows that the maximum and therefore the actual values of current and voltage are related by equality from Ohm's law [1] :

$$U_m = RI_m \text{ si } U = RI \quad (1.2)$$

When using mutual dependence of the conductance and active resistance (G = 1 / R) , expression (1.2) becomes [1] :

$$I_m = GU_m \text{ şi } I = GU$$

When building the phasor diagram , usually,the phasor current I is plotted on the abscissa axis at the appropriate scale , with size equal to the actual value of the current. Phasor voltage U is parallel to the phasor current I ($\varphi = 0$) and its size is equal to the actual value U = RI appropriate scale (Figure 2). Actual value of the power in the circuit is equal to the product of the instantaneous voltage and current values [1]:

$$p_R = u_R \cdot i = U_m I_m \sin^2\omega t = \sqrt{2}U\sqrt{2}I\frac{1-\cos 2\omega t}{2} = UI(1-\cos 2\omega t) \quad (1.3)$$

From equation (1.3) results that that the instantaneous power changes by a sinusoidal law from 0 to 2UI with double pulsation 2ω, compared to the current and voltage frequency(Figure 2) . It is only positive , because the current and voltage are all the same signs and their product at any point in time is positive. Furthermore, the instantaneous power has two components :

- A continuous UI;
- a sinusoidal variable with amplitude UI and double pulsation 2ω .

The average value of power p_R for a period is called the active power P and is determined by the expression [1] :

$$P = \frac{1}{T}\int_0^T p_R dt = UI = RI^2 \ [W] \quad (1.4)$$

The energy consumed in the circuit for a period is [1]:

$$W_R = \int_0^T p_R dt = UIT = RI^2T$$

that is, all the energy , which acts on the circuit turns into heat . The phenomena are similar to those in DC circuits .

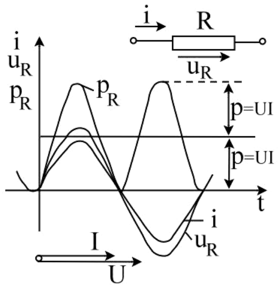

Figure 2[1]. Power variation circuit representation of based on the current values of the circuit (u, i)

It follows , however, some features. It is known that in continuous current ,the resistance of a conductor with length l , with the cross-sectional area S, and resistivity ρ (resistivity - the specific resistance of the material) , is determined by the expression [1] :

$$R = \rho \cdot \frac{l}{S}$$

From equation (1.4) is apparent , that in alternative current this resistance can be determined by the expression [1] :

$$R = \frac{P}{I^2}$$

In the general case , there are differences between the sizes of the two resistors . For this reason, the continuous current resistance of the conductor , commonly is called ohmic and in alternative current it is called active. The difference between the two resistors is explained by active resistance variation due to unequal alternating current density at different frequencies.

Thus , for example, at sufficient high frequency it is strongly manifested the discharge effect ,meaning that the current is distributed unevenly across the surface of the conductor , and in the center of his section , the current is practically zero. This effect does not have a strong showing at the frequency f = 50 Hz and it is neglected . For this reason ,at the industrial frequency, the active resistance of alternative current conductor is allowed equal to the ohmic resistance in continuous current.

3. LINEAR ELECTRIC ALTERNATIVE CURRENT CIRCUITS ANALISYS WITH INDUCTANCE

Considering a current passing through the circuit with the inductance L (ideal inductor) which varies according to the law $i = I_m \sin \omega t$. With this variation in coil ,it is induced the self-inductance electromotive tension $e_L = -L\frac{di}{dt}$, which is balanced with the applied voltage circuit ($u_L = -e_L$) . Momentary value of the voltage is [1] :

$$u_L = L\frac{di}{dt} = \omega L I_m \cos \omega t = U_m \sin\left(\omega t + \frac{\pi}{2}\right) \quad (1.5)$$

From the expressions for the instantaneous values of current and voltage results that the voltage exceeds in phase the current with the angle $\frac{\pi}{2}$,meaning that the phase difference between them is $\varphi = \Psi_u - \Psi_i = +\frac{\pi}{2}$. When current passes through the value zero (Figure 3) his speed of variation is greater , because of e_L respectively u_L, reaches its maximum value . Reverse ,the voltage is zero when the current reaches maximum value .From relation (1.5) it follows that the maximum and therefore the actual values of current and voltage are related by the equalities from Ohm's law [1] :

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$$U_m = \omega L I_m = X_L I_m \quad \text{şi} \quad U = \omega L I = X_L I$$

(1.6)

The size $X_L = \omega L = 2\pi f L$ is called the inductive reactance of the circuit and is measured in ohms [Ω] . Its mutual value is called susceptible and is measured in Siemens [S] . If we take into account the mutual dependency between B_L and X_L, equality (1.6) takes the form [1] :

$$I_m = B_L \cdot U_m \quad \text{şi} \quad I = B_L \cdot U$$

Characteristic for the inductive reactance is that it is frequency dependent For f=0 (in continuous current) X_L=0, and for $f \to \infty$, $X_L \to \infty$.

Actual value of the power circuit is [1] :

$$p_L = u_L \cdot i = U_m \cdot I_m \cdot \sin \omega t \cos \omega t = U \cdot I \cdot \sin 2\omega t \quad (1.7)$$

From equation 1.7 , it follows that momentary power varies as a sine law with double pulse 2 ω from the frequency of current and voltage (Figure 3). It becomes equal to zero , when the voltage or the current is passing through their zero values .

Its maximum value is $Q_L = UI = X_L I^2$ and is called inductive reactive power . It is measured in volt-amperes reactive (VAr) . Energy of magnetic field in the coil is [1] :

$$W_L = \frac{1}{2}Li^2 = \int_0^t UI\sin 2\omega t dt = -\frac{UI}{2\omega}\cos 2\omega t\Big|_0^t = \frac{UI}{2\omega}(1-\cos 2\omega t)$$
(1.8)

If it is considered that $U = \omega LI$ then the relation (1.8) takes the form [1] :

$$W_L = \frac{LI^2}{2}(1-\cos 2\omega t) \qquad (1.9)$$

From equation (1.9) it follows that the energy varies as a sine law with double pulsation 2ω besides the current and voltage frequency (Figure 3). The factor (the coefficient) $(1-\cos 2\omega t)$ has a value from 0 to 2, from which it follows that all the energy is positive and varies simultaneously with of the current in the circuit in the range of from 0 to $LI^2\left(\frac{LI_m^2}{2}\right)$.

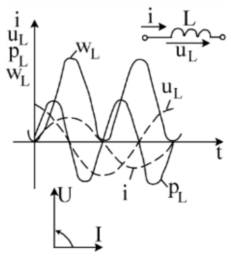

Figure 3[1]. Representation of the variation curve of power according to a double frequency sinusoidal law besides the current and voltage frequency

From Figure 3 it is observed that when the current the passes through the coil increases,the energy also increases . Power pL > 0 (i and uL are identical signs), meaning that that the energy is absorbed by the source and is momentary stored in the magnetic field of the coil.At reducing the current , the energy is also reduced. Momentary power in this case is negative (pL < 0) , which means that the energy released by the magnetic field of the coil to the source . Mean pL for a period that determines the active power in the circuit is zero [1] .

$$P = \frac{1}{T}\int_0^T p_L dt = 0$$

By this judgment is made continuous transfer of energy from the source to the coil and vice versa , without heat perform inverse transformation (P = 0) .

5.CONCLUSIONS

In the general case , there are differences between the size of the continuous current and alternative current of two resistors . For this reason, the continuous current resistance of the conductor ,is commonly called ohmic and in alternative current is called active . The difference between the two resistors is due to the change in active resistance of current , due to the unequal current density at different frequencies . Thus , for example, at sufficient high frequency it is strongly manifested the discharge effect ,meaning that the current is distributed unevenly across the surface of the conductor , and in the center of his section , the current is practically zero. This effect does not have a strong showing at the frequency f = 50 Hz and it is neglected . For this reason ,at the industrial frequency, the active resistance of alternative current conductor is allowed equal to the ohmic resistance in continuous current.

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6. REFERENCES

[1] Popescu C.,Cozma V ş.a.- *Electrotehnică şi maşini electrice*, ISBN 978-973-746-862-8,Ed. Sitech, Craiova, 2008.

[2] Popescu C., Cozma V ş.a. – *Materiale electrotehnice utilizate în construcţia maşinilor, aparatelor şi reţelelor electrice*, ISBN 978-606-11-2636-2,Ed. Sitech, Craiova, 2012.

[3] Cozma V., Popescu C, -*Electric transformers paralel working,* Annual of university of Mining and Geology St. Ivan Rilski, Bulgaria, pp.183-185, 2008.

[4] Cozma V, Panov V,Popescu C- *Maşini electrice*, *Maşini de curent continuu şi transformatoare,* ISBN 978-606-11-2637-8,Ed. Sitech, Craiova, 2012.