UDC 621: 631.3: 519.711.3
DOI: 10.37128/2520-6168-2022-2-12

THE NEW IMPLEMENTATION METHODS MANAGEMENT MECHANICAL CUTTING AND VIBRO PROCESS

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The problem of ensuring the required quality and operation of the properties of machine parts is becoming increasingly important in mechanical engineering. However, to date, no generalized theoretical relationships between surface quality parameters, machining accuracy, performance properties of parts and parameters of machining processes, which allow to solve the problem of technological support of the specified performance properties of parts. The control of the surface formation process with the required properties is carried out mainly by using partial experimental dependences and tables of processing modes. The complexity of the problem is that when machining parts it is necessary to establish such processing conditions that would provide a set of requirements for tool wear, machining accuracy, surface quality characteristics, productivity and more.

Working machines of special and general purpose, their separate knots and mechanisms are constantly improved, thus increase of a technical level of machines is carried out by introduction of new technical decisions, use of modern technologies and scientific developments.

The experience of development and operation of mechanisms of parallel kinematics confirms their high efficiency and prospects of this direction of mechanical engineering. Due to the design features of the layout, the mechanisms of parallel kinematics have closed kinematic chains that form spatial structures. As a rule, these structures are based on triangular rod systems. They have high rigidity characteristics, provide high speeds and acceleration of working bodies. Accordingly, these capabilities can significantly increase the static and dynamic accuracy of positioning mechanisms. The lack of theoretical foundations for the development of mechanisms, in particular high-precision mechanisms, hinders the widespread introduction of parallel kinematics mechanisms. Improving accuracy requires a comprehensive study of kinematics and work processes, taking place in their main nodes. Therefore, studies aimed at improving the parameters of static and dynamic accuracy of spatial mechanisms of parallel kinematics are relevant.

Key words: *Mathematical model, machine complex, functionality, monitoring, calibration of equipment, machining vibro process, vibromachines, machines with parallel kinematics.*

Fig. 7. Ref. 9.

1. Problem formulation

Working machines of special and general purpose, their separate knots and mechanisms are constantly improved, thus increase of a technical level of machines is carried out by introduction of new technical decisions, use of modern technologies and scientific developments.

During machining in the technological system there are many processes that affect the results of processing: oscillatory and thermal processes due to internal and external perturbations, others. Mathematical modeling of these processes at the stage of development and assessment of their impact on the initial performance of parts is difficult due to the diversity of physical processes, so it is difficult to predict with sufficient reliability the value of quality parameters of manufactured parts. It is known that the main production reasons for deviations of the actual size and shape of parts from theoretical are: errors of equipment, devices, cutting and measuring tools; inaccuracies in the installation and deformation of parts and tools under the action of forces applied to them; uneven heating of parts and tools and tool wear during machining; deformation of cast, welded and heat-treated parts under the action of residual and internal stresses. The nature of the manifestation of these errors is random, so their calculation is based on the probabilistic characteristics of scattering, which is determined by the characteristics of the tolerance field and the assumed distribution laws of the corresponding errors.

To maintain the working condition of the technological system and ensure the specifiedthe quality of parts must be monitored in the conditions of operation of machines and technical process. Machine monitoring is understood as a scientifically designed system (means and methods) of continuous observations and measurements using appropriate assessment procedures for identification, analysis of the current situation, recognition of special situations, short-term and long-term forecasting and automatic operational and tactical decisions. The monitoring system allows you to operate the equipment by condition, resource or level of reliability and on this basis to use the concept of maintenance as the most economical, flexible and efficient method of operation of factory equipment and vehicles, which is a key component of the operation process . Analyzing the initial results of monitoring, a conclusion is made about the need for additional work. Programming the route of the technological process of machining a part is to set the trajectory and speed of mutual movement of the tool and part, as well as the actions of auxiliary mechanisms of the machine with parallel kinematics numerical program control device with appropriate control program.

To obtain the control program of the route of the technological process of machining parts:

– determine the amount of processing and select the machine;
– determine the method of fixing the workpiece in the working area of the machine and select the necessary tools;
– to organize a rational sequence of surface treatment and the possibility of replacing the tool;
– determine the processing conditions of each surface, namely the spindle speed, cutting speed, etc.

To control the movement of the tool forming the contour of the part, it is necessary to determine the relative position of the workpiece and the tool in the working space of the machine with parallel kinematics, the accuracy of which directly affects the accuracy of the workpiece. This is due to the fact that the accuracy of the dimensions of the part is maintained relative to the origin of the coordinate system of the multi-purpose machine, and not relative to the base surfaces of the device, as when processing workpieces on machines with unprogrammed processing. The location of individual surfaces and structural elements in the volume of the part is set in the coordinate system of the part, which is associated with the coordinate system of the machine. Therefore, during the technological process of machining on multi-purpose machines use three coordinate systems: the coordinate system of the machine, the coordinate system of the part, the coordinate system of the starting point. Accordingly, the accuracy of the location of the treated surfaces relative to the technological bases of the part depends on the accuracy of the coordinate system of the part in the coordinate system of the machine. When fixing the workpiece, the technological base is combined with the corresponding support surface of the device. To ensure the connection between the coordinate systems of the part and the machine, the coordinates of the base points are used. The base points of the machine characterize the position of the working bodies in its coordinate system, which are determined by the design features of the working bodies. To ensure the connection between the coordinate systems of the part and the machine, the coordinates of the base points are used. The base points of the machine characterize the position of the working bodies in its coordinate system, which are determined by the design features of the working bodies. To ensure the connection between the coordinate systems of the part and the machine, the coordinates of the base points are used. The base points of the machine characterize the position of the working bodies in its coordinate system, which are determined by the design features of the working bodies.

2. Analysis of last researches and publications

The existing fleet of multi-purpose technological equipment in Ukraine has a fairly large stock of management, which almost completely meets the needs of production, but there is a problem of extending the technological life of this equipment. Suffice it to say that the cost of a new machine for the manufacture of mechanical parts of the machine is up to 70-80%, and the possibility of restoration work with equipment of modern automated control systems will significantly extend the service life of machines [1-3]. In addition, the gradual rise of Ukrainian industry leads to the need to put into operation modern technological equipment with mechanisms of parallel kinematics, but there is a problem of certification of this equipment for accuracy. Existing methods of calibration of technological equipment or are not accurate enough.

3. Aim of the researches

The task of developing a methodology for studying the errors of multi-purpose technological equipment using the universal complex of computer modeling STATEFLOW-SIMULINK, which in contrast to the existing ones will be cheaper and not inferior in accuracy in application.

4. Results of the researches

Implementation of a software method to increase the efficiency of machining process management.

The structure of decision - making strategy in technological process management is offered in the work. The strategy is based on the use of special features of the Stateflow-Simulink complex, the purpose of which is to create models of systems that can change their structure depending on changes in the state and parameters of systems. The complex is selected from a large number of available software products. Its capabilities exceed the capabilities of other modeling systems. This complex does not limit the level of complexity of systems.

The use of this product is a new interactive tool for development in the field of modeling of complex systems that are controlled by events and can significantly increase the efficiency of process control in machining systems. An integrated environment with Mathlab and based on finite state machine theory is proposed for the design of systems with built-in logic. New improvements include: data and operations support; performing cancellation and repetition functions; programmable access to the complex; support for two-dimensional matrices for data transmission; export of graphic functions from library tables. With the help of this complex it is possible to control the technical condition of multi-coordinate equipment, parameters of machining modes and parameters of the machine and parts.

Stateflow - a tool for numerical modeling of systems characterized by complex behavior. Such systems include hybrid systems. Such systems consist of analog and discrete components. Therefore, hybrid systems are systems with complex interaction of discrete and continuous dynamics. They are characterized not only continuous change in the state of the herd system, but also abrupt variations in accordance with the logic of the control program device. In the case when the logic of the control subsystem is rigid, and external conditions are relatively stable, we are talking about transformation systems (Fig. 1). For such systems, the acquisition phase is obtained information, its processing and output signals are clearly demarcated. At the time of access to the system, all input signals are identified. Output signals are generated after then some period of calculations, which calculations are produced according to some algorithm that transforms the input data set into the output. Otherwise, the system is classified as event-driven or reactive (Fig. 2). Reactive is a dynamic system that perceives external discrete actions and responds with its reactions to these actions. Moreover, the reactions of the system are different and themselves depend on both the actions and the state of the herd in which the system is located. The main difference distinction reactive systems from transformational - in the unpredictability of the moments of entry certain actions. Otherwise, the system is classified as event-driven or reactive (Fig. 2). Reactive is a dynamic system that perceives external discrete actions and responds with its reactions to these actions. Moreover, the reactions of the system are different and themselves depend on both the actions and the state of the herd in which the system is located. The main difference distinction reactive systems from transformational - in the unpredictability of the moments of entry certain actions. Otherwise, the system is classified as event-driven or reactive (Fig. 2). Reactive is a dynamic system that perceives external discrete actions and responds with its reactions to these actions. Moreover, the reactions of the system are different and themselves depend on both the actions and the state of the herd in which the system is located. The main difference distinction reactive systems from transformational - in the unpredictability of the moments of entry certain actions. The main difference distinction reactive systems from transformational - in the unpredictability of the moments of entry certain actions. The main difference distinction reactive systems from transformational - in the unpredictability of the moments of entry certain actions.

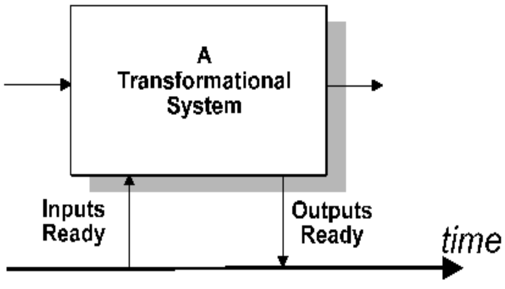

Fig.1. Transformation system

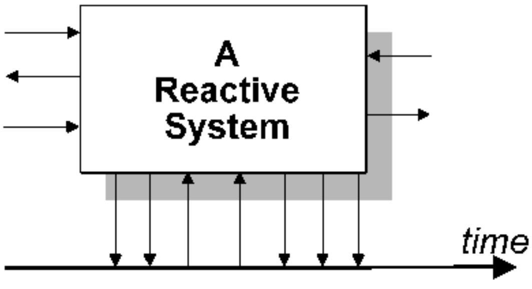

Fig.2. Reactive system

Modeling of physics of technological processes (continuous component of system behavior) is supplemented by modeling of logic of work by control devices (discrete component). The mathematical apparatus of description in this case is a system of differential-algebraic-logical equations, for which there is no coherent theory and a single approach, as well as with clarity. Visualization of the course of physical processes is provided by graphs of changes in time of certain quantities. Currently now for modeling the discrete dynamics of jet systems is widely used visual formalism - Statechart (diagrams of states estates and transitions). The main non-graphical components such diagrams are an event and an action, the basic graphic components - state herd and transition. Construction lineup models are possible using Stateflow programs and Simulink , which are part of the MATLAB package .

MATLAB provides access to various types of data, high-level programming and tools visualization. Simulink supports the design of continuous and discrete dynamic systems in a graphical environment (in the form of block diagrams). Stateflow - charts , included in Simulink - models to to provide the ability ability modeling of event-driven processes. MATLAB-Simulink-Stateflow combination is powerful universal tool for modeling systems. Additional capability monitor in real time the process of chart execution by enabling animation mode does the process of modeling systems visually. Stateflow - powerful powerful graphical tool for designing and modeling complex systems of local control and supervisory logical control allows :

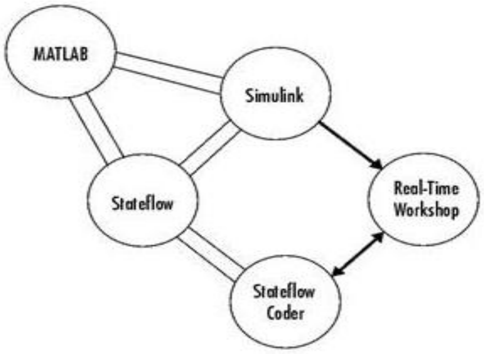

Fig.3. Integration of MATLAB , Simulink and programs Stateflow

1. Visually model complex systems.
2. Design deterministic supervisory management systems.
3. Easy to change. Betray project, evaluate the results of changes and investigate the behavior of the system at any stage of the project.
4. Automatically generate software code directly on the project.
5. Take advantage of integration with environments MATLAB and Simulink in the process of modeling and analysis of systems (Fig. 3).

Stateflow consists of the following components:
1. Stateflow graphics editor - graphic editor
2. Stateflow Explorer - conductor
3. Stateflow Coder -generator object codes
4. Stateflow Debugger - debugger
5. Stateflow Dynamic Checker -dynamic test device device .

During the task provides verification of looping conditions and violation of the data range. When designing models of jet systems Stateflow used in conjunction with Simulink and with with RTW (Real-Time Workshop - real-time workshop) managed by MATLAB . The model is designed starting with with control part of Stateflow share , and then composed Simulink model and the Stateflow It is possible to improve the existing Simulink model by replacing Simulink logic blocks on Stateflow charts. Stateflow machine - a set of Stateflow blocks in the Simulink model. Simulink Model and Stateflow the machine work together. Running the simulation automatically starts both Simulink and Stateflow parts particles models. Simulink model may consist of combinations of Simulink blocks, additional blocks with from Toolkits and Stateflow blocks (Stateflow charts). Stateflow diagram (Stateflow chart) consists of a set of graphical (states states , transitions, connections connections (nodes), chronological connections connections) and non-graphical (events, data, program program codes) objects (Fig. 4). Is available mutually unambiguous correspondence between the Simulink model and Stateflow by car. Each Stateflow block in the Simulink model presented imagine in Stateflow separate chart (Stateflow chart). Each Stateflow the machine has its own hierarchy of objects. Stateflow machine - the highest level in Stateflow hierarchy. Below in the object hierarchy Stateflow the machine is located a combination of graphic and non-graphic objects. Stateflow diagram (Stateflow chart) consists of a set of graphical (states states , transitions, connections connections (nodes), chronological connections connections) and non-graphical (events, data, program program codes) objects (Fig. 4). Is available mutually unambiguous correspondence between the Simulink model and Stateflow by car. Each Stateflow block in the Simulink model presented imagine in Stateflow separate chart (Stateflow chart). Each Stateflow the machine has its own hierarchy of objects. Stateflow machine - the highest level in Stateflow hierarchy. Below in the object hierarchy Stateflow the machine is located a combination of graphic and non-graphic objects. Stateflow diagram (Stateflow chart) consists of a set of graphical (states states , transitions, connections connections (nodes), chronological connections connections) and non-graphical (events, data, program program codes) objects (Fig. 4). Is available mutually unambiguous correspondence between the

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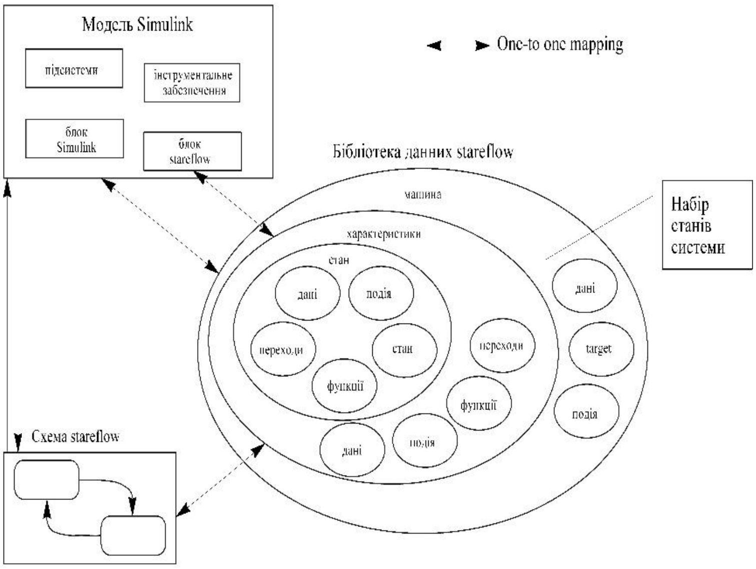

Fig.4. Simulink combination blocks, additional blocks with from Toolkits and Stateflow blocks

Defining the interface for the Stateflow block may include the following tasks:
1. Determining the method of modification of the Stateflow block
2. Defining Output to Simulink events.
3. Adding and determining nonlocal events and nonlocal data within the Stateflow diagram.
4. Defining connections with with by any external sources.

Consider in more detail the main features of this complex. The complex allows you to create and model systems with complex behavior. In this case, the system, which can be in different states (modes) and make transitions from one state to another when an event occurs. Using the complex, you can create diagrams that are a graphical representation of the finite state machine. States and transitions are the main blocks of the system that create a hierarchical system. Hierarchy allows you to organize a complex system of location of some objects (states, decision points) within other objects (states, sub-diagrams). It is possible to perform several operations with parallel access to the simulation unit simulink, as well as the use of recursive control algorithms, performing a set of predictive estimates to clarify the strategy of GVS.

Optimization of the machining process on a parallel kinematics machine in a flexible production system using Stateflow-Simulink.

As already mentioned, automation and technology cannot be separated. The areas of the most efficient use of flexible production systems are primarily determined by technological equipment, which is an integral part of the system, the range of machining parts and automated control system. With the help of Stateflow-Simulink the general model of flexible production processing system is shown, which is shown in Fig.6. The input data of the model is an electronic image of the part, which includes geometric and design parameters. This system describes all the above streams and displays the following actions:

1) decomposition of the electronic image and its transformation into a technological process of processing, which reflects the system;

2) obtaining an optimized technological process (by simulation in simulink);

3) depending on the current state of the system, the processing route is selected.

The model of flexible production processing system consists of subsystems:

– decomposition of the geometric image of the part obtained from the computer-aided design system;

– decoding the control program for the numerical program control system obtained from the adaptive control system;

– selection and purpose of the tool;

– monitoring the state of the machining process on the machine, etc.

In addition to automated production, monitoring of equipment and process is focused on the maintenance of machines on the actual technical condition and includes in practice a control system that monitors, monitors, protects and manages the technical condition of the object using real-time computer systems. In the general case, equipment monitoring is an integral part of production monitoring together with monitoring of work processes that provide control of determining parameters of machines, technical process and products, detection of degree of disorder, forecasting of moments of correction, prevention of emergency modes, etc. Some different concepts of monitoring include diagnosing, identifying, forecasting and managing the state of the machine system based on information analysis and decision making. In the machines of traditional circuit solutions are set and measured relatively simple graphic objects lines, planes, cylinders, which correspond to simple movements. Machines of parallel kinematics have complex elementary movements which are difficult to control. Elementary movements change under the influence of operational factors of temperature, deformation, etc., so in order to significantly increase the processing, periodic control of the accuracy of the machine is proposed to determine its actual geometry. With the help of STATEFLOW-SIMULINK a set of rational processing options in GIVS is formed.

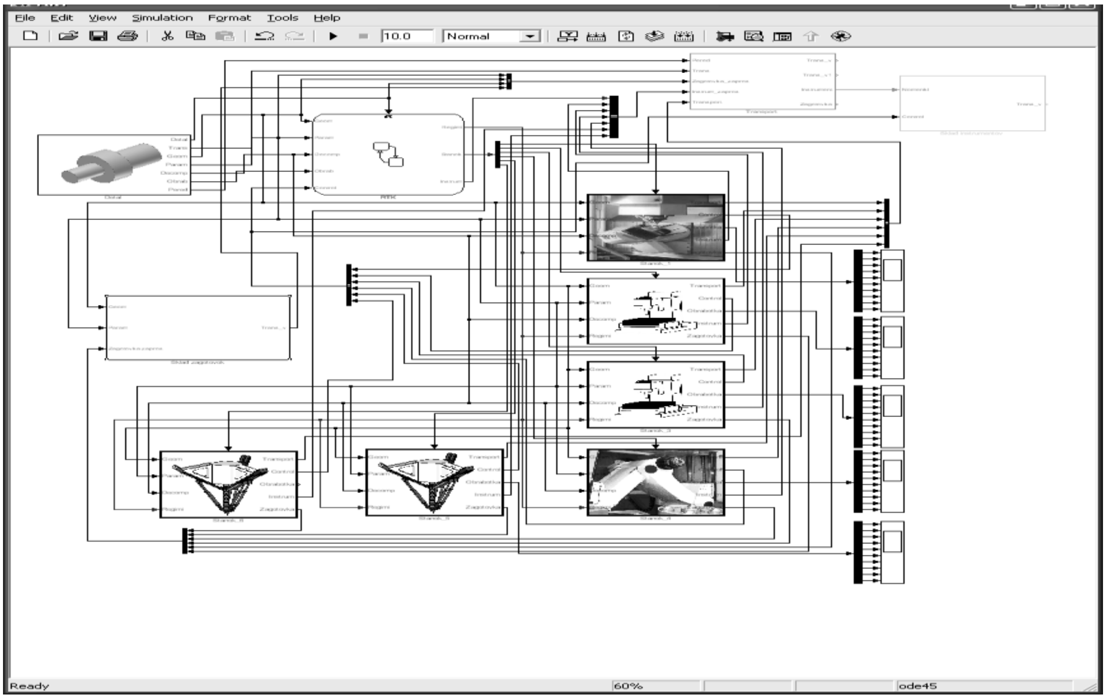

Fig.5. The general model of a flexible production system is implemented by means Stateflow Simulink complex

Options are compared by modeling or calculation. The best options for a certain period of time are selected. The stage (interval) of monitoring after the implementation of this optimal option is repeated. At the same time the optimum and rational variant of all system is chosen. The application of the complex requires a detailed description of each element and flow in the system. The obtained model of part processing from the sequence of control actions and STATEFLOW-SIMULINK diagrams of the state of a separate block of the model and monitoring of the state of both the individual machine and the system as a whole is given. The possibilities of monitoring are quite wide, from determining the efficiency to the energy of the whole complex. An event-oriented graph of the states of the processing process has been developed and implemented with the help of the complex. The mode in which the event-driven system is located is presented. Events change their properties, and the state of the system can be active and passive. The occurrence of such events is controlled by the STATEFLOW-SIMULINK diagram. As you can see - all states can be located in each other. Modeling the behavior of the system is carried out by changing the active states, ie the system changes its modes, moving from one state to another through objects.

The main production reasons for deviations of the actual size and shape of parts from theoretical are: errors of equipment, devices, cutting and measuring tools; inaccuracies in the installation and deformation of parts and tools under the action of forces applied to them; uneven heating of parts and tools and tool wear during machining; deformation of cast, welded and heat-treated parts under the action of residual and internal stresses.

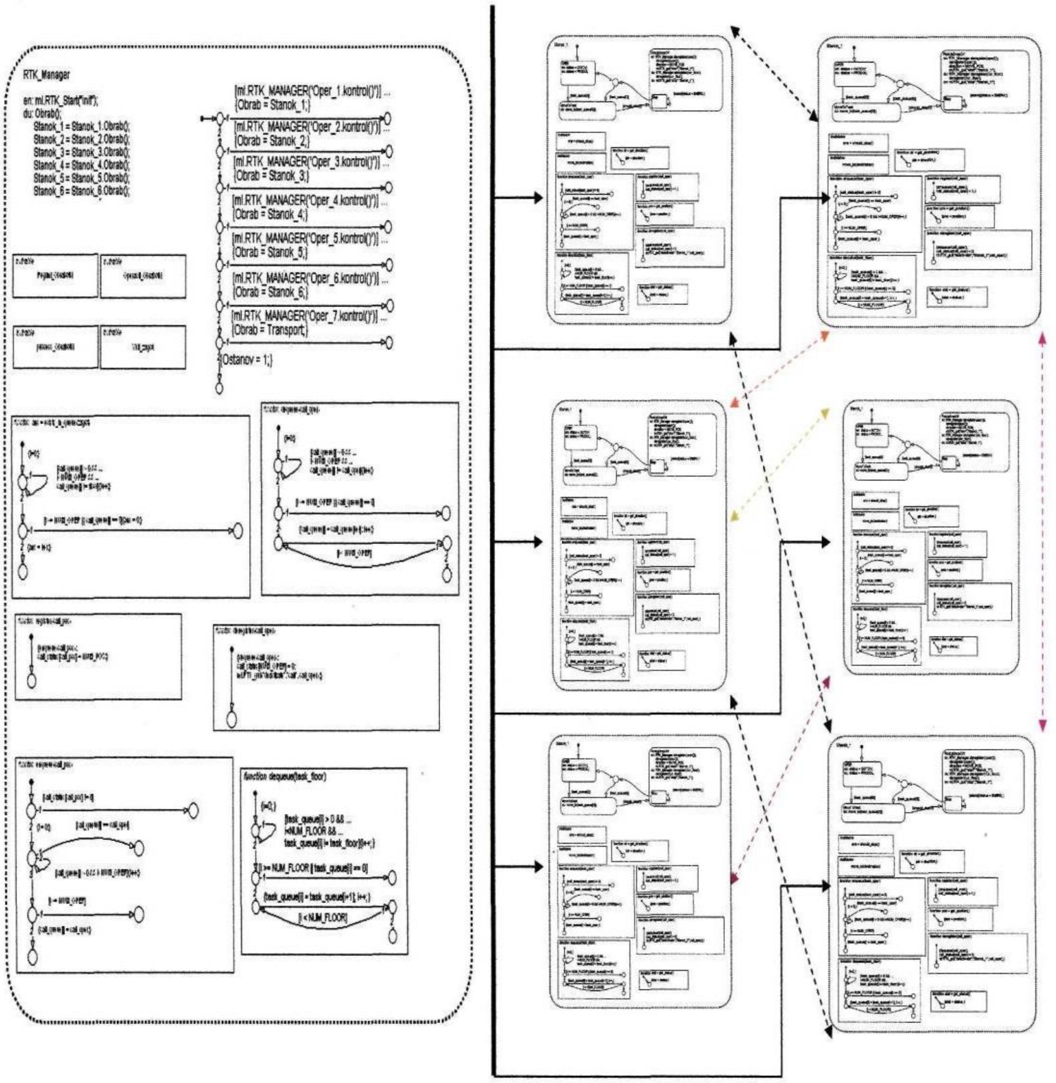

Fig.6. Event-oriented graph of the machine tool complex for cutting process, implemented by means of the STATEFLOW-SIMULINK complex

The nature of the manifestation of these errors is random, so their calculation is based on the probabilistic characteristics of scattering, which is determined by the characteristics of the tolerance field and the assumed distribution laws of the corresponding errors.

Dimensional errors are scalar primary errors and cause the accumulated errors of movement and deviation of the velocities of the known links. Errors in the location of working surfaces, as well as assembly shifts and skews, scalar and vector; in the first case, they cause the accumulation of errors of movement and deviations of velocities, and in the second - periodic errors of movement and fluctuations of speeds. Errors in the shape of the working surfaces are always caused by variable irregular errors of movement and fluctuations in speed. During the operation of the mechanisms there are errors caused by shifts in the gaps of kinematic pairs, deformations of parts and wear. They can be caused by forces acting on the parts, heating of parts and internal residual stresses. The magnitudes of these displacements are determined by the magnitudes of the gaps, the directions of the displacements - the direction of the forces. The gaps are technological errors and are random. Their values are determined by the probabilistic characteristics of scattering. Regular and smooth shifts in the gaps cause the accumulated errors of movement or deviation of the speed of the known link. Jump shifts that occur when reversing motion are the main causes of deadlifts.

The causes of force deformations of parts are the forces of gravity of parts, external forces, friction forces, forces arising from statically indeterminate design. The greatest influence on the accuracy of the mechanisms are usually deformations from external forces. However, in machines with massive structures, deformations due to the forces of gravity of parts are also important.

Deformations can be of the following types:

1) volumetric- stretching, compression, displacement, bending, torsion;
2) contact;
3) deformation in the oil layers.

Volumetric deformations are determined quite accurately by conventional methods of resistance of materials. The greatest influence of them is made by deformations of cross bending and torsion.

Temperature deformations of detailsarise from fluctuations in the thermal mode of operation of the machine. The errors of the mechanism caused by thermal deformations are small, and they can be ignored if all parts are made of one material and are evenly heated or cooled. In this case, the volume and dimensions of all parts change evenly and the accuracy of the mechanism changes little. If the parts are made of materials with different coefficients of thermal expansion, the thermal deformations will significantly affect the accuracy of the mechanism and must be taken into account. At uneven heating and at heating of bimetallic details deformations of a bend also appear.

Deformations of parts from friction forces in kinematic pairs are the main causes of elastic deadlocks, which play a particularly important role in long kinematic circuits. Wear of parts - one of the characteristics of the reliability of the mechanisms of precision instruments.

Irregular displacement of parts in kinematic pairs due to the instability of friction forces are the main reasons for the non-reproducibility of the positions of the known links.

The causes of oscillations and vibrations in machines are:

- imbalance of parts rotating at high speed;
- gaps and friction in kinematic pairs;
- insufficient rigidity of load-bearing structures;
- absence or insufficiency of depreciation devices.

The influence of primary errors on the accuracy of the mechanism must be limited by rational design and manufacturing technology. The indication of the states of the unit of equipment during monitoring (pulses on-off), the parameters to be monitored are presented (Fig. 7).

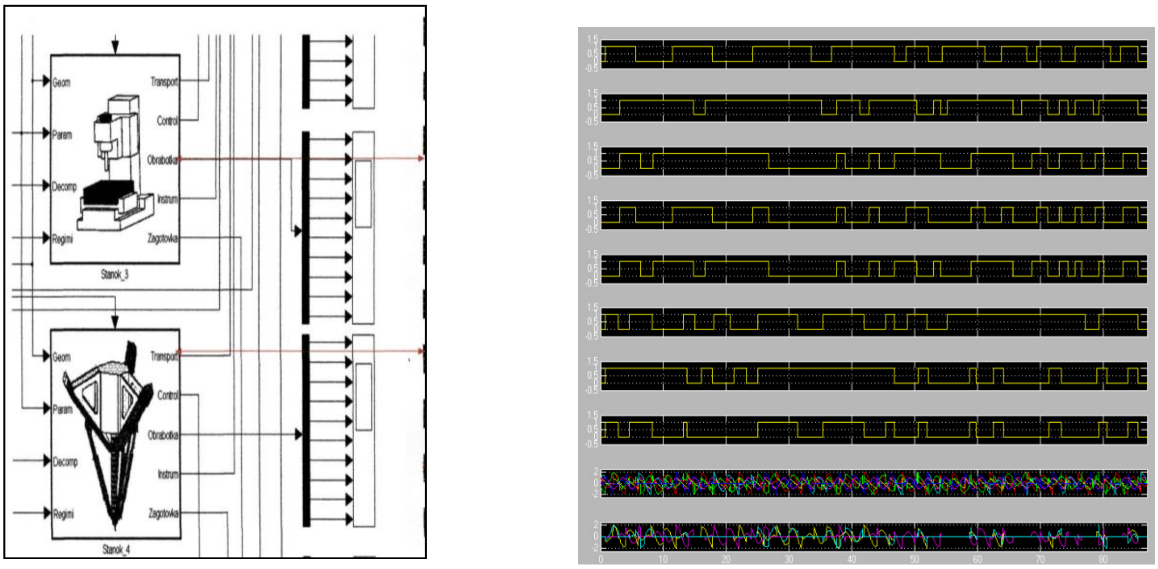

Fig.7. Indication of the state of the equipment unit during the monitoring of the machine tool complex cutting by means of the STATEFLOW-SIMULINK

After running the STATEFLOW chart and fully processing the initial startup of the SIMULINK event, it passes control of the SIMULINK model and enters standby mode, but remains active. In the work of improving the management efficiency with the help of the STATEFLOW-SIMULINK complex, it is possible to significantly improve the quality of the processing process organization and streamline the system of optimization strategy selection taking into account the results of DHW monitoring. The presence of an extensive system of modeling complex implements effective simulation modeling of the processing process.

5. Conclusions

1. The use of this tool allows you to automate the process of programming and modification and configuration of the CNC system in order to reduce the complexity of the control work.

2. The use of work results will significantly increase the efficiency and reliability of production systems of machining and will allow to adjust the schedule of the automated line, which provides more efficient use and reduction of energy consumption by eleven percent (11%).

3. The established conditions of processing provide the requirement to tool wear, accuracy of processing, characteristics of quality of a surface, productivity. The productivity of the body part with the number of holes to be processed, 8-12 increases the efficiency of processing by 15-20%, and with a larger number of holes is 25-32%. Error compensation by calibration reduces the overall error rate by 2-10 times.

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УПРАВЛІННЯ НОВІТНІМИ МЕТОДАМИ МЕХАНІЧНОЇ ОБРОБКИ ТА ВІБРО ПРОЦЕСАМИ

Проблема забезпечення необхідної якості та функціонування властивостей деталей машин стає все більш актуальною в машинобудуванні. Проте на сьогоднішній день відсутні узагальнені теоретичні зв'язки між параметрами якості поверхні, точністю обробки, експлуатаційними властивостями деталей і параметрами процесів механічної обробки, які б дозволили вирішити задачу технологічного забезпечення заданих експлуатаційних властивостей деталей. Контроль процесу *формування поверхні з необхідними властивостями здійснюється в основному за допомогою часткових експериментальних залежностей і таблиць режимів обробки. Складність проблеми полягає в тому, що при обробці деталей необхідно встановити такі умови обробки, які б забезпечували комплекс вимог до зносу інструменту, точності обробки, якісних характеристик поверхні, продуктивності праці тощо.*

Робочі машини спеціального та загального призначення, їх окремі вузли та механізми постійно вдосконалюються, при цьому підвищення технічного рівня машин здійснюється шляхом впровадження нових технічних рішень, використання сучасних технологій і наукових розробок.

Досвід розробки та експлуатації механізмів паралельної кінематики підтверджує їх високу ефективність і перспективність цього напряму машинобудування. Завдяки конструктивним особливостям компонування механізми паралельної кінематики мають замкнуті кінематичні ланцюги, які утворюють просторові структури. Як правило, в основі цих конструкцій лежать трикутні стрижневі системи. Мають високі характеристики жорсткості, забезпечують високі швидкості і прискорення робочих органів. Відповідно, ці можливості дозволяють істотно підвищити статичну і динамічну точність механізмів позиціонування. Відсутність теоретичних основ розробки механізмів, зокрема механізмів високої точності, перешкоджає широкому впровадженню механізмів паралельної кінематики. Підвищення точності вимагає всебічного дослідження кінематики і робочих процесів, що протікають в їх основних вузлах. Тому актуальними є дослідження, спрямовані на підвищення параметрів статичної та динамічної точності просторових механізмів паралельної кінематики.

Ключові слова: *математична модель, машинний комплекс, функціональність, моніторинг, калібрування обладнання, вібропроцеси, механічна обробка, вібромашини, машини з паралельною кінематикою.*

Рис. 7. Літ. 9.

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