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ВИМІРЮВАННЯ ТЕМПЕРАТУРИ ЗЕРНОПРОДУКТІВ ШУМОВИМ МЕТОДОМ

Показана можливість вимірювання температури зернових продуктів з використанням їх власного теплового випромінювання. Запропоновані функціональна схема та алгоритм вимірювання, які забезпечують виключення впливу зміни опору досліджуваного об'єкту при коливаннях вологості та мінімізацію неідентичності підсилювальних елементів схеми.

Відомо, що важливим аспектом зберігання зернопродуктів є контроль температури в заповненій частині зерносховища. Використовувані для цього перетворювачі (терморезистори, термомпари та ін.) як правило надають можливість лише вибіркового точкового контролю. Для отримання картини просторового об'ємного розподілу температури необхідно використовувати велику кількість перетворювачів, що викликає проблеми їх розташування, зменшує надійність системи контролю. В таких умовах доцільним є використання термошумових методів вимірювання, які забезпечують можливість об'ємного контролю температури та знаходять широке застосування в техніці і науці. Однією з головних переваг шумового вимірювання температури є відсутність датчиків, що перетворюють температуру у електричний сигнал [1]. При шумових вимірюваннях визначають середньоквадратичне значення (СКЗ) напруги теплового шуму, яке пропорційне термодинамічній температурі досліджуваного об'єкта.

Основна проблема використання шумових методів полягає у залежності результатів вимірювання від електричного опору об'єкта, наслідком чого є відносно невисока точність вимірювання. Опір зернових продуктів, як відомо, суттєво залежить від їх вологості.

Для виключення впливу опору в алгоритм роботи вимірювача вводять додаткові операції обробки сигналів [2, 3], однак, повністю компенсувати похибку в процесі вимірювання неможливо, а неідентичність характеристик перетворювачів обумовлює додаткову похибку вимірювання. Авторами запропоновано функціональну схему та алгоритм роботи шумового вимірювача температури зернових продуктів, в якому усунути перераховані вище недоліки. Електрична функціональна схема шумового вимірювача температури наведена на рис. 1.

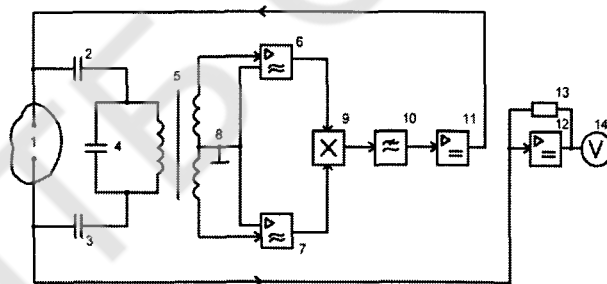


Рис. 1. Електрична функціональна схема шумового вимірювача температури зернопродуктів.

Зерно, температуру якого потрібно вимірювати, умовно показане позицією 1. Схема складається з роздільних конденсаторів 2 і 3, конденсатора 4, трансформатора 5, ширококутових підсилювачів 6 і 7, загальної шини 8, перемножувача 9, фільтра нижніх частот 10, підсилювача постійної напруги 11, операційного підсилювача 12, постійного резистора 13 і вольтметра 14.

В об'єкті контролю 1, з температурою T_x , завжди присутній тепловий шум, викликаний флуктуаціями елементарних носіїв електричного заряду. Спектр теплового шуму досить широкий: від низьких до високих частот. Однак, напруга на резонансному контурі з конденсатора 4 і індуктивності трансформатора 5 визначається тільки тими коливаннями, які потрапляють в смугу пропускання цього контуру. Резонансну частоту паралельного коливального контуру обирають в діапазоні частот 100 - 300 кГц, в якому відсутні низькочастотні шуми типу фліккер-шуму, а високочастотні електромагнітні наводки ще невеликі.

За високої добротності еквівалентний опір коливального контуру набагато більший за опір об'єкта 1. Тому СКЗ шумової напруги визначається формулою Найквіста:

$$\bar{U}_1 = \sqrt{4kT_x \Delta f R_0}, \quad (1)$$

де k - постійна Больцмана; Δf - смуга частот спектру теплових шумів, що виділяються коливальним контуром; R_0 - опір провідного об'єкта.

Шумова напруга (1) трансформується у вторинну обмотку трансформатора 5 і далі підсилюється широкосмуговими підсилювачами 6 і 7. Підсилені середньоквадратичні напруги з урахуванням власних шумів підсилювачів набувають вигляду:

$$\bar{U}_2 = \sqrt{4K_1^2 K_2^2 \bar{U}_1^2 + \bar{U}_{ш2}^2}, \quad (2)$$

$$\bar{U}_3 = \sqrt{4K_1^2 K_3^2 \bar{U}_1^2 + \bar{U}_{ш3}^2}, \quad (3)$$

де K_1 - коефіцієнт трансформації трансформатора 5; K_2 і K_3 , $\bar{U}_{ш2}$ і $\bar{U}_{ш3}$ — коефіцієнти підсилення підсилювачів 6 і 7 та СКЗ їх власних шумів відповідно.

При перемноженні напруг (2) і (3) слід врахувати, що власні шуми підсилювачів 6 і 7, які мають широкую смугу пропускання, між собою некорельовані, тому їх усереднений добуток дорівнює нулю. В той же час шумові напруги від об'єкта 1, отримані на обмотках трансформатора 5, залишаються корельованими. В результаті середній квадрат шумової напруги на виході перемножувача визначається тільки тепловими шумами зернопродукту:

$$U_4^2 = K_1^2 K_2 K_3 S U_1^2, \quad (4)$$

де S — крутість перетворення перемножувача 9.

Напругу (4) усереднюють фільтром нижніх частот 10, виділену постійну складову подають на вхід підсилювача постійної напруги 11. Підсилену напругу через досліджуваний об'єкт подають на підсилювач 12, охоплений від'ємним зворотним зв'язком через резистор 13 з опором R .

При послідовному включенні операційного підсилювача 12 з досліджуваним об'єктом його коефіцієнт підсилення K_6 визначається виразом:

$$K_6 = R/R_0.$$

Напруга (4), після підсилення набуває вигляду

$$U_6 = 4kK_1^2 K_2 K_3 K_4 K_5 S \Delta f R T_x. \quad (5)$$

Як видно з виразу (5), в результаті підсилення в функції перетворення відбулося заміщення опору досліджуваного об'єкта R_0 опором постійного резистора R ланцюга зворотного зв'язку підсилювача 12. В результаті виключається вплив опору R_0 зернопродукту, а відповідно, і його вологості, на результат перетворення температури T_x на постійну напругу U_6 , яка вимірюється вольтметром 14.

Завдяки використанню підсилювачів 6 і 7 з широкою смугою пропускання усереднений добуток власних шумів підсилювачів прагне до нуля, що забезпечує вимірювання температур при низькоінтенсивному тепловому шумі зернопродукту. Необхідне обмеження смуги частот теплового шуму, що виділяється, здійснюється резонансним контуром, що виключає кореляцію власних шумів підсилювачів.

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INCREASING OF EXACTNESS MEASURING SENSORS IN CONTROL SYSTEMS BY TECHNOLOGICAL PROCESSES

In paper presented ways to increasing exactness of technological parameters control for capacity sensors in control system by technological processes.

Sensors based on resonant circuit are used in automatic control system by the technological processes for food and grain processing spheres of industry. For example, sensors for raw material (processing products) control of humidity and loading in technological capacities. The dielectric control method is more appropriate for this purpose [1]. The resonant methods of measuring of electric capacity are widespread enough [2]. Differential method of small capacities measuring on the lateral branch of resonant curve used for decreasing of the measuring errors related to instability of frequency and amplitude of generator voltage and instability of parameters oscillating circuit [4, 5]. Well-known devices [3] don't provide high exactness for measuring of electric circuit resonant frequency.

We may to promote exactness of resonant frequency measuring for electric network by exception of error in the indication of phase change $\pi/2$ at the change of resonant frequency in a wide frequency range.

In Figure 1 presented flow-chart of device for measuring of electric circuit resonant frequency. Device for measuring of electric circuit resonant frequency [3] contains a variable frequency oscillator 1 hanging by electric circuit at the output; electric circuit formed by the inductances spools 2 and 3 that are connected, wound on toroidal cores; condenser 4 with the winding connection 5 that come through toroidal cores. Outputs of spool 3 connected with the entrances of automatic switch 6, the management circuit of that is connected to the LFO of rectangular voltage 7. Output of automatic switch 6 connected with the first entrance of differential amplifier 8 and the second entrance connected with the output of HFO 1 through attenuator 9. General point of differential amplifier 8 connected with the middle point of spool 3 and earthed. Output of differential strengthener 8 connected with consistently included amplitude detector 10, a selective amplifier 11 that adjusted on frequency of LFO 7, a phase-sensitive rectifier 12, the management winding of that is also connected to the rectangular voltage LFO 7. Output of phase-sensitive rectifier 12 through integrator 13 connected with the managing entrance of HFO 1. The output of HFO is connected with digital frequency meter 14.

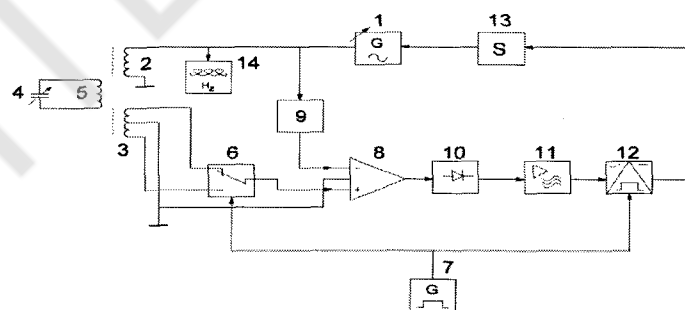


Fig. 1. Schematic of device for electric circuit resonant frequency measuring.

A device works in the following way. High-frequency signal from the output of variable frequency oscillator 1 comes on a spool 2 and forms in her core the alternating magnetic field that excites a high-frequency current that contain condenser 4 with the winding connection 5. High-frequency current in the core of spool 3 creates the alternating magnetic field and corresponding high-frequency voltage.

Amplitude and phase of high-frequency voltage of spool 3 it is determined by an impeder to the circuit at presence of winding connection 5. Resistance to the circuit is capacity if the frequency of excitation is less then resonant frequency, and inductive if the frequency of excitation more than resonant. Circuit resistance is cleanly pure resistance if the high-frequency oscillations frequency coincides with resonant frequency. Spool 3 connected by an automatic switch 6 to one of entrances of differential

strengtheners 8. It appears loaded on practically endless resistance in different frequencies. Therefore it works in the mode of idling and formed the phase change that equals $+\pi/2$ in relation to the current of winding connection 5.

Phase of current to the circuit, and, as a result, current of winding connection as to variable frequency oscillator 1 can be variable from $-\pi/2$ to $+\pi/2$ depending on relative disorder to the circuit. It happens if the circuit is imbalance in relation to frequency of own resonance. As a result of it a phase voltage change on the output of spool 3 in relation to the phase of voltage of variable frequency oscillator 1 can change from 0 to π in the change of frequency of high-frequency signal in wide limits. Phase change, that is brought in by an electric circuit that consists of spools 2, 3 condensers 4 and winding connection 5 is equal $\pi/2$ if the resonance to the circuit 4, 5. The last one is used for the indication of resonance of electric circle. To the one of entrances of differential strengthener 8 through attenuator 9 continuous voltage of generator For the receipt of signal, that are phase change proportional rejection from $\pi/2$, and to the second entrance alternately of voltage from the conclusions of spool 3 in relation to the earthed middle point. Frequency of switching of voltage pool 3 set by frequency of LFO 7 and tension that manages of switch 6 work. So as tension of conclusions of spool 3 in relation to a middle point are in anti phase, then at one position of switch initial tension of differential strengthener 8 proportional to the vectorial difference of entrance voltage, and at other to the vectorial sum. At the change of phases, even $\pi/2$, amplitude of difference voltage is equals amplitude of total voltage independently from correlation of amplitudes on the entrances of differential strengthener. In case of increase of phase change ($\varphi = \frac{\pi}{2} + \delta$) difference voltage is grows, and the total is decreasing. At deviation of phase change from $\pi/2$ in other side ($\varphi = \frac{\pi}{2} - \delta$) total tension becomes more difference. As a result of continuous work of switch 6 with frequency of LFO 7 for differential strengthener 8 is appears modulated on amplitude with frequency of commutation of voltage spool 3. The voltage is distinguished by a amplitude detector 10. It increases a selective amplifier 11 that adjusted on frequency of LFO 7, and becomes straight phase-sensitive rectifier 12 on the managing entrance of variable frequency oscillator 1 by changing frequency of vibrations in the direction of rapprochement with resonant frequency to the circuit 4, 5. At the coincidence of variable frequency oscillator 1 with resonant, difference voltage on the output of differential strengthener 8 the even becomes total and amplitude modulation on the entrance of detector 10 is disappears. Output voltage of integrator 13 the retains frequency of generator resonant 1. At phase change deviation from $\pi/2$ as a result of circuit 4 capacity change there is circumflex in output voltage of differential strengthener 8, voltage of that then the phase sensitive straightening additionally charges or discharges integrator 13. Integrator 13 changes frequency of variable frequency oscillator 1 to the new value of resonant frequency to the circuit 4, 5. The value of the resonant frequency is measured by a digital frequency meter 14. Instability of integrator 13 and other converting units (detector 10, amplifier 11 and rectifier 12) do not affect the accuracy of the oscillator 1, the resonant frequency of the circuit, as well as equality of difference voltage total does not depend on the settings and the form of amplitude-frequency characteristics of intensive-rectifier tract (8, 10, 11, 12). The weakening of the attenuator 9 is chosen from the equalization conditions of differential amplifier 8 input voltages with an average of the difference frequency. But arises the inequality of summary or voltage difference by changing the resonant frequency over a wide range that doesn't affect the accuracy of detection of the phase deviation from $\pi / 2$.

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ANALYSIS OF THE CLUSTERING OF RESULTS USING THE METHOD OF K-MEANS
AND WAYS TO IMPROVE THEM

For development of control algorithms of difficult objects methods of data mining (Data Mining), in particular – clusterization can find the effective application. It is known that methods of the cluster analysis are realized in rather large number of program tools from different producers. But estimates of results of their use continue to be considered not as absolutely satisfactory. Therefore development of advanced algorithms of the cluster analysis of data continues to remain an urgent task.

Before carrying out the cluster analysis three examples of a data set have been created:

- 1) «The 2-dimensional test» – 34 objects with two signs on values of coordinates of X and Y (4 clusters are provided);
- 2) «The 3-dimensional test» – 204 objects with three signs on values of coordinates X, Y and Z (8 clusters are provided);
- 3) «Flour - figures of merit» – 730 objects with three signs on values of number of falling, IDK, quantity of a crude gluten for the batches of flour arriving on bakery within ten months (the cluster design is unknown).

By the first two examples existence of such objects was in advance provided («disputable») which can belong to different clusters.

As a basic algorithm of a clustering the k-means method which is well described is chosen, it is applied in the majority of the known program tools and yields positive results. And Deductor Studio Academic, Statistica StatSoft, SPSS Modeler IBM became tools which were used for a clustering of the presented examples and carrying out the comparative analysis.

It is known that the choice of initial centers of clusters (centroids) has very significant effect on correctness of results of a clustering. As for the k-means method this procedure has no rigid determination and initial centres are selected in a random way or on some special algorithm, it affected the accuracy of the received results on the first two examples. Any of tools didn't reach ideal filling of clusters, i.e. «disputable» objects appeared in «others» clusters.

The main criterion that determines the accuracy of hitting the object in the corresponding cluster, we used the value of the total distance between all objects and their centroids. This criterion can be considered sufficient to justify the assessment of the quality of clustering within a single analysis of the distribution of objects on a fixed number of clusters. Additional criteria appeared: Dan's index and index of assessment of a silhouette.

Therefore the software module realizing the procedure of an advanced clustering of data by k-means method was developed. Algorithms of automatic calculation of quantity of clusters and determination of provisions of initial centers of clusters (centroids) became its distinctive feature. At the same time, creation of polygons of frequencies on each sign was used.

The results provided the advantage of this module for all criteria.

THE NEAREST NEIGHBORHOOD OF PERCOLATION CLUSTER'S ELEMENTS
AS COMPLEX SYSTEM'S PROPERTY INDICATOR

The algorithm for determining the Lévesque measure on the set of "conductive" sites of the nearest neighborhood and the algorithm for calculating the dimension of describing the scaling behavior of their division's entropy is designed in the evolution of nearest neighborhood model; the set-theory description of percolation transitions in the continuum and fractal arrays was given; the idea of the relative degree's order of the structure was introduced, the suitability of this value to evaluate the drift of the nearest neighborhood properties is shown.

In recent years, concepts and methods of percolation theory are used effectively in natural and engineering sciences such as biophysics, theoretical chemistry, materials science, network technologies and other. It is interesting to watch that the percolation theory more clearly manifests itself as an interdisciplinary knowledge and a conception of the connectivity (in the broad sense) reveals traits of general scientific concepts.

The nearest neighborhood of percolation cluster elements conception allows significantly extend theory's features in detailing of the generation processes and at the cluster systems research [1-3].

In the proposed approach, the nearest neighborhood, in fact, is itself a percolation field in n -dimensional space properties that allows to increase the number of parameters cardinally which describe the state of the percolation clusters elements and increases conditions variability of their association in the process of clustering. Perhaps, in a short time, this will make the nearest neighborhood one of the key components of percolation models.

One aspect of the model is to consider the nearest neighborhood like set belonging to the class of "thick" fractals.

In addition, the model suggests that each site of percolation problem can be defined as a region of finite size in which, in its turn, possible to solve a percolation problem, et cetera. Those sites are simulated as Sierpinski gasket of arbitrary generation, which depends from prescribed accuracy. In the model, authors determined centers of the "sites" locations by a random number generator, and used uniform distribution generator (in variant of the model – the Gauss distribution).

It is well known that the Sierpinski gasket can be considered as the two-dimensional Cantor set. Let is two-dimensional Cantor set of the two-scale s_1 and s_2 , with a measure generated by a multiplicative process p_1, p_2 . Since we have $n!/k!(n-k)!$ segments of space $s_1^k s_2^{n-k}$ and weight $\mu_i = p_1^k p_2^{n-k}$ in the n -th generation of the Cantor set. So measure given by

$$M_d(q, \delta) = (p_1^q s_1^d + p_2^q s_2^d)^n = (p_1^q l_1^{2d} + p_2^q l_2^{2d})^n,$$

where δ is the same box size on all cells used to cover the set; and q – the moment order of M . For $q = 0$ the mass exponent is the fractal dimension of the set, and equals 0.6110...

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RESEARCH OF SELF-TUNING ACS WITH VARYING TRANSITION COEFFICIENT CONTROL
OBJECT OF TECHNOLOGICAL TYPE

In this thesis the research of the band pass filtering utilization for extracting free motion of the ACS in order to provide self-tuning of such system is provided.

Introduction. Many factors have influence on technological process variables when this process is contemplated as control object (CO). These factors are usually represented as non-controllable coordinate and parametric disturbances. Parametric disturbances more often reveal themselves in CO transition coefficient changes. On a number of occasions it can change in a wide range – 2...10 times in comparison to initial value [1]. Traditional automatic control system (ACS) with this CO would lose stability because controller parameters remain the same. That's why self-tuning of the controller is a non-alternative instrument of compromise saving between quality factors and processes stability in ACS with such CO.

A lot of known self-tuning ACS utilize specially organized search movements in ACS for identifying current changes in CO transition coefficient. Besides, there are dangers of violations in regimes and regulations in CO operation. Nevertheless identification in the closed-loop circuit of the ACS can be carried out using those changes of the controlled variable $y(t)$ of the CO which arise naturally as the result of coordinate disturbances impact [2]. This is favoured by the fact that for CO of technological type parametric disturbances spectral density is much more lower in frequency range if compared with spectral density of coordinate disturbances [3]. This specific feature distinguishes CO of technological type from many mobile and electromechanical types.

In fact, occurs the possibility of using band pass filtering to divide low-frequency part $y_l(t)$ of $y(t)$ changes, which is generated by the influence of coordinate disturbances and high-frequency part $y_n(t)$, which is the result of the noises impact, from low-frequency part $\tilde{y}(t)$ of the controlled variable movement. The latter characterizes own movement of the ACS, in particular, changes of the CO transition coefficient. The topic of band pass filtering is given in more detail in [4].

Problem statement. Let's examine in more detail the block diagram and the working principle of the self-tuning ACS (STACS) with passive identification.

During operation CO receives impact from external non-controllable coordinate $f_k(t)$ and parametric $f_p(t)$ disturbances, and also from high-frequency noises $f_n(t)$, which in general represent stochastic processes. When changing operating modes, and also, as a result of equipment degradation processes, changes, specifically, CO transition coefficient k_o . ACS controller stabilizes controlled variable $y(t)$ on the level y^z , suppressing low-frequency part $f_k(t)$, remaining functional in some narrow range of k_o . For noises suppression $f_n(t)$ low-frequency filter is used in the system (LFF).

Substantial parametric disturbances $f_p(t)$, which excite k_o changes, require tuning of the transition coefficient k_r of the ACS controller in real time for saving the stability of the system. This function in STACS is implemented by the self-tuning block (see fig. 1). It consists of CO model, which receives as its input control impact $u(t)$ of the ACS controller. Controlled variable $y(t)$ of the CO and the output of its model $y_m(t)$ go to the inputs of band pass filters. They suppress the sequels of coordinate disturbances $f_k(t)$ and noises $f_n(t)$ influence on $y(t)$ and $y_m(t)$. In the outputs of the filters the signals $\tilde{y}_a(t)$ and $\tilde{y}_{ma}(t)$ are formed, which characterize own movement of the ACS. This topic is given in detail in [4].

Dispersion estimations evaluations on sliding time interval τ_{oc} averages the signals $\tilde{y}_a(t)$ and $\tilde{y}_{ma}(t)$, evaluating the estimations of their dispersions $\hat{D}_{\tilde{y}_a}(t, \tau_{oc})$ and $\hat{D}_{\tilde{y}_{ma}}(t, \tau_{oc})$, which, as shown in [4], are proportional to the squared transition coefficient values $k_o^2(t)$, $k_m^2(t)$ of the CO and its model. the level of CO dispersion estimation $\hat{D}_{\tilde{y}_a}(t, \tau_{oc})$ by virtue of model transition coefficient $k_m(t)$ change. In other words, CO model and parametric controller k_m in the real time implement the identification of the model transition coefficient $k_m(t)$, by tracking CO transition coefficient $k_o(t)$.

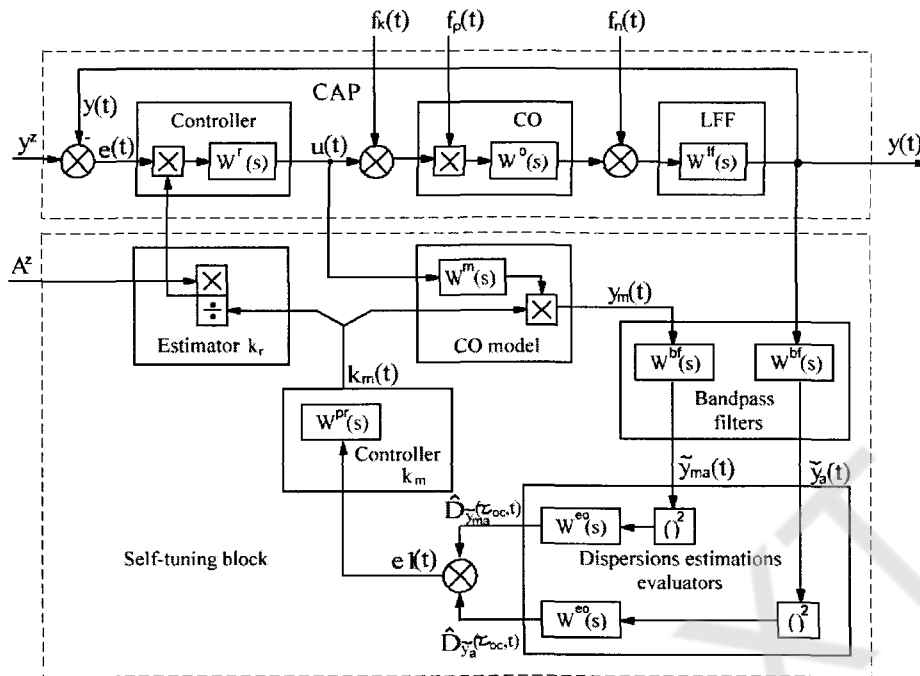


Fig. 1. Block diagram of the STACS

The current value of $k_m(t)$, which is proportional to $k_o(t)$, from the output of the controller k_m goes also to the evaluator k_r , which calculates the value of $k_r(t)$, on the assumption of the product constant $A^z = k_o \cdot k_r$, where A^z – some constant, which sets the desired appearance of the transient process in ACS. Thereby ensuring of the stable operation of the ACS main circuit during CO transition coefficient changes.

In the STACS structure a couple of non-linearities are presented, that's why analytical solving of the analysis and synthesis problems is complicated. Known solutions have approximate character and have been obtained for some particular cases. Considering this fact, as an instrument for STACS research was chosen computer modeling in Simulink of the MatLab environment.

In the report the conditions and the plan of carrying out comparative researches are announced, the analysis of computer experiments is carried out, revealed the influence of external disturbances spectral composition changes and noises on the quality factors of the STACS operation with different parameters of the self-tuning block.

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DECISION SUPPORT SYSTEMS AND THEIR POSSIBLE USE FOR FOOD PRODUCTS' ISSUES

General definition of Decision Support Systems, their possible application as well as the most common structure have been considered. The possibility of use such kind of systems in the food products sector has been described. The four specific issues for their operation in this area have been defined.

Decision Support Systems (DSS) represent a concept of the role of computers within the decision making process. Even though DSS has become an area of research in the middle of the 1970s [1], the concrete definition of it still doesn't exist. The thing is the definition and scope of DSS has been migrating over the years. What's more, different kinds of specialists (researchers from different areas of science, practitioners, managers, etc.) have different points of view on this question [1, 2].

As one of the most common definition of DSS could be given the following: DSS are interactive computer-based systems and subsystems intended to help decision makers use communications technologies, data, documents, knowledge and/or models to complete decision process tasks. Here at once should be precise types of problems which DSS help to solve. It comes mostly about problems that may be rapidly changing and not easily specified in advance – i.e., unstructured and semi-structured decision problems [3].

Given that DSS has as the criterion the relationship with the user, they could be separated on: passive, active, and cooperative. A passive DSS is a system that aids the process of decision making, but that cannot bring out explicit decision suggestions or solutions. An active DSS can bring out such decision suggestions or solutions. And a cooperative one allows the decision maker (or its advisor) to modify, complete, or refine the decision suggestions provided by the system, before sending them back to the system for validation [4].

There are three fundamental components of DSS architecture are [4-8]: the database (or knowledge base), the model (i.e., the decision context and user criteria), the user interface. The users themselves are also important components of the architecture [4, 8].

Nowadays DSS are extensively used in business, management and transportation, applied in medical clinics, jurisprudence, forest management, agricultural production, etc. Basically, there are theoretical possibilities of building such systems in any knowledge domain. Therefore, the choice of DSS implementation in the food products sector has been made.

The idea is to use this kind of systems as a tool that could help to make decisions, based on the database of experts' marks of wide range of food products in accordance to the specific criterions. Model of the decision process depends on what are we going to achieve. There are 4 specific problems that have to be solved:

- 1) analysis of a final product in order to improve the technology of its production and further suggestions for it;
- 2) analysis of a final product in order to decrease costs and further suggestions for it;
- 3) analysis of different products of one kind in order to choose the best one according to the specific criterions;
- 4) analysis of products in order to create the innovative one.

This project is going to be elaborated in the frames of Laboratory of Sensory Analysis, ONAFI. Planned stages of this research include elaboration of database, models for decision making process and software for user interface organization.

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INFORMATION-MEASURING SYSTEM OF UAV (QUADCOPTER) AND IMPLEMENTATION OF FLIGHT MODES BASED ON IT

In article the description of information-measuring system, a description of the working principle of sensors. Given the dependence of the functioning and implementation of the flight mode from the sensors on Board the UAV.

Today UAV's first of all are subjects of automation, this means that the drone on Board has a number of sensors to ensure a safe flight. All kind of these sensors are building the Information-measuring system (IMS).

IMS of UAV's includes:

- Altimeter, is an instrument used to measure the altitude of an object above a fixed level;
- Compass (magnetometer), is an instrument used for navigation and orientation that shows direction relative to the geographic "cardinal directions", or "points";
- Gyroscope, used for measure or maintain orientation;
- Accelerometer, is a device used to measure the corresponding acceleration;
- Ultrasonic rangefinder, rangefinder used for remote detection of various objects and measuring distance;
- The Global Positioning System (GPS), is a global navigation satellite system (GNSS) that provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites.

Each of this sensors necessary for the implementation of flight modes such as:

- **Loiter mode** — automatically attempts to maintain the current location, heading and altitude;
- **RTL (Return To Launch) mode** — navigates Copter from its current position to hover above the home position;
- **Land mode** — attempts to bring the copter straight down;
- **Auto mode** – In Auto mode the copter will follow a pre-programmed mission script stored in the autopilot which is made up of navigation commands (i.e. waypoints);
- **Follow Me mode** – this one makes it possible for you to have your copter follow you as you move, using a telemetry radio and a ground station;
- **Guided mode** – this mode is a capability of Copter to dynamically guide the copter to a target location wirelessly using a telemetry radio module and ground station application.

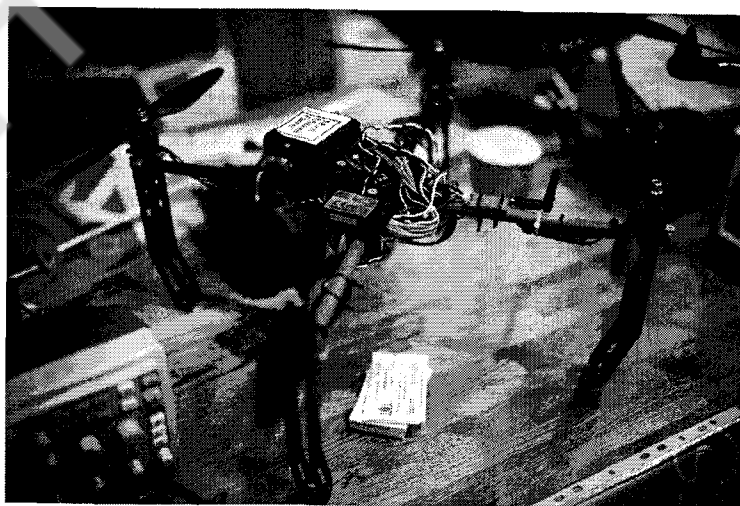


Fig.1. The appearance of the drone, assembled in the «Mechatronics Robot laboratory».

Conclusions: implementation of IMS on Board of the UAV allows to realise the flight modes and the required functionality. At the moment provides 6 flight modes.

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ИТБ ОНАХТ

БЕСПИЛОТНЫЙ АВТОМОБИЛЬ ДЛЯ УЧАСТИЯ В ГОНКАХ

Робототехника постепенно, но стремительно внедряется во все уголки жизни человека, пропагандируя безопасность для жизни человека и освобождая его от скучной и неинтересной работы для преследования высших целей. Не обходит роботизация и автомобильные средства передвижения. Вооружившись современными средствами автоматизации, становится возможным превратить довольно опасное средство передвижения в систему, полностью управляемую более надежным искусственным интеллектом.

Ежегодно проводится конкурс автономных мобильных роботов «Roborace». Для участия в конкурсе необходимо сконструировать и запрограммировать масштабную модель автомобиля, сделав его автономным, что означает, что человек вообще не должен быть задействован в процессе управления.

В 2015 году НИИ мехатроники и робототехники Одесской национальной академии пищевых технологий впервые оказалась в списке участников этих соревнований. Нашей команде был предоставлен автомобиль фирмы HIMOТO на радиоуправлении.

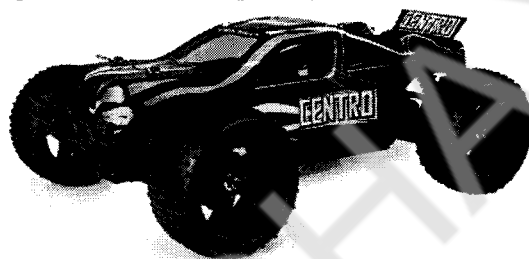


Рис. 1 Радиоуправляемый автомобиль Himoto

В качестве “мозга” робота участники вооружили микроконтроллером STM32F3 (рис. 2), который обеспечивает разработчика всем необходимым функционалом. Модуль радиоуправления был изъят.

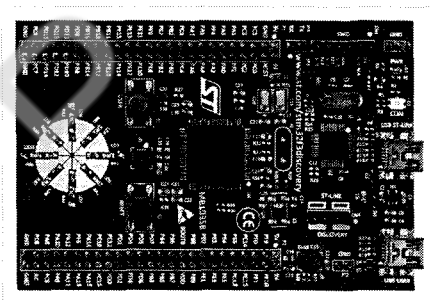


Рис. 2 Плата управления автономным роботом

Для приведения автомобиля в движения используется двигатель, установленный на борту робота. Для его управления используется драйвер фирмы ST, который также был предоставлен. Механика автомобиля переделке не подверглась. Штатный сервопривод был заменен на более мощный, обеспечивающий большую грузоподъемность.

Для обнаружения и измерения расстояния до препятствия были приобретены ИК-датчики фирмы Sharp. Всего в схеме используется 3 датчика, измеряющие расстояния до препятствия соответственно справа, слева и спереди от робота. Крепятся датчики на бампере, который был изготовлен на 3-D принтере.

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DEVELOPMENT OF THE PORTABLE SELF-PROPELLED ROBOTIC DEVICE

The principal idea consists in creation of a working prototype of the portable self-propelled robotic device with optimum energy efficiency. In the report are described: the reference list, compare results of control samplings of primary and operating prototypes. The type selection of the chassis and additional equipment is reasonable.

In the process of working the following tasks have been implemented.

First of all we identified construction of the chassis. Wheelbase of classical type has been chosen. It's 4x4 type. Its field of use is most of the roads and landscapes as well as certain types of cross-country.

After that we've chosen controller, motor control unit, sensors and power cell. Also we calculated electric elements for reduced voltage. They are used for sensors and other devices.



Fig. 1. The portable self-propelled robotic device on a wheelbase

In partnership cooperation Scientific Investigation Lab "Mechatronics and Robotics" and the company "LuxOff" was a competition for the best development of the portable robot.

It was the first stage of preparations for national and worldwide competition among robotic automobile known as "Roborace". Robot must move on the surface and avoid obstacles.

To implement the company «Luxoft» competition problems presented all the necessary equipment.

There have already been drawn up the necessary electrical circuits, 3D models, and developed appropriate software.

According to the total, 3 test samples were made. Their tests and the subsequent correction of mistakes were carried out. By the end of work, the present device, on the same wheelbase, decreased in weight from 2.6 kg to 1.1 kg. As a result, range of the course increased from 83 m to 125 m and maximum speed increased from 18 km/h to 26 km/h.

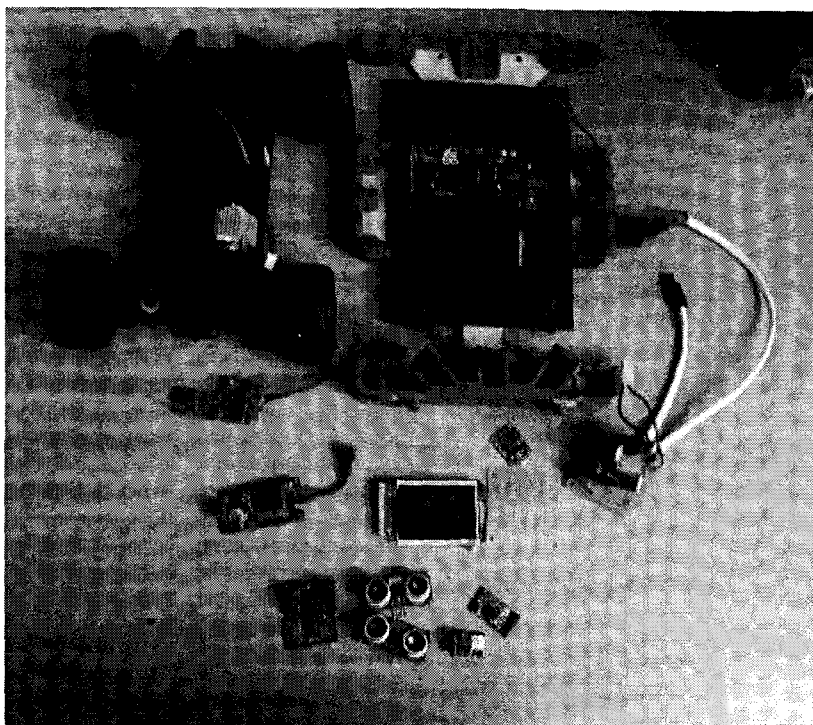


Fig. 2. Part of the Equipment provided by the Luxoft company

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REALIZATION OF A DELTA-ROBOT FOR CHOCOLATE PRINTING

In current years delta-robot can use in many industries (such as engineering, automobile industry and etc.). Delta robot has a difficult structure, but his functionality can provide different opportunities and precise positioning of output devices that perform processes in industry. Since the inception of this project, we have a lot different constructions and functionality. At the 1980's delta was designed for process for packaging conveyor lines, but now we can see this robot on many areas.

The basic idea behind the Delta parallel robot design is the use of parallelograms. A parallelogram allows an output link to remain at a fixed orientation with respect to an input link. The use of three such parallelograms restrain completely the orientation of the mobile platform which remains only with three purely translational degrees of freedom. The input links of the three parallelograms are mounted on rotating levers via revolute joints.

This robot is like a mechanical system, which changes position of extruder to print chocolate for confectionery and creating 3D objects made of chocolate.

A delta robot is a type of parallel robot. It consists of three arms connected to universal joints at the base. The key design feature is the use of parallelograms in the arms, which maintains the orientation of the end effector. By contrast, a Stewart platform can change the orientation of its end effector. Delta robots have popular usage in picking and packaging in factories because they can be quite fast, some executing up to 300 picks per minute.

Parallel manipulators are characterized as having closed-loop kinematic chains. Compared to serial manipulators, which have open-ended structure, parallel manipulators have many advantages in terms of accuracy, rigidity and ability to manipulate heavy loads. Therefore, they have been getting many attentions in astronomy to flight simulators and especially in machine-tool industries. Also known as parallel robots, or generalized Stewart platforms (in the Stewart platform, the actuators are paired together on both the basis and the platform), these systems are articulated robots that use similar mechanisms for the movement of either the robot on its base, or one or more manipulator arms. Their 'parallel' distinction, as opposed to a serial manipulator, is that the end effector (or 'hand') of this linkage (or 'arm') is connected to its base by a number of (usually three or six) separate and independent linkages working in parallel. 'Parallel' is used here in the computer science sense, rather than the geometrical; these linkages act together, but it is not implied that they are aligned as parallel lines; here parallel means that the position of the end point of each linkage is independent of the position of the other linkages.

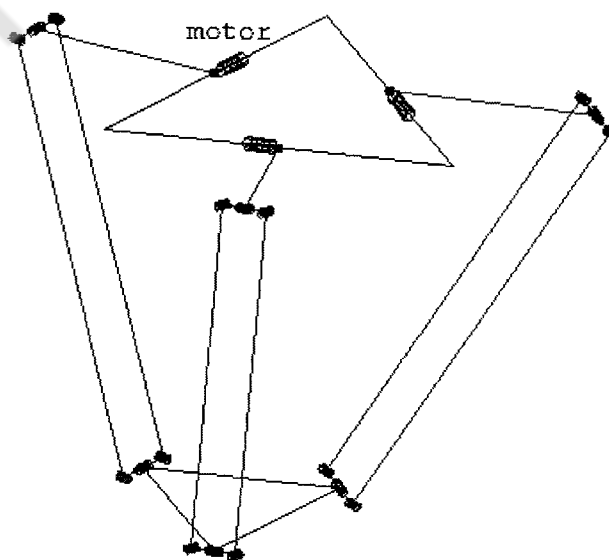


Fig. 1. Kinematic model of a delta robot

The key concept of the delta robot is the use of parallelograms which restrict the movement of the end platform to pure translation, i.e. only movement in the X, Y or Z direction with no rotation. The robot's base is mounted above the workspace and all the actuators are located on it. From the base, three middle jointed arms extend. The ends of these arms are connected to a small triangular platform. Actuation of the input links will move the triangular platform along the X, Y or Z direction. Actuation can be done with linear or rotational actuators, with or without reductions (direct drive).

The delta robot (a parallel arm robot) was invented in the early 1980s by a research team led by professor Raymond Clavel at the École Polytechnique Fédérale de Lausann. Since its invention in the early 1980s, the delta robot has evolved into an innovative and high-speed solution for a wide range of assembly, picking, and material handling applications.

The revolute joints of the rotating levers are actuated in two different ways: with rotational (DC or AC servo) motors or with linear actuators. Finally, a fourth leg is used to transmit rotary motion from the base to an end-effector mounted on the mobile platform.

Automation in the food industry has moved far beyond the simple labelling machines and conveyor belts. Now intelligent robotic arms perform dazzling movements and expert feats of coordination, getting everything from frozen fish chunks to cookies swiftly into their packaging. It's not a side of processed foods you see that much, but it is everywhere.

In this situation we are considering possibility of edible printing on the confectionery products. We can use this project for food manufactures such as a confectionery factories of course.

Chocolate delta robot. In contrast to 3D delta printers using as a plastic material, chocolate delta robot will use melted chocolate to create a confectionery products. Advantages of confectionery products by the delta robot consists including that you can create fabulous products that can be decorated a variety of higher value products (such as cakes). By accurately positioning of the extruder, products will have a perfectly forms that can't be set up in casting them in forms.



Fig. 2. Chocolate printing

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SECONDARY EXPLOSION ESTIMATIONS FOR THE GRAIN PROCESSING ENTERPRISE

Mathematical model for the possible development of the primary explosion at the grain processing enterprise is created. This model enables to estimate possibility of the secondary explosion at any object of the enterprise and forms the base for mathematical support of the decision support system for explosion-proof. Such decision support system can be included in the control system of the processing enterprise.

There are a lot of explosions at the grain processing enterprises all over the world every year. Numerous researches and investigations are dedicated to the problem of the prevention of primary explosions, but there are too little scientific works concerning problems of secondary explosions. It is necessary to create effective control system for prevention of secondary explosions at the grain enterprises. Such control system must include appropriate decision support system (DSS).

Aim of the research is to create mathematical model for the possible development of the primary explosion at the grain enterprise. This model must give an opportunity to estimate possibility of the secondary explosion at any object of the enterprise in the presence of the primary explosion at the other object. DSS for explosion-proof of the grain processing enterprises must be based on such mathematical model.

Let us consider grain processing enterprise which consists of n different objects such as silos, bunkers, business buildings, conveyers etc. It is supposed, that fuzzy estimation \tilde{E}_i ($0 \leq \tilde{E}_i \leq 1$) for the explosiveness of i -th object ($1 \leq i \leq n$) is known.

Value \tilde{E}_i can be estimated on the solution of the flame stability problem. It is obvious that

$$\exists \alpha \in \{1, \dots, n\} \quad \tilde{E} = \tilde{E}_\alpha \quad \tilde{E}_\alpha = \max_i \tilde{E}_i, \quad (1)$$

where α is the number of the most explosive object of the enterprise, \tilde{E} can be considered as the explosiveness of the enterprise as a whole and expresses the possibility of the primary explosion.

For every moment of the time grain processing enterprise is modeled by graph with n nodes. Every node corresponds to specific object of the grain processing enterprise. Two nodes i and j ($1 \leq i \leq n$, $1 \leq j \leq n$) are adjacent if the possibility \tilde{S}_{ij} ($\tilde{S}_{ij} = \tilde{S}_{ji}$) of the penetrating of the fire or of the weak shock wave from the object i (to be more correct, from the object, corresponding to node i) into object j is more than zero; \tilde{S}_{ij} is fuzzy value, that is $0 \leq \tilde{S}_{ij} \leq 1$.

This graph is undirected graph. It can be either connected or disconnected. If it is disconnected it means that it consists of two or more connected subgraph. Those subgraphs corresponds to such sites of the enterprise which are independent in terms of explosion-proof, that is the primary explosion at any object of any site can't be a reason for the secondary explosion at any object of the other site. So it is necessary to solve the problem of the graph connectivity and than to estimate separately the possibility of the secondary explosion for every site of enterprise corresponding to connected subgraph. So let us consider only connected graphs.

The graph is weighted. The weight of the node i is fuzzy estimation \tilde{E}_i . The weight of the edge ij is fuzzy value \tilde{S}_{ij} . The value of \tilde{S}_{ij} depends on the physical way of connection for objects i and j . This graph is also fuzzy graph, because the weights of the nodes and the weights of the edges are fuzzy logical values.

Every node i (except α) gets value \tilde{P}_i^m , where \tilde{P}_i^m expresses inability of the object i to explode in the presence of the primary explosion at the object α . Problem of finding of the shortest path in the graph is solved by Dijkstra's algorithm.

It is obvious that

$$\exists \beta \in \{1, \dots, n\} \quad \beta \neq \alpha \quad \tilde{P}_i^m = \min_i \tilde{P}_i^m, \quad (2)$$

To find the most explosive object in situation when object α (1) explodes (that is to find the most explosive object towards the possibility of secondary explosion) algorithm for the search of the shortest path from node α to node β is used. Object β is the object with the minimal inability for secondary explosion, that is object β is the most explosive object in the presence of the primary explosion at the object α .

Technological processes of grain storage and grain processing are modeled as the sequence of steps. Those steps are divided with important technological operations or organizational events (such as loading of grain into silos, aspiration, cleanup or wet cleaning). Every step in sequence of technological processes corresponds to the graph described above. Every transition from one step to another changes weights of nodes and weights of edges. That means that explosiveness of different objects of grain processing enterprise changes and ability for penetration of explosion from one object to another changes also.

Transition from one step of technological processes to another sometimes leads to changing of corresponding graph. New edges can be added to graph; some edges can be deleted. For example, filling of silo leads to removal of the edge, connecting two nodes; one of these nodes corresponds to this silo, the other node corresponds to the under-silo gallery. Closing of a silo makes the node, corresponding this silo, the isolated node of the graph.

It is obvious, that addition or removal of the graph nodes as a result of any technological operation or organizational event is impossible; addition of the node means appearance of new object at the grain processing enterprise, removal of the node means vanishing of some object (corresponding to this node) at the grain processing enterprise, such appearances and disappearances are possible only as a result of the reconstruction or rebuilding of this enterprise. So nodes of the graph are invariable, but their weights are changeable.

Thereby for every step of technological processes reassessment of explosiveness of every object of the enterprise is done. Ability of every object for primary explosion and secondary explosion (in presence of the primary explosion of the most explosive object) is reassessed and scenarios of the explosion development are reviewed. Control action must be applied:

- 1) to the most explosive object in terms of the primary explosion;
- 2) to the most explosive object in terms of the secondary explosion in presence of the primary explosion of the most explosive object item 1).

Control action aims to decrease explosiveness of the objects. This action can be technical, technological or organizational. The example of technical control action is phlegmatization or inhibition; the example of technological control action is technological operation such as silo filling; the examples of organizational control action are cleanup and wet cleaning.

Selection of the appropriate control action is prerogative of decision maker, but DSS on the base of the described above mathematical model prompts the decision maker direction of the action, that is DSS recommends the decision maker the objects for immediate control action.

Solving of the described above problem enables to enlarge and to improve DSS for explosion-proof of the grain processing enterprises of different types: elevators, flour milling plants, compound feed plants.

This DSS enables:

- to specify the most explosive objects of the grain processing enterprise either in terms of the primary explosion or in terms of the secondary explosion in presence of the primary explosion;
- to specify the most effective control actions (be technical, technological or organizational) for ensuring of the explosion safety of the grain processing enterprise;
- to specify the most effective control actions for suppression of the secondary explosions, such actions prevent development of explosions.

THE DATABASE MANAGEMENT SYSTEM AS THE BASIS OF BILLING SYSTEMS

The basic concepts and definitions relating to the billing systems are discussed. The database management system Oracle is also considered. Structure and functions of billing systems, i.e. the pre-processing data subsystem, the subsystem of operational management of the billing, the subsystem for notifying the customer, are studied. Groups of standards and important qualities of billing systems are also considered.

Systems, which calculate the cost of communication services for each client and store information about all the tariffs and other value characteristics, which are used by telecommunication operators for billing customers and settlements with other service providers, are called billing systems (BS); the cycle of what they do is called billing. Any BS is created on the basis of a certain database management system (DBMS). Most BS in the world were created on the basis of DBMS Oracle. Among other products, it is possible to allocate Sybase and Informix as designed for large volumes of information. Examples of billing systems are BIS Flagship, the CBOSS Arbor, Bill-2000-prepaid.

There are a few names of the billing system: ASR — automated system for calculations; IBS – information billing system.

One of the important qualities of BS is its flexibility, i.e. the ability to adapt to changing circumstances. The modular design of the system provides for the subsystem of preliminary processing of the data, the operational control subsystem and subsystem of alerts.

The system openness means the openness of the source code of a software product, which allows the operator not to depend on the developer in the future and to maintain and upgrade the system.

Scalability on load. With the growth of the subscriber base and additional services it would not be necessary to change or modify the software part of BS. Increase of the capacity of BS should be achieved through the modernization of the hardware of the system. What is important to consider when designing scalable systems? It is necessary to use a DBMS designed for large data volumes. DBMS needs to be compatible with different computer platforms to support multi-processor mode.

Reliability is one of the main requirements of any system. The reliability of the BS is determined by the reliability of the DBMS and technologies used in the development of the system. The reliability of the supplier (vendor) application software is not least. It is important The time that supplier runs in the market is of great importance. The percentage of the presence of developed systems on the telecommunications market is indirect indicator.

Multi-language means possibility to set different languages for reporting.

Multicurrency support means ability to work with any currency.

Delayed billing is billing, in which payments are made after successful calls.

Hot billing means that changes in the account balance take place in the process of conversation, and information about the balance on Your account can be obtained immediately after the call.

Optimization of billing means improvement of BS by its operator.

Large BS is system, used by big operators.

Posting of billing means fixation for the results of the calculation of billing; after the calculations are done the results are available to users (sent to print).

Scheme of the billing organization means that information about the calls and their duration is recorded by the switch and after pre-processing is passed to accounting system. Accounting system identifies the call and performs the necessary calculations, thereby forming the subscriber account. Standards, tariffs, information about services, data about customers, their contracts with subscribers and third-party providers of services, as well as the cost of transmitting information through various channels are kept in the system memory.

In addition, any BS should have a database that stores the history of payments; only these data allow to monitor the payment process and automate the so-called activation/deactivation of subscribers.

Functionality of BS can be divided into three classes:

- designed for transnational Telecom operators;
- registered on a national scale;

- systems of the middle class for regional networks.

BS belonging to the first class, should provide interoperability at the international level, in different time zones, i.e. they must be of multi-currency and multilanguage.

Registered systems of national significance are produced for definite operator. The operator may need a new BS that is compatible with the existing design system. Of course, the cost of such isolated systems is much higher than of the systems, belonging to the first class.

On the regional level it is possible to do the standard BS. However, such systems must possess the qualities listed above: flexibility, scalability, reliability.

Any BS is created and configured on the business process of Telecom operator, has its own set of functions corresponding to the technological cycle of service, and can interact with specific network equipment, that supplies it with information about calls and connections. But there is a standard set of functions supported by almost all BS. It includes:

- the operations performed by pre-processing and analysis of initial information (for example, a function for receiving of data about the connections and services, i.e. requests to a switch),
- operations for management of network equipment, i.e. functions for activating/deactivating (lock/unlock) of subscribers, and commands of changes in the terms of subscription of subscribers sent directly to the switchboard,
- the main functions of DBMS applications, including billing records of switch on calls and services, creating and editing database tables of the accounting system, billing and printing of the bills, the credit control of accounts, preparation of reports and archiving.

The pre-processing subsystem of the data. This application analyzes the original information of connection, determines the class of service and the traffic parameters (direction of the call, the source areas of billing, roaming conditions). This subsystem includes the decoder for original information about connections.

The subsystem of operational management for the billing. This subsystem provides the ability (automatically or through the operator of billing system) to modify the terms of subscription for subscribers at the switch, i.e. to block the communication of the individual subscriber or to remove this blocking, to activate or cancel the service.

Subsystem of alerts of customers by voice or electronic communications. This subsystem takes from database tables information to send notifications and announcements.

Division of system into functional subsystems (that is mentioned above) is not "strict" for all of the BS. This is just an example of the "classic" ASR.

There are three main groups of international standards. In 1998 the American National Standards Institute (ANSI) approved standard ANSI 124. In 1998 it published the first North American standard for billing, named CIBER, which is currently supported by the firm CIBERNET and its Committee CAC-IS. This Committee unites developers of billing systems and Telecom operators.

The main scope of CIBER is cellular network of standard AMPS.

European (by origin) standard TAR appeared in 1992. It is supported by the TADIG working group. Most of the operators in Europe use TAP2, although there is a third version of TAP. Since 1995 modification TAP2 that is known as specification TD.27, or NAGTAP2, began to be used in the United States.

THE PRACTICAL REALIZATION OF ENGINEERING-ECOLOGICAL MONITORING

A powerful force in the development of modern society is the rapid global spread of information and communication technologies that help gather, store, analyze, and disseminate information.

Functional engineering and environmental monitoring includes two separate varieties: the first is environmental monitoring, as a system of observations of anthropogenic changes of the environment and prediction of its status; the second is geotechnical monitoring, as a system of assessment of anthropogenic source, and ecological risk in the process of functioning of the object. Currently, the practical realization of engineering-ecological monitoring can be performed using automated working place (AWP).

Automated working place of Ecologist is specialized software that constitutes the core of the environmental monitoring system. It provides a solution to the complex task of gathering, processing, storage, presentation and distribution of monitoring information between system users (user terminals).

AWP of Ecologist is a distributed data processing system operating in a local area network in real time. Distributed AWP of Ecologist can be combined by the united monitoring Centre (territorial, regional, departmental, sectoral).

As part of the basic software AWP of Ecologist provides specialized software systems, which are necessary for the functioning of the automated part of the system for environmental monitoring. Those systems are:

- Dispatching complex;
- Archival complex;
- Communication complex;
- Editor classifier.

The control system is designed for maintaining databases for environmental monitoring and operational monitoring of the parameters of the environmental situation in the controlled area. The input control and processing received information, formation and display of alarms and messages in case of exceeding the controlled parameters of normative values, or detection of extremely high pollution levels in real time are automatically produced in dispatching complex.

The archival system is designed to maintain databases and information services for users. Archive complex interacts with the database management system and can work only in dialog mode. Software for archive complex guarantees information search and interactive access to the accumulated results of environmental monitoring; supports communication interface with the database management system and provides reporting and information services for users.

The communication system is designed for data exchange between automated measuring units of the monitoring system through existing channels of communication. Communication and data exchange takes place via the operator or via a planned schedule (the exchange schedule data).

The editor of the classifiers is destined for running the tables of reference data bases of environmental monitoring. Those data are used during the operation of the automated part of the system. Software for editor of classifiers provides information search and interactive access to reference tables in databases that support a communications interface with database management systems for manually entering and adjusting data from the keyboard, and to view and display the regulatory reference data in the form of screen forms and output documents.

3D PRINTER AS A WAY OF MATERIALIZATION OF BOTH CREATIVNESS AND ENGI-
NEERING THOUGHT

In today's environment of human diversity sometimes there is an urgent need for the manufacture of unique parts of varying complexity. And to be tested with the least expenses of time and money, as well as to find more efficient solutions created prototypes with different physical properties. In this area we have proven 3D printers of various designs. Their main advantage - is to minimize manual labor, the ability to create accurate, both physical and electronic copies of various sizes, unique manufacturing process automation, as well as identical parts. Laboratory of Mechatronics and Robotics Onaft due to the urgent need, decided to buy such a device. After analyzing the characteristics of different printers, we settled on the original and Ultimaker Wanhao Duplicator i3. After receiving the first print results, as well as the invaluable skills in this area, we decided to improve print quality without breaking the manufacturer's warranty. For this purpose it was decided to build something like a sarcophagus with ventilation. Its main task is to maintain a constant temperature during printing in the workspace of printers.

The process of parts manufacturing in the printer consists of modeling three-dimensional model in any CAD program. Once implemented the so-called slaying model is the creation of support structures, clarifying the various printing characteristics and create a simple G-code printer control through stratification model layers. Location model on the table. Directly print the details. Physical or chemical treatment of details.

Because of the simplicity layered printing technology, as well as analyzing the pros and cons of this type, the idea to create your own design of the first printer in our laboratory.

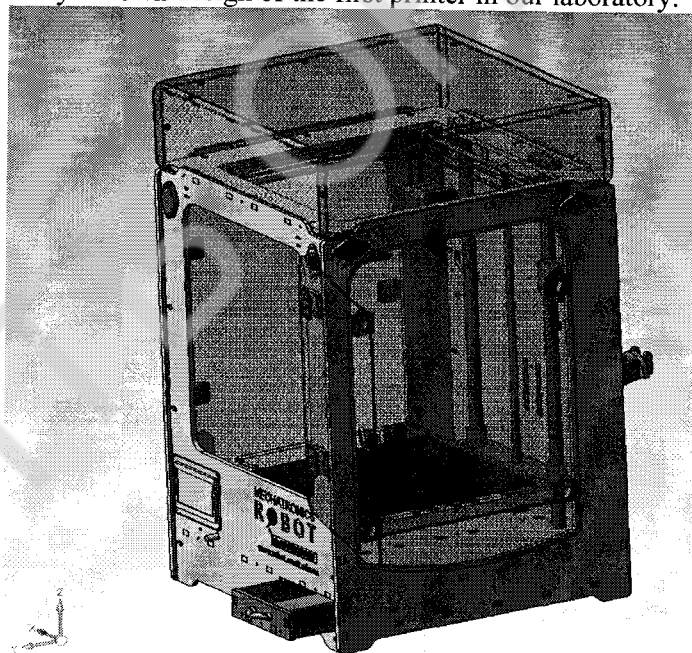


Fig. 1. Designing the program ASCON KOMPAS – 3D V16

When creating parts with overhanging and projecting plane support structures are used, which are disposed after the creation of parts. For rational use of the more soluble material such as PVA, if there are two extruders. Priority polylactide (PLA) due to the excellent properties important for prototyping and recycling of used parts of yourself prototypes: biodegradability, biocompatibility, thermal plasticity. Projected our printer has the ability to print and other types of plastics. Print styling by fusing layering (Fused deposition modeling) can be different plastics with different shades.

The advantages of printing FDM (. English Fused deposition modeling (FDM)) are:

Reasonable cost of raw materials for printing (various polymers, plastics).

Easy to manufacture, the mechanical part of the maintenance and repair of the printer.

The ability to use different colors of the filament.

Low cost of printing

Among the shortcomings should be noted:

Spreading plastic beyond the printable area due to the heat.

The restriction in the selection of materials with respect to temperature.

Sensitivity to temperature during printing.

Many details are printed on the printer. Some parts were made to order. The electronics includes: Arduino Mega 2560, RAMPS 1.4, as well as the driver DRV8825 stepper motor and stepper motor. As the power supply using the standardized switching power supply (12V, 30A). For ease of navigation in the program, information on the state of the printer and printing is enabled with an LCD screen control panel board RAMPS 1.4 and it has a slot for an SD card that provides the ability to print from removable media.

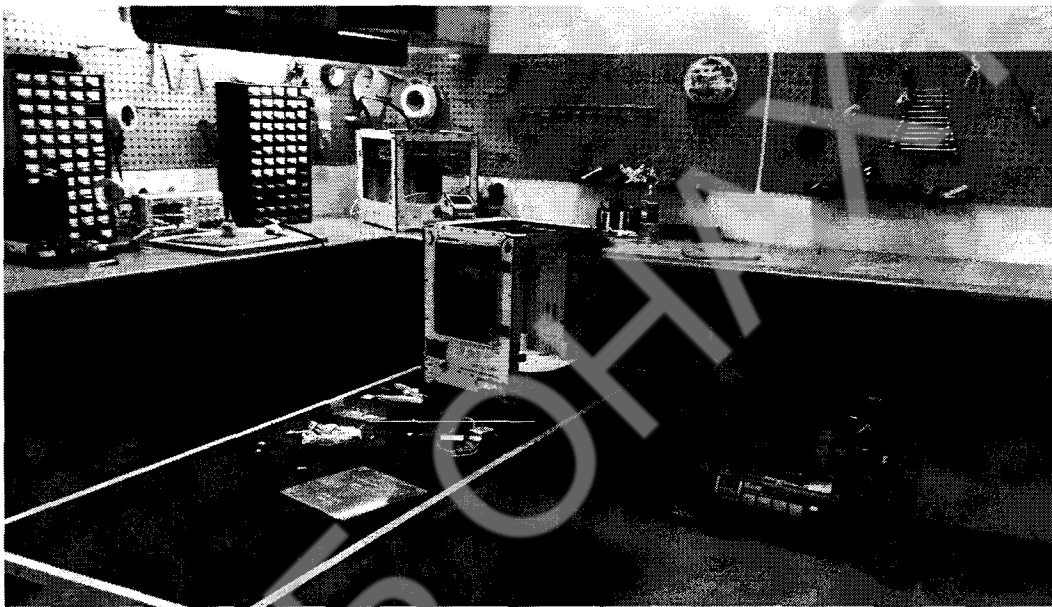


Fig. 2. Completion of the housing assembly and electronics

To date, collected absorbs vibration, the body of plywood, is debugging axes X Y and Z. Completion axle assembly also has collected the bulk of the electronics and you are debugging a program.

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