CONTROL OF ENERGY CONVERSION QUALITY IN ELECTRIC DRIVES *WITH* ASYNCHRONOUS MOTORS

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Abstract: *The task of control of energy conversion quality in electric* drives *with* asynchronous motors *which have a certain form of parameter of asymmetry acquired in operation or repair* is resolved. *The research for application of the principles developed for control of energy conversion quality in regulated AC electric drives are presented. The possibility of compensation of high-order harmonics of an electric motor's power absorbed and electromagnetic moment through control by the energy converter is shown. The principles proposed are extended to systems with thyristor voltage regulators in the stator, systems with frequency converters including an autonomous voltage inverter with a pulse-width modulation system for AC motor drives and thyristor excitation systems for synchronous motors, as well as to search optimization systems.*

Keywords: *Quality of energy conversion, control conversion of energy, AC electrical drive, energy converter.*

1. Introduction.

Electrical energy conversion quality is a recent term that has yet to find its place in the vocabularies of metallurgists, miners, transport workers and all producers who use electromechanical equipment composed of electric motors and energy converters. Another term is usually employed: "indicator – electric energy quality".

There are also standards applicable to electric energy quality [1], along with indicators of performance and efficiency of electrical equipment operation in the event of electric energy not corresponding to such standards [2]. Electrical drive systems consume electrical energy, converting it into useful work; during the conversion process, however, energy is distorted and harmonics of high orders of current and voltage appear in energy convertor output, caused by non-linearity of power circuits and generating non-sinusoidal currents: reactive elements – inductive and capacitive – installed in supplement, asymmetry of voltage due to disequilibrium of charge, etc. All this is well-known, and methods exist to reduce the factors listed above [3,10]. At the same time, however, an electric motor, as well as being a consumer of energy, is regarded as a good, electrically symmetrical electromechanical convertor: its phase currents are symmetrical and sinusoidal, and undulations of the electromagnetic torque and speed oscillations are almost non-existent. Meanwhile, any divergence in the design or calculation of the motor's parameters, resulting from repair or following operation over long periods, makes the motor a highly non-linear system and leads to production of non-sinusoidal currents, supplementary tangential forces and pulsating electromagnetic torques [4]. Such electromagnetic torques are the result of interaction between the various temporary harmonics of the main field and of fields resulting from temporary harmonics caused by static and rotor currents produced by the motor's new non-linear characteristics. The appearance of enormous and highly complex energy processes is also to be observed, characterised by instantaneous values of voltage, current and power dependent on time. It is therefore energy conversion quality which is first of all taken into consideration.With this, there does not exist currently any quality control of transformation energy in the electrical motors. In the same way the systems of indicators allowing the quantitative evaluation of the value of the energy transformation are absent today.

Taking into account the urgent need for the creation of a system of evaluation of the quality of transformation energy, and by holding account that the quality of energy does not have any absolute scale and being characterized not by a number but by a whole of various characteristics, We were proposed analytical coefficients describing the various aspects of a process - process of energy transformation. These coefficients are called "indicating quality of energy transformation" (IQCE) whose principles are given [7, 8, 9]. On the basis of coefficient and these indicators, it was proposed to employ it for the evaluation of the state of the electrical motors, which have a certain form of parameter of asymmetry acquired in operation or repair.

However, there is currently no single approach to generation of the energy conversion quality process.

The developed set of established indicators enables us to pass on to the subject of control of electrical energy conversion quality and to empower the consumer by the functions of regulating consumption patterns. This guarantees a positive solution to a whole range of problems:

- Ensuring efficient operation of electromechanical systems in limited-power networks.
- Ensuring efficient operation of electromechanical systems, taking account of the impact of the network's asymmetry and non-sinusoidality; [1].
- Reducing the impact of electromechanical systems with the divergence in the network's and other users' parameters;
- Minimising power losses, and reducing heat loss, noise and vibrations;
- Making available the technology required for start-up mode, recharging capacities, etc., as well as for electromechanical systems with divergences in size parameters;
- Ensuring electromagnetic compatibility and reduction of electromagnetic influence on biological entities and people.

Consequently, such an electromechanical system control can only do its job when the energy converter ensuring a specific mode of electrical drive not only converts energy but also controls its conversion quality. This, in brief, is the objective of this work, which seeks to formulate principles and means of control of energy conversion quality in AC electrical drive systems.

2. Research data and results:

Establishing indicators of poor energy conversion quality and creating a mathematical tool for its evaluation bring to light a number of means of control via the conversion process with the aim of reducing the components of the power and moment of the motor's electromagnetic torque, and of ensuring the equipment operates efficiently when faced with variations in factors influencing its normal operation.

The alternating power causes torque pulsation, speed oscillation and motor vibration. The general expression of the instantaneous power in a phase may be written in the form:

$$\begin{aligned} p(t) &= u(t)i(t) = \\ &= \sum_{m_a=0}^{M} I_{m_a} \cos(\Omega_{m_a} t) \sum_{n_a=0}^{N} U_{n_a} \cos(\Omega_{n_a} t) + \\ &+ \sum_{m_{\hat{a}}=0}^{M} I_{m_{\hat{a}}} \sin(\Omega_{m_{\hat{a}}} t) \sum_{n_{\hat{a}}=0}^{N} U_{n_{\hat{a}}} \sin(\Omega_{n_{\hat{a}}} t) + \\ &+ \sum_{m_{\hat{a}}=0}^{M} I_{m_{\hat{a}}} \sin(\Omega_{m_{\hat{a}}} t) \sum_{n_a=0}^{N} U_{n_a} \cos(\Omega_{n_a} t) + \\ &+ \sum_{m_a=0}^{M} I_{m_a} \cos(\Omega_{m_a} t) \sum_{n_b=0}^{N} U_{n_{\hat{a}}} \sin(\Omega_{n_{\hat{a}}} t) \end{aligned} \quad (1)$$

Where $Im_{\mathbf{a}}$, $Im_{\mathbf{b}}$, $Un_{\mathbf{a}}$, $Un_{\mathbf{b}}$ designate the sine and cosine amplitudes of the components of the currents' and voltages' polyharmonic signals.

And for three-phase electric motors:

$$p(t) = \sum_{j}^{A,B,C} u_j(t) i_j(t) \quad (2)$$

From expression (2) and taking account of expression (1), it follows that the instantaneous power is formed by the sum of the products of unique and distinct frequential components [5]. By transformation, (1) can be converted, in the form:

$$P(t) = \sum_{k=0}^{K} P_{k_0} + \sum_{k=2}^{M+N} P_{k_a} + \sum_{k=2}^{M+N} P_{k_в} \quad (3)$$

Where Pk_0; Pk_a; Pk_b – constant components of the active power and variable components of the instantaneous power (sine and cosine components respectively).

Equation (3) may seem somewhat complicated, if account is taken, for example, of the acquired asymmetry of the motor's electromagnetic parameters. In this case, there will not only be the magnetic field spectrum turning with different frequencies in the motor's air-gap, but also the spectrum of another non-circular field forming an inverse magnetic field.

The value of the inverse magnetic field may be reduced by carrying out harmonic composition of the stator's supply voltage.

The problem of control of energy conversion quality comes down to seeking out exactly these asymmetries and, above all, the non-sinusoidal voltages that satisfy the following condition:

$$\left\{ \sum_{k=2}^{M+N} P_{k_a} + \sum_{k=2}^{M+N} P_{k_b} \right\} \rightarrow min \quad (4)$$

Equation (4) may be solved in a number of different ways: by application of a corresponding voltage at the voltage regulator output, or at the frequency converter output in the case of electrical drives with asynchronous motors, or by application of a voltage at the excitation winding in the case of electrical drives with synchronous motors [6,12,13].

The solution to equation (4) may be formulated as follows:

$$p(t) = u(t)i(t) \quad (5)$$

On the other hand, the following convolution equation corresponds in the frequential field:

$$P(\omega) = U(\omega) * I(\omega), \quad (6)$$

Therefore, in order to accomplish deconvolution (inverse convolution) for a given power spectrum $P_{pr}(\omega)$

$$U^{*}(\omega) = P_{pr}(\omega) * I^{-1}(\omega) \quad (7)$$

(7) Enables definition of the spectrum and harmonics of the voltage signal sought for, enabling resolution of (3).

Indice (-1): Symbolic designation of the deconvolution operator.

In fact, the aim of deconvolution is to find the solution to the convolution equation:

$$P_{pr}(\omega) = U^{*}(\omega) * I(\omega) \quad (8)$$

While solving the above equation, it is necessary to take account of the fact that it is not always possible to solve the energy conversion quality equation by using law (4). The real character of energy conversion in a motor is determined by the electromagnetic torque $M_e = p_n \frac{\partial W_e}{\partial \gamma}$

Where, We – electromagnetic energy in the motor's air-gap

γ – Angle of rotor rotation

p_n – Number of pairs of poles.

Use of (4) is only possible if $J_{ed} >> J_e$,

Where J_{ed} – the electromechanical system's equivalent moment of inertia

J_e – Motor's moment of inertia

In the contrary case, in order to reduce speed oscillations and dynamic charges in the mechanical components of electromechanical systems, it is necessary to use the following equation (9)

$$\left\{ \sum_{k=2}^{M+N} M_{e.k_a} + \sum_{k=2}^{M+N} M_{e.k_b} \right\} \rightarrow min. \quad (9)$$

Taking account of (4) and (9), the following structures (figs.1 and 2) and paths for control (fig.3) may be proposed.

In figure 1, the following terms designate:

E.C. - Energy Converter;
AC.Motor - Asynchronous motor;
E.P.M. - electric power meter
E.T.C. - Electromagnetic torque calculator;
MI.SV.-Measuring instrument of state variables;
QC.EC. - Quality Controller of Energy Conversion.

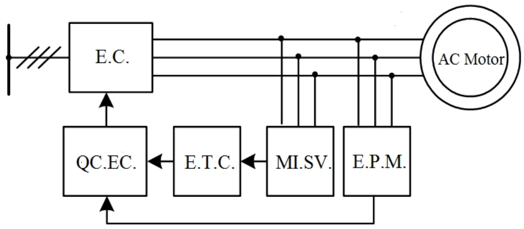


Fig 1: Functional diagram of the energy quality conversion control system with compensation for variable components of the torque's power

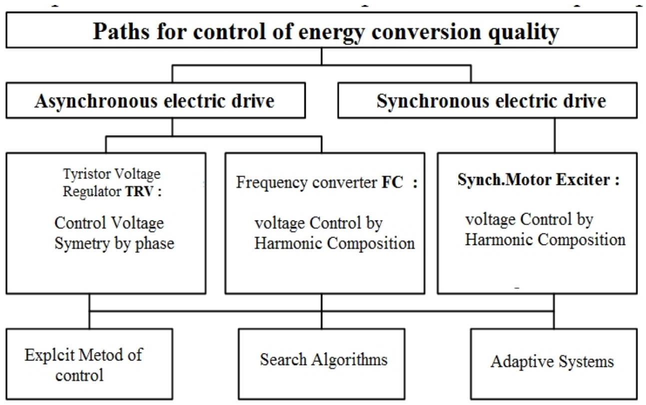


Fig.2: Paths for control of energy conversion quality

Let's consider some examples of control of energy conversion quality in nonlinear circuits.

3. The first case study: Electric circuit with a nonlinear active resistance

Supposing that it is a question of an electrical circuit composed of an active resistance (Fig.3). Where the active resistance is a non-linear function of current.

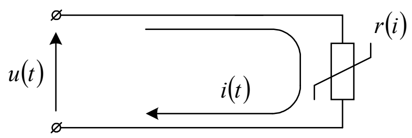


Fig. 3 - Electric circuit with a nonlinear active resistance

By supplying the nonlinear active resistance with a sinusoidal voltage waveform . Its Parameters are as follows:

$$u(t) = U_m \sin(\omega t) \tag{10}$$

Where $U_m = 300$ V - The amplitude of the first voltage harmonics. The Current in the circuit will have poly harmonic nature.

We consider the case of a harmonic compensation in an electrical circuit with a linear inductance which is a function of current:

$$i(t) = I_1 \sin(\omega t) + I_5 \sin(5\omega t). \tag{11}$$

Then, according to (5), the equation of instantaneous power will take the form.

$$p(t) = P_0 + P_2 \sin(2\omega t) + P_4 \sin(4\omega t) + P_6 \sin(6\omega t) \tag{12}$$

The time functions of current, voltage and power for 10 – 12 are shown in the figure 4.

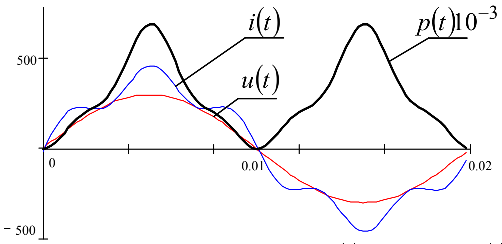


Figure 4. Voltage $u(t)$, current $i(t)$ and power $p(t)$ as function of time.

For equation (12), according to (4) all power harmonics to the order K > 2 must be compensated. The compensation equation will therefore be sought in form:

$$\sum_{k=4}^{M+N} P_k \to \min \tag{13}$$

In order to achieve condition (13), the sinusoidal voltage u*(t) must vary in accordance with law

$$u^*(t) = \sum_{n=1}^{N} U_{2n-1} \sin((2n-1)\omega t) \tag{14}$$

In the special case of N = 3, taking account of (11), the power supply voltage equation will only contain three harmonics:

$$u^*(t) = U_1 \sin(\omega t) + U_3 \sin(3\omega t) + U_5 \sin(5\omega t) \tag{15}$$

By solving equation (5) for (11) and (15), we obtain equation (13), for which M+N = 6, and which can be converted with the help of trigonometric transformations in a system of equations with power components.

We now have the equation system:

$$\begin{cases} U_1 I_1 + U_3 I_3 = P_0 \\ U_1 I_1 + U_1 I_3 - U_3 I_1 + U_5 I_3 - U_3 I_5 = 2P_2 \\ U_1 I_3 - U_3 I_1 + U_1 I_5 - U_5 I_1 = 2P_4 \\ U_3 I_3 - U_1 I_5 - U_5 I_1 = 2P_6 \\ U_3 I_5 + U_5 I_3 = 2P_8 \\ U_5 I_5 = 2P_{10} \end{cases} \tag{16}$$

In order to solve it, we rewrite (16) in the form of a matrix transposed in relation to the sine and cosine components :

$$\begin{array}{lclclcl} P_0 & = & U_{b1}(I_{b1}) & + & U_{b3}(I_{b3}) & + & U_{b5}(I_{b5}) \\ 2P_{a2} & = & U_{b1}(-I_{b1}+I_{b3}) & + & U_{b3}(I_{b1}+I_{b5}) & + & U_{b5}(I_{b3}) \\ 2P_{a4} & = & U_{b1}(-I_{b3}+I_{b5}) & + & U_{b3}(-I_{b1}) & + & U_{b5}(I_{b1}) \\ 2P_{a6} & = & U_{b1}(-I_{b5}) & + & U_{b3}(-I_{b3}) & + & U_{b5}(-I_{b1}) \\ 2P_{a8} & = & 0 & + & U_{b3}(-I_{b5}) & + & U_{b5}(-I_{b3}) \\ 2P_{a10} & = & 0 & + & 0 & + & U_{b5}(-I_{b5}) \end{array} \tag{17}$$

Solving (17) enables definition of the parameters of the harmonic composition of (15) necessary to compensation.

Generally speaking, methods for solving linear algebraic equation systems should be used, but in the case of a limited number of harmonics – for N = 3, for example – obtainment of an analytic solution is possible:

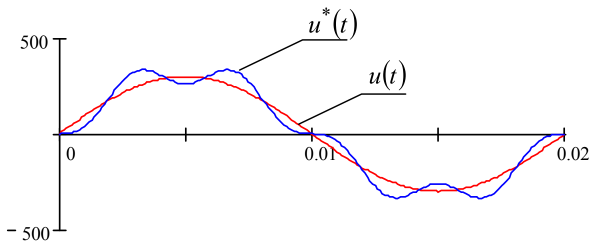
$$U_1 = P_z^{-1}(P_0 I_1 + P_0 I_3 - P_0 I_5 + P_2 I_3 - P_2 I_5) I_1$$

$$U_3 = P_z^{-1}\left(I_1 I_3 P_0 - I_3^2 P_0 + I_3 I_5 (2P_0 + P_2) - I_5^2 (P_0 + P_2) - I_1^2 (P_0 + P_2)\right)$$

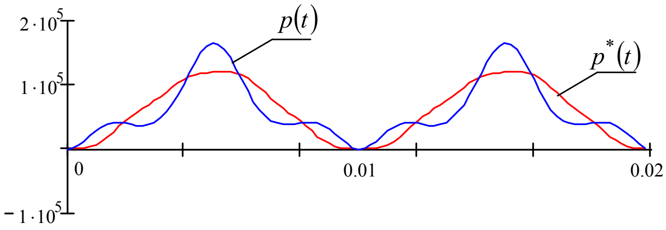
$$U_5 = P_z^{-1}\left(P_0\left(I_1 I_5 - I_1^2 - 2 I_1 I_3\right) + P_2\left(I_1^2 + I_3 I_5 - I_3^2\right)\right)$$

Where $P_z = I_3^2 + 2I_1^2 + I_1(I_3 - I_5)^2 + I_3 I_5 (2I_3 - I_5) - I_3^3$

Figure 5 shows variations in voltage and power depending on time before and after compensation.



a)



b)

Fig . 5. The original u(t)
and compensation u*(t) voltage – a),
The original p(t)
and compensation p*(t) power – b)

Harmonic composition of the original power and compensation power is shown in Figure 6.

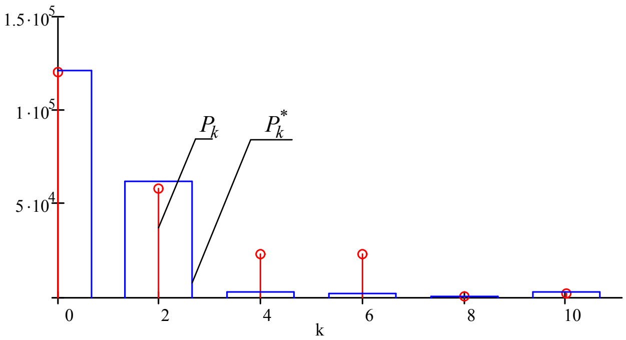


Figure 6. Harmonic composition of the original power and compensation power

4. The second case study: Electric circuit with a nonlinear inductance

Supposing that it is a question of an electrical circuit composed of an active resistance and an inductance connected in series [11]. Furthermore, the inductance is a nonlinear function of the circuit's current (Fig.7). The circuit's components' parameters are shown in table 1

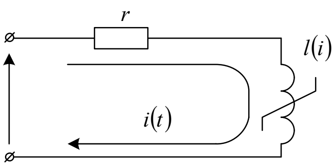


Figure 7 - Electric circuit with a nonlinear inductance

Nonlinear inductance is given in the form of model:

$$l(I) = d\left(g + \frac{1}{a + bI^{c}}\right) l_0 \tag{18}$$

Where a, b, c, d and g represent the model's coefficients and g = 0.255

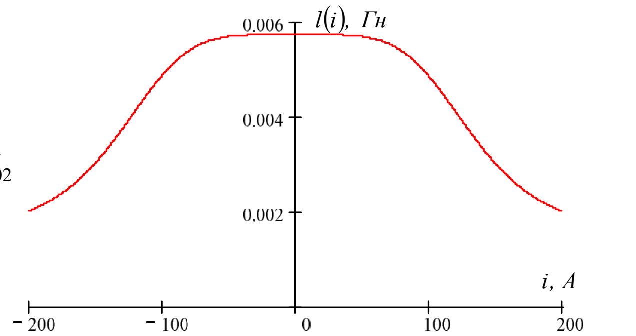


Fig. 8 shows the variation of the nonlinear inductance as a function of current

The table below shows the circuit parameters used including a nonlinear component:

Parameters	values
Amplitude of the power supply voltage's first harmonic, Um, V	311
Inductance, Lo, H	0.00573
Active resistance, r , Ом	0.312

The calculation is made under sinusoidal power supply voltage: u(t) = Um sin ωt
Temporal functions of current, voltage and power are shown in Figure 9.

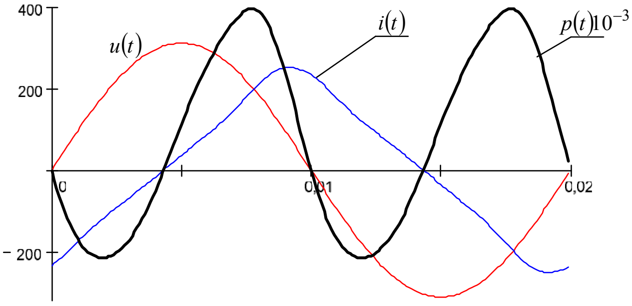


Fig. 9. Voltage, current and power as function of time.

Taking account of nonlinear inductance (18), the current is polyharmonic in character. This being so, the current equation, followed by the voltage and power equations, will be rewritten and analysed taking account of their sine and cosine components.

- For the current:

$$i(t) = \sum_{k=1}^{M} I_{k_a} + \sum_{k=1}^{M} I_{k_b} \tag{19}$$

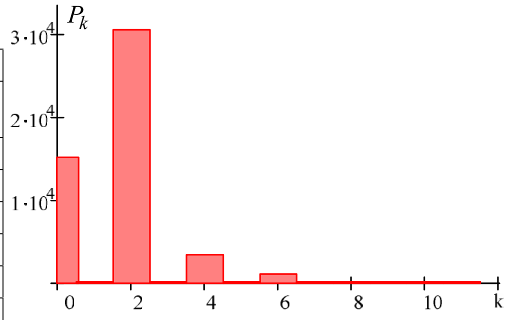
- For the power:

$$p(t) = P_{k_0} + \sum_{k=2}^{N+M} P_{k_a} + \sum_{k=2}^{N+M} P_{k_b} \tag{20}$$

The harmonic composition of the current and power (5) is shown in Table 2, and the harmonic spectrum in Figure 10.

Table 2: Sine and cosine components of the current in the circuit and the instantaneous power.

Current harmonics		
№ of harmonic	Cosine components	Sine components
1	-212.487	-48.419
3	-19.304	-19.151
5	-1.709	-6.755
7	0.407	0.232
9	-0.284	0.501
11	-0.147	0.024
Power harmonics		
№ of harmonic	Cosine components	Sine components
0	$1.506 \cdot 10^4$	0
2	$-4.553 \cdot 10^3$	$3.005 \cdot 10^4$
4	$-1.928 \cdot 10^3$	$2.737 \cdot 10^3$
6	$-1.087 \cdot 10^3$	329.233
8	-41.86	-107.485
10	74.18	21.318
12	7.509	27.174



b) Harmonic spectrum of the instantaneous power

Fig. 10. Harmonic spectrum

For equation (20), according to (4) all power harmonics must be compensated k > 2.

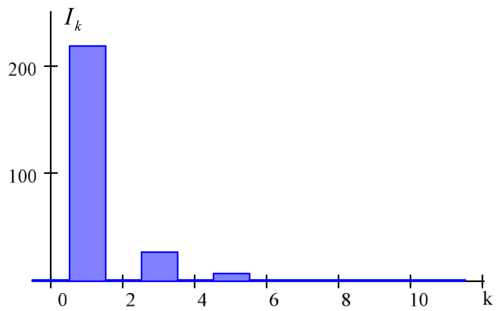
Thus, the compensation equation will be sought for in form:

$$\sum_{k=4}^{N+M} P_{k_a} + \sum_{k=4}^{N+M} P_{k_b} \rightarrow \min . \qquad (21)$$

Let us assume that voltage u*(t) necessary to fulfil condition (21) varies in accordance with law:

$$u^*(t) = \sum_{n=1}^{N} U_{2n-1} \sin((2n-1)\omega t)$$

The equation system for power components, composed of M+N+1 equations, may be expressed as a matrix for N = 3:



a) Harmonic Current Spectrum

$$\begin{array}{lclclclclclcl}
P_0 & = & U_{a1}(I_{a1}) & + & U_{b1}(I_{b1}) & + & U_{a3}(I_{a3}) & + & U_{b3}(I_{b3}) & + & U_{a5}(I_{a5}) & + & U_{b5}(I_{b5}) \\
2P_{a2} & = & U_{a1}(I_{a1}+I_{a3}) & + & U_{b1}(-I_{b1}+I_{b3}) & + & U_{a3}(I_{a1}+I_{a5}) & + & U_{b3}(I_{b1}+I_{b5}) & + & U_{a5}(I_{a3}) & + & U_{b5}(I_{b3}) \\
2P_{b2} & = & U_{a1}(I_{b1}+I_{b3}) & + & U_{b1}(I_{a1}-I_{a3}) & + & U_{a3}(I_{b1}+I_{b5}) & + & U_{b3}(-I_{a1}-I_{a5}) & + & U_{a5}(I_{b3}) & + & U_{b5}(-I_{a3}) \\
2P_{a4} & = & U_{a1}(I_{a3}+I_{a5}) & + & U_{b1}(I_{b3}+I_{b5}) & + & U_{a3}(I_{a1}) & + & U_{b3}(-I_{b1}) & + & U_{a5}(I_{a1}) & + & U_{b5}(I_{b1}) \\
2P_{b4} & = & U_{a1}(I_{b3}+I_{b5}) & + & U_{b1}(I_{a3}-I_{a5}) & + & U_{a3}(I_{b1}) & + & U_{b3}(I_{a1}) & + & U_{a5}(I_{b1}) & + & U_{b5}(-I_{a1}) \\
2P_{a6} & = & U_{a1}(I_{a5}) & + & U_{b1}(-I_{b5}) & + & U_{a3}(I_{a3}) & + & U_{b3}(-I_{b3}) & + & U_{a5}(I_{a1}) & + & U_{b5}(I_{b1}) \\
2P_{b6} & = & U_{a1}(I_{b5}) & + & U_{b1}(I_{a5}) & + & U_{a3}(I_{b3}) & + & U_{b3}(I_{a3}) & + & U_{a5}(I_{b1}) & + & U_{b5}(I_{a1}) \\
2P_{a8} & = & 0 & + & 0 & + & U_{a3}(I_{a5}) & + & U_{b3}(-I_{b5}) & + & U_{a5}(I_{a3}) & + & U_{b5}(-I_{b3}) \\
2P_{b8} & = & 0 & + & 0 & + & U_{a3}(I_{b5}) & + & U_{b3}(I_{a5}) & + & U_{a5}(I_{b3}) & + & U_{b5}(I_{a3}) \\
2P_{a10} & = & 0 & + & 0 & + & 0 & + & 0 & + & U_{a5}(I_{a5}) & + & U_{b5}(-I_{b5}) \\
2P_{b10} & = & 0 & + & 0 & + & 0 & + & 0 & + & U_{a5}(I_{b5}) & + & U_{b5}(I_{a5})
\end{array} \qquad (22)$$

Solving the redefined system (22) using standard methods for solving linear algebraic equations is difficult. This being so,let us try to solve the system with the help of the first transformation of the Gauss algorithm.

Our equation system (22) may be expressed as the following matrix: $\mathbf{I} \cdot \mathbf{U} = \mathbf{P}$ (23)

The system is multiplied by its transposed matrix

$$\mathbf{I}^T \cdot \mathbf{I} \cdot \mathbf{U} = \mathbf{I}^T \cdot \mathbf{P} \qquad (24)$$

We obtain: $\mathbf{G} \cdot \mathbf{U} = \mathbf{f}$

Where $\mathbf{G} = \mathbf{I}^T \cdot \mathbf{I}$ square matrix (Gram matrix) of (n x n) dimensions and non-degenerate symmetric quadratic form.

Following this, (22) is solved in the form:

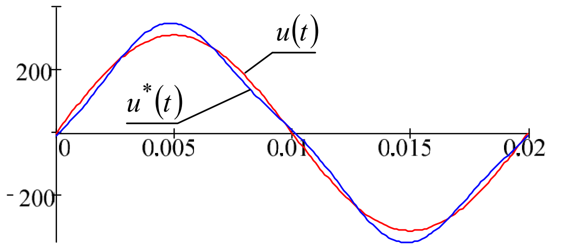
$$\mathbf{U}^* = \left(\mathbf{I}^T \cdot \mathbf{I}^{-1}\right) \cdot \mathbf{I}^T \cdot \mathbf{P} \qquad (25)$$

Solution results are shown in Table 3:

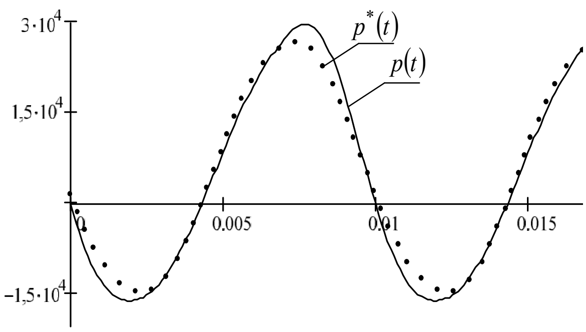
Table 3: harmonics of compensated voltage

Voltage harmonics		
№ of harmonic	Cosine components	Sine components
1	0.1	-319.563
3	-9.051	29.319
5	-0.193	0.763

Figure 11 shows variations in voltage and power depending on time before and after compensation.



a)



b)

Fig. 11. The original u(t) and compensation u*(t) voltage – a),
the original p(t) and compensation p*(t) power – b)

The harmonic composition and harmonic spectrum of initial and compensated power are shown in Figure12 and Table 4

Table 4: Sine and cosine components of instantaneous power before and after compensation

Power harmonics		
№ of harmonic	Before compensation	After compensation
0	$1{,}506 \cdot 10^4$	$1{,}506 \cdot 10^4$
2	30395,25	27946,03
4	3348,07	354,673
6	1136,64	703,882
8	115,35	131,16
10	77,18	78,413
12	23,16	17,357

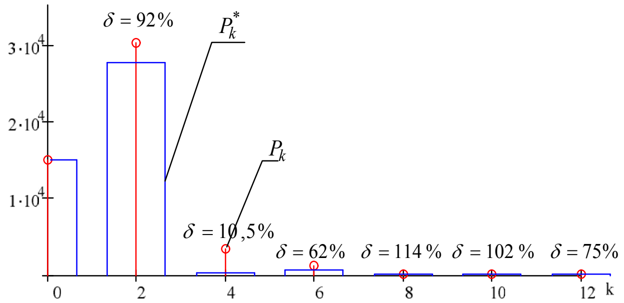


Fig. 12. Harmonic composition of the original power and compensation power

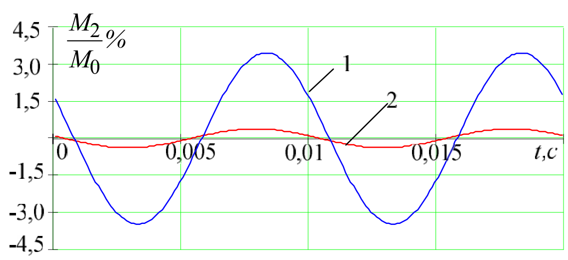
5. The third case study: Asynchronous motor

In the case of an asynchronous motor (Table 5), let us consider the process for compensation of the asymmetry of the stator windings' parameters.

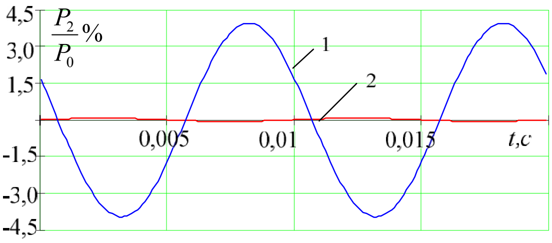
Table 5: Nominal data for the asynchronous motor

Parameters	values
Nominal power, KW	14
Nominal current, A	102.36
Nominal voltage, V	61
Nominal power factor	0.804
Nominal efficiency	0.858
Nominal speed, revolutions/minute	615
Number of pairs of poles	4
Overload capacity	2.8
Moment of inertia , Kg. м^2	24
Parameters of equivalent diagrams	
Active resistance of one stator phase,Ω	0.0427
Inductance of one stator phase, H	0.073

Simulation of the motor's operation was carried out using Matlab.
Results of simulation of various processes before and after compensation are shown in Figures 13 and 14:

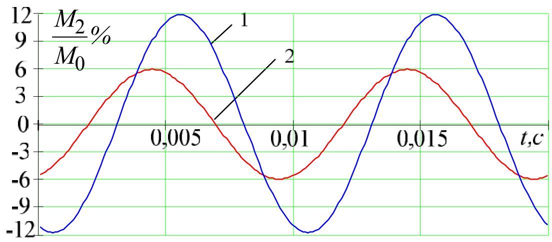


a)

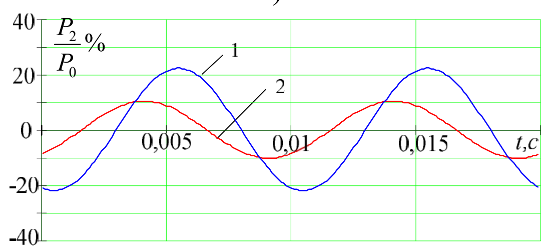


b)

Fig. 13: variation of the second harmonic of electromagnetic torque (a) and of power absorbed (b) of the asynchronous motor with 5% dissymmetry of stator active resistance, operating at a load of 0.5 Mn:
1 – with symmetrical power supply;
2 - with compensation of imbalance



a)



b)

Fig. 14: variation of the second harmonic of electromagnetic torque (a) and of power absorbed (b) of the asynchronous motor with 5% dissymmetry of stator leakage inductances, operating at a load of 0.5 Mn:
1 – with symmetrical power supply;
2 - with compensation of imbalance

6. Conclusion

It is certain that the base of natures of the quality of energy transformation should put back on the electromechanical and electromagnetic interactions fields and couples generated by the latter.

The absence of a clear evaluation of the quality of the processes of energy conversion in the electrical motors indicates the complexity of these processes on the one hand and the characteristics of posting of these processes in systems and equipment particular on the other hand.

That requires to find indicators suitable of the quality of energy conversion and also the development of the tools mathematical corresponding allowing their qualitative and quantitative evaluation. It can be a question, for example of the methods based on an analysis of the variables of state, but according to us, being given the nature of the energy conversion, the best results are obtained on the basis of analysis of the instantaneous power and the moment of the torque developed by the electrical motor.

It has been stated that instantaneous power is the main indicator characterising processes of energy conversion in electromechanical systems.

At the start, the method for control of energy conversion quality was put forward in the context of AC electrical drives with asynchronous motors. Control of energy conversion quality is carried out via the power converters supplying the statoric circuits of asynchronous motors, or the exciters in synchronous motors, and requires no other special systems or extra devices.

It has been shown theoretically that it is possible to compensate for high-order harmonics present in torque powers, the result of parametrical no-linearity and asymmetry in electromechanical systems.

The laws and algorithms proposed by the authors in the form of mathematical models show the possibility of reducing the variable components of power and those of the electromagnetic torque.

Practical work has established that the nature of parametrical variations in electric motors has no influence on the process of compensation of variable components.

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