AZERBAIJAN REPUBLIC

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DEVELOPMENT OF LOCAL INTELLIGENT MEASUREMENT AND CONTROL DEVICES IN TECHNOLOGICAL PROCESSES (IN ROBOTOTECHNICAL COMPLEXES)

Specialty: 3337.01 - "Information-measurement and management systems"

Field of science: Technical sciences

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Doctor of Science degree

of the dissertation submitted to receive

ABSTRACT

Baku - 2022

Dissertation work was performed at the " Electrical Engineering and Power Engineering " department of Sumgayit State University.

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OVERALL QUALITY OF THE STUDY

Relevance of the topic and degree of elaboration. The intensification of science and technology in robotics and automation of flexible technical systems in various fields of industry is widely applied.

The modern stage of development of science and technology requires complex automation of various production areas and technical systems. One of the important issues towards the creation of technical systems is the organization of information provision of automated systems. As a rapid development of scientific and technical progress, the direction of automation of the technological process of production is first of all accepted. At the expense of automation, the quality strategy of the material base is changed, the scope of work is changed, and the automation of various areas of the national economy is performed.

This strategy has been widely used in recent years, mostly in discrete manufacturing. First of all, such fields can be attributed to machine building and device manufacturing. For scientific and technical progress in this field, it is necessary to move from the automation of separate technological units (digital software control of machines, application of industrial robots) to flexible production systems and to organize it at different levels.

The technological process is considered the material base of any production area. Therefore, it is necessary to implement the management process and the application of automated systems in order to improve the characteristics of such production, including its productivity, the quality of the released product, and the profitability of production.

The quantitative indicator of automatic management is primarily the time spent on solving management issues, which is determined by a large number of parameters in a specific case. These parameters characterize the automatic control itself and its elements and are related to the operating conditions of the controlled system and the implementation of the implemented algorithm.

Based on the given indicators, one of the main aspects of the control system is its performance, i.e. the processing of the transmitters, or system operation time, system operation time, system idle time, planned prevention, repair, technical control of the unplanned system, etc. should be done according to the standard.

In modern automated control and management systems, various technological and physical processes use a wide range of raw materials and information processing. In this case, the transmitters allow practically complete determination of the metrological characteristics of any information - measurement and control systems. Ultimately, when losses in accuracy and reliability are due to improper use of transmitters, data conversion is also incorrect. The design and operation of systems is a big challenge when they include a large number of transmitters measuring different parameters. Such transmitters have a different working principle, metrological characteristics, structural dimensions, output signal form and level, a special data processing scheme and a different power source.

The solution of the issues presented is when there are unstable effects, for example, changes in the temperature and humidity of the environment, the presence of a toxic environment, the effect of radiation, etc. becomes difficult when

The nomenclature of the transmitters released in the industry is limited, their effective operation and evaluation of the results of the experiment is extremely difficult. As each new product is created, the arrangement of the apparatus to practically make the transmitter significantly delays their research.

Currently, due to the lack of selection of this or another type of transmitters according to the object, reasoned engineering calculations and operational studies, their operation according to the technological possibilities, many types of transmitters and their constructions are not reliable.

The large variety of parameters that are given to the input of existing transmitters and need to be measured, their wide amplitude and frequency range, poses the issue of creating a number of universal typical converters, which also provide the required initial information-measurement.

Among numerous different types of mechanical quantity transmitters, transmitters based on magnetic systems are of great interest, but numerous constructive options do not reflect their quality indicators, but reflect their technical and economic indicators. Structurally, the magnetic system of existing transmitters is rectangular, cylindrical, etc. is prepared in the form Cylindrical magnetic systems are highly resistant to obstacles, have low scattered magnetic flux, high sensitivity, and simple manufacturing technology.

The magnetic system of the transmitters in this form is made of ferrite material, which is fragile from mechanical shocks and vibrations, so they quickly disintegrate and lose their working ability. Thus, on the basis of a long-term study, it was determined that when the core of the magnetic system of existing inductive transmitters is made of ordinary structural steel, its above-mentioned shortcomings are reduced, that is, their sensitivity increases, they are resistant to mechanical shocks, their reliable operation is ensured, and their quality indicators increase.

In this regard, many Azerbaijani and Russian scientists, including academician T.M. Aliyev, M.A. Nabiyev, R.A. Aliyev, F.I. Mammadov, B.H. Mostovoy, T.A. Ahmadova used structural steel in their research to make transmitters.

The comparative analysis of magnetic circuits of different designs allows such transmitters to be used in the measurement of mechanical quantities. According to the setting conditions of the magnetic system, it is necessary to create it consisting of a high-grade homogeneous magnetic field of the magnetic system and to calculate the high-precision displacement, speed, oscillation, acceleration, force, pressure, torque, etc. at the base of this system. it is necessary to create transmitters that measure quantities. Thus, it is necessary to unify different types of magnetic systems.

The mass, dimensions, energy demand, structural simplicity of the transmitters, and the demand for manufacturing technology are the main important issues .

Automation of various technological processes, effective management of units, machines, and mechanisms requires the measurement of many different physical quantities.

All the requirements for the elements of automation to increase the reliability, quality and economic efficiency, the increase of all the requirements for the information-measurement and management (IMM) technique require new developments, extensive field research. In this field, great attention is paid to the development of electromagnetic elements, including their reliability, simplicity of technology and low cost. The magnetic circuits of such transmitters are usually described as electric circuits with distributed parameters, and their theoretical research is carried out based on the equations of long transmission lines.

Until the modern era, theoretical researches are carried out using classical calculation methods of distributed parameter circuits.

In the modern development of production areas, the use of new advanced technologies, the purchase of working or designed equipment minimizes losses during production. All this requires a significant increase in the quality of management in industrial facilities and the widespread use of the IMM system and technological process automation. Increasing the degree of automation of production requires the central control of new units. As a result, the degree of interaction of individual units, technological devices and lines increases, and the degree of their control, measurement and management becomes more complicated. Under these conditions, the problem of creating a IMM arises, and with its help, information acquisition, transmission, processing, analysis, and decision-making process operations are performed. The problem that has arisen requires the availability of modern technical means for control, measurement, regulation and management. The emergence of new technical means of the IMM, on the one hand, the creation of converters and transmitters with a standard signal at the output, and on the other hand, the problems of centralized processing of signals reflecting the model of the object's operation mode.

Aspects of the complexity of a technological system consist of monitoring, regulating and controlling a large number of interrelated technological parameters required, ensuring their operation by continuously affecting various execution mechanisms.

The management of technological processes is carried out on the basis of the received data, and the operation of the IEP is performed only on its basis.

At present, every robotic complex (RC) and automated flexible production system (AFPS), IMM systems are widely used and they contain numerous non-contact transmitters, and with their help, various physical quantities are converted into electrical quantities and provide information about the technological process [1, 2, 4, 9, 19, 23-25, 40].

In recent years, the creation of a database of the latest achievements of AFPS and RC computing techniques, the creation of transmitters suitable for the direction of the development of the IMM system increases the technical and economic indicators of production and at the same time the effective function of the management system.

Providing an accurate model of the object's state depends mainly on its accurate reception and transmission, analysis, and processing by the transmitters involved in the IMM systems.

AFPS and RC are equipped with a large number of different types of transmitters. Such transmitters should be comparably inexpensive, simple in construction, stable in parameters, high in mechanical strength, reliable, and shielded from interference. However, the transmitters of the existing IMM do not fully satisfy the requirements imposed on them.

Some of the converters used in AFPS and RC mainly work in relay mode. In such systems, in addition to transmitters working in relay mode, measuring transmitters that can measure technological parameters with high accuracy or various vision devices are also used.

In the technological lines of AFPS and RC systems, the product is moved along the line and is subjected to certain technological operations in different parts of this line. In this regard, in order to ensure continuity and consistency in the technological line, it is necessary to use devices that indicate the presence of products in one or more places of the line. For this purpose, electromagnetic inductive transmitters are used in the IMM systems. The primary elements of the current IMM systems - the transmitters - have low reliability. They fail quickly due to the corresponding mechanical vibration and shocks under heavy duty conditions. Measuring transmitters, technical vision systems and other control and regulatory devices working in such harsh conditions work unsteadily. Thus, it is necessary to increase the stability of the transmitters and the IMM. This remains a problem in production.

It is possible to solve the problem in two ways: the first way is to increase the reliability of the used transmitters and devices, and the second way is to use modern devices created on the basis of microelectronics technology to analyze and process information. This is the acquisition of an effective calculation method and their precise characteristics for the creation and design of the initial elements of the IMM systems.

The object and subject of the research: development of local intelligent measurement and control devices in robotic complexes.

The goals and objectives of the research : It is the development of algorithms and models that are researched with multi-functional, new construction and intellectual methods at the level of information-measurement and control of the automated management of robotics in production areas .

Research methods. Calculation of electrical circuits is carried out using the theory of linear and non-linear circuits; a study of the magnetic field in intact nuclei using electromagnetic theory is given, experimental results are confirmed approximately.

The main provisions defended:

1. Analysis of the research object, selection of types of information-measuring and control elements of the robotic complex and creation of a structural scheme;

2. Constructor design of transmitters of new construction for the active elements of the robotic complex, justification of increasing technical characteristics and determination of intellectual properties;

3. Development of non-standard manipulators of new design for robotic complexes and determination of their technological, kinematic and functional characteristics;

4. Calculating the functional parameters of electromagnetic type transmitters with a core made of structural steel and justifying the advantages of the transmitter based on measurement error, core material and dimensions;

5. Development of the algorithm for increasing the reliability and accuracy of the management functions of the equipment performing complex technological operations in the flexible production system;

6. Development of inductive transmitters that ensure the reliability and accuracy of information-measurement of complex angular and linear displacement technological operations in robotic complexes;

7. Construction of the replacement scheme and algorithm that keeps the output frequency of the transmitters stable at the information-measurement level of the automated control system in robotic complexes;

8. Development of mathematical analysis models of transmitters designed for information-measurement level of active elements depending on the type of production.

Scientific novelty of the research: As a result of the research conducted in the dissertation, the following scientific results were obtained:

1. The issues of constructor design of transmitters of new construction for the active elements of the robotic complex have

been resolved, and the increase in their technical characteristics has been substantiated;

2. Constructions of non-standard manipulators with a new design for robotic complexes were developed, and their information-measuring elements were selected;

3. Mathematical models were established for determining the functional parameters of electromagnetic type transmitters with a core made of structural steel, and the advantages of these transmitters were justified.

4. Inductive transmitters that ensure the reliability and accuracy of information-measurement of complex angular and linear displacement technological operations have been developed in robotic complexes;

5. At the information-measurement level of the automated control system in robotics complexes, a replacement circuit that keeps the output frequency of the transmitters stable was established and a research algorithm was developed;

6. Mathematical analysis models of transmitters designed for the information-measurement level of active elements depending on the type of production have been developed.

Theoretical and practical significance of the study: As a result of the studies, the cutting operation, polishing, the process of putting images on sheets, the process of drying the image and transferring it to the step conveyor, doubling operation, loading of the machine, working of the heating furnace, opening of the "kolokolchik", loading and unloading of hydraulic devices, from the furnace operation of drying air or water on the passing conveyor, inspection of technical vision system, provision of all technological operations with operating transmitters or measuring devices.

Realization of work results. On the basis of theoretical and practical studies, the development of mechanisms that ensure the operation of technological equipment in all parts of the transmission line and transmitters were applied in these parts. The results of the dissertation work were used in the scientific research works of the

"Electromechanics" and "Electrical engineering and energy" departments of Sumgayit State University.

The proposals, results, and scientific innovations given in the thesis work can be applied to the theoretical and experimental management of other objects.

Approval and application of the work: The main results of the dissertation work were discussed at the following conferences:

- On the issues of creating a distance transmitter with frequency output based on microelectronics elements. Republican Scientific-Practical Conference dedicated to the 60th anniversary of AzTU, - Baku: - 2010;
- Provision of th row-over Manipulator and step Conveter with Sensor Conference- IV International conference " Problems of Cyberneties and informatics " - Baku: vol.1, - September 12-14 , - 2012 ;
- On issues of the automated flexible production system working with transmitters - SDU-50. "Proceedings of the VII International Scientific Conference on Ecology and Life Activity Protection" - Sumgayit: - 2012;
- The main problems of information-measurement and control systems in robotic complexes. Proceedings of the 1st International Scientific Conference of Young Researchers. – Baku: Qafqaz University, April 25-26, 2013;
- Regarding the issue of temperature regulation of the transmitter's LC-autogenerator. "Modern scientific-technical and application problems of energy" International Scientific Conference. - Sumgait: - October 27-28, - 2015;
- On the development of locally intelligent measuring and control devices in robotic complexes. " Actual problems of science and technology , 2017 " X international scientific and practical conference of young students, - Ufa: Ufa State Oil and Gas Technical University, - May 17-19, - 2017;
- Fuzzy Logic Controller to Control Voltage and Reactive Power Flow at the Network with Distributed Generation. // Proceedings

of the Tenth International Conference on Management Science and Engineering Management, Springer, - 2017;

- Determination of inductance and transient processes in a distance sensor with a continuous magnet wire. Instrumentation and automated electric drive in the fuel and energy complex and housing and communal services. Materials IV national scientific-practical conference, - Kazan: - 2018;
- On the use of an inductive transmitter with a structural steel core in lectures and workshops in the subject of electrical and electronic devices. Actual issues of personnel training in energy specialties. Republican scientific conference. - Sumgait: - May 30-31, - 2019;
- On the study of the whole-core electromagnetic angular displacement transmitter used in robotic complexes. Current issues of applied physics and energy. International conference, - Sumgait: - November 23-24, - 2020.

Name of the organization where the dissertation work was carried out: The dissertation work was carried out at the " Electrical Engineering and Power Engineering " department of Sumgayit State University **.**

Dissertation structure and scope: The dissertation consists of 252 pages, including an introduction, 6 chapters, main results, 66 figures, 1 table, and a bibliography with 251 titles. Dissertation consists of 334829 characters without tables, pictures and bibliography.

Main content of the dissertation: In the introduction the topicality of the subject of the dissertation is justified, the purpose of the research is formulated, the main issues that need to be solved are defined, the main propositions defended are indicated, the scientific innovations and practical significance of the obtained results are indicated.

Chapter I of the dissertation, the aim of the dissertation was formed and the issues that needed to be solved in order to achieve this goal were determined.

In Chapter II of the thesis the structural analysis of the information-measuring and control system of the robotic complex and the arrangement of the transmitters are considered. Automation of robotic complexes (RC) created on the basis of widely used industrial robots (IR), manipulators, microprocessor control systems (MCS) and information-measuring systems is widely used in the device manufacturing industry. Issues such as improvement of IRs, increase of service life, increase of productivity are considered more priority. The research works conducted in this direction devote more space to research issues such as improving the structural, technological, electrotechnical characteristics of the transmitters used at the information-measurement (IM) level of the automated control system (ACS) of IR. In order to increase the efficiency and reliability of the management system of RC, it is appropriate to design intelligent transmitters, analyze and study their technical indicators with computer experiments, and solve the issues of improving the accuracy of transmitter measurements, processing and decision-making process.

According to the structural scheme of RC, which belongs to the appliance manufacturing industry and manufactures evaporators for household refrigerators, the scheme of its ACS information-measurement system is proposed. RC of evaporators conventionally consists of flexible automated areas (FAA) that perform the following individual functions, the inputs and outputs of each other are connected with the flow of products and semi-finished products. At the information-measurement level of the RC automated control system, *Di* transmitters are positioned in the active elements of production modules (Fig. 1).

Automated control systems of RC are equipped with information and measurement systems during their operation and perform their functions with their help. For this purpose, the module of each area is equipped with electromagnetic distance transmitters, measuring devices, with the help of which the dimensions of aluminum sheets are determined. The connection between the transmitters and the control system is connected with a multi-channel information-measurement system. The length of the communication channel between the transmitter and the processing unit is considered to be up to 100 m . Experiments show that there are no obstacles to the data signal in such a communication line. In this case, the characteristics of the information-measurement system are the same as the characteristics of the transmitter. In this regard, in order to increase the reliability of the information-measurement system (IMS), it is necessary to reduce the number of wires connecting the transmitter and the IMS.

For this purpose, feeding the transmitters and extracting information from them is performed with three wires, and all transmitters are fed in a centralized form. Thus, the wiring of the communication line is greatly reduced. A large number of transmitters are used in different positions of the field automation control system to provide function x, and these are used to control the execution mechanisms. The transmitters of the IR and the manipulator used in the technological line are selected from the point of view that their construction is simple and small in mass. The diameter of such transmitters ÷should not exceed $(10\div15)10^{-3}$ m, length $50\cdot10^{-3}$m, mass (100÷150) g. The sensitivity of the transmitters $(1\div2)10^{-3}$is assumed to be m. With the help of transmitters, the initial and final positions of İR's hand are determined. Microswitches are sometimes used as transmitters in İR. Such transmitters are installed directly in the pneumo-hydraulic system at the tail of the hand and are not reliable for long-term operation. It is necessary to replace them with small contactless transmitters.

From the conducted studies, it is clear that it is convenient to use small size transmitters of electromagnetic type in handles. While working İR, their hand needs to move up and down along with the handle. A device is used that raises it up and down. Such transmitters should have a small size. It should be noted that the sheets in the technological line move in a wave-like manner and their amplitude $7\cdot10^{-3}m$ can vary from zero to . Therefore, $15\cdot10^{-3}$ transmitters with sensitivity m are placed on such a line. Such transmitters are also used in portal robots. With the help of these transmitters, the initial state of the portal robots and at the same time

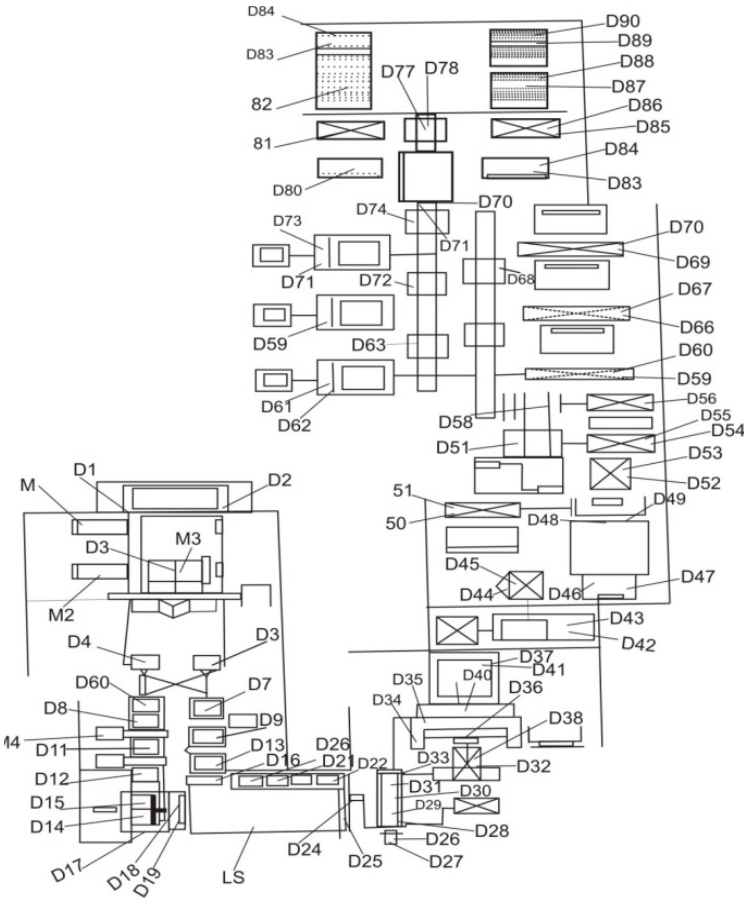


Figure 1. Positioning scheme of transmitters at the information-measurement level of the RC automated control system

determines the position of the sheet stacker. Transmitters are also used to determine the state of the transport system when transporting sheets. Counter communication transmitters are also used in this part.

The result of the current processing of information is used depending on the condition of the field, the control system, the execution mechanism of the gantry robot, the lifting device of the handle, the loader of the transport system, the control system of the heating furnace of the cutting geliatin tool. It should be noted that the control of all executive mechanisms is performed by MCS.

The study of the design stages of ACS of RC determined that the productivity of its future activity depends on the creation of information security, that is, the formation of the database and knowledge management systems during the design of ACS, the search and selection of its information and measurement elements in the initial stages. reliability depends on many aspects. The analysis of ACSs of existing RCs in various fields of industry of developed countries shows that the efficiency of the activity of such large enterprises with hierarchical levels of automated management in many cases depends on the correct selection of how many elements of the management system, the assessment of the productivity and efficiency of the production process, in the scheme of ACS depends on effective use of innovative management tools.

Cases such as assembly, classification according to forms, detection of internal and external defects of materials, products and their analysis, analysis of mechanical quantities, and diagnostics find their application in the studied RC. In this regard, each technical unit of the RC is equipped with primary converters and transmitters working on the principle of touch for the purpose of technical diagnostics and processing units with diagnostic data, mini and MCS or programmable logic controller.

İn general, RC's information-measurement system (IMS) consists of technological measurement, electrical conversion of input parameters, communication tools that provide signal transmission, software tools that provide processing, regulation, management and logical decision, and expert knowledge processing systems. Here, with the help of the contour, displacement of transmissions, manipulators, diagnostics, classification of the studied parameters, their automatic analysis and the adopted decision are performed.

The İMS of the RC includes special measurement transmitters and diagnostic devices (Figure 2).

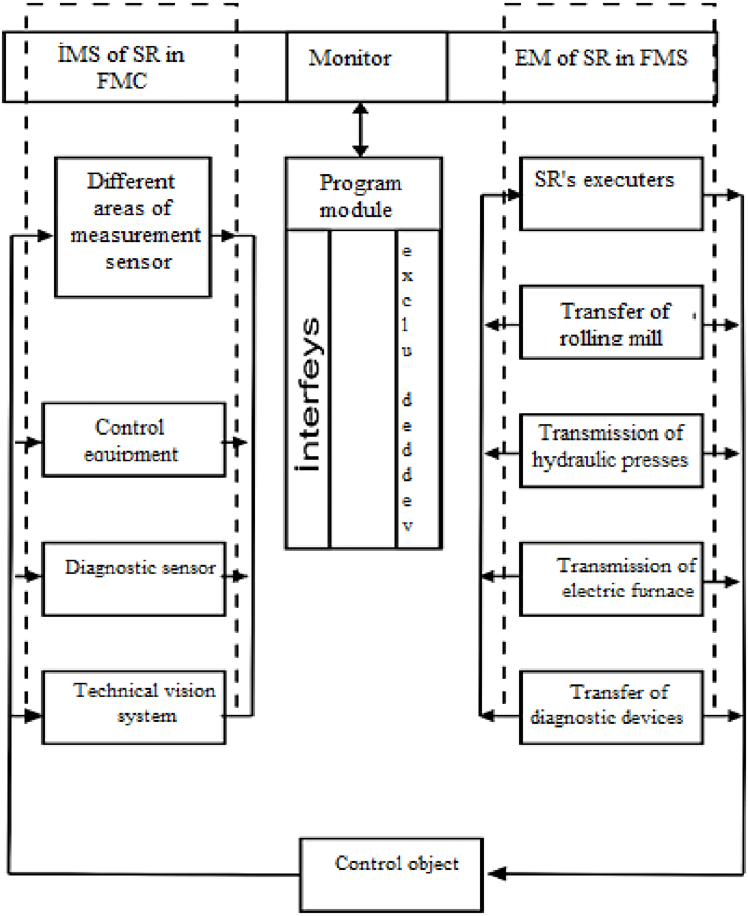


Fig. 2. Scheme of connection of SR technological measurement and execution mechanisms to the control object in RTC

RC 's İMS includes the following: a transmitter that determines the presence or absence of a part in the technological line, transmitters that determine the position of the manipulator and İR's hand, transmitters that determine the temperature in the ovens, diagnostic transmitters, measuring transmitters, transmitters that measure the length of the sheet, internal defects determining transmitters, a device for determining the quality of polishing, a device for determining the uniformity of the image on the surface of the sheets, a device for measuring the thickness of the sheets, a device for determining the distance between the rollers of the rolling mill, a device for determining the temperature of the oil, a device for diagnosing cracks that can be found on the shafts, a device for detecting the appearance of cracks in the sheets of evaporators a diagnostic device that determines, a device that opens the mouth of the channel in evaporators (opening the valve), a transmitter that measures the pressure of the hydraulic press, technical vision that determines defects in finished products, a technical vision system that informs the collection of products in crates, used in the storage of finished products lunan technical vision systems and implementation mechanisms, special measuring transmitters.

The following measurement systems are used at the 1st level of ACS in the studied RC: 1. Measurement and regulation of the temperature of the furnace used for heating metal sheets and finished products; 2. Measuring and regulating the temperature of drying ovens. In such ovens, the color applied to the sheets is dried and the water of the expanded channels of the finished product is dried; 3. Measurement of mechanical force in the hand of İR at several points; 4. To measure and adjust the distance between the shafts of the rolling mill; 5. To measure the pressure of the air entering the executive mechanism of İR; 6. To measure the pressure of the liquid used in expanding the channels of the evaporators; 7. Measuring the pressure of non-standard elements implementation mechanisms; 8. To measure linear dimensions of products, etc.

İn Chapter III of the thesis for non-standard devices and manipulators applied in the robotics complex the issue of processing and research of information-measurement elements is considered.

Along with standard active elements, non-standard technical tools are used in the studied RC, because in order to ensure the quality of products in production processes, it is required to re-design, conduct tests and apply special manipulators, control, executive, and information-measuring tools. . Due to the fact that RC has complex technological, functionally related production modules, areas, active elements with special properties are used, it is required to use non-standard mechanical, electronic and plastic devices and equipment. As can be seen from the general structure of the RC, RC i ($i=\overline{1,6}$) requires the use of technical means such as special manipulators (elevator and positioner), İR handles, new information-measuring elements, and control elements.

Logical, heuristic algorithmic methods and mathematical numerical calculation, matrix, differential calculation, and mathematical physics methods are used in order to effectively implement the procedures of accurate selection and design of non-standard elements. For example, accurate calculation of structural dimensions, material, static and dynamic parameters of an industrial robot's grip device, determination of active element ranks, structural parameters, determination of kinematic characteristics, determination of heat transfer values, selection and drawing of non-standard elements and their parts with logical models. , the procedures for building network models by heuristic methods can be mentioned. At the stage of system engineering design, the capabilities of the computer-graphics system, data and knowledge base management system, technological analysis software systems are used to ensure the automatic selection and design of mechatronic elements of the RC.

RC's non-standard in the technical proposal stage in order to place the elements in exact positions in the layout scheme, to determine safe distances, to calculate the optimal working zone of production areas, modules, the initial set of input parameters is defined:

$$\boldsymbol{M}_{\boldsymbol{KS\_RTKi}} \in \{ \forall \boldsymbol{M}_{\boldsymbol{KS\_RTK1}} \in \{ Q^{ei}_{RTK1} \}, \forall \boldsymbol{M}_{\boldsymbol{KS\_RTK2}} \in \{ Q^{ei}_{RTK2} \}, \ldots , \forall \boldsymbol{M}_{\boldsymbol{KS\_RTK6}} \in \{ Q^{ei}_{RTK6} \}\},$$

where M_{KS_RTKi} – the set of layout schemes of production areas of RTK; $\forall M_{KS\_RTKI} \in \{ Q^{ei}_{RTK1} \}$, – RCi – is a property of a set of non-standard elements in the kompanoka schema.

In the sketch design stage, which is distinguished by large-scale scientific and research works, information provision based on the data and knowledge base of non-standard elements of RC, depending on the providing, management and functional properties, mathematical provision based on mathematical methods and models, operating system, office, designer, animation, general and special software is organized on the basis of computer tests, network programs. Tests are carried out in laboratory conditions based on the results of graphic and technical documents, specification data, animation research models, mathematical and algorithmic models prepared at the sketch design stage.

Its structure is created on the basis of information, mathematical and software tools formed in the automated design stages of non-standard elements of RC. Automated design and selection operations of industrial robots, technological equipment controlled by a digital program, and mechatronic devices of the management and control system are provided in accordance with the CAD, CAM, CALS systems of the progressive information technology used in the structure and the productivity and high memory volume indicators of the computer equipment. The structure of the automated design tool of non-standard elements of RC is formed in the form of generation of subsystems. Automated search and selection of mechatron devices by mathematical and logical methods is provided by means of subsystem of design, search and selection of non-standard elements of RC . The selection of standard and non-standard elements of information-search algorithmic provision is considered the base model of the subsystem. An algorithmic tool of the search system is created in the subsystem based on the logical and heuristic knowledge formed in this subsystem, the determined indicators of construction forms, kinematics, layout schemes, strength report and working zones.

The types of RC non-standard information-measuring and performance elements and their static and dynamic parameters are stored in the database (DB) created in the "Microsoft Access" system. Conditional queries (based on logical operators of the "Microsoft Access" software system) for searching and optimal selection of standard and non-standard elements from the database are prepared according to production requirements. The values of the expression entered in the search request are compared with the data stored in the tabular database, and the technical indicators of the selected mechatronic elements are displayed on the screen.

İn order to ensure the efficient implementation of construction project works, the procedures for drawing up sketch documents are automated through a computer graphics system. In the computer graphics system, the input information entered by the designer is processed and the operations of selecting 2-dimensional graphic elements in the projection areas and applying them in the main drawing area are performed in the format required for the description of the non-standard object. Based on the in-computer representation of the object, the output unit generates the digital data of the designer documents and transmits the information in the form of commands to the graphics unit, graphic display or other peripheral devices. The control project procedure is executed in exchange mode to affect program processing and data exchange. The data bank is consulted for correction, updating and drawing, editing, and placement of measurements on other objects on the constructor documents. The geometric shape of the object drawn in the "CAD" system is given by two or three-dimensional images. As a non-standard element of RC, a two-dimensional graphic representation of the handle of an industrial robot is provided in the "AutoCAD" system. Two-dimensional drawings are more suitable for electronic components, surface details and rotating parts. With the help of a two-dimensional image, in addition to the contour of the part, its normal section is given. Mathematical support models and software tools are built to perform in-computer generation of projections of details and lines at the expense of a two-dimensional image. More complex mathematical tools must be built to perform three-dimensional images and in-computer generation. In three-dimensional drawings, detail is formed as standard elements (rectangular prisms, cylinders, cones and complex elements). Line segments and circular arcs are commonly used for two-dimensional representations of objects. Information exchange operations between subsystems are provided on the basis of the automated design interface. In the menu blocks of the interface, tasks such as saving separate algorithmic, mathematical, informational projects in the form of files, editing procedures, ensuring connection with the network system, drawing graphic images, recording dimensions, creating tables, designing presentation operations, using ready-made image forms performed. At this time, the commands issued by the control system and execution mechanisms and the corresponding manipulators' body condition and relationship with the external environment are ensured. In order to keep the required shape stable, it is necessary to control the movement of the manipulator of the object along the required trajectory. In this case, the robot and the manipulator have seven working states.

İn the studied RC a manipulator drawing a stencil of non-standard channels is proposed for the operation of placing a picture on aluminum sheets (fiq. 3). A non-standard manipulator consists of a combination of three manipulator parts. One of them positions the imaged product according to the stencil. Second, he transfers the image on the stencil onto the product. The third manipulator transfers the imaged product to the entrance of the heating furnace.

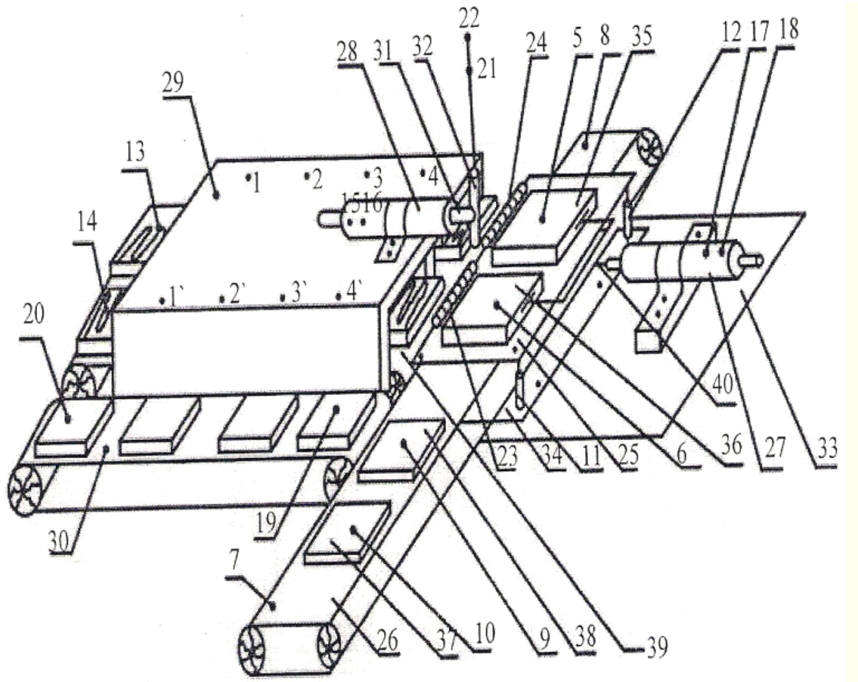


Figure 3. Schematic diagram of a non-standard manipulator drawing a stencil of channels

All three of the manipulator are equipped with transmitters and actuators. At the beginning of the technological process, all parts of the manipulator are in a static state. The process of automatic image placement on sheets is performed in the following order. Metal sheets are brought to conveyors 5 and 6 with the help of a belt conveyor (BC). In this case, the BC stops according to the command of the central control machine. At the moment when the BC stops, the second manipulator starts and with the help of electromagnets 11, 12, 13, 14 presses the stenciled sheet to the metal sheet on the conveyor. At this moment, the roller hand of the first manipulator moves in the horizontal direction with the help of the executive mechanism 28. Rollers dipped in color roll over the stencils and, with their help, put the stenciled images on the sheets and move back to take their original position. The rollers are in the form of cylindrical rods, which are always pressed to the stencil sheet by means of 32 springs and can move on it in the horizontal direction. In the initial state, the distance between the conveyor 26 and the sheet 25 $10^{-2}\,m$ – does not exceed. The initial and final positions of the part of the manipulator are determined by transmitters 15,16 (in the horizontal direction), the lower and upper positions of the hand are determined by transmitters 21,22. After finishing drawing on the metal sheets on the transmitters 5 and 6, the executive mechanism of the third part of the manipulator 23 starts and hands the picture sheets to the entrance of the furnace 29, changes its position in the horizontal direction, and then the hand returns to its original position. In this case, BC 26 works, moves the metal products on transmitters 9 and 10, puts them on transmitters 5 and 6, and indicates that it is ready for the next imaging operation. The above-mentioned drawing operation and placing the product in the oven are repeated. With the help of BCs in the oven, the pastas are moved inside the oven and at the same time they are dried and moved towards the outlet. The products received at the exit of the oven are picked up by special manipulators and transferred to the step conveyor (fig. 4). In order to ensure the automation of the operations of the manipulator, which moves pastas from the exit of the oven to the step conveyor in the 1st production area of RC, it is required to determine the sequence of its technological operations and to select and arrange information-measuring elements at the primary level - transmitters, execution mechanisms and control means. In this regard, the metal sheets from the exit of the furnace to the step conveyor let's analyze the work of the manipulator. Here, 1 pneumointigal 2 is attached to the support 3 by hand. 3 There are two arms equidistant from the support. 11 pneumointigal with 6 arms is connected to 4, 10 T-shaped parts on both of these hands, and the same pneumointigal with its fingers 5 and 7 squeezes the paste 9 through fingers 12-13 with a small force.

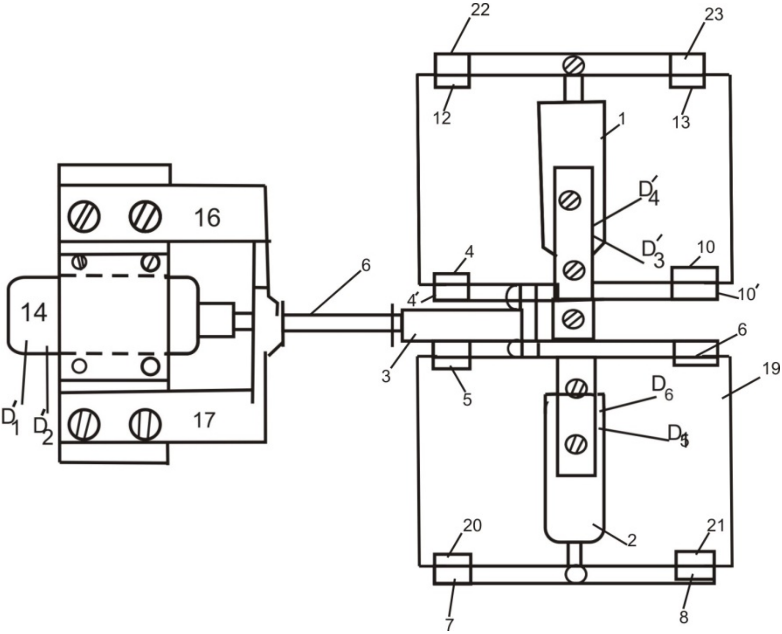


Figure 4. Oven-dried sheets to step conveyor moving manipulator

İn the same way, 14 pneumointigals are attached to 16-17 picture plates. With the help of T-shaped bars 16-17 and 20-21, the paste 19 is pressed between the bars 22 and 23 with a small force. After the pistachios are pressed between the bars, pneumointigal 1 starts, transfers the pistachios onto the step conveyor and moves the pistachios to positions 24, 25 on the step conveyor. When the manipulator takes position 24-25, the bars open (12-13 and 22-23), the pins fall to positions 24 and 25, and after the bars of the manipulator are freed from the pins in the positions, it returns to its original position. The initial state of the manipulator is considered to be the output of the furnace. In the next case, if there is a pair of pestles at the output of the furnace, then the bars of the manipulator 1 close again and the arm goes forward and takes the position 24-25. In this case, the bars are opened, the manipulator is freed from the bars.

İn the next stage, the process of filling and emptying the manipulator is repeated. Depending on this, the step conveyor is also filled and emptied. Distance and contact transmitters are widely used here for the periodic operation of the manipulator . These transmitters are placed at the outlet of the electric stove in such a way that each of them senses the presence of a pesta. The contact transmitters used here control the linear forward and backward movement of the manipulator's arm. Distance transmitters are placed at the outlet of the furnace. According to the information received from them, both fingers of the manipulator have to move to the top of the step conveyor after receiving the paste. Its final position is positions 24-25. If one of the painted pasthas remains in these positions, then the bars are not opened in the last position of the manipulator 1. As soon as the positions 24-25 are free of pastashes, the bars of the manipulator are opened and freed from pastashes, the manipulator should return to the front of the stove. When the grates of the manipulator are in front of the furnace, they are closed in the first position when positions 24-25 of the step conveyor are free from the pestle. As a result, the bars of the manipulator close and it goes back. When the fingers are in the 24-25 position, the bars are opened and the pashtos are placed in the 24-25 position. This process is repeated in the next step. When the pastes received at the exit of the oven that dries the color painted on the metal sheets are on the transmitters 13 and 14 (picture 4), information enters the industrial computer, and the manipulator is activated according to the command received from it. His hand attached to transfer 4 (Fig. 5) goes forward horizontally and rests on the products on transmitters 13 and 14, and at this moment transfer hands 2 and 3 are activated, $12'$, $14'$ and $12''$, $14''$ and 12, 13, $16'$, $18'$ and $21''$, $24''$and with the help of bars 22, 23 products 15, 16, $12''$, $13''$ and $15'$, $16'$, $15''$, $16''$, 4, 10 and $4'$, $10'$ are squeezed between the bars. As a result, the products squeezed between the bars are moved onto the step conveyor with the help of the manipulator. The products between the hand and bars of the manipulator are thrown onto the step conveyor (fig. 5) and after one step, the transmitter D_6, which indicates its final position, turns on and stops the manipulator. If there is no product on the D_1, D_2, D_3, D_4 transmitters placed on the step conveyor , transfers 2 and 3 work and open their hands and drop the colored sheets on those transmitters. If there are additional products at the outlet of the drying oven, then the manipulator moves forward again and brings them onto the step conveyor. If during this period the transmitters D_1, D_2, D_3, D_4 have been freed from products, the load of the manipulator is unloaded to the conveyor and this process is repeated at the next stage. The created manipulator consists of the following parts: 1- $3 \cdot 10^{-2}$ a narrow steel plate with a thickness of no more than m; from pneumatic integrals 2 and 3 attached to it with clamps 15 and 16; 5 and 6 are immovable and 7, 8 are movable hands. The moving hands 2 and 3 are fixed according to the axes 9, 10 of pneumo transmissions. Transmission clamps are attached to 1 steel sheet with 20, 21, 22, 23 bolts and nuts. Each hand consists of 12, 16, 12, 13 and 15 $^{//}$, 16 $^{//}$, 15 $^{//}$, 16 $^{/}$ fingers, respectively. Here, since the bars 11 $^{/}$, 14 $^{/}$ and 11 $^{//}$, 14 $^{//}$ are attached to the hands 5 and 6, they are considered immovable. But since the bars 11 $^{//}$, 14 $^{//}$and 15 $^{//}$, 22 $^{//}$ are attached to the hands 7 and 8 respectively, they are movable. Fixed hands are attached to 1 steel sheet with bolts 24 and 25. The hand of the manipulator is attached to 4 transmissions and can move along with its axis. The axis 17 of the transmission 4 is connected to the steel sheet 1 by passing through the hole 17 $^{/}$ and with the help of the handles 18 and 19. 4 is connected to the base 26 with the clamp 28 through the bolts 29, 30, 34, 35. The axes of the gears 2, 3 and 4 used here do not have a rotational movement. They can only move horizontally (forward, backward, right, left).

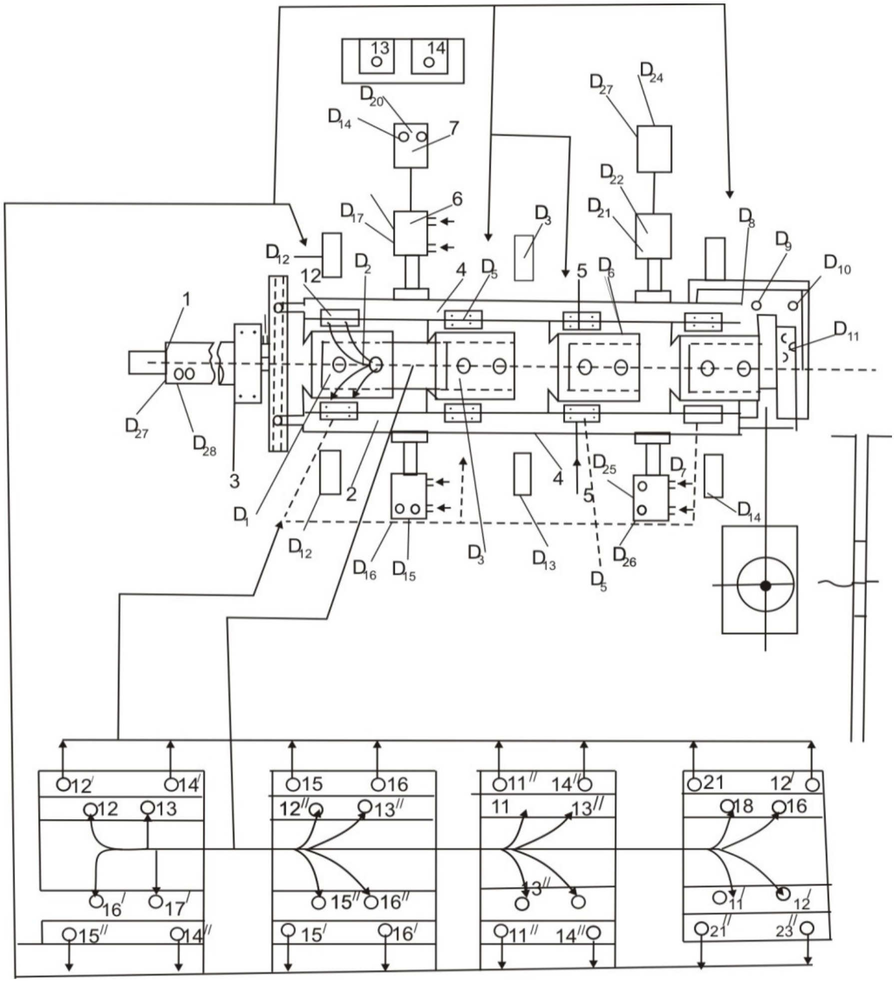


Figure 5. Arrangement scheme of information-measuring elements of a non-standard manipulator on a step conveyor in RC

D_1, D_2, D_3, D_4, D_5, D_6 in the manipulator are related to the industrial computer, commands are received from the industrial computer to perform the operation depending on the information received from them. For example, when the D_{13} and D_{14} feeders have colored sheets on top of them, they move them to the top of the step conveyor. The distance of the outlet of the drying oven from the floor of the step conveyor should differ from each other by no more than $15 \cdot 10^{-2}$ m. Figure 5 shows the interaction between the step conveyor of the created manipulator and the drying oven. The picture shows the outlet of the drying oven. In this part, 38 pestles are shown on top of the BC and its holding by bars $11^{/}$, $13^{/}$, 40 drums of the BC of the furnace, 37 step conveyors in front of it and its 36 transfer, 26 bases attached to the body of this transfer are shown. 4 transmissions are attached to the base with 28 clamps. 17 axes of 4 conveyors hold 38 products on 1 steel sheet with the help of grippers, and with the help of 4 conveyors, they are moved onto the 37 step conveyor and the next technological operation is started. A resistance converter is also placed in this furnace. Next, the technological process consists of doubling metal sheets (pictured and non-pictured) on top of each other. In the construction of the step conveyor standard and non-standard transmitters are shown. Here (D_{12},$D_{12}^{/}$), (D_{13},$D^{/}_{13}$), (D_{14},$D^{/}_{14}$), (D_{15},D_{16}), (D_{17},D_{18}), (D_{19},D_{20}), (D_{21}, D_{22}), (D_{23}, D_{24}), (D_{25}, D_{26}), (D_{27}, D_{28}) standard and D_1, D_2, D_3, D_4, D_5, D_6, D_7, D_8, D_9, D_{10}, D_{11} are non-standard transmitters. Figure 5. The arrangement scheme of the information-measuring elements of the non-standard manipulator on the step conveyor in RC is given.

Machines with complex technological operations work in the studied production module. The types, number and positions of the transmitters necessary for reliable and accurate provision of automated control of this type of active technical unit should be selected. One of the equipment that performs complex functions in the device manufacturing industry is a rolling mill. To ensure normal operation of the rolling mill, it is necessary to adjust the distance between its shafts. If the adjustment between the shafts of the machine is not carried out correctly, then the geometric dimensions of the product are disturbed in cold soldering in such a way that sometimes it is even impossible to fix it (when it is longer than the norm).

However, if the product passing through the stand is smaller than the norm, it can be corrected by releasing it from the spreading stand again. In the system of making vaporizers, it is necessary to measure the geometric dimensions of the product - width and length - after the rolling stand. At present, geometric measurements are made by the worker with an ordinary ruler. Taking into account the aspects of the technological process, a device for measuring the length of the product was proposed. Four distance transmitters are used in the created device (Figure 6).

The electromagnetic type transmitters used here work in relay mode.D_1 and $D_2$the distance between the transmitters is selected according to the normal length of the product. When entering the product D_1dispenser zone, the S_1counter starts working. However, the counter stops when entering $D_1$the product D_2dispenser zone .D_1 and D_2 when the transmitters work, they D_3 connect the circuit of the transmitter with their normally open contacts, and the pulses of this coil indicate the degree of increase in the length of the product. According to the products received from the transmitters, if there is a waste product at the place of measurement, the SR takes that waste product and puts it in the 2nd box. So he records the D_3 longer than normal size and D_4 the shorter than normal size and SR takes it and puts it in the second bin near the conveyor. Products with short dimensions are returned for recycling.

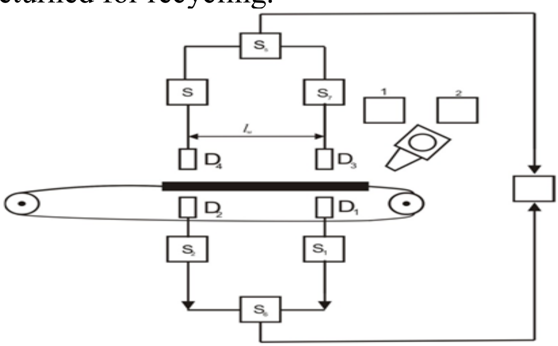


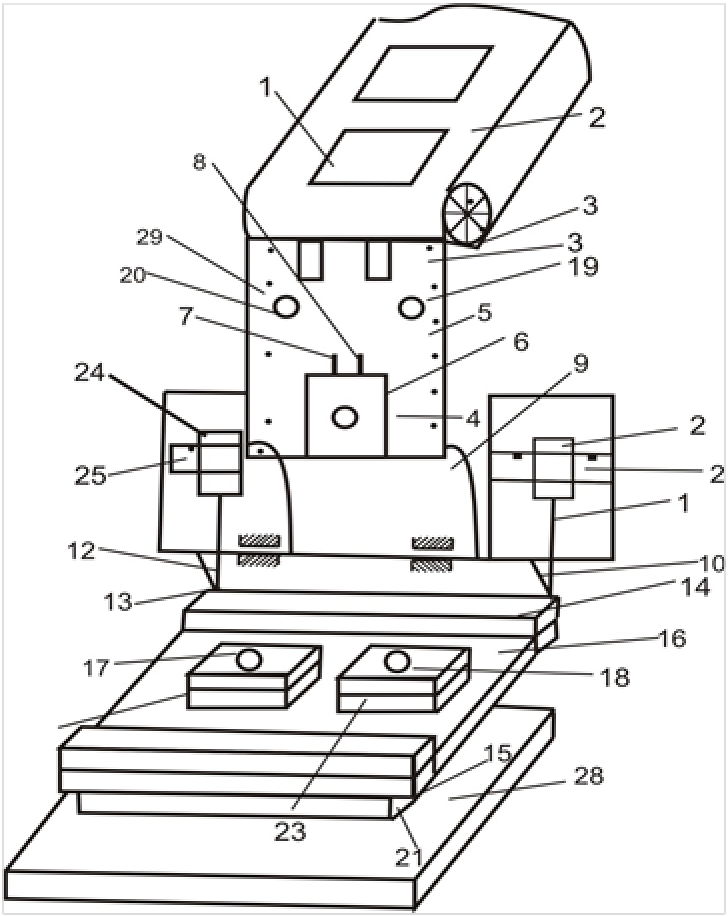
Figure 6. Structure diagram of the device measuring the length of the product

İn robotic complexes, a special converting manipulator is used to turn the part in the form of one sheet onto the second sheet. The generated manipulator is shown in figure 7.

This manipulator consists of the following parts: 1-sheet-shaped metal part made of non-ferrous metal; 2- the conveyor that transfers this sheet to the manipulator; 3- auxiliary shaft; 4-the part of the manipulator that receives the sheet; 5-manipulator's hand; 6-support; 7- the part that presses the sheet to the pillow; 8- power transmitter; 19 and 20 - distance transmitters indicating that the metal sheet is on the hand of the manipulator; 9-arm of the manipulator; 10- rotating pneumointigal, 11- linear displacement transmission; 12-transfer sheet; Arms of the 13-14-step conveyor; 15 a sheet with a picture on it; 16-the table where the sheet sits; 17-legs of the table; 18- supports of rotating pneumoitigal; 21,22,23,24-EMVs; 25,26-distance transmitters; 27, 28-angle rotation transmitters; 29, 30-transmitters indicating the initial and final position of the manipulator.

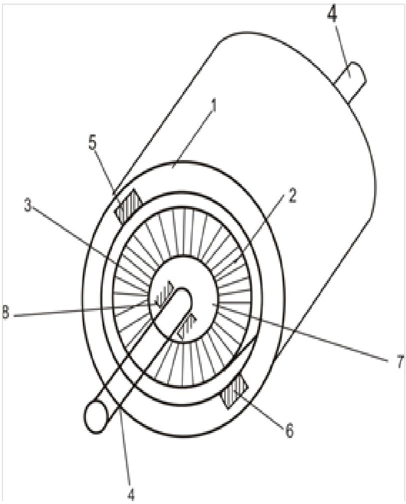
The manipulator works as follows: when there is a sheet with a picture on it on a flat surface between the arms of the 13, 14-step conveyor, and at this time the 5 hands of the manipulator are loaded, the arm of the manipulator rotates with the help of a rotating pneumatic transmission, turns 1 sheet onto the 15-picture sheet.

Paired sheets 12 are compressed with little force through the arms of step conveyors 13 and 14 and transferred to the next position. The manipulator returns to its previous position after placing the transferred sheet in position 12 and is ready to accept the next sheet. When the next blank sheet is received by the hand of the manipulator, the distance transmitters 19-20 work and indicate the presence of a sheet in the hand. At this moment, if there is a picture sheet between arms 13-14 on the step conveyor, the manipulator is working, and the sheet is transferred to the picture sheet again. The hand of the manipulator is freed. Thus, the indicated process is repeated at the next stage. During the course of the process, the initial and final positions of the manipulator's hand are recorded with electromagnetic transmitters 29 and 30. It is also necessary to know the intermediate values of the rotation angle during the rotation of the manipulator's hand. In this case, 27 and 28 angle encoders are used. The generated angle transmitter is calculated according to the rotation angle of 180 ^{0}. Such a turning angle



Fiqure 7. Special converting manipulator for turning a part in the form of one sheet onto a second sheet

transmitter is shown in figure 8. As can be seen from Figure 8, the transmitter consists of two ferromagnetic cylinders 1 placed coaxially with respect to each other, 3-winding 2 wound on a ferromagnetic core, 4- axis, 5, 6 windings placed longitudinally from the inner part of the 1-core. The windings are wound on the 3-core by the autotransformer rule. The axis of the transducer is attached to 7-non-metallic ebonite material. The coils located in slots 5 and 6 are induction coils. The coils wound on the 3-core have regular current branching. The distance between each current branch is taken equal to the width of the slot along its length inside the cylinder 1-. The axis of the converter sits on 8-pads on both sides. These pads, in turn, are attached to the 1-core of the converter as a cover. Half of the transmitter's total turns are involved in the measurement, which covers approximately 160 ^{0} . Since the angular rotation of the arm of the manipulator does not exceed 150 ^{0} , it fully covers the size limit of the transmitter.



Fiqure 8. 3D construction view of the angle transducer

The transmitter works on the following principle. When the wound core passes in front of the 5-slot, the magnetic flux created by it cuts the section windings and creates an induced emq in it. Induction ehq passes due to 3 cylinders rotating alternately from one section to the second section, and as a result, the current flowing through the resistance at the end of the sections increases proportionally, which is proportional to the angle of rotation of the arm of the manipulator.

For accurate and reliable management of complex technological operations in RC, precise analog signals of the measured parameters must be received and processed from the information-measuring transmitters used at the 1st level of the ACS to the input of the microprocessor control system and the programmable logic controller. When measuring the current technological operation, it is necessary to use the expression ehq to determine the error of the transmitter whose output is analog. The modulus of this expression is written as follows:

$$E = \frac{\omega W_1 W_2 \mu\mu_0 S u}{2(h+a+\mu\delta)\sqrt{r_1^2 + \left(\frac{\omega W_2^2 \mu\mu_0 S}{2(h+a+\mu\delta)}\right)^2}} \qquad (1)$$

where ω- the angular frequency W_1, W_2 – of emf, the number of windings of the section wrapped around the core, h , a - the geometric dimensions of δ – the core, the distance between the moving core and μ the stationary core, - the relative magnetic permeability of the material from which the core is made, S - the cross-sectional area of the core; r_1 - the ohmic resistance of the winding of the core, u - is the voltage applied to the winding of the core.

Experience shows that the geometric dimensions of the transmitter and the number of windings remain unchanged during the work process. Here $\omega, \mu, u, \delta, r$ it is changed due to the influence of the environment. If we consider this change in expression (2) and make some transformations for the error

$$E_{ao}\left(1\pm\frac{\Delta E}{E_{ao}}\right)=\frac{W_1W_2\mu_0S\omega_{ao}\left(1\pm\frac{\Delta\omega}{\omega_{ao}}\right)\left(1\pm\frac{\Delta\mu}{\mu_{ao}}\right)}{2\left[\left(h+a+\mu_{ao}\left(1\pm\frac{\Delta\mu}{\mu_{ao}}\right)\delta_{ao}\left(1\pm\frac{\Delta\delta}{\delta_{ao}}\right)\right)\right]}\times \tag{2}$$

$$\times\frac{1}{\sqrt{r_{1ao}^2\left(1\pm\frac{\Delta r}{r_{1ao}}\right)^2+\left(\frac{\omega_{ao}\left(1\pm\frac{\Delta\omega}{\omega_{ao}}\right)W_2^2\mu_0S\mu_{ao}\left(1+\frac{\Delta\mu}{\mu_{ao}}\right)}{2\left(h+a+\mu_{ao}\left(1\pm\frac{\Delta\mu}{\mu_{ao}}\right)\delta_{ao}\left(1\pm\frac{\Delta\delta}{\delta_{ao}}\right)\right)}\right)^2}}$$

$$\beta_0=1\pm2\frac{\Delta\omega}{\omega_{a0}}\pm3\frac{\Delta U}{U_{a0}}\pm(1-K_1)\left(\frac{\Delta\mu}{\mu_{a0}}+\frac{\Delta\delta}{\delta_{a0}}\right)\mp2\frac{\Delta r}{r_{a0}} \tag{3}$$

we will buy It is clear from the last expression that the largest error is obtained from the change of voltage, the second error is obtained from the change of the frequency of the network, the 3rd largest error is obtained due to the change of the active resistance in the opposite direction, and the smallest error is $(1-K_1)$ obtained from the product of the expression of $\frac{\Delta\mu}{\mu_{ao}}+\frac{\Delta\delta}{\delta_{ao}}$

İn chapter IV of the thesis , the issues of development and research of electromagnetic type transmitters for information-measurement of active elements of RC were considered.

Automatic loading and unloading manipulators are used in the process of purchasing aluminum evaporators at RC. Such manipulators consist of a handle and a transmission (Figure 9). In turn, the manipulator consists of 1-body, 2-pneumocylinder, 3-stock, 4-handle, 5-pneumatic slide, 6-bracket, 7-support, 8, 9-transmitters. Here, the handle is attached to the hand of the industrial robot and performs the following functions. The İR takes the evaporator from the table and places it on the device that opens the nozzle of the "collocolchik", then the evaporator is transported to the position of the hydraulic press. By İR, the evaporator is placed in the matrix of the hydraulic press and grounded at three points. At the end of the technological operation, the evaporator is picked up with the help of an industrial robot and placed on the conveyor for the next operation.

İR $_{18}$works when there is an evaporator on the BC$_8$ conveyor (fiq.1) and loads the initially empty table.

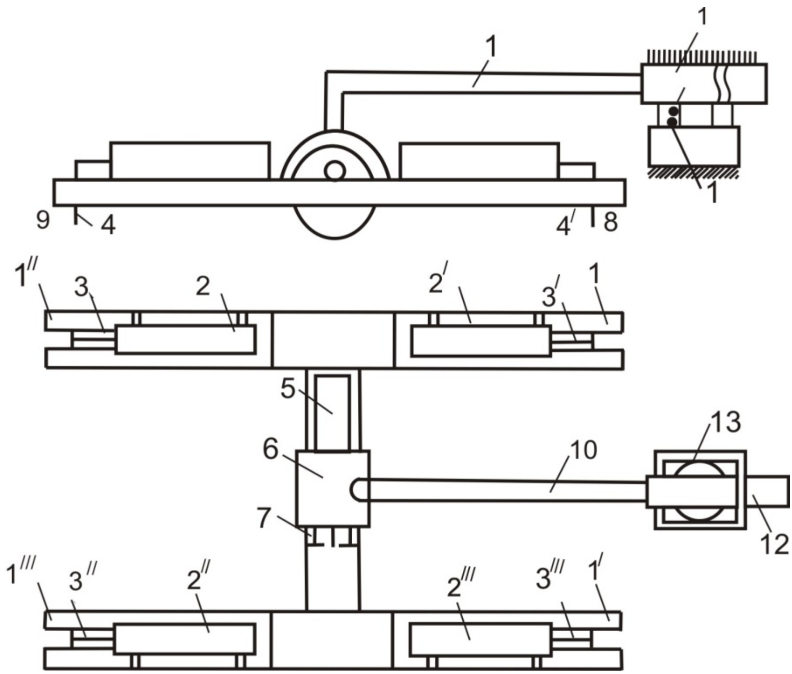


Figure 9. Schematic diagram of the loading and unloading manipulator

However, if the "kolokolchik" operation is finished on any of the tables, then the evaporator is removed from that table and placed on the BC $_9$ conveyor. The vaporizers placed on the BC $_9$ conveyor are transferred to hydraulic presses, where the channels of the vaporizers are expanded. Two distance transmitters are placed on each of the tables with "Kolokolchik" devices, which increases its reliability. Distance transmitters are placed on the BC $_8$ conveyor in the same way. Evaporators are placed on the table in such a way that the "bell" falls to its working point. İn this case, the "kolokolchik" is opened qualitatively.

Here, the maximum travel of İR's arm is measured by its initial position. The maximum travel of the arm of the İR is to the middle of the BC 9 conveyor. If there is an evaporator in the position of the transmitters of this conveyor, then the BC_8 conveyor starts moving. İR can turn 90 ^{0} , 180 ^{0} left and 90 ^{0} right according to the defined program . Therefore, the angle transmitter used for this purpose should have two or three outputs (Figure 10).

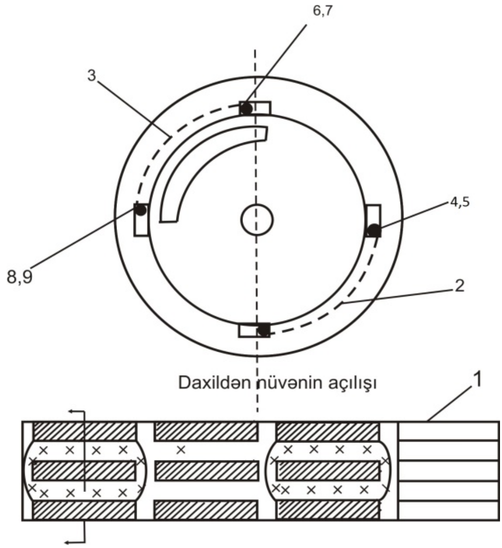


Figure 10. Magnetic circuit of the angle rotation transmitter

From the literature reviews, it is known that the SR used in direct production should be able to move 90 ^{0} to the right and 90 ^{0} to the left. Therefore, to measure the rotation angle in the specified range, an integral core angle rotation transmitter was created in a simple structure.

The transmitter consists of a fixed 1-table and 2, 3-rotors, 4, 5-impact loops, 6, 7 and 8, 9 - measuring loops. The transmitter's measuring and acting coils are wound together and placed in two parallel slots. The positioning of the loops is opposite to each other, when the top of one of them is fully opened, the transmission of the second loop system starts. Thus, the moving part of the transmitter can turn 90 ^{0} to the right and 90 ^{0} to the left.

The cross-section of the magnetic system is in the form of a Ш-shaped core (Fig. 11). If the full current law is applied to the closed loop taken at this core

$$\left(\dot{H}_{1m}+\dot{H}_{2m}\right)a+\left(\dot{H}'_{\delta m}+\dot{H}_{\delta m}\right)\delta+ \\ +\left(\dot{H}_{hm}+\dot{H}'_{hm}\right)h=\frac{\dot{I}W}{2} \quad (4)$$

we will buy

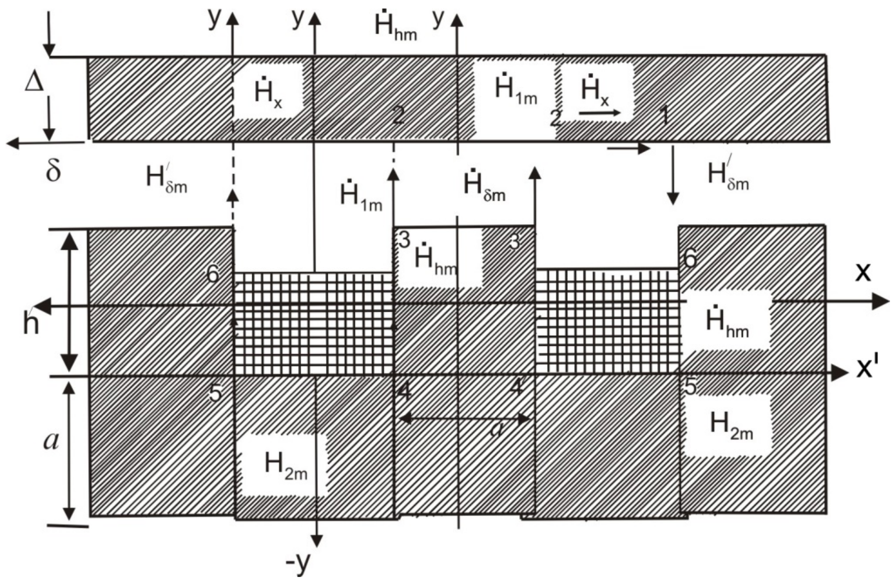


Figure 11. Cross-section of the magnetic circuit of the transmitter

The equation of the magnetic field in the middle of the Ш-shaped core is the following expression

$$\frac{d^2\dot{H}'_h}{dx^2} = p^2\dot{H}'_h \tag{5}$$

is like

From the solution of these equations (4 and 5) , the expression of the induction e.hq in the output loop of the transmitter

$$E = \sqrt{\frac{\omega\mu\mu_0}{\gamma}} \cdot \frac{aWU}{\sqrt{R^2 + X^2}} \cdot \frac{1}{\sqrt{\left(a^2 + 2a(h+\mu\delta)K_{1m}\right) + 2(h+\mu\delta)^2 K_{1m}^2}} \tag{6}$$

is taken. Here

$$R = r + \frac{1}{2}\sqrt{\frac{\omega\mu\mu_0}{\gamma}}\, aW_1^2 K_{im}(N_1 + N_2),$$

$$X = \frac{1}{2}\sqrt{\frac{\omega\mu\mu_0}{\gamma}}\, aW_1^2 K_{1m}(N_1 - N_2),$$

$$K_{1m} = \sqrt{\omega\gamma\mu\mu_0}.$$

İnductive distance transmitters are widely used for systematic control of the technological process in the production area and at the same time for measuring many parameters. With their help, defects arising in the preparation of individual technological operations and equipment are easily detected and transferred to the information-measurement and management system, through which quality improvement and measurement accuracy improvement operations are performed.

For this purpose, an inductive distance transmitter was created for determining the location of metal products from a small distance in technological lines and robotic complexes. The inductance of the generated transmitter is based on the fact that it varies depending on the location of the product . The transmitter is built on the operating principle of an autogenerator with LC elements. In the process of obtaining the resonance frequency of the transmitter, the existence of an analytical dependence between the parameters of the autogenerator circuit and the parameters of the oscillation contour is not adequately covered in the technical literature.

It is proposed to obtain the analytical dependence between the parameters of the oscillation contour of the distance sensor and the autogenerator circuit, which is one of the main primary elements of the information measurement and control systems. Therefore, the existence of a mathematical dependence between the parameters of the LC autogenerator scheme and the oscillation contour of the distance transmitter working on extinction is considered in the work.

autogenerator is inductive feedback, its scheme is given in figure 12. The inductance of the oscillation circuit of the LC autogenerator is placed on the entire core. The core is made of 45 grade structural steel. The structure of the nucleus is in the form of a cylinder. Since there is a cylindrical protrusion inside the cylinder, it is considered as a Ш-shaped core. An inductive coil consists of two windings with inductances L_1 and L_2. The windings L_1 and L_2 of the transmitter are made on the transformer principle. The inductance L_1 and the capacitor C_2 are connected to each other in a parallel circuit and create an oscillation contour, the reverse communication voltage of the inductance L_2 taken from the loop is supplied to the base-emitter circuit of the transistor T with the help of the capacitors $L2$, C_1 and C_4. The output of the transmitter consists of a capacitor divider C_3, C_5, and is taken from the resistance R_y connectedin paralel to the capacitorC_5.. The transmitter works on the following principle. İn the initial state, the parameters of the oscillator circuit and circuit of the transmitter are selected in such a way that a non-vanishing sinusoidal voltage is obtained in its circuit and at the same time in the clamps of the resistance R_y.

When the metal product falls into the magnetic field in front of the cylindrical core of the transmitter, the inductance L_1 takes a large value and the voltage between the 1-2 clamps of the oscillation circuit decreases rapidly.

As a result, the generation in the circuit of the transmitter is disrupted and the voltage in the resistance R_y taken a zero value. When the product leaves the magnetic field of the inductance L_1 of the transmitter , the generation in its circuit is restored again. At each subsequent stage, the cases of generation shutdown and recovery are repeated.

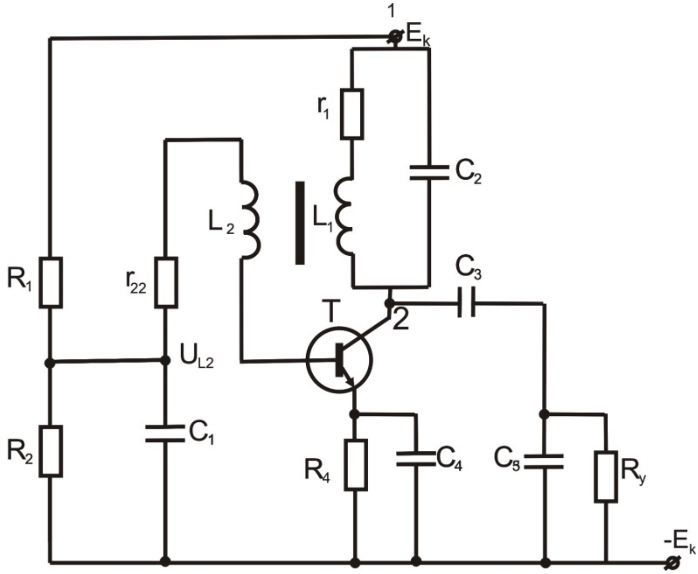


Figure 12. Scheme of inductive feedback LC-autogenerator

It can be seen from the basic electrical scheme of the transmitter that its oscillation circuit is connected to the collector of the npn-type transistor T, and the inductive coil L_2 is connected to the base-emitter circuit of the transistor. In this regard, the resonant frequency of the autogenerator assembled on the T transistor depends not only on the parameters of the circuit, but also on the parameters of the generator circuit. In this regard, the L_1, L_2, C_2 parameters of the oscillation contour and the R_1, R_2, C_1, C_3, C_4, C_5, R_y parameters of the circuit and at the same time r_b belonging to the transistor - base, r_e – emitter, r_k - the output frequency of the autogenerator according to the obtained substitution scheme of the generator using the T-shaped substitution scheme of the transistor to determine analytically its dependence on the collector resistances

$$\omega = \omega_0 \sqrt{\frac{r_e - (r_b + r_L)}{r_e + (r_b + r_2)(1 - \alpha)}} \tag{7}$$

taken as an expression . Here $\omega_0 = \frac{1}{\sqrt{L_1 C_2}}$ – is the specific frequency of the dance contour.

Frequency, taking into account the fact that the transmitter is in the form of an autogenerator and the parameters in its circuit

$$\omega = \sqrt[3]{\frac{3(r_2 + R)(L_{1a} + M_a)(L_{2p} + M_p)}{C\left[(L_{2p} + M_p)^2 + (L_{2a} + M_a)^2\right]\left[(L_{1a} + M_a)^2 + (L_{1p} + M_p)^2\right]}} \tag{8}$$

is appointed. Here L_{1a}, L_{2a}, M_a, M_p – inductances and mutual inductances of the oscillation contour, respectively; C-dancing contour capacity; r_2, R – are the active resistances of the oscillation contour, respectively.

Various electromagnetic distance transmitters are used as the primary element in the control systems of industrial enterprises and robotic complexes. Such transmitters are used as a device indicating the presence of metal products in the flow line. Such transmitters differ according to the principle of operation, the construction of the magnetic system, the modulation of the output signal and the information processing conditions. The application of electromagnetic type transmitters becomes difficult when there are unstable effects on it during its operation. One such effect is the wide range of changes in ambient temperature due to the effect on the object. When the automatic control system is used, the transmitter used should be placed at a certain distance, approximately $15 \cdot 10^{-2}$ m. In this case, the temperature of the product is (30 ÷70) ^{0}C.

Due to the heavy technological operation in the flow line, the electromagnetic type transmitter created must meet all the requirements of the facility. The generated transmitter consists of a coreless inductive coil, which enters the LC-dance circuit of the LC-autogenerator. The transmitter consists of 1-effect loop, 2-ferromagnetic sheet, 3-product, 4-non-metallic body, 5-

autogenerator. When the transmitter is placed on the object, it is from the top and bottom
covered with ferromagnetic material (Fig . 13).

The transmitter is covered with 3 objects from the top, and a flat metal layer (thick 10 mm) from below. According to the demand, the thickness of the object ÷varies in the range of (8 12)10 $^{-2}$ m. Since the generated transmitter has a frequency output, its metal part is in a changing magnetic field. The transmitter works on the principle of generation disruption. When the product is above the coil 1, the amplitude of the signal received at the output of the LC autogenerator becomes zero. To get such a characteristic, it is necessary to select the electromagnetic parameters of the transmitter. It can be seen from Figure 13 that there is a large air gap in the magnetic circuit and therefore most of the magnetic field stress falls

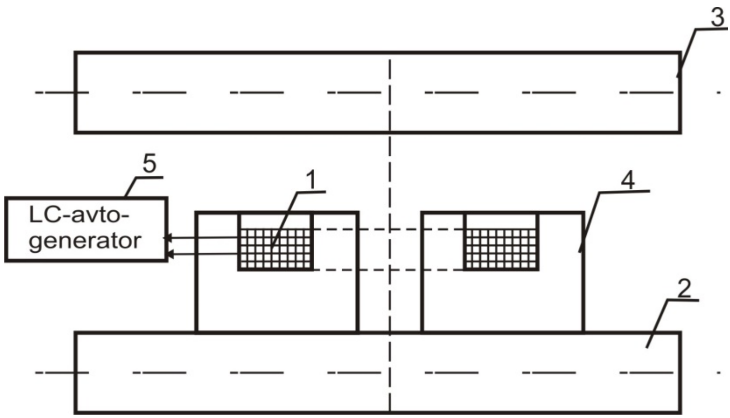


Figure 13. Magnetic system of an electromagnetic type transmitter

on the ferromagnetic core and the remaining major part falls on the air gap.

To carry out the study of the created device, it is necessary to choose a coordinate system, which depends on the constructive dimensions of the magnetic system. Here, the ferromagnetic product consists of a thick material and itself moves at a constant speed along the technological line. In practice, since the dimensions of the area of the product (object) are much larger than the dimensions of the winding, the planes of the two ferromagnetic materials are parallel to the product. In addition, it should be noted that the lines of magnetic force pass from the ferromagnetic material to the air gap, approximately parallel to the normal, and this angle is 89 ^{0} . It also $\approx 90^{0}$ means. Such an approach allows determining the magnetic field with an accuracy of (4 5)%. ÷Such a small error obtained allows us to simplify the study of the electromagnetic field, and therefore we adopt a cylindrical coordinate system for the analysis. The slip current in the magnetic system of the device considered in the air gap of the magnetic system is not taken into account.

If we apply the full current law to the closed circuit to establish the relationship between the magnetic field voltages and the induced current (Fig. 14) and

$$a\left(\dot{H}_{3m}+\dot{H}_{2m}\right)+h\left(\dot{H}^{3m}_{\delta z=0}+\dot{H}^{2m}_{\delta z=0}\right)=\dot{I}W \, . \quad (9)$$

if we take into account and make some conversion

$$\dot{H}_{3m}=\frac{\dot{I}W}{a\left(1+b_3\right)+h\left(b_1+b_2b_3\right)} \quad (10)$$

can Considering expression (10).

$$\dot{\Phi}_{3m}=\frac{\mu_3\mu_0\left(\pi D+a\right)\left(1-e^{-K_3\Delta_3}\right)\cdot\dot{I}W}{K_3\left[a\left(1+b_3\right)+h\left(b_1+b_2b_3\right)\right]} \quad (11)$$

we will buy The received expression (11) allows determining the inductance of the affected loop, the mutual inductance, the specific frequency of the oscillation contour of the LC autogenerator and other characteristics of the transmitter. In the measurement of non-electrical quantities, it is often necessary to convert the output of distance transmitters into frequency. In such transmitters, the inductance of the LC-autogenerator is accepted as a variable parameter. The LC-autogenerator is assembled on a semiconductor micro-transistor. The scheme of the LC-autogenerator of such a transmitter is extremely diverse.

İt can be seen from Figure 14 that the oscillating circuit is connected to the collector circuit of the transistor. The oscillator circuit of the transmitter consists of parallel L and C elements. The inductance of this circuit is variable depending on the distance of the product from the transmitter. The main interesting issue in the study of such a transmitter is to keep the frequency of the autogenerator stable depending on the ambient temperature. The created distance transmitter works in a wide temperature range. Temperature-dependent parameters of such transmitters are also variable. Therefore, there is a question of preventing or stabilizing the change of the transmitter depending on the ambient temperature. In this regard, the question of reducing the temperature-dependent error of the transmitter's general error by analyzing the temperature dependences of individual elements is raised. İt was determined from the conducted studies that the temperature error corresponding to ÷each 10 ^{0} C temperature be (3÷4)% of the main error according to the State Standard. To get such a temperature error, it is necessary to include an additional compensation element in the circuit of the autogenerator. The created transmitter works in the temperature range of 0 ÷60 ^{0} C. To keep its output frequency stable, it is necessary to obtain an analytical expression of the frequency.

Angular displacement transmitters are widely used in the information-measurement and control systems of robotic complexes used in the instrument-making and machine-building industries . The principle of operation of such transmitters can be based on the change of active resistance, inductance, and capacitance in the circuit.

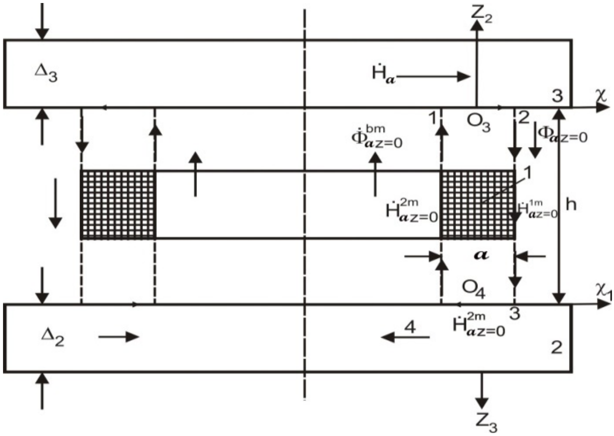


Figure 14. The magnetic field formed in the coordinate system of the n-section of the transmitter

On the basis of comprehensive studies, it was determined that angle-turning transmitters working on the principle of inductive or mutual inductance change have a high, strong information signal. Therefore, it is convenient to use angular rotation transmitters in RC. The core of existing inductive angle encoders is made of electromechanical sheet-shaped steel, and their manufacturing technology is difficult. In this regard, the economic indicators of such transmitters decrease. In order to increase the economic indicators of the angle encoder, it is necessary to make their cores from common structural steel, widely used in the machine-building industry. In this case, it is possible to prepare the construction of the axis of the core with simple technology.

The angular rotation of the arm of industrial robots used in robotic complexes is different. Depending on their field of application, the angular rotation of the arm is 60 ^{0}, 90 ^{0}, 120 ^{0}, 180 ^{0}, 240 ^{0}, etc. can be. Angular rotation transmitters used in device manufacturing have the characteristics of rotating their arms at an angle of 90 ^{0}, 120 ^{0}, 180 ^{0}. In this regard, the angular rotation of the arm of the SR in the opening of the "kolokolchik" used in the manufacture of vaporizers can be 90 ^{0} and 180 ^{0} . Ago hydraulic presses are used to expand the channels of other evaporators. Depending on the placement of such presses in the flow line, the angle of rotation of the arm of the SR that loads and unloads them can be 90 ^{0} or 180 ^{0}.

Output frequency of intelligent angle transmitter with frequency output:

$$\omega = \sqrt[3]{\frac{2\gamma(b+h+\mu\delta)^2}{C_2^2\mu\mu_0 W_1^2 z^2}} \cdot \sqrt{1-\frac{r_2+r_\delta}{r_e}} \tag{12}$$

as it is written.

İf the hydraulic press is located parallel to the flow line , then loading and unloading is performed at an angle of 90 ^{0}. The hydraulic presses used here are placed at an angle of +30 ^{0} and -30 ^{0}. In this case, the direction of the maximum turning angle of the arm of the İR is perpendicular to the front plane of the hydraulic press. This perpendicularity is performed both to the right and to the left with respect to İR. Based on the intended application, the İR loads or unloads the right or left hydraulic press. In this case, two hydraulic presses are served by one SR. In this regard, it is necessary to prepare a three-step 90 ^{0} , 120 ^{0} and 180 ^{0} transmitter that measures the angular rotation . So two cylindrical cores coaxial to each other are made to form the transmitter. Both cylinders are thin-walled and have a very small δgap between them. The opening of prepared cylinders is given in figure 15.

According to the obtained magnetic flux expressions for the corresponding parts of the core, the expressions of the periodic currents are obtained as follows:

$$i_1 = -\frac{2\pi R_2 \dot{I} W}{\frac{2(R_2+a)}{R_2+2a}(h+\mu\delta)+\frac{2aR_2}{R_2+a}\left(1+\frac{\mu K a}{K}\right)}, \tag{13}$$

$$i_2 = -\frac{2\pi(R_2 + 2a)\dot{I}W}{\frac{2(R_2 + a)}{R_2 + 2a}(h + \mu\delta) + 2a\frac{2aR_2}{R_2 + a}\left(1 + \frac{\mu Ka}{K}\right)}, \tag{14}$$

$$i_2 = -\frac{2\pi(R_2 + 2a)\dot{I}W}{\frac{2(R_2 + a)^2}{R_2(R_2 + 2a)}(h + \mu\delta) + \left(1 + \frac{\mu Ka}{K}\right)2a}, \tag{15}$$

At the end of the chapter, the frequency error is calculated and the following

$$\beta_1 = \left[\mp\frac{\Delta l_1}{n_1} \mp \frac{\Delta\mu}{m_1} \mp \frac{\Delta\delta}{m_2} \pm \frac{\Delta\mu}{\mu_{00} m_1} \pm \frac{\Delta S}{S_{ao} m_2}\right]\frac{1}{3} \tag{16}$$

$$\beta_2 = \left[\mp\frac{\Delta l_2}{n_2} \mp \frac{\Delta\mu}{m_1'} \mp \frac{\Delta\delta}{m_2'} \pm \frac{\Delta\mu}{\mu_{ao} m_1'} \pm \frac{\Delta S}{S_{ao} m'}\right]\frac{1}{3} \tag{17}$$

is taken. With these expressions, the error of the intelligent angle transmitter with frequency output is calculated.

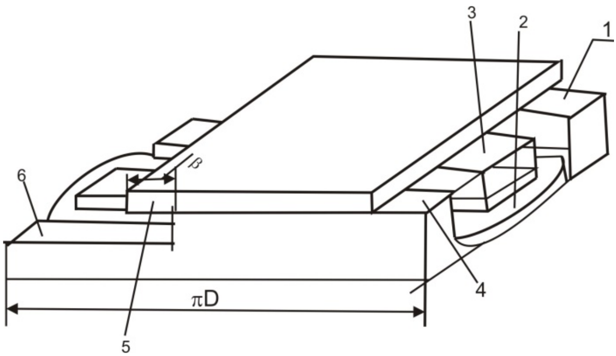


Figure 15. Constructive opening of the transmitter

İn chapter V of the thesis , the issues of analysis of electro-physical quantities of the transmitters of the RC information-measurement system and conducting computer experiments were considered.

RC for the reliable, accurate and long-term operation of the control system, the correct selection and application of information-measuring elements in industrial robots, automated lines, technological equipment and other active elements according to the demand is considered one of the practically important issues. In this regard, micro-programmable logical controllers (PLC), microprocessors, and integrated microcircuits have been widely used in their control systems. The development and progress of such tools gives a great impetus to the creation of automated flexible production, robotic complexes and their application. To perform their functions, industrial robots use manipulators equipped with actuators (grippers, welding devices, probes, etc.) and perform automatic cycles based on the required function. The control system of İR ensures that the manipulators' execution mechanisms are given commands depending on the state of the working bodies. In these commands, the internal information of the working body (about the state of the manipulator), the state with the external environment, for example, the dimensions of the product, mass, temperature, etc. is determined. İn the automatic loading of the robot, as means of complex automation of production, autooperators are widely used, with their help, it is possible to ensure the easy reconstruction of the control system. İndustrial robots created in this regard are simple and compact compared to auto operators. Each robot can replace a large number of auto-operators.

One of the important issues in the direction of improvement and development of transmitters of the information-measurement and control system of RC active elements applied in the device-making industry is the application of microelectronics and high-reliability microminiature, innovative electronic devices, transmitters, converters, quality control, etc. elements should be processed and simulated. A characteristic feature of microelectronics is that it is possible to easily move from the physical research conducted on them to their engineering solution.

In this chapter, the expression of the output frequency of the autogenerator is obtained based on the integral scheme, and this expression is written as follows:

$$\omega = \sqrt{\frac{L_{21}R_{11}C_3 + L_{27} + L_{31}}{L_{2p}R_{11}C_3 - L_{26} - L_{30}}} \times \left[\sqrt{1 + \sqrt{1 - \frac{4(L_{22}R_{11}C_3 - L_{22} - L_{32})(L_2 R_{11} C_9 L_{36} - L_{30})}{(L_{21}R_{11}C_3 + L_{27} + L_{34})^2}}} \right] \quad (18)$$

Included in this statement are $L_{21}, L_{22}, L_{26}, L_{27}, L_{30}, L_{31}, L_{34} L_{36}, R_{11}, C_3$ the parameters included in the scheme of the autogenerator.

The question of the synthesis of the frequency transmitter created on the basis of the operational amplifier is considered and the frequency change is determined.

$$\Delta\omega = \frac{13}{6\pi} \sqrt{\frac{1 + r_b g_e}{(L_{10}L_{2a0} + L_{1r0}L_{2r0})g_e C_1} \frac{(L_{1ao} + L_{1r0})n + L_{2ao} + L_{2r0}}{h_{1a0}L_{2r0} + L_{1r0}L_{2a0}}} \cdot \Delta L_1 \quad (19)$$

Here $L_{1ao}, L_{2ao}, L_{1r0}, L_{2r0}, \Delta L_1, g_e, C_1$ are the parameters included in the scheme of the autogenerator.

İn practice, inductive transmitters are widely used as primary elements in automatic control systems and robotic complexes applied in various fields of industry. With the help of such transmitters, it is possible to determine the presence of products moving in the technological line and the consumption of liquid. The sensitivity of these transmitters is determined depending on the material of its core, the geometric dimensions of the magnetic system, and the material of the product.

Determination and evaluation of the sensitivity of the transmitter is presented as an important issue and for the sensitivity

$$S_b = \frac{K_{10} b_3}{\delta \sqrt{q_{1m}^2 + 2q_m \delta + \delta^2}} \quad (20)$$

received. Here $K_{10}; q_{1m}; b_3; \delta -$ are the parameters included in the scheme of the autogenerator.

According to the received expression (20), the δ dependence of the sensitivity of the transmitter on is given in figure 16. It is clear from the figure that as the distance between the product and the end of the magnetic system of the transmitter increases, its sensitivity decreases in a non-linear way, which is confirmed by the results obtained in practice.

Based on the theoretical transformations, the analytical expression obtained for sensitivity allows determining the zone of influence of the transmitter. The obtained expression provides a basis for evaluating the sensitivity depending on the parameters of the electromagnetic system of the transmitter and the product, the magnetic permeability of the core, its geometric dimensions, the conductivity of the core and the product.

İn Chapter VI of the thesis , the issue of the study of the functional characteristics of the information-measurement and control tools of the intellectual management system of RC is considered. As it is known, when coal increases, the specific resistance of structural steels also increases. Chromium content in many structural steels varies between (0.3÷ 1) % and their specific resistance accordingly varies in the range of (0.175 ÷0.2) . $\frac{Om \cdot mm^2}{m}$ In the structural steels mentioned above, the relative magnetic permeability of the core of the transmitter made from them varies by a small percentage according to the amount of carbon. This shows that they have relatively stable characteristics. The shape of the core of the transmitters is chosen depending on the demand, it is clear from the results of the conducted studies that in order to get the necessary sensitivity and accuracy in the transmitters, it is necessary to choose the shape of their geometric dimensions.

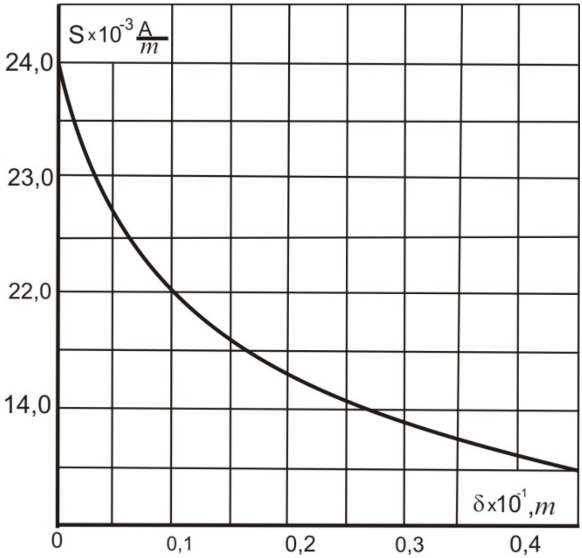


Figure 16. Dependence of distance transmitter sensitivity on δ –

When the core of electromagnetic transmitters is selected from solid structural steel, their construction is simplified and the manufacturing technology is simplified.

Thus, when the core of electromagnetic transmitters is made of structural solid steel, all the requirements facing them are met. When the core of electromagnetic transmitters is made of solid structural steel, their shape should be chosen to provide the necessary sensitivity, accuracy and minimum power loss. For this purpose, it is necessary to provide the condition of replacement of electrotechnical steel assembled from sheets with whole structural steel. For this, a comparative analysis of the electromagnetic parameters of the core made of electrotechnical sheets with the parameters of the transmitter with a core made of structural steel was carried out.

Based on the reports, the following statement was received

$$a_k \approx a_e \frac{\mu_e}{\mu_k} \sqrt{\frac{\mu_e \rho_e}{\mu_k \rho_k}} \tag{21}$$

Here a_k - are the thickness of the structural sheet, μ_c, μ_k – are the relative magnetic influence coefficients of the structural and electrotechnical core, ρ_c, ρ_k – respectively, and are the specific resistances of the structural and electrotechnical steel, respectively.

İt should also be noted that the common structural steel core P20, P55 and P35 are very cheap. In this case, the transmitter created is three times cheaper than electrotechnical steel.

From the results of the conducted studies, it can be seen that the $\frac{\mu_e}{\mu_k}$ ratio is practically 5, the ratio of their specific resistances $\frac{\rho_e}{\rho_k} = \frac{1}{3}$. From here it is clear that if we have passed from electrotechnical steel to structural steel, the following relationship is obtained between the overall dimensions of the transmitter

$$a_k = 6,5a_e. \tag{22}$$

Due to this, the geometric size of the structural steel increases by 6.5 times due to the thickness, and due to this, the length of the path of cyclic currents increases. İn this case, the value of resistance to cyclic currents increases. Thus, the power loss caused by cyclic currents is reduced. If we have made a cylindrical core of structural steel with a thickness and assume that the core is Ш-shaped, then the magnetic flux generated in the core will increase to a certain extent. $a_k = 6,5a_e$ At the next stage, to increase the value of the periodic currents, it is necessary to reduce the length of the path where the magnetic flux is closed. This allows reducing the weight of the transmitter core and increasing its sensitivity accordingly, as well as increasing economic indicators. İn this regard, the geometric dimensions obtained from structural steel allow the weight of the core to be minimal.

İn the process of manufacturing products in the technological line of RC, it is required to control the quality of the layout, adjust and manage the measurement parameters. Two heating furnaces are used in the automated RC, which is a research facility. One of them is used to heat the sheets after the cutting operation, and in the second furnace, the finished product is heated after the rolling stand. Both ovens are equipped with a chain conveyor. Sheets are inserted into the entrance of the first furnace after the initial cutting operation is finished. This operation is achieved with the help of İR and placed on the K_1 conveyor of the furnace, when the sheets pass through the furnace, the plastic property is eliminated when the cold soldering is fully opened.

To heat the sheets, the power of the furnace is 460 kW and provides a productivity of 2000 units/hour. This furnace is equipped with chambers located along the length of the conveyor and at the same time electromechanical transmission. The oven consists of 10 heating zones, each of which consists of a free calorimeter heater, a heat exchanger and a temperature controller. Temperature zones vary from 230 ^{0} C to 550 ^{0} C. Sheets should be in the working zone of the oven for 40-50 minutes. Sheets should be moved at a speed of 0.154 m/min in the zone of the furnace to make the heating high-quality. Here, the speed of the conveyor cannot exceed 0.154 m/min.

Regulation and control of the temperature at the base of the oven is carried out by electronic potentiometer EPD-120V in the electric oven . Its measurement range is 0 ÷800 ^{0} C and measurement accuracy is 0.5. The potentiometer is placed in each zone depending on the degree of loading of the furnace. Therefore, according to the technical manual, the temperature regulation and control of the thyristor control should be checked once every hour. To measure the temperature in such furnaces, thermocouples and differential transformer core displacement are used. Figure 17 shows the arrangement of the furnace in one section.

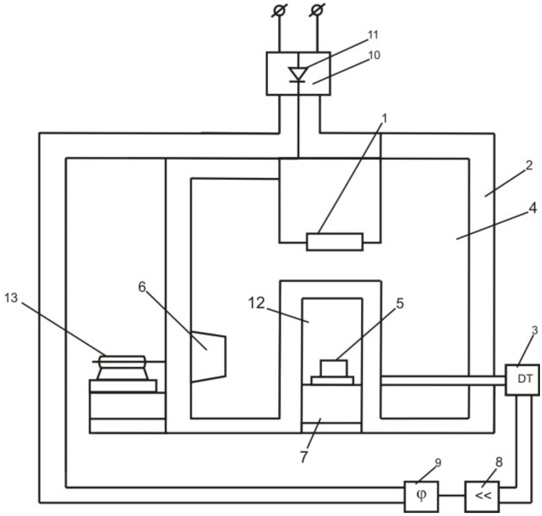


Figure 17. Construction scheme of a section of the furnace

The sensitive element of the temperature measuring device is connected directly to the working chamber. During the operation of the stove, 6 compressors pump hot air into the working zone. Each chamber is provided with 2 - thermal insulation. During the operation of the furnace, the alternating voltage received at the output of the differential transformer is amplified. The signal received at the output of the amplifier is fed to the control unit of the thyristor, which adjusts the output current of the thyristor according to the temperature. At the output of the regulator, the reduction or increase of the output voltage according to the temperature is achieved due to the interruption of the sinusoidal voltage . Let's consider the development of the drying oven used after the expansion of the channels of the evaporators. The main task of the oven here is to dry the channels. Drying is carried out at a temperature of 150 ÷200 ^{0} C. This oven can also use the temperature control device used in the lamp oven. A heating element made of nichrome wire is also used here. Temperature regulating devices are also used to regulate the temperature of the rolling stock oil. Small powerful heaters are used here and the oil temperature is regulated in the range of (180÷200) ^{0}C.

About 30% of waste product is obtained in the process of product preparation in the studied RC. The purchase of heavy products is related to the presence of devices of various forms. The purchased devices are irregularly distributed along the length of the technological line. The defects found in the product at the beginning of the technological line are also manifested in the subsequent positions. All this depends on the influence of active elements and technological equipment, unpleasant conditions, monotonous repetition of operations.

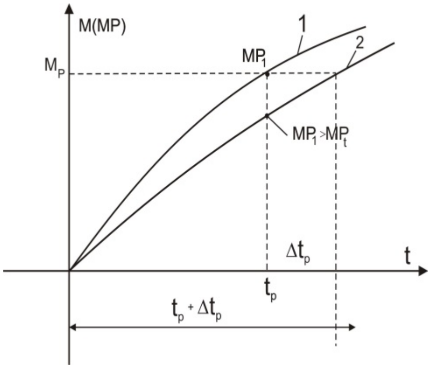
By conducting a static analysis, the type of defects that are of great importance in individual parts is determined. Acquired defects are correctable and non-correctable. The main defects in RC are the defects in geometric dimensions depending on the violation of the operating modes of the gelatin type shears. Such defects are also obtained if the mouth of the cutting scissors is not properly sharpened. After cutting the gelatin with scissors, the aluminum sheets are heated in the temperature mode of the oven. In this case, blisters appear on the sheets and cause certain defects. Such defects are irreparable defects. In this technology, dust residues and marks are formed on the sheets. The defects received here cause a violation of the regime of the technological and cleaning device and the receipt of a high temperature after polishing. When painting the sheets, there are cases where the color does not fall off in certain parts. Such defects are considered repairable defects. In addition to these, there are defects caused by thick, thin, wide and narrow color, which are caused by improper use of the template, change of rubber in the drying oven, change of the physical and chemical properties of the color, etc. is taken into account. In the transfer, extension, shifting of the images on the sheets, the creation of marks on the surface of the sheets, the presence of cracks, etc. the resulting defects consist of the correct selection of the distance between the shafts, the sheets sliding over each other, breaking, falling apart, forming a groove, the sheets are not correctly placed between the shafts, the distance between the shafts is too large, the sheets are not cut correctly, and the temperature regime is not maintained correctly in the individual sensors in the oven.

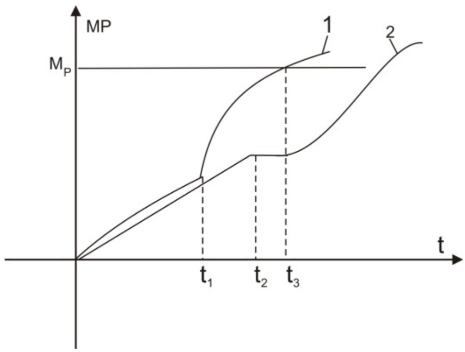
Deformation, channel expansion, compression and cracking occur in shafts without proper lubrication regime. A technical vision system (TVS) is used to correctly determine the occurrence of the above-mentioned defects during the course of technology. TVS is created using elements of artificial intelligence to control defects that occur at several positions of the technological line. With the help of TVS, the coordinates and location of the object are determined. A large number of defects in RC occur in the part where the image is drawn on the sheets. The amount of defects in this part is 30% of the defects in the total production. Defects occur here due to the following reasons: the high temperature of the polished sheets entering the drawing table; unstable physical and chemical properties of the images on the sheets; imperfect distribution of the thickness of the color applied to the sheets; the presence of small particles and layers of dust on the sheets.

Metrological tools are used in separate production modules to ensure technical control in the technological line of RC. With the help of hydraulic presses, liquid is injected into channels under pressure through needles. This value of pressure is increased from zero to 10 MPa. Nowadays, liquid pressure is measured with the help of a manometer with an electrical contact. Measuring liquid pressure with a contact manometer is not considered reliable. In this regard, a non-contact manometer is created. Such a transmitter works in relay mode. Here, the transmitter determines the final pressure value at which the channels are fully expanded. It should also be noted that the value of the final pressure is determined depending on the type of evaporators. In this regard, a transponder is installed on it. The manometer measures the pressure of the liquid together with the transmitter. In this device, the transmitter is placed in such a way that the last position of the manometer hand shows all the current values of the inductive transmitter and at the same time the maximum information signal is received. The received signal is given to the processing unit and analyzed freely, and based on the received decision, it makes a decision to lift the end of the hydraulic press.

During the expansion of the channel of evaporators, external and internal defects are formed in them. Among the disadvantages mentioned, the most difficult to determine is the presence of perforation. Such a deficiency is not visible to the eye. This can only be determined by the nature of the pressure change. If there is a perforation in the channels, then the time of full opening of the channels increases and this time is taken more than the opening time of normal channels. Figure 18 shows the characteristics of the manometer. Here, curve 1 is the curve corresponding to the case of full opening in the channels. It can be seen from the graphs that the maximum pressure $\left(t_p + \alpha t_p\right)$ is obtained at the time of puncture. Graphically, it is determined that, depending on the size of the holes and where it is located in the channels of the evaporator, the maximum pressure is always lower than the pressure corresponding to the purchase of a normal evaporator. Let's see how the time-dependent variation of the output voltage of the transmitter depends on the expansion and contraction in the channels of the evaporators. If there is a compressed channel in the evaporators, then the pressure in that part increases rapidly in the direction of the ordinate axis (Fig. 18 a), if there is an expansion, then the pressure decreases in the direction of the abscissa axis (Fig. 18 b). Channel compression and expansion can occur at different locations along the length of the evaporators.

The actuators used in the FAA systems used in the preparation of vaporizers serve robots or manipulators. Some of these may be standard or non-standard elements. An electric contact torque is used to measure the air pressure at the inlet of the İR used in the FAA system . İn the preparation of vaporizers





Fiqure 18, a **Fiqure 18, b**

The implementation mechanisms used in the used CPI systems serve robots or manipulators. Some of these may be standard or non-standard elements. An electric contact torque is used to measure the air pressure at the inlet of the İR used in the FAA system. Non-contact torques are used to increase their operational reliability. Electromagnetic type transmitters are used for them, the principle of operation of which is the same as distance transmitters. The measurement of the parameters of a moving object involves the synchronization of the image of the object, which is performed with the help of a telecamera device. In the sensing system of İR, a control unit is used, which consists of the following blocks (Fig. 19): 1-telecamera, 2-disc, 3-step motor; 4-monitor support, 5-object, 6-illumination source, 7-transmitter indicating the presence of parts; 9-frequency converter; 10- from the control unit, 11- from the command unit; 12-from the image-sensing block, 13- from the interface device and 14- from the personal computer.

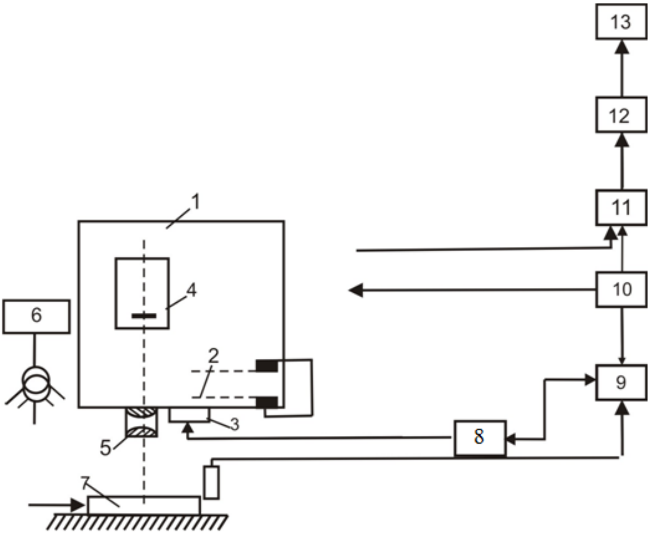


Figure 19. Block diagram of the moving object vision system

MAIN RESULTS

1. Selection of the types of information-measuring elements in the base of transmitters that provide intelligent control and automation of the technological processes of the RC under study, the structural scheme of the positioning of the active elements of the RC in the moving nodes was proposed and analyzed [13].

2. İn order to increase the level of the intelligent management system of RTK, a functional scheme of other elements of the technological measurement, control, regulation, diagnostics and sensor system with high measurement capabilities of the information-measurement sub-level was proposed [16, 18, 22, 24].

3. Based on the structure of the robotic complex, a database of information-measuring transmitters and execution mechanisms was established in the researched technological line for the creation of information support of non-standard elements and their measuring devices, and information-search and selection algorithms were developed [6, 10, 19, 20, 27 , 28 **]** .

4. Constructor-structural schemes of non-standard elements used in RC were proposed, information provision, positioning, block-schemes of their technological measurement transmitters were established, and dependency graphs were constructed based on computer experiments [11, 23, 31, 35].

5. A mathematical model for determining the error of the analog transmitter applied at the 1st level of the ACS was built for accurate and reliable management of complex technological operations in RC.

6. İn the process of operation of the technological equipment of the production module of the RC, the purpose of the study of the physical properties of the transmitter for distance measurement was set. distance-dependent characteristics were substantiated by computer experiments [3, 4, 5, 15, 17, 32, 33, 35, 39].

7. İn order to justify the supply of the control system with the required transmitters based on the types of industrial robots operating in the RC, the magnetic system of the transmitters is made of the entire structural steel and the supply voltage (12 V or 24 V) is standard according to the load-lifting, manipulation ability,

workability and type of transmission. it was proposed to bring to the price [3, 4, 8, 12, 15, 21, 29, 34, 38].

8. İt was proposed to use the information-measuring devices of the robotic complexes to implement the regulation and full automation of the temperature regime in the RC technological line. [1, 2, 14, 26]

9. The issue of detecting defects that may appear on the outer surface of sheets during the application of a technical vision system to ensure technical control in the process of product development at RC is substantiated [36, 37].

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The defense of the dissertation will be held on September 30, 2022 at 11:00 a.m. at the meeting of the ED 2.41 Dissertation Council operating under the Azerbaijan Technical University.

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Dissertation in the scientific library of Azerbaijan Technical University.

Electronic versions of the dissertation and abstract are posted on the official website of Azerbaijan Technical University .

Abstract was sent to the necessary addresses on 07.07.2022 .

Seal signed: 04.07.2022

Paper format: 60x84 1/16

Volume: 80059

Circulation: 40