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MODULE "TECHNOLOGIST ASSISTANT" AS PART OF AN EXPERT SYSTEM FOR CABLE PRODUCTION

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Abstract: *the article discusses the development of a set of technological documentation to support the manufacturing technology of cable and wire products. The system that the Chief Technologist's service adheres to regarding document management is analyzed. The main functional responsibilities of a process engineer are formulated, and the relationships in the work of structural units with technological documentation for the production process are determined. The functional load of technologists has been defined as the area of design preparation of production, which includes an extensive array of heterogeneous production, technological and economic information of a cable enterprise. Various options for solving problems of organizing the work of a cable production engineer are considered. On the basis of the expert system, the "Technologist Assistant" Module has been developed, the use of which in the technological process eliminates the influence of the "human factor" and the presence of subjective assessment in this area of tasks, ensuring speed in the implementation of the technology. The task is solved on the basis of artificial intelligence, which ensures speed and reliability in the development of technological documentation and its integration into technology.*

Key words: *regulatory and technical documentation, cable production, technological process, expert system, route map, technological map, sketch map, cable design, artificial intelligence, cable machines, cable and wire products, machine vision.*

Introduction

The use of artificial intelligence (AI) at production sites allows engineering and technical workers to significantly free up their working and intellectual time, because This system makes it

possible to implement the majority of work by solving standard production tasks using existing search algorithms and their reproduction. As a rule, the functionality of this system includes two components: rules that recognize conditions and actions containing data on how to cope with the condition. The cable production engineer plays one of the main roles in the production process of cable and wire products [1-3]. His job responsibilities include ensuring the effective functioning of the technological process, both for an individual cable machine and for the entire technology as a whole, taking into account its optimization. The functions assigned to the cable production technologist are given in Table 1 [1-3].

In addition to the above functions, a cable production engineer performs [1-3]:

• introduction of automation tools, which are built on the basis of modern technologies and capabilities for automating production processes,

• development of new types of cable products in order to develop and increase the competitiveness of the cable factory,

• management of new projects within the framework of the establishment of new types of products, in terms of commissioning new cable machines and putting cable products into production.

Functional responsibilities of a cable production engineer

Table -1

Name of function	**Description of work**	**Regulatory and technical documentation**	
		Entrance	Exit
1	**2**	**3**	**4**
1. Organization of the technological process	Separately for each brand position of the cable product, develop design and technological documentation with the selection of raw materials and materials	IEC(International Electrotechnical Comission); GOST(EASC)	Cable product design
			Consumption rates for raw materials and supplies
	Development of a technological process for the production of cable products, taking into account quality requirements, production deadlines and economic efficiency. Determination of requirements for raw materials and supplies.	Cable product design; Technical data sheet for cable equipment	Route map
2. Design and optimization of cable	Development of manufacturing technology	Route map; Consumption	Route map

Name of function	Description of work	Regulatory and technical documentation	
		Entrance	Exit
1	2	3	4
product manufacturing	in relation to equipment, technological equipment, lifting mechanisms and service personnel. The entire range of work is built taking into account production capabilities, as well as optimization of production processes to increase productivity and reduce production costs.	rates for raw materials and materials; Time standards for the manufacture of cable products	Standards for waste of raw materials and supplies
			Sketch map
3. Quality control of manufactured cable products	Implementation of inter-operational quality control of manufactured products	Cable product design; Technical passport for cable equipment (main and auxiliary); Passport for control and measuring equipment	Sketch map
	Development of control methods and ensuring their implementation in technology	Passport for control and measuring equipment; Certificate for laboratory testing equipment. Passports for measuring	Testing and laboratory research methods
4. Development of regulatory documentation	Generalization of available information: a set of technological documentation, technical passports for equipment, control and measurement, laboratory and testing equipment.	Range of manufactured cable products; Set of regulatory and technical documentation; Technical data sheets for cable equipment (main and auxiliary). Methods of laboratory research and testing	Technical specifications

It should be noted that the work of the process engineer is carried out in close connection with the production and metrological services of the enterprise, as well as the internal structures of the Chief Technologist Service (technical bureaus for cable areas, department of standardization and normative control), which constantly helps to maintain productivity, accuracy and reliability of work as main and auxiliary production, as well as ensure high quality of cable and wire products (cable conductor products).

Formulation of the problem: This work of an employee of the Main Technology Service of a cable plant can be attributed to the field of *"Production preparation designer"* [1-3], in which he constantly concentrates and processes a fairly extensive array of heterogeneous information, namely:

Initial - contains information on all technical documentation (IEC, GOST) used in the production process, nomenclature (macro positions) of the CCP(cable conductor products), data from technical passports for the cable equipment involved in the technological process (main and auxiliary), technical characterisstics of technological tools and equipment, data from certificates of conformity for raw materials used in production (technical parameters);

Calculation - designs and structural parameters of cables and wires, route, technological and sketch maps, calculation of masses of materials for cable and wire structures, norms and consumption of raw materials and materials necessary for the production of cable products, as well as their waste norms;

Control parameters, operating modes of technological cable equipment and instrumentation that comply with the design requirements and regulatory documentation in force at the enterprise.

It should be noted that the *"initial information"*, being the input or initial data array, with the correctly chosen methodology, should form settlement documents focused on certain technological chains within the brand of cable product designated as the manufactured nomenclature. It determines the structure of technological chains for the production of CCP (cable conductor products)ranges, indicating controlled parameters by operating modes, instrumentation and interoperational controls. All this work is considered as a single volume and is performed within the framework of the established production task. Despite the fact that this approach to work is general, it is primarily adapted to the requirements and characteristics of the production task for a specific cable product [1-3].

The main working time, in the functional load of the technologist, is spent on developing a set of design technological documentation (cable product design, route, technological and sketch maps, consumption and waste standards for the manufacture of CCP), which can be used more rationally, while ensuring effective automation of this process [1-3]. Currently, cable companies use various software and tools to simplify this work associated with multiple (typical) calculation arrays. The development and documentation of cable conductor products manufacturing technology is carried out according to certain algorithms, where the operation of input and output data, as well as the limitations and features operating in the technology, have setting values regulated by regulatory and technical documentation. It should be noted that the Set of Design and Technological Documentation is the initial and fundamental document for the work of other services of the cable enterprise (Table 2):

Interrelation of data from the Set of technological documentation for the manufacture of CCP with the work of structural divisions of the cable plant

Table -2

Title of the document	**Options**	**Structural division**
1	**2**	**3**

Title of the document	Options	Structural division
1	2	3
Cable product construction	Operating (actual) speed of the cable machine involved in technological operations	**Production service:** production order completion time; consumption of raw materials and supplies
		Quality Department: control of quality parameters for finished products (input, interoperational, output control, acceptance tests)
		Department of Labor and Wages: labor costs; calculation of employees' wages; number of staff; standard time
		Economic service: Consumption of raw materials and materials; Costs of raw materials and materials
Route map	Operating (actual) speed of the cable equipment fleet; Number of units of technological equipment and technological equipment; Number of metrological instruments; Number of loading and unloading units; Number of employees in main and auxiliary production	**Production service:** production order completion time; list and consumption of raw materials and materials; list and consumption of technological tools and equipment; volume of production inventory in workshops for raw materials, materials and technological equipment; process equipment settings
		Metrological service: settings of metrological equipment
		Quality Department: control of quality parameters for finished products (input, interoperational, output control, acceptance tests)
		Department of Labor and Wages: labor costs; number and employment of employees
		Economic service: consumption of raw materials and supplies; volume of production inventory in warehouses; meeting deadlines for delivery of finished products
		Transport service:

Title of the document	Options	Structural division
1	2	3
		list and quantity of loading and unloading equipment; production reserves of fuels and lubricants
Routing map	Operating (actual) speed of the cable equipment fleet; Number of units of technological equipment; Number of metrological instruments; Number of loading and unloading units; Number of employees in main and auxiliary production	**Production service:** actual production order completion time; consumption of raw materials and supplies; consumption of technological tools and equipment; volume of production inventory in workshops; settings of technological equipment; excess costs of raw materials and materials;
		Quality Department: control of quality parameters for finished products (input, interoperational, output control, acceptance tests)
		Metrological service: settings of metrological equipment
		Department of Labor and Wages: labor costs; number and employment of employees; payroll
		Economic service: consumption of raw materials and supplies; volume of production inventory in warehouses; meeting deadlines for delivery of finished products cost price of the produced gearbox
		Transport service: list and quantity of loading and unloading equipment; production reserves of fuels and lubricants
Sketch map	Operating (actual) speed of the cable equipment fleet;	**Production service:** settings of technological equipment; operating modes of technological

Title of the document	Options	Structural division
1	2	3
	Number of units of technological equipment; Number of metrology instruments	equipment; maintaining the quality of the finished product
		Metrological service: settings of metrological equipment
Specifications	Design parameters of manufactured cable and wire products; A set of internal organization requirements for the production process	**Production service:** technical requirements for the product manufacturing process; requirements to ensure achievement of the required level of safety at work; conditions for storage and transportation of goods
		Technical Safety Department: requirements ensuring the preservation of a favorable state of the environment during the production process
		Quality Department: control of quality parameters for finished products (input, interoperational, output control, acceptance tests) rules for acceptance of the finished product; methods for implementing quality control of manufactured products
		Economic service (finished product sales department): conditions for storage and transportation of goods; rules for using products; scope of guarantees provided by the manufacturer

However, using a software product only for the development of regulatory documentation cannot give a fully satisfactory result, because The job responsibilities of a process engineer are not limited only to work related to the development of a set of technical documentation for the manufacture of a certain range of gearboxes, his functions are broader [1-3], he must:

- *accompany the technology*, constantly monitoring changing parameters: technological equipment, changes that depend on its physical and technical condition of the machine; the level of technology provision with raw materials and materials that meet the requirements of regulatory and technical documentation, as well as the qualifications of operating personnel; the influence of disturbing influences (drops in network voltage, vibration, changes in the external temperature field);

- *make changes to the source data in the calculations* of the Technological Documentation Set, because there are irreversible changes in the technical condition of cable equipment, which negatively affect the accuracy and reliability, having negative consequences for increased consumption of material and raw materials, increased energy consumption;
- *monitor compliance with the design parameters* of the manufactured cable product during the production process, through visual inspection of the manufactured cable product, in order to determine the quality of the surface of the wire, conductor, insulation, hose/sheath;
- *control the operating modes of technological equipment* during the production process.

It should be noted that the technologist monitors more than one (in some cases up to 8) technological operations and the operation of up to 20 units of technological and measuring equipment, then the scope of his attention expands, and a very large flow of information is concentrated in the control zone, which significantly increases the influence "human factor" on the quality of manufactured cable products, which is becoming very large [4].

A quick response to changes in technological parameters and control over the implementation of such a volume of information flows by one person is impossible, because requires a lot of time for physical execution, analysis and compliance with constantly updated values in the production, technological and calculation databases. Therefore, solving the issue of proper organization of the work of a process engineer comes down to the creation of an information and computing Module as an expert system "Technologist Assistant", which will eliminate the influence of the "human factor" and subjective assessment in this area of tasks, ensuring speed in the implementation of technology, fast and timely, and most importantly, reliable functionality in making production and technological decisions within the framework of fulfilling a production task. The task posed, for the case we are considering, can be solved by introducing the intellectualization of this volume of work [5-9].

Solution methods:

The entire listed scope of work assigned to the process engineer, his functional load within the framework of the production of a certain range of cable products, can be summarized in "Design preparation for production" (Fig. 1), which includes the scope of tasks:

Technological equipment of the production process, including technical and passport information about the primary and secondary technological equipment involved (passport and actual parameters), measuring instruments, including data from technical passports for each unit, as well as technical parameters of technological equipment and tools;

Regulatory documents: complete information, including all regulatory and technical documents in force at the legislative level in the Republic of Uzbekistan (IEC, GOST), as well as sets of technological documentation (previously developed and approved by GosStandard).

The range of manufactured cable products, which contains the entire range of manufactured cable products, design parameters, properties, certification information for both raw materials and materials, and for the finished product, under operational standards for consumption of raw materials and materials and waste standards.

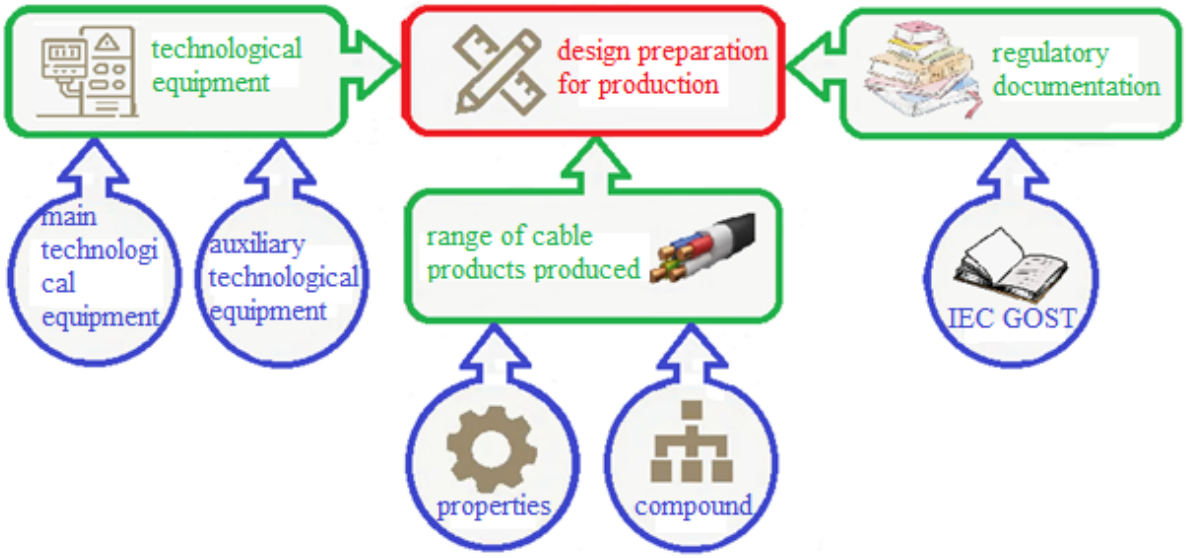

Figure. 1. Scope of tasks of the Module "Design preparation for production"

Analysis of production and technical data on the operation of cable equipment showed that there are serious deviations in the passport and actual technical indicators, which negatively affect both the ability to comply with technological regulations and the quality indicators of the finished cable product. Quick and accurate adjustment of values in technological documentation can be achieved by introducing an Expert System - the "Technologist Assistant" Module, the work of which will improve not only the quality of the produced CCP, but also contribute to the growth of economic indicators (saving raw materials and materials due to the rationalization of their consumption system, accounting for balances and work in progress in workshops/areas, reducing cable production waste), and also ensure the speed and flexibility of production, both in case of failure of technological equipment, changes in the technological route and the involved technological equipment, and in terms of synchronizing the speed parameters of cable machines in the technological chain within the framework of a certain technology [9-11].

The Module under consideration is a system that uses big data, which can be divided into sequential subsystems with functions of generating, collecting, storing and analyzing data (Fig. 2) [9, 11, 12].

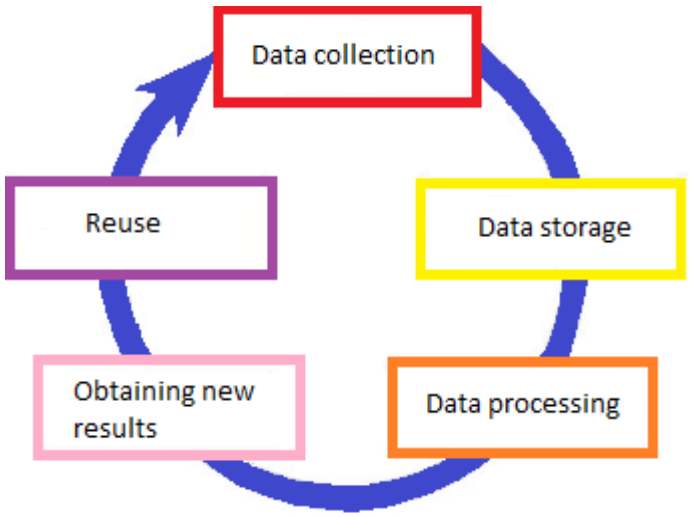

Figure. 2. Life cycle of expert system data - Module "Technologist Assistant"

Rational management of large amounts of variable information flows and data in maintaining the required "data quality" through properly selected or developed applications plays a key role in ensuring the efficiency of the technology and will accordingly ensure high quality of the finished cable product (Fig. 2) [4]. The very definition of "data quality" reflects the processes occurring in technology to identify, analyze and eliminate errors in data sets, which ensures high efficiency in decision making, as well as regulation and optimization of various processes occurring within certain patterns in the production and technological system under consideration enterprises [9-11]. The functions for working with data streams that circulate in the technological sector of cable production, at the level we are considering, the "Technologist Assistant" Module, include: *Processing of unstructured data*, which are large data streams with unstructured information (text document, images, video, etc.).

Real-time analysis of large amounts of data requires a quick response in decision-making, in terms of restructuring the operating modes of process equipment and issuing recommendations on the possibility of changing the manufacturing route and using backup cable machines.

Formation of statistics and forecasts to maintain technology in the required quality range, required production volumes, optimization of raw materials and supplies, analysis of the load of production equipment and its rational use.

Manage production processes by increasing the level of automation and optimizing the operation of cable equipment, predicting failures and accidents, as well as effective energy management to improve production efficiency and reduce production costs.

Ensuring high quality of finished cable products through constant monitoring (directly on cable machines - testing equipment), the quality of raw materials and materials (incoming control), control of production processes to prevent defects and deviations (interoperational control), as well as analysis of feedback from consumers for continuous improvement of the quality of sold cable products.

Results.

The end result of the actions of the *"Technologist Assistant"* module is the approved *"Set of technological documentation"*, hereinafter *"Object"*, which has the form of a text document consisting of the design of the cable product, route, technological and sketch outlines, as well as consumption standards for raw materials and materials and waste standards for implementation of technology. These documents are subject to agreement with the metrological service and standard control and are guiding for the entire production and technological process of manufacturing gearboxes, being the initial data for the development of Technical Specifications for the manufacture of this type of cable products, calculating wages of service personnel, as well as the cost of finished cable and wire products [13-23].

However, not all data at the current point in time for production can be obtained using a system of sensors and analyzers. Existing shortcomings of a cable product are not recorded by these devices; they can only be noticed by a person - *"visual control"*.

In this case, it is necessary to equip the technology with sensitive cameras - *"Machine Vision"*, thanks to which defects in the surface of the wire, conductor , insulation, and sheath are detected. This process becomes possible for the system due to the ability to *"see"* them and identify them by recording them with video or photo surveillance cameras. Subsequent sending of the resulting images by the system to the process engineer will ensure that the system receives permission to continue the technology or cancel it.

Taking into account possible changes that may occur in the system: technical condition of cable machines; defects in cable products and the effect of disturbing influences on the system as a

whole; discrepancy between the monitored parameters of technological modes of cable machines, readings of instrumentation equipment, testing equipment, video or photographic recording; each such request is associated with an increase in information about the variable state of the object, compared with data from the database (DB), which is accumulated in the integrated passport - in the Knowledge Base (KB). The numerical value of the number of such increases in the system data values coincides with the number of time intervals between the facts of interaction of these data [20-23]. The process of managing the "Object", during the period of its completion, is equal to the time and information intervals, respectively, where it is broken and the existing event - the information increment of data is recorded together with the corresponding values of the time range (Fig. 3).

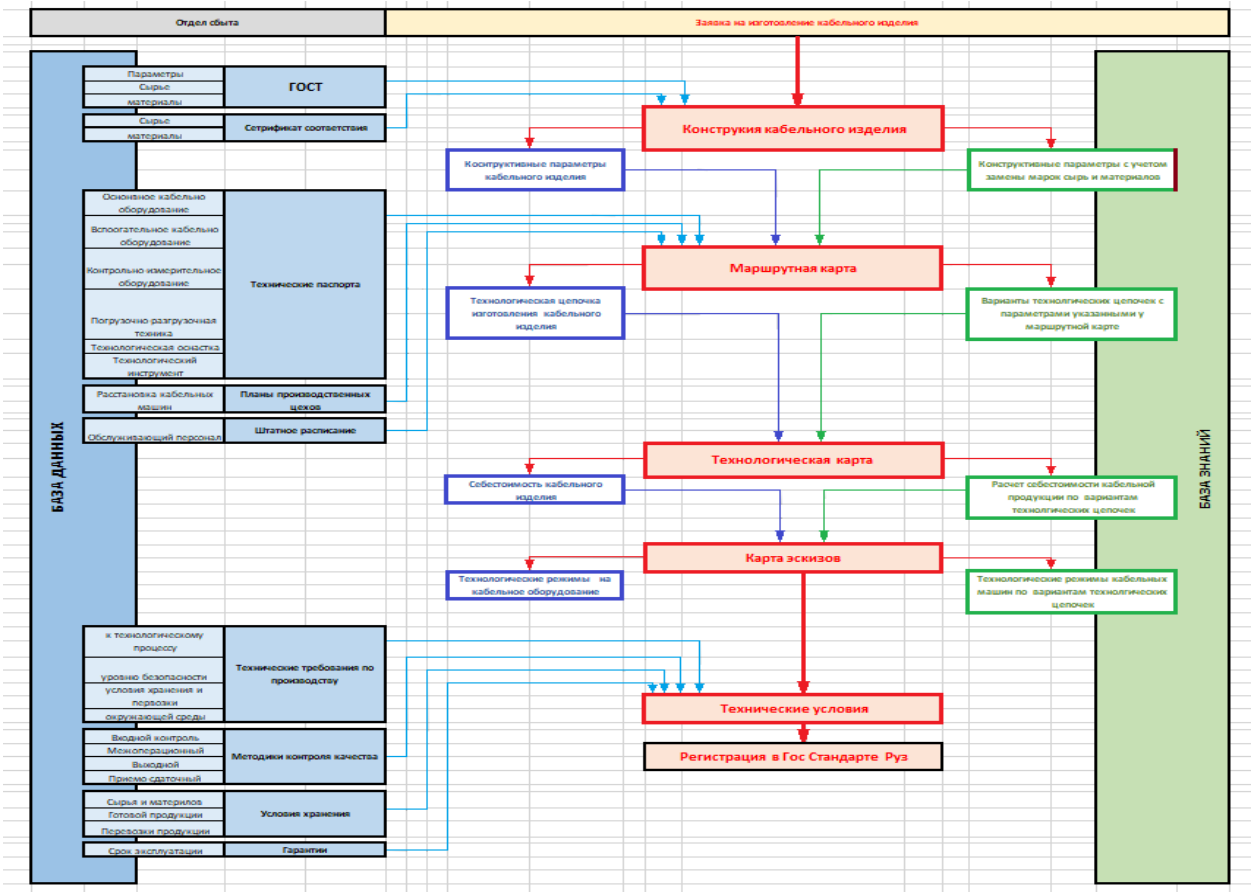

Figure. 3. Distribution of information about the life cycle of the "Object" - module of the expert system "Technologist Assistant"

The use of an array of big data (Table 3) of AI in industrial applications will improve the efficiency of the production process, improve quality and ensure the speed and trouble-free operation of production processes, which is a key factor for the successful functioning of the cable business in the modern industrial industry [9, 13-23] .

Data quality control of the "Technologist Assistant" module

Table-3

Module «Technologi	**Compliance check requirements**	**Monitoring**	**Improving data quality**

	Subject area	Set of technological documentation	**Aggregation and analysis of statistics**	Data: Passports; Calculated; actual	**Cleaning**	Random filter
	Method	Calculation by algorithm	**Education**	Memorizing new information/ data and their sequences; Defining logical interactions	**Source selection**	Fixed sequences
	Task	Design parameters; Production data; Technological Chinese regimes			**Combining data**	Sequence classification

In the production and technological process of manufacturing gearboxes, an intelligent cable production management system can be used, which will allow you to instantly analyze data and provide recommendations or forecasts in real time; helping in the creation of accurate statistical reports and forecasts based on big data (for example, forecasting required production volumes, optimizing inventories of raw materials and materials, analyzing market dynamics and consumer demand for certain brands of cable products) [23-28].

Conclusion:

The use of the "Process Technologist Assistant" Module as an expert system in the production and technological process will reduce the time required to develop technical documentation for gearbox manufacturing technology, ensuring the variability of calculations, flexibility of production processes and reducing the amount of excess cable production waste.

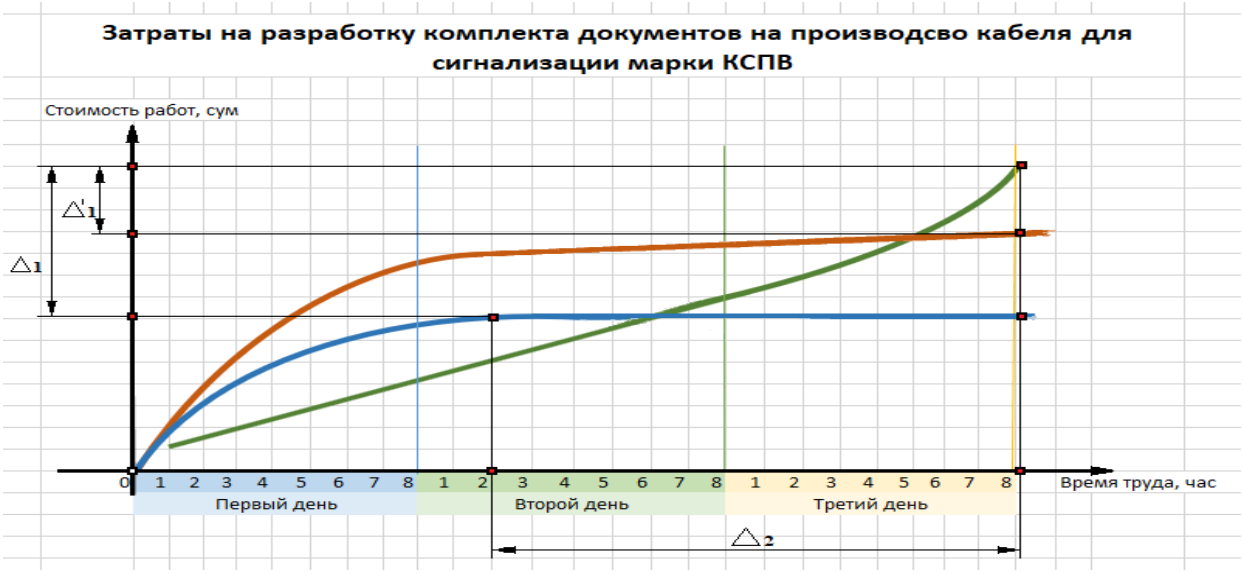

Figure. Costs for developing a set of technological documentation for the production of signaling cables of the KSPV brand

-development of a set of technological documentation by the responsible process engineer;

- development of a set of technological documentation using the AI Module "Technologist Assistant" during the implementation period;

- development of a set of technological documentation using the AI Module "Technologist Assistant"; Δ`1 - budget savings during the development of the "Technologist Assistant" Module; Δ1- budget savings when working with the "Technologist Assistant" Module; Δ1 - savings in development time when working with the "Technologist Assistant" Module.

The analysis of costs for the development of a set of technological documentation for the production of signaling cables of the KSPV brand using the "Technologist Assistant" Module (Table 4), within the framework of the Expert System, allowed us to obtain very good economic results:

Results of the implementation of the "Technologist Assistant" Module for the development of a set of technological documentation

Table-4

Index	**Results**	
	Standard system	With the "Technologist Assistant" Module
1	**2**	**3**
Time spent, hours	24	12
Reducing the cost of developing a Set of technological documentation, %	-	50

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