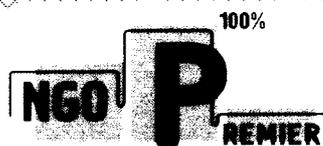


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Contents

Section 1. Biology	3
<i>Melibayeva Feruza Solijanovna, Kamalov Bakhodir Asamovich</i>	
Evaluation of the possibility of sewerage wastewater usage for irrigation in case of irrigation water shortage.	3
<i>Syrovaya Anna Olegovna, Grabovetskaya Evgeniya Romanovna</i>	
Experimental substantiation for new medicinal compositions design	6
Section 2. Geology	10
<i>Shermatov Magbut Shermatovich, Tadjibaeva Nadira Ruzievna</i>	
Influence of geotechnical factors on the increase of seismic intensity Bukhara city	10
Section 3. Demography and ethnography	14
<i>Gokova Olga Vladimirovna, Kiseleva Albina Musaevna</i>	
Comparative analysis of reproductive aims and the attitude of the youth to the institution of a marriage (case study some regions of RF, France and Germany)	14
Section 4. Mathematics	17
<i>Akhmedov Akrom Burkhanovich</i>	
Numerical solution of spectral problem for self-adjoint operators	17
Section 5. Medical science	22
<i>Davis Nikolay Aleksandrovich, Bektimirov Amir Mangu-Temirovich,</i> <i>Merkushkina Tatyana Aleksandrovna, Toychiev Abdurakhim Khodjiakbarovich,</i> <i>Parpieva Nargiza Nusratovna, Osipova Svetlana Olegovna</i>	
Influence of intestinal parasites on cytokine profile of patients with pulmonary tuberculosis, including cases complicated with aspergillosis.	22
<i>Ismailov Said Ibragimovich, Rashitov Murodjon Muxamedjanovich, Atadjanova Muborak Masharipovna,</i> <i>Allayarova Gulya Ibadullaevna, Muratova Shahlo Tahirjanovna, Yuldasheva Feruza Zafarjanovna,</i> <i>Elov Azizqul Aliqulovich</i>	
Results of epidemiological studies of prevalence of iodine deficiency disorders in Uzbekistan	25
Section 6. Pedagogy	28
<i>Mukhametzhanova Aigul Olzhabaevna, Beisenbaeva Aigul Merekeevna,</i> <i>Abisheva Sandugash Kanatovna, Bakina Yuliya</i>	
Improvement of professional training of future specialists	28
<i>Chumak Larisa Vladimirovna</i>	
Optimization of teaching work of pupils at lessons of foreign literature by means of professional skills of teacher	30
<i>Shalashova Marina Mihaylovna, Shevchenko Natalia Ivanovna</i>	
Professional development of teachers in Russia: searching for new models.	32
Section 7. Regional studies and socio-economic geography	34
<i>Abdulkasimov Ali, Davronov Kamoliddin, Davronova Robiyakhon</i>	
Anthropogenic oasis landscapes zarafshan valley, their ecological condition and optimization issues	34
<i>Abdulkasimov Ali, Yarashev Quvondiq Safarovich, Fazilov Azamat</i>	
Morphological structure and geoecology Samarkand oasis of Zarafshan valley	36
<i>Askerova Mekhriban Aydin, Tarverdiyev Tair Ramazan, Abdullayev Asadulla Qamzat</i>	
Elektromagnetic radiation sources and their neqative impact on the human bodu	39
<i>Kadirov Murodillo Aslamovich</i>	
Economic, geographical and historical background of the formation of a network of sites of Samarkand region.	41
<i>Yarashev Quvondiq Safarovich</i>	
Researching the paragenetic landscape complexes and separating them into taxonomic units (in the example of Surkhandarya intermountain depression)	42
Section 8. Agricultural sciences	45
<i>Ashirov Bakhtiyor Muradovich</i>	
The dependence of red desert pedigreed cows to the genotype of dairy productivity	45
<i>Buriev Hasan Chutboevich, Nazarov Khudayberdi Kuydimuratovich</i>	
Phenological characteristics of plants and seed yield of oilseed flax in Uzbekistan	47
<i>Ruziboev Nuraddin Rakhimovich</i>	
Productive qualities of cows of red — steppe breed in the conditions of hot climate.	50
Section 9. Technical sciences	52
<i>Amirov Sultan Fayzullaevich, Babanazarova Nargisa Kamilovna</i>	
Research of dynamic operating mode of wide-range current transformer.	52

Section 9. Technical sciences

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Research of dynamic operating mode of wide-range current transformer

Abstract: The current given in article results of research of a dynamic mode of the developed widely range transformer at impact on its entrance of the current consisting from sinusoidal and periodical components.

Keywords: current transformer, sinusoidal and aperiodic components, periodic component, forced component, expansion theorem, wide-range CT

The dynamic operating mode of current transformers (CT) arises at jumping of operating modes of objects of operation of power systems (PS) and electric technological installations (ETI)¹. Practically widely applicable model of primary current is the expression consisting of the sum of sinusoidal and aperiodic component of input signal². In this connection we research dynamic characteristics of developed wide-range CT — control system element at its connection to the current source representing the sum of sinusoidal and aperiodic components³.

For research of operation of developed wide-range CT in dynamic mode we will use the mathematical model, resulted in⁴. After simple conversions it will assume the following:

$$T \frac{di_2}{dt} + i_2 = (T - T_2) \Delta \frac{di_1}{dt}, \quad (1)$$

Where — $T = \frac{L_{E0} + L_{E02}}{R_{E2}}$ constant of time of the contour formed by branches of the secondary current and magnetization, sec; — $T_2 = \frac{L_{E2}}{R_{E2}}$

constant of time of branch of secondary current, sec; — $R_1(\alpha) = \rho \frac{l_2(\alpha)}{S} = \rho \frac{\pi r}{S} \alpha$, $R_2(\alpha) = \rho \frac{l_1(\alpha)}{S} = \rho \frac{\pi r}{S} (180^\circ - \alpha)$ electric resistance of ring elements with length $l_1(\alpha)$, $l_2(\alpha)$ and cross-section section S ; — ρ resistivity of material of ring elements — $R_{II}(\alpha) = \rho \frac{l_{II}}{S} = \rho \frac{2r}{S}$ resistivity of diametrical crosspieces of ring elements; $\Delta = \frac{R_2(\alpha) - R_1(\alpha)}{R_1(\alpha) + R_2(\alpha) + R_{II}}$.

Substituting in last differential equation expression $i_1 = I_{m1} \sin(\omega t + \psi_1) + I_{a1} e^{-t/T_1}$, we will receive:

$$T \frac{di_2}{dt} + i_2 = (T - T_2) \omega \Delta I_{m1} \cos(\omega t + \psi) - \frac{\Delta I_{1a.0}}{T_1} e^{-\frac{t}{T_1}} (T - T_2). \quad (2)$$

The solution of the differential equation (2), i.e. finding $i_2(t)$, will be realized by the operational method⁵. At initial conditions $i_2(0_-) = i_2(0) = 0$, $i_1(0_-) = i_1(0) = 0$, $I_{1a.0} = -I_{m1} \sin \psi$, equation (2) in the operational form has the following state:

$$TpI_2(p) + I_2(p) = \frac{\omega(T - T_2) \Delta I_{m1} (p \cos \psi - \omega \sin \psi)}{p^2 + \omega^2} - \frac{\Delta I_{1a.0} (T - T_2)}{T_1 (p + \frac{1}{T_1})}$$

Or

$$I_2(p) = \frac{\omega(T - T_2) \Delta I_{m1} p \cos \psi}{(1 + pT)(p^2 + \omega^2)} - \frac{\omega^2(T - T_2) \Delta I_{m1} \sin \psi}{(1 + pT)(p^2 + \omega^2)} - \frac{\Delta I_{1a.0} (T - T_2)}{(1 + pT)(1 + pT_1)} = \frac{H_1(p)}{G_1(p)} - \frac{H_2(p)}{G_1(p)} - \frac{H_3(p)}{G_1(p)}. \quad (3)$$

Originals of components of the operational current are on the basis of expansion theorem⁶. Here we will only show the resultant expression of original of the secondary current according to (3):

$$i_2(t) = \frac{\omega(T - T_2) \Delta \cdot I_{m1}}{\sqrt{1 + \omega^2 T^2}} \sin(\omega t + \psi + \phi) - \frac{\omega(T - T_2) \Delta \cdot I_{m1} e^{-\frac{t}{T}}}{\sqrt{1 + \omega^2 T^2}} \sin(\psi + \phi) + \frac{T - T_2}{T - T_1} \Delta \cdot I_{1a.0} e^{-\frac{t}{T_1}} - \frac{T - T_2}{T - T_1} \Delta \cdot I_{1a.0} e^{-\frac{t}{T}} = i_{2np}(t) + i_{2a}(t) = i_{21}(t) + i_{22}(t) + i_{23}(t) + i_{24}(t). \quad (4)$$

The magnetizing current according to $i_1(t) = i_0(t) + i_2(t)$ is defined as

¹ Afanasyev Y. V., Adonyev N. M., Kibel V. M., Sirota I. M., Stogniy B. S. Current transformer. – L: Energoatomizdat, 1989. – P. 417.

² Stogniy B. S., Kirilenko A. V., Puylo G. P. and other. Modeling and automation of designing of current measuring converter/Executive editor Rogoza V. V. – Kiev: Naukova dumka, 1989. – P. 267.

³ Patent of Republic of Uzbekistan. № 03858. Current transformer/Amirov S. F., Halikov A. A., Hushbokov B. H., Shoyimov Y. Yu., Balgaev AD//Official bulletin 2009. – № 1.

⁴ Afanasyev Y. V., Adonyev N. M., Kibel V. M., Sirota I. M., Stogniy B. S. Current transformer. – L: Energoatomizdat, 1989. – P. 417.

⁵ Demirchyan K. S., Neyman L. R., Korovkin N. V., Chechurin V. L. Theoretical bases of electrical engineering: In 3 vol. Textbook for HEI. Edit. 4 – St. Petersburg: Peter, 2006. – P. 576

⁶ Ibidem.

$$i_0(t) = i_1(t) - i_2(t) = \Delta I_{m1} \sin(\omega t + \psi) - \frac{\omega(T-T_2)\Delta I_{m1}}{\sqrt{1+\omega^2 T^2}} \sin(\omega t + \psi + \phi) + \frac{\omega(T-T_2)\Delta I_{m1} e^{-\frac{t}{T}}}{\sqrt{1+\omega^2 T^2}} \sin(\psi + \phi) - \frac{T_1-T_2}{T-T_1} \Delta I_{1a0} e^{-\frac{t}{T_1}} + \frac{T-T_2}{T-T_1} \Delta I_{1a0} e^{-\frac{t}{T}}. \quad (5)$$

The analysis of components of the secondary current. The first term of the right side of equation (5) represents the forced sinusoidal component of a transitive secondary current. The second term is free aperiodic component of the secondary current, which during the initial moment (at $t=0$) of transient compensates periodic component of the secondary current. The analysis of the equation (5) shows that the second summand at the moment of switching is equal to initial value of the general aperiodic component of the secondary current $i_{2a,0}$.

The third summand is forced aperiodic component of the secondary current. The fourth summand is free aperiodic component, compensating third summand at the moment of switching. Components $i_{22}(t)$ and $i_{24}(t)$ also become isolated in a contour formed by branches of the secondary current and magnetization of a CT and fade from time constant T .

Fading of the component $i_{23}(t)$, as well as a primary current i_{1a} , is defined by time constant T_1 . Here at $L_{E2} = 0$, i.e. purely active loading branch, and at $\psi = 0$ component $i_{22}(t) = 0$.

Analyzing the equation (5), we can be sure that at $t=0$, i.e. during the initial moment of transient $i_2(0) = 0$, and at $t=\infty$ will be $i_2(\infty) = \frac{\omega(T-T_2)}{\sqrt{1+\omega^2 T^2}} \Delta I_{m1} \sin(\omega t + \psi + \phi)$, i.e. to equally established value of the current $i_2(t)$. Signs of components $i_{22}(t)$ and $i_{24}(t)$ depend on the parity between time constants T_1, T_2, T . In control systems of EES and ETU in most cases performed conditions $T_1 > T_2$ ¹. If, besides, there is $T = T_1$, and amplitude of a variable component of primary current in a transitive mode exceeds amplitude of a current of normal mode, then current component $i_{23}(t)$ will be opposite to the sign of aperiodic component of a primary current i_{1a} .

From the equation (5) we can see that at any moment the secondary current of the CT $i_2(t)$ differs from its primary current in value of magnetizing current. At $t=\infty$ periodic and aperiodic components of magnetizing current, according to the equation (5), are equal to zero and all primary current will be transformed to the secondary chain of CT. At $T = T_2$, i.e. $L_{E0} = 0$, all primary current passes on magnetization branches, and current $i_2(t) = 0$. In actual conditions distribution of periodic components of currents between magnetization branches and the secondary current depends on parity between full resistances of these branches².

At performance of condition $i_1(0_-) = i_1(0) = 0$ we have

$$i_{2a}(0_-) = -\frac{\omega(T-T_2)\Delta I_{m1}}{\sqrt{1+\omega^2 T^2}} \sin(\psi + \phi),$$

which is equal on value and opposite to the sign of initial current $i_{21}(t)$. If $T > T_1$, so in process of current fading the third $i_{1a}(t)$ component of the secondary current starts to influence more strongly than its second and fourth components as they fade more slowly. On fig. 1 are resulted curve changes in time $i_{2a}(t)/I_{m1}$, put to amplitude of periodic component of the primary current ΔI_{m1} at different values of T_1 ; and on fig. 2 are resulted curves $i_0(t)$ at $T_1 = 0,1$ sec, $T_2 = 0,016$ sec, $\psi = 30^\circ$ and different values T ;

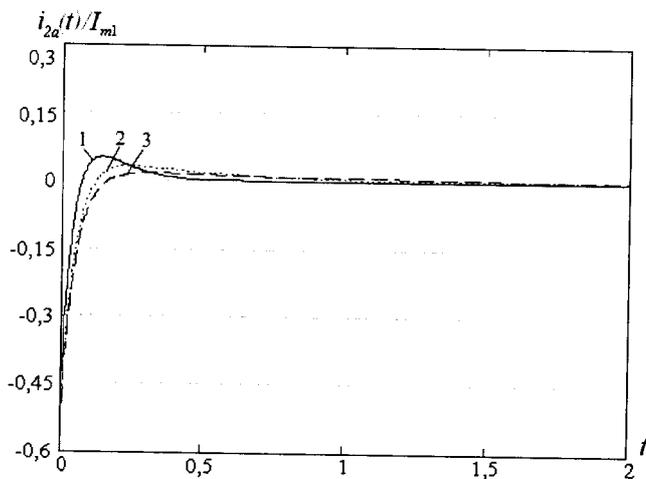


Fig. 1. Curves, $i_{2a}(t)/I_{m1}$ $T_1 = 0,05$ $T_2 = 0,016$, $\psi = 30^\circ$ at the different values: 1 - $T = 1$ sec; 2 - $T = 0,4$ sec; 3 - $T = 0,1$ sec

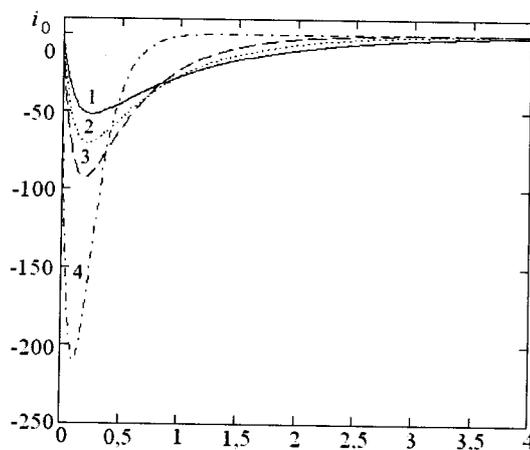


Fig. 2. Curves at $i_0(t)$ $T_1 = 0,1$, $T_2 = 0,016$, $\psi = 30^\circ$ at the different values T : 1 - $T = 1$ sec; 2 - $T = 0,7$ sec; 3 - $T = 0,5$ sec; 4 - $T = 0,015$ sec

The resultant aperiodic component $i_{2a}(t)$ decreases and during some moment of time even changes the sign. Further the current i_{2a} reaches negative maximum and gradually abates to zero. The resultant aperiodic component of current $i_{2a}(t)$ has maximum value at $t=0$, but in all cases it cannot exceed amplitude of the periodic component I_{m2} .

Thus, the analysis of components of the secondary current in a dynamic operating mode of developed wide-range CT has shown that the first term represents the forced sinusoidal component, and the second term represents free aperiodic component, compensating the periodic component of the secondary current. The third summand is the forced component, and the fourth summand is free aperiodic component, compensating third summand at the moment of switching. Also was established that signs of the second and fourth components depend on parity between constants of time of primary, secondary chains and magnetization chains.

¹ Afanasyev Y. V., Adonyev N. M., Kibel V. M., Sirota I. M., Stogniy B. S. Current transformer. - L: Energoatomizdat, 1989. - P. 417.

² Stogniy B. S., Kirilenko A. V., Puylo G. P. and other. Modeling and automation of designing of current measuring converter/Executive editor Rogozha V. V. - Kiev: Naukova dumka, 1989. - P. 267.

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3. Patent of Republic of Uzbekistan. № 03858. Current transformer/Amirov S. F., Halikov A. A., Hushbokov B. H., Shoyimov Y. Yu., Balgaev AD//Official bulletin 2009. – № 1.
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The method of determining design value of a combination separator

Abstract: Scientific development after separation and fractionation of grain of wheat is given in article. The received results allow to investigate and define one of the key design data of the car for separation and fractionation of grain.

Keywords: fractionation, wheat, separation, efficiency.

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Методика определения конструктивных параметров комбинированной машины для сепарации и фракционирования зерна

Аннотация: В статье приведены научные разработки по сепарированию и фракционированию зерна пшеницы. Полученные результаты позволяют исследовать и определять один из основных конструктивных параметров машины для сепарации и фракционирования зерна.

Ключевые слова: фракционирование, пшеница, сепарация, эффективность.

Недостатком очистительных машин является низкая эффективность разделения и отсутствие очистки от примесей. Однако известное устройство не обеспечивает достаточную сепарацию сыпучих продуктов, в частности зерна и зернопродуктов¹.

Для этой цели нами предлагается комбинированный сепаратор для очистки зерна в мукомольно-крупяной, комбикормовой и других отраслях промышленности. Комбинированный сепаратор повышает эффективность очистки и сепарации сыпучих продуктов, в частности зерна и зернопродуктов на желаемое количество фракций.

Пыль и легкие частицы (соломистые и другие примеси), которые меньше массы зерна удаляются из камеры сепарации аспирационными каналами путем всасывания. Оставшаяся зерновая примесь, попадая на поверхность наклонной перфорированной полки просеивается. Из-за того, что размеры отверстия перфораций больше, чем размеры зерен, то зерна проходят через отверстия и подаются к питающему валу. При этом другие крупные примеси (соломы, камни и др.), перемещаясь по поверхности наклонной перфорированной полки, через выходное окно поступает в емкость для сбора крупных тяжелых примесей.

Одним из основных механизмов новой двух этапной комбинированной машины для сепарации и фракционирования зерна являются питающий валик и направляющей лоток, которые в свою очередь определяют дальнейший технологический процесс работы машины, то есть очистки и фракционирования зерна по массам². При вылете из питающего валика зерновая смесь будет иметь одинаковую начальную скорость v_0 , вектор которой лежит на плоскости Oxy и направлен под некоторым углом β к оси Ox (рис. 1). Направляющий лоток установлен с возможностью регулирования угла наклона в пределах: $\beta = 0^\circ \div 45^\circ$. Специальный механизм регулирования угла наклона, направляющего лотка, позволяет его установить на требуемую величину.

При полете на частицу действуют сила тяжести $m_i g$, где m_i – масса i – частицы, g – ускорение свободного падения и $k\dot{x}$ – сопротивление воздуха, пропорционально первой степени скорости.

Уравнение движения произвольной частицы массой m_i ($i = 1, \dots, n$) в проекции на ось Ox имеет вид

$$m_i \ddot{x} = -k\dot{x}, \text{ или } \ddot{x} = -\frac{k}{m_i} \dot{x}. \quad (1)$$

После некоторых преобразований определим расстояние от начала координат до точки, когда частица массой m_i поднимется на максимальную высоту h (см. рис. 1)

$$s = \frac{V_0^2 \cdot \sin 2\beta}{\frac{2k}{m_i} (V_0 \cdot \sin \beta + \frac{m_i \cdot g}{k})} + R, \quad (2)$$

где, R – радиус барабана.

Установлено, что расстояние от начала координат до точки, когда частица массой m_i поднимется на максимальную высоту h прямо пропорционально начальной скорости массы и угла подъема направляющего лотка, обратно пропорционально коэффициенту сопротивления воздуха. На рис. 2 приведена график изменения расстояния полета зерновой смеси S от начала координат

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