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THE PROBLEM OF MODELLING FOR DESIGNING PROCESS OF CONTROL SYSTEM OF THE FLEXIBLE MANUFACTURE AT THE TECHNOPARK IN THE HIGHER EDUCATIONAL INSTITUTION

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Abstract The purpose of the article is to develop the algorithm and model for designing the management and control system of the flexible production of the technological park created in the higher education institution (HEI). As a result of the analysis, as the main research issues of the article, the organization of information provision for the management of the production areas of the technological park of the higher education institution, the selection of the composition scheme of the flexible manufacture areas, the modeling of the design process of the information-measurement, management and control system and the architecture of the automated management and control system based on SCADA issues of construction, management and control operation algorithm processing are set.

HEI (on the example of Sumgayit State University) was proposed, and the process of designing the automated management and control system of the production process was modeled. Flexible manufacturing system (FMS) machines, industrial robots, manipulators, etc. the architecture of its automated control system based on the general structure scheme and SCADA based on the base of active elements is proposed. In order to control the quality of the product manufactured in the FMS of the technological park of HEI, the production area was analyzed and an algorithm was developed for the selection of technical control tools. Based on SCADA, the technical, informational and software tools of the automated management and control system of the FMS of the HEI technology park were selected and studied with experiments. A frame model was built for the functional analysis of technological operations and the study of the quality control process of the manufactured product on the example of the mechanical cutting production module of the FMS.

Key words: higher education institution, technological park, flexible manufacture system, design, automated management system, information-measurement and control, SCADA, frame model.

AMS Mathematics Subject Classification: 70Q05.

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Introduction

In most developed countries of the world, the economy is developed on the basis of innovations. In the regulation and management of activities in this direction, important tasks fall on the technoparks in those countries. In this regard, advanced countries have experience in the field of creating technological parks which in [1, 2] considered. It is possible to take advantage of the existing experiences of technological parks in developed countries, to better achieve the goal set in a specific country by using specific features and trends. Applying the successful results of the international experience on the creation, organization and management of innovative technology parks to the structures of technology parks being formed in Azerbaijan is considered one of the most urgent issues for the current period. In the "Azerbaijan 2020: vision of the future" Development Concept, the main goal in the coming years is to double the gross domestic product mainly due to the development of the non-oil sector, and to implement this increase due to the establishment of an innovation-oriented and knowledge-based economy in the republic. One of the main direction of such development shown in [3, 4] what is creation of modern innovation structures aimed at the development and application of high technologies.

Currently, for the formation of competitive and high export potential, innovative product or service production, in other words, with the aim of developing an innovative economy, industrial and chemical technology parks in Sumgait, the State Fund for the Development of Information Technologies under the Ministry of Communications and High Technologies, in Baku - Pirallahi “High technologies park”, an agropark for agricultural technologies in Shamkir, an industrial park for waste processing in Balakhani, and a high technologies park in Mingachevir were established. Such new institutions will provide financial and organizational support for the strengthening of Azerbaijan’s economy, the attraction of foreign investments, the expansion of the production of quality industrial products in the country, as well as the organization of the activities of other newly created socio-economic and public institutions.

As it is known, technoparks are one of the widely used innovation institutions in HEI. The task of the technological park of HEI is to improve the social condition of professors and teachers, adapt scientific research and innovative projects to modern requirements and standards, test startup works in research laboratories and apply them in production, use and development of automated management systems, and ensure interregional and international relations in the field of innovation. In order to increase the potential of Azerbaijani science and to recognize our scientists in the international world of science, it is necessary to organize modern scientific research, production, teaching-training centers in higher education institutions and involve bachelors, masters and doctoral students in research and production work. By integrating scientific research and production centers created in the sphere of high technologies with the economic institutions of higher education schools, it is possible to achieve the formation of a complex innovation infrastructure - technoparks and give a great impetus to the development of the country’s economy.

Thus, the organization of production areas of technological parks in the sphere of high technologies of the higher education system in Azerbaijan and the automation of design processes with the help of modern computer equipment, bringing management and control issues to the agenda and researching them with the methods of intellectual modeling are considered to be a scientifically relevant problem.

Research goals and objectives. The purpose of the research is to develop algorithms and models for designing the management and control system of the flexible manufacture at the technological park created in the higher educational institution.

To achieve this goal, the following tasks are defined in the article:

1. Development of information provision formed from information-search and data, knowledge base management tools for the management of the production areas of the technological park of the higher educational institution.

2. Development of algorithmic support for the selection of the composition scheme of the flexible production areas of the technological park of the higher educational institution.

3. Development of algorithmic support for modeling the design process of the infor-mation-measurement, management and control system of the flexible production system based on the complex structure scheme of the technological park of the higher educational institution.

4. Of the technology park of the higher educational institution.

5. Development of the algorithm for the functional study of the management and control system of the production of the technological park of the higher educational institution .

1 Analysis of technological parks at HEI

In order to adapt Azerbaijan's higher educational institutions to international educational standards and increase their rating, extensive application of innovative methods, innovative scientific research areas, new technologies, and automated information systems is required. As see of [5], technoparks are one of the priority areas for the implementation of the innovation development model. The main issues of the scientific-technological park created at the higher educational institution are the development of scientific research and projects, the application of the results of scientific work in production, the creation and development of new scientific technologies, and the development of interregional and international relations in the field of innovation. Scientific-research, selection of educational directions, effective use of scientific and personnel potential, organization of scientific-technological park and establishment of its activity model to ensure marketing of new projects in local and foreign markets are considered to be scientifically relevant problems in HEI.

As a result of the analysis and research of technology parks of leading countries and special technological-economically oriented zones in modern times, it was determined that 59% of urban technology parks (or 44% of world technology parks) are located in the territories of small cities. In Europe, this indicator is 71% of all urban technology parks (53% of all European technology parks). Due to the high density of the urban population, these indicators are higher in central Europe, what in [6] is given. Technoparks and scientific parks are mainly created on the basis of higher education and research institutions or in nearby areas. Thus, 48% of all world technology parks are located in the territories of universities and research centers. From [7] see that usually these areas belong to the private properties of those higher schools or research centers. Thus, it can be noted that the placement, planning, management, financing mechanisms of technology parks, determining the level of infrastructure development and the main development problems of technology parks are important factors for the successful creation and development of technology parks.

In [8, 9] shown management principles are used and management institutions are applied to ensure the efficient operation of the technological park in HEI. The following functions are performed with the help of traditional management subsystems of the technological park of HEI:

— organization of the corporate management system and network of the specialized research center and production areas;

— implementation of the expert assessment system (scientific, technical, commercial and financial) of the technological park's supervisory board, which performs the functions of project selection;

— organization of technical, software and information provision of the hierarchical management system of the specialized research center and production areas.

[10] is dedicated the issues of creating technology parks and their work principles in information technologies, process automation and management, economic cybernetics and other specialties in the leading higher education schools of Europe and South America. The impact of the researched technology parks on the economic development of those countries and their role in the higher education system have been reflected in these works. The analysis of the materials shows that the large-scale investments in the organization of technological parks and the results of the economic efficiency in those areas have determined that in many cases the financial expenditures are not carried out according to their purpose, there are excess costs, and this has a negative effect on the quality of education.

The analyzed articles [11, 12] are devoted to issues of planning and management of technological parks and their research and production areas in higher education schools of developed countries. The tasks of the working units in the general structures of the university science parks are to comprehensively ensure the issues of scientific research, production and commercialization of the developed innovative projects. In order to increase the efficiency of the work of the technological parks, the issues were resolved by setting the demand to increase the activity of the professor-teacher staff of the higher education school, to raise the level of professionalism of mentoring.

In the United States, China, Japan and Israel, technological parks and special technological-economically oriented zones [13] where studied, and it was determined that technological parks are mainly located in cities (3/4). In the regions (25 km at a distance from the city) there are parks mainly focused on the food industry or processing of agricultural products (Fig. 1).

The analysis of technology parks located in universities of Central European cities showed that most technology parks are located in the territories of small cities due to the high density of the urban population. In Eastern Europe, most technology parks are located in large cities. In the form of a diagram, the location of technoparks in Europe [14, 15] is given as follows (Fig. 2).

One of the strategic economic issues of the Republic of Azerbaijan is the development of small and medium-sized businesses. [16] shows that for this purpose, relevant state institutions were established in independent Azerbaijan, and state programs were adopted in a number of directions.

In [17] is given the second half of the 20th century, one of the factors that stimulated the economic development of Western and Central European countries was the use of high innovation technologies and the economic development experience of the United States. Great Britain, France, Germany, Italy, etc. from European countries. by fur-

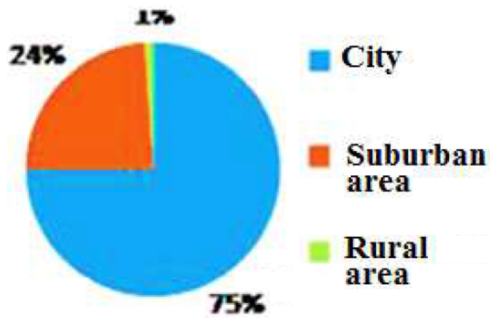

Figure 1: Placement areas of technoparks.

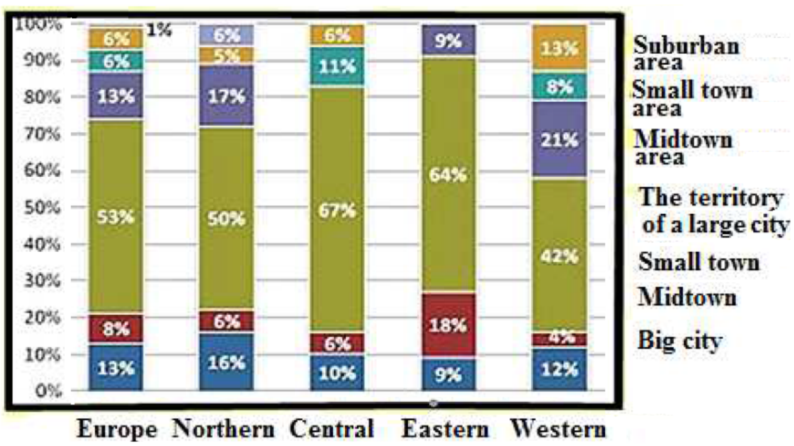

Figure 2: Placement of technoparks in Europe.

ther improving the principles of construction of technological parks, in accordance with the adopted state scientific-production program, microelectronics, informatics, communication, medical and biotechnology, medical equipment, etc. new technological parks are being created in scientific fields. In [18] is considered technological parks, which differ in management principles, create ample opportunities for conducting scientific experiments and researches, and in the process of higher education, practical works and tests are realized.

As in [19] shown the reason for the economic breakthrough of Asian countries was the integration of industrial concerns located in Japan, South Korea, China, etc. countries with national scientific academies and higher education institutions, and in addition, large-scale technopolises were formed based on residential buildings, markets, educational centers and other areas.

However, the comparative analysis shows that large investments used in the construction and development of technological parks, complex economic management issues have a negative impact on the quality of the teaching process of the higher education system in many cases. Thus, individual university departments are not able to realize their scientific potential, being excluded from scientific-research-production and commercial work and the large-scale economic process. In many cases, students studying in higher education schools do not have the opportunity to realize their scientific potential.

In this regard, one of the main issues considered in the article is the creation of an automated management and control system to ensure the complex activity of scientific research and active production areas of the technopark in the example of Sumgayit State University.

2 Analysis of control system of FMS at HEI technopark

Management of economic activity in the conditions of a market economy is mainly carried out with the help of individual decisions made in enterprises. Technical, economic, financial, etc., meeting the needs of the society through the optimal use of limited production resources in accordance with the goals and existing conditions in the technological park of HEI. issues are resolved. The ability of the enterprise to produce innovative new products is the main factor of future economic efficiency and development.

In order to ensure the efficiency of HEI technology park, the production and economic activity of the enterprise is based on the principles of continuity, optimality, economy, stability, planned unity of scientific research and flexible production areas of the enterprise, determination of priorities, complexity, control of plan implementation.

However, the reviewed materials in the publications of [20,21] do not take into account the conditions of adaptation and integration to the market economy in the processes of enterprise planning, management and control. The principles of flexibility, mobility and cooperation of management and control in productions applied in innovation-oriented technological parks are not sufficiently ensured.

In the publication of [22], when defining the structure of the technological park's scientific research and production management system, attention is paid to the technological park's organizational structure, the composition of investors, and the mechanisms for realizing the tasks and goals of the technological park. In this process, normative documents related to the creation of technoparks, tax and customs concessions, infrastructural characteristics of technoparks, indicators of scientific-innovative and educational activity of technoparks are also taken into account. The structural element that implements the management of ICT technology parks - the management company performs the current and strategic management of the technology park. In addition, it helps the development of business residents and provides them with business services.

[23] shows that the issues of management of production institutions of the technological park are complex in nature. A management system based on corporate methods of management principles and corresponding implementation mechanisms are proposed. Conditions such as efficiency strategy based on balanced indicators are determined in the management concept of the technopark's production. The management and control model of the production areas of the technopark reflects the socio-economic goals of the technopark, the management system, the requirements of innovation-investment projects, the mechanisms of commercialization of the results of scientific and research works, and the principles of production organization.

In the management and control systems of industrial enterprises of technological parks analyzed to the research articles of [24,25] various international standards, economic programs, management of electronic documents, database management systems, computer network tools, etc. information-measurement, control and management subsystems are used. At the levels of research and production institutions of the technopark, the issues of activity planning at different levels of the automated management and control system prevail.

However, despite all these advantages, there are also negative aspects of creating industrial parks. This is due to the fact that the integration of industrial parks with research and higher education institutions is quite low. The professor-teacher and student staff of higher schools and scientific-research institutions do not directly participate in the process of designing innovative objects, scientific-research works and production of products in industrial parks. The principles of flexible and corporate management are not ensured in industrial parks, because these types of enterprises produce standard products of the same type based on orders. Access to the international market is limited.

Taking into account what has been said, in order to increase the reliability, mobility, efficiency and productivity of the technology park and the automation of the management and control system of its production process in the higher education institution, the solution of the following scientific-research issues should be required [26]:

1. Creation of information provision for the management and control of flexible production areas of the technological park of the higher educational institution;

2. Development of algorithmic support for choosing the composition of flexible production areas of the technological park of the higher educational institution;

3. Designing the complex structural scheme of the technological park of the higher educational institution, the management and control system of its flexible production system;

4. Selection and application of technical support tools of the management and control system of the flexible production area of the technological park of the higher education institution;

5. Organization of the system and technical design stages and tools of the scientific research and production areas of the technological park of the higher educational institution;

6. Construction of the SCADA-based automated management and control system architecture of the flexible production area of the technopark of the higher education institution and development of the algorithm for planning information-measurement and management procedures;

7. Development of the management and control algorithm of the flexible mechanical assembly production area.

The goal of the problems is the development of algorithms and models for the design of the complex management and control system of the flexible manufacture system of the technological park in the higher educational institution.

3 Designing process of FMS at technopark of HEI

As shown in [26], placement, planning, management, financing mechanisms of technological parks in HEI, determining the level of infrastructure development and the main development problems of technological parks (location at a distance from economic centers, availability of transport infrastructure, sufficient social infrastructure, availability of required specialists, developed marketing having a strategy and choosing the right specialization) are important factors for the successful creation of technological parks. The structure of the step-by-step design process should be determined to solve the mentioned complex issues. In this regard, the structure of the stages of designing flexible production areas, its management and control system, which is the main institution of the HEI (in the example of Sumgayit State University) technology park, is proposed (Fig. 3).

Of the paper of [27], folowed to make that one of the important conditions for the efficient operation of the flexible manufacturing system of HEI technopack is the size of the area where they are located and the provision of certain conditions of that area.

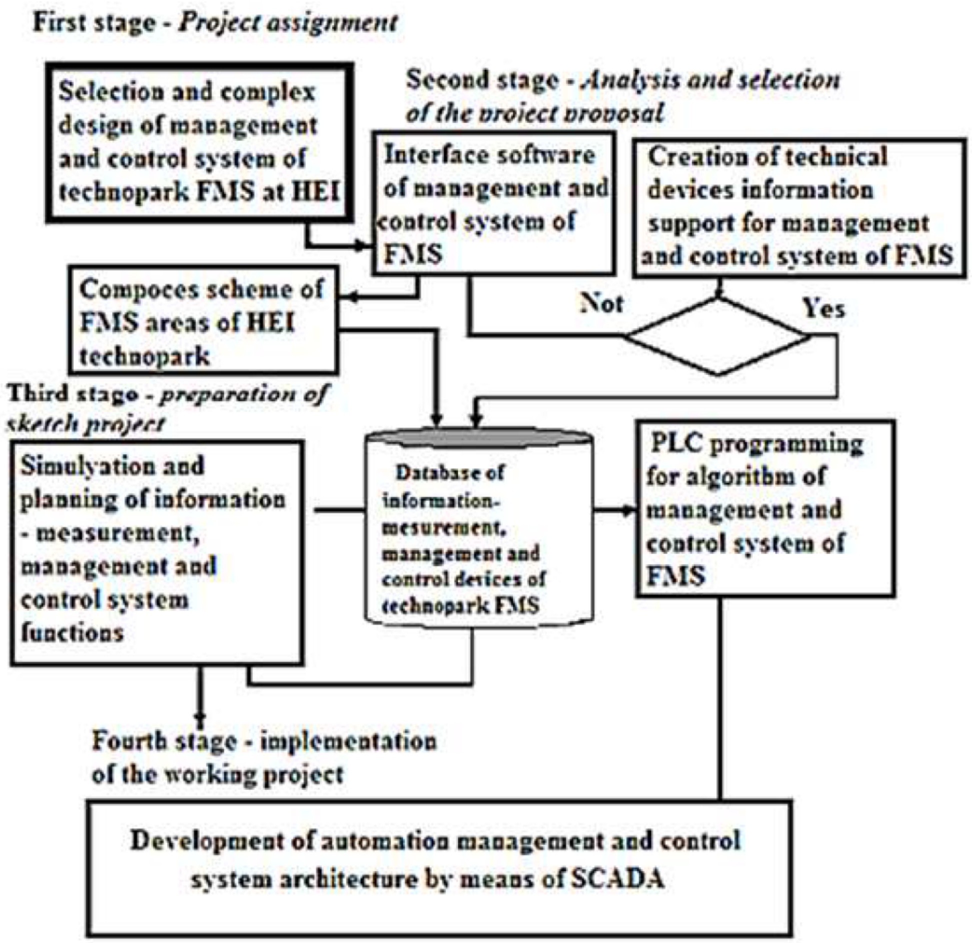

Figure 3: The structure of the stages of designing the management and control system of the flexible manufacture system of the technological park of HEI (on the example of Sumgayit State University).

As indicated in [28], the selection of the area allocated for HEI technological parks is determined according to the following conditions:

1. being near the city;

2. being in a region with favorable conditions for the population;

3. that the scientific-research and educational institution is based in the region and consists of personnel engaged in highly qualified scientific research work; location close to scientific research and universities that conduct scientific research and are capable of developing new technological developments.

As can be seen from Fig. 3, the procedures of the design stages that ensure the automation of the design operations of the FMS management system are provided on the basis of the software interface [29]. In the 1st stage, the input data of the design task is pre-processed with the help of the automated design interface (ADI). Analyzing the problem area, the information provision of the technical means of the management and control system of the FMS for various fields of application is formed from specific projects. Based on the analysis of existing projects, their technical and economic inadequacies are determined, a database management system is created from proposals for new projects (2nd stage). In the 3rd stage, the types of active elements of the application object, their measurement, implementation, regulation, control and management tools are selected from the database for planning and simulation of the functions of the information-measurement, management and control system of the FMS of the technopark, and the planning and management algorithms corresponding to the technological operations are created. Modeling and simulation of management and control algorithms of all areas of FMS are carried out separately and comprehensively in the mathematical programming environment, Labview and TIA logical programming environment. The software of the programmable logic controller (PLC) is developed and verified for the real evaluation of the operation of the management and control system of the application object.

In the 4th stage, with the connection of PLC to the industrial network, testing of programs for automation and management of technological operations of all objects is carried out, laboratory tests are conducted.

At the next stage, the integration of the automated management and control system (TPAINS) of the technological process of the FMS into the industrial network is provided by the IEC61158 standard. According to the IEC61158 standard, the following functions are performed in an industrial network:

1. Data transfer between information-measuring transmitters, PLC and execution mechanisms applied in the facilities of the FMS (fiber-optic lines and wireless connection is provided by WiFi);

2. Diagnostics of FMS objects, remote configuration of transmitters and execution mechanisms;

3. Hummingbird of transmitters;

4. Feeding transmitters and executive mechanisms;

5. Relationships of transmitters, executive mechanisms with PLC of the upper level and TPAINS.

4 Composition and control of FMS of HEI technopark

For the efficient organization of the production of the technological park of HEI (in the example of Sumgayit State University (SSU)), the justification and composition of the selection of infrastructure facilities is considered one of the important design issues. Information about the agreed project solutions, issues of confirmation of compliance of the project-estimate documents with the state standards, rules and norms are implemented in the sketch design stage of the technical park of SSU (stage 2, 3).

At the initial stage, it is justified that the architectural-construction solutions of the technological park meet the urban construction requirements. The composition scheme and architecture of the production areas of the SSU technopak are proposed. In order to ensure the efficient operation of the flexible production areas of the technological park of SSU, the introduction of internal and external power supply network, additional distribution transformer station, organization of water supply and water distribution network, organization of heat supply and sewage network, creation of an automated management system of energy resources, telephone and the organization of computer network connections and landscaping of the areas are envisaged.

In the article [30], the problem of production areas of SSU technological park, the process of equipping, providing technological processes with basic means, equipping with special technical means in accordance with the directions of the specialty profile, installation, tuning, and the production and export of innovative projects is planned.

Initial requirements for creating a flexible production system of the technopark are determined:

1. Principles of preparation, processing and assembly of mechanical parts of projects;
2. Assembly and tuning of electronic parts and devices of projects;
3. Provision of technological measurement, metrological regulation and technical vision of the quality control process of projects;
4. Automation and intellectual management of the technological process.

Based on the above-mentioned requirements, the layout of the FMS is determined by a sequential structure scheme (Fig. 4).

In the 1st stage, depending on the type of product produced in the FMS, which is researched in the article [31], machining, drilling, cutting, bending, welding, etc., are carried out on its mechanical parts. technological operations are performed on the

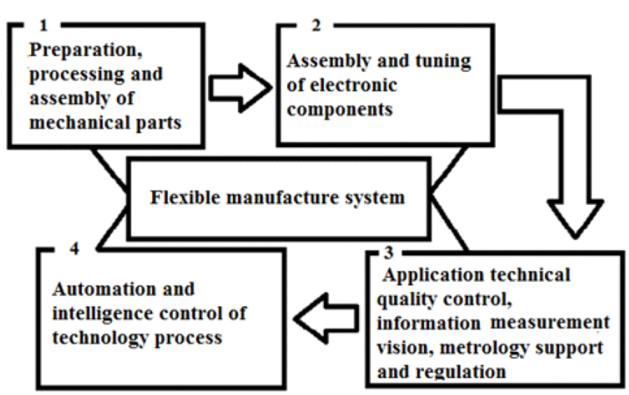

Figure 4: Schematic diagram of sequentially structured FMS.

appropriate machines of the FMS (Di).

At this stage, liftronic manipulators (*Intelligent Lift Assist Devices*) are used for safe transportation of heavy mechanical parts of the product. This type of manipulator automatically balances the load so that whenever the load is lost from the holding zone, the Liftronic manipulator remains stationary and ensures the safety of the operator. The up-down movement of the manipulator is regulated by electronics.

When the load leaves the support, the manipulator first moves slowly and then quickly, making the system work reliably and efficiently. The Liftronic manipulator is able to work 8 times faster than the lifting device.

In [32] the experimental investigation executed on the 2nd stage, the electronic elements of the product (measurement, execution, adjustment, control, technical vision, management, communication lines, etc.) are assembled with the help of a special balanced manipulator and its handle supported by users.

In order to ensure the quality control process of the product prepared in the 3rd stage, technological measurement, metrological assurance, regulation and technical vision system are used in each module of the FMS according to the specifications of technological operations presented in [33].

Of the analyzing [34] follows that the production area to control the technological operations of FMS and the quality of the manufactured product, the precise selection of technical control tools is ensured. Since the object of application has very functional, complex technological characteristics and structure, the following technological control issues should be ensured in the process of product development:

Cutting raw materials with standard sizes:

$$\begin{cases} \text{if } P_1, & \text{then } a_1 \times b_1 \times \delta_1 \quad (\text{mm}) \\ \text{if } P_2, & \text{then } a_2 \times b_2 \times \delta_2 \quad (\text{mm}) \\ \text{if } P_3, & \text{then } a_3 \times b_3 \times \delta_3 \quad (\text{mm}) \end{cases}$$

where P_i – parameters reflecting the perimeter dimensions of the i-th product; a_i-length of i-th board; b_i-the width of the i-th board; δ_i-the thickness of the i-th plate.

For industrial robots (IR_i) and machines (M_i) in the production modules of FMS, the manipulyation zones are defined:

For IR_i X, Y, Z coordinates

$$\begin{cases} \text{if } IR_{Xi}, & \text{then } -0,1 \leq \Delta X_i \leq +0,1 \quad (\text{m}) \\ \text{if } IR_{Yi}, & \text{then } -0,15 \leq \Delta Y_i \leq +0,15 \quad (\text{m}) \\ \text{if } IR_{Zi}, & \text{then } -0,05 \leq \Delta Z_i \leq +0,05 \quad (\text{m}) \end{cases}$$

For M_i X, Y, Z coordinates

$$\begin{cases} \text{if } M_{Xi}, & \text{then } \Delta x_i \approx 0.15 \quad (\text{m}) \\ \text{if } M_{Yi}, & \text{then } \Delta y_i \approx 0.15 \quad (\text{m}) \\ \text{if } M_{Zi}, & \text{then } \Delta z_i \approx 0.35 \quad (\text{m}) \end{cases}$$

Ensuring the standard polishing size of the top layer of the product $0.5 \leq \Delta\delta \leq 0.9$ mm.

Based on the conditions adopted above, it is possible to create a control system for the product preparation process in FMS. For this purpose, starting from the initial technological operations, the technical support of the generalized control system is established by determining the appropriate sub-control means. The analysis of the technological process shows that special cutting machines, polishing machines, welding machines, leveling machines, hydraulic presses and vehicles are used for product preparation in the analyzed FMS.

The technological analysis of the applied FMS in the articles [35] shows that it is required to control the accuracy of the execution process of operations (cutting, polishing, cold welding, straightening, slotting and channeling) in each production areas and modules. For this purpose, different types of control systems of the production modules of the FMS of the technopark can be expressed by the following set:

$$NS_{ij} \in \left\{ \begin{array}{cccc} CS_{11}, & CS_{12}, & \dots & CS_{1n} \\ CS_{21}, & CS_{22}, & \dots & CS_{2n} \\ . & . & & . \\ . & . & & . \\ CS_{k1}, & CS_{k2}, & \dots & CS_{kn} \end{array} \right\}$$

here, the type, technical properties and parameters of the control system corresponding to each technological operation and type of technical unit are determined. The established dependency is written in the logical expression: $CS_{ij} \to P_{ij}$ & T_i, where P_{ij}-controlled parameter; T_i is the type of control tool.

At the 4^{th} stage, the question of automation and management of the application object is raised. SCADA technology is used to ensure the automation of the FMS control system. SCADA technology is used to ensure the automation of the FMS control system. In the scientific paper [36], the problem of development of SCADA (Supervisory Control And Data Acquisition) a package program designed for the development of systems for collecting, processing, describing and archiving information about control objects or ensuring their real-time activities is conciedered.

The SCADA system of FMS of technopark performs the following functions:

1. Visualization of FMS technological process management. Data collection (Dynamic Data Exchange (DDE) and PC (OLE for Press Control) protocols) from information-measuring, regulation and control sources of SIS machines (D i), industrial robots, automatic transport lines;

2. Modification, storage, deletion and reading of information in database tables based on SQL;

3. Remote control of the active elements of the FMS, actively participating in the technological process;

4. Provision of control and diagnostic procedures, their protocol and automatic notification of the operator;

5. System protection.

As shown in [37], the issue of designing a distributed control system of FMS based on TRACE MODE is considered for the implementation of the software and hardware of the interface of the automated management and control system of the FMS of the technopark. All modern means of communication are used for data exchange of TRACE MODE-based GPS management system: local network; interface RS-232, RS-485, RS-422; radio channel; leased and replaced telephone lines; GSM networks; standard interfaces (OPC, DDE, NetDDE, ODBC) and transport tools. Using these tools, information exchange is organized between all levels of the automated management system (AMS) of the FMS (Fig. 5).

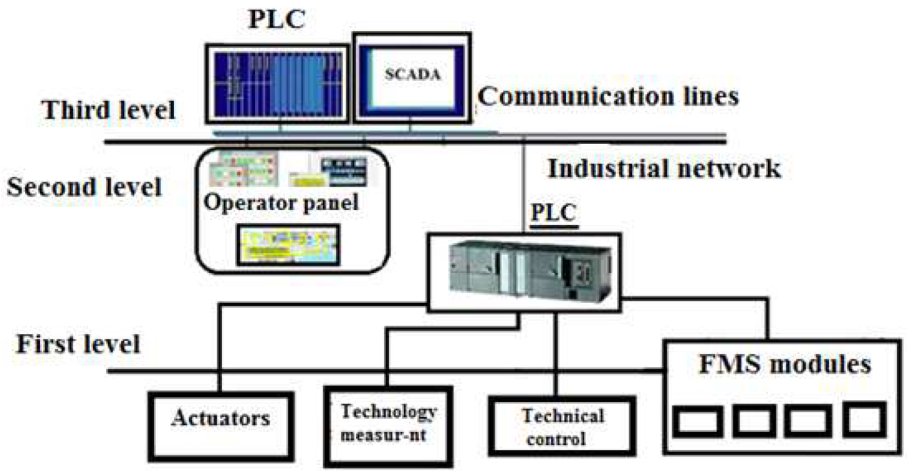

Figure 5: ACS of FMS of technopark based on SCADA.

As marked in [38] the process of collecting information from objects for processing, analysis and management of technological objects from a distance [SCADA (Visual Control and Data Acquisition) system] consists of three components: a remote terminal that performs management and control tasks [Remote Terminal Unit (RTU)]; a control room [Master Terminal Unit (MTU)] that performs data processing and high-level control; communication system [Communication System (RS)], transmitting data from remote points or objects to the central interface of the operator-dispatcher and transmitting control signals to the RTU.

A block diagram of a SCADA system is used to collect reliable and high-level data from FMS and wireless cellular communications sites. As a distributed communication system, the wireless mobile GPS of the GSM digital standard centrally informs the operator of the FMS in the event of an emergency. With the help of GSM, each client of the system is provided with current information about the progress of the technological process of the FMS and the values of technological parameters and a management command at any time. The following mechanisms are used to connect SCADA input/output drivers:

1. Dynamic exchange of data (VDM-DDE);

2. Special protocols of the manufacturer of the SCADA system that ensure fast data circulation; (OLE for Process Control) protocols supported by SCADA.

The OPC server supported by the SCADA system is applied in all workplaces of the automated control system of the studied FMS. With the help of OPC, data about all technological operations performed in the FMS are transferred to the SCADA visualization program and database.

SCADA operating in the Windows operating system environment is formed from the database presented in [39]:

1. Static library (C++, Java);

2. Dynamic library (DLL - based on Visual Basic, Visual C/C++, Borland C/C++, Delphi, LabWindows CVI, LabView);

3. DDE- server (implemented with 16 and 32 bits);

4. FastDDE - packet implementation of DDE protocol for Wonderware, Advanced-DDE and Rockwell lines ;

5. The SuiteLink server is implemented with the SuiteLink protocol using the FactorySuite (Wonderware) package;

6. OPC – the server is supported by an interface defined by the OPC specification.

The analog signals recorded by means of real-time technological measurements and technical control of the automated control system of the FMS of the Technopark are transmitted through communication channels and processed in PLC. The indicators obtained as a result of technological measurement, technical control and diagnostics are stored in the database of the InTouch server. Communication channels of InTouch server provide mutual connections between DDE and OPC servers.

The SuiteLink protocol is used to ensure completeness of data, high productivity and simplicity of control during information exchange on the server . SuiteLink protocol is based on TCP/IP. This protocol is used to ensure high productivity and mobility in industrial systems.

At the 3rd level of the architecture of the automated management system of Technopark's FMS, the WindowViewer execution environment is applied to provide an interface for data collection and dispatcher management on the industrial server. Through the InTouch I/O server, the analog input signals of the transmitters entering the PMK are written and the output execution signals from the PLC are read. The following parameters are used to organize the exchange with the software add-ons on the industrial server:

1. Name of the network node (Node Name);
2. The name of the applied software (Application Name);
3. Name of data group or topic (Topic Name);
4. Item Name (Item Name).

DDE, FastDDE, SuiteLink server functions, Windows program name. The name of the data group depends on the specific server. Given that a Modbus server is being used, the name of the interface program with the Modicon Micro 984 PLC controller is assumed to be Modbus.

5 Construction and functional modelling

The main task of the automation scheme of the technical control system of the FMS based on SCADA is to collect data about the real measurement from the technical control devices of the active elements of the FMS and the quality of the manufactured product and display this information on the monitor of the single dispatch center. Also, the SCADA system provides long-term archiving of received data. The dispatcher often has the ability not only to passively observe the object, but also to control it by reacting to various control situations. The operator, using his smartphone, obtains operational information about the technological operations of each active element of the FMS and the states of the mechatronic parts and the standard quality of the manufactured product from any place and at any time.

The SCADA system proposed for automating the operations of the mechanical cutting and heating FMS control system measures the technical control tools in real time with the help of drivers, and the data communicated by GPRS is described at the dispatcher's input/output point. Real-time processing of current information about the phased preparation of the product is provided by PLC, and the output information is displayed in an understandable form on the screen of the operator's monitor (Fig. 6).

At this time, a real-time database (data base management system (DBMS)) of information about product development and quality is formed in the applied FMS. If the data on AEi of FMS and the violation of product quality are reflected in the block diagram of the technical control system, the operator makes a size adjustment to the technological process and prepares reports on the progress of the technological process. The operator's automated control center performs data processing and high-level control in quasi-real time. It provides human-machine interface. An industrial network server is used to connect the communication channels to the MTU.

Analog signals from technical control devices about the technological operations of each active element and product development to ensure a reliable automated control process with the FMS SCADA system It enters the entrance of PLC. To program the SCADA system, custom software is used, designed for greater flexibility than a distributed control system. Information about the current parameters and product quality of the active elements of the FMS (industrial robot (IR), manipulator (M), cutting machine (CM), conveyor (C) and furnace (F)) is automatically collected, processed and classified. All information is provided to the operator in real time with visualization on the control panel and monitor. Thanks to this, a quick decision is made to manage and change the parameters of the operating equipment.

The algorithm of operation of each active element (AEI) and product quality control is designed to build the software modules of the FMS technical control process within SCADA. Showing in [41] a task of distribution of technological process at the initial stage, the names of AEI included in the production modules of FMS (AEI_name), measured control parameters (MCP), product name (PN), type of technical control element (TTCE), control zones (CZ), operation mode of technical control (OMTC) data are classified by the frame modeling principle as follows:

Frame name : Technical control system of FMS

Name of Slot 1 : AEi technical controls

(Technical control tool of aluminum roll (TCT_AR)$-x_{11}$; TCT of cutting machine $1 - x_{12}$; TCT of IR $-x_{13}$; TCT of the cutting machine $2 - x_{14}$; TCT of manipulator $-si - x_{15}$; TCT of the conveyor of the furnace – x_{16}; TCT of the furnace - x_{17});

Name of Slot 2 : Product technical controls

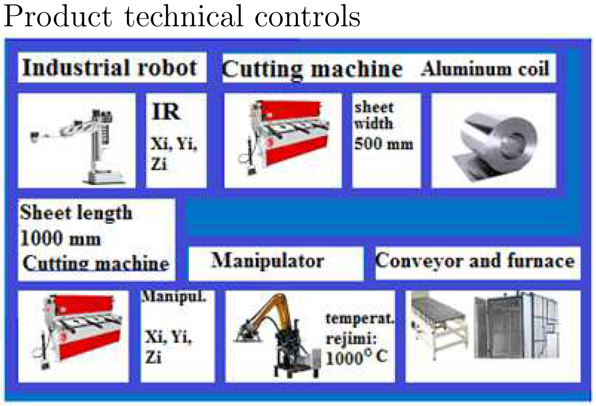

Figure 6: The block diagram of the real technical control system of each production module of the FMS reflected on the screen of the operator's monitor.

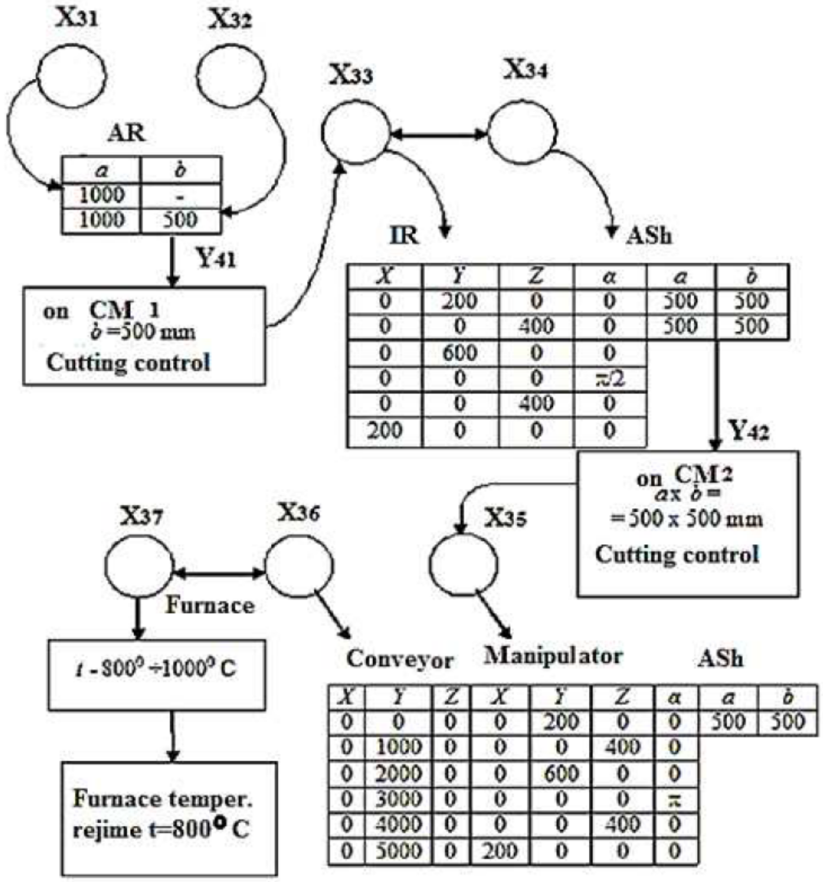

Figure 7: Management of the quality control process of the product of SIS1 block diagram.

(TCT of longitudinal cutting of AR on cutting machine $1 - y_{21}$; TCT of transverse cutting of aluminum sheet (into 2 parts) on cutting machine $2 - y_{22}$; TCT of loading and heating aluminum sheet on conveyor of the furnace $-y_{23}$);

In order to ensure the process of remote control, the input of the PLC must include the signals of the current measurements of the control. In this regard, the multiplicity of slot 3 is defined as follows:

Name of Slot 3 : Indicators of AE technical controls

(Width of the aluminum roll $-a = 1000\,mm - hx_{31}$; Length of the positioning template of the cutting machine 1 (corresponds to the width of the aluminum roll) $a \times b = 1000 \times 500\,mm - x_{32}$; 3-dimensional coordinates of the working area of the IR (X_i, Y_i, Z_i), where $X_i \in \{X_1, X_2, ..., X_n\}$, $Y_i \in \{Y_1, Y_2, ..., Y_n\}, Z_i \in \{Z_1, Z_2, ..., Z_n\} - x_{33}$; The length and width of the positioning template of the cutting machine 2 is equal to $a \times b = 500 \times 500; mm(a \times b = 1000 \times 500\ mm$ aluminum sheet is cut into 2 equal parts) $-x_{34}$; 3-dimensional coordinates of the working zone of the manipulator (X_i, Y_i, Z_i), where $X_i \in \{X_1, X_2, ..., X_n\}$, $Y_i \in \{Y_1, Y_2, ..., Y_m\}$, $Z_i \in \{Z_1, Z_2, ..., Z_m\} - x_{35}$; Coordinates of the working zone of the automatic conveyor of the furnace (X_i, Y_i, Z_i), where $X_i \in \{0\}, Y_i \in \{Y_1, Y_2, ..., Y_n\}$, $Z_i \in \{0\} - x_{36}$; Temperature regime of the oven $-850^0\ C - x_{37}$).

Name of Slot 4 : technical control indicators of the product of FMS

(Cutting of an aluminum roll along the length of $b = 500\ mm - y_{41}$; Cutting of an aluminum sheet in the size of $a \times b = 500 \times 500\ mm - y_{42}$; Heating of an aluminum sheet in the temperature mode of the furnace at $850^0\ C - y_{43}$).

The following slot is written for the step-by-step programming of the technical control process of the FMS based on the operation types of the active elements of the FMS and the stages of product development:

Name of Slot 5 : Algorithm of technical control procedures of FMS

(If $x_{31}\&x_{32}$, Then y_{41}; If $x_{33}\&x_{34}$, Then y_{42}; If $x_{35}\&x_{36}\&x_{37}$, Then y_{43}).

Here, the indicators of x_{3i} and y_{4i} are selected from *slot 3* and *slot 4*, respectively.

The block diagram of FMS product manufacturing quality control is built as in the Fig. 7.

6 Conclusion

Based on the solution of the considered issues, the following results were obtained in the article:

1. The structure of the stages of designing the management and control system of the flexible manufacture system of the technological park of HEI (in the example of Sumgayit State University) is proposed.

2. The composition of the production areas of the FMS of the HEI technology park was established and the architecture of the automated management system was proposed.

3. In order to control the quality of the product manufactured in the FMS of the technological park of HEI, the production area was analyzed and an mathematical model was developed for the selection of technical control units.

4. The technical, information and software tools of the automated control system of the FMS of the technopark were selected and applied based on SCADA.

5. A frame model is built to ensure a reliable automated control process with the FMS SCADA system.

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