

The Specific Features of designing and technological preparation of production in territorially remote branch of the industrial enterprise

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Abstract. Output of products at the industrial enterprise means - the debugged working mechanisms at each stage of product's life cycle: from initial design documentation to product and finishing it with utilization.

The topic of the article is development of mathematical model of system of designing and technological preparation of production in branch of the industrial enterprise, and also statistical processing of estimated implementation result of the developed mathematical model in branch, and demonstration of its advantages at application at this enterprise.

During the creation of model of a data flow about driving of information, orders, details and modules in branch of the enterprise groups of divisions were classified. Proceeding from the analysis of activity of divisions, a data flow, details and documents the state graph of system of designing and technological preparation of production was constructed, transitions were described and coefficients are appropriated. To each condition of system of the constructed state graph the corresponding limiting state probabilities were defined, and also Kolmogorov's equations are worked out. When integration of sets of equations of Kolmogorov the probability of conditions of activity of the specified divisions and production as function of time in each instant is defined.

On the basis of the developed mathematical model of uniform system of designing and technological preparation of production and manufacture, and a state graph by authors statistical processing of results of application of mathematical model was carried out, and also its advantage at application at this enterprise is shown. Researches on studying of probability of loading of services of branch and third-party contractors (the orders received from branch within a month) were conducted.

The developed mathematical model of system of designing and technological preparation of production and manufacture can be applied to definition of probability of conditions of activity of divisions and manufacture as function of time in each instant that will allow to keep account of loading of performance of work in branches of the enterprise.

1. Introduction

Production output at the industrial enterprise means the debugged working mechanisms at each stage of the product's life cycle: from initial design documentation for the product (depending on a sort of the work – the preliminary design, the engineering design, development of working design documentation, further DD) [1], and finishing it with utilization. In the part of development and preparation of production of products this refers to uniform system of designing and technological preparation of production (DTPP). It's considered processes of design, design-preparation, engineering studies, preparation of documentation (design, technological, program) for production and directly production.

2. Problem definition

The work of territorially remote branch which is in other city is carried out by means of connection to informational resources and databases of head plant through the protected Internet channel. At the same time licenses for operating system, office programs, and CAD-systems, take also via the Internet.



The branch carries out development of DD and manufacture of a prototype of a product with the subsequent small-scale and serial production. In this regard technological preparation of production passes on the second plan, however in the long term at expansion of private production base these works will be performed (proceeding from technological equipment of branch and optimization of production).

Development of DD is conducted in CAD-system the Kompas. For elements, necessary to application (reference products, materials) requests for adding in databases and reference books are made out, and business processes in the PDM-system Lotsman are started.

Generally the scheme of processes of design and technological preparation of production has the appearance presented in fig. 1. In branch of the enterprise in the conditions of original lack of equipment, the mastered technology and licenses for CAD/CAM/CAE systems [2] the scheme of processes of design preparation is submitted in fig. 2.

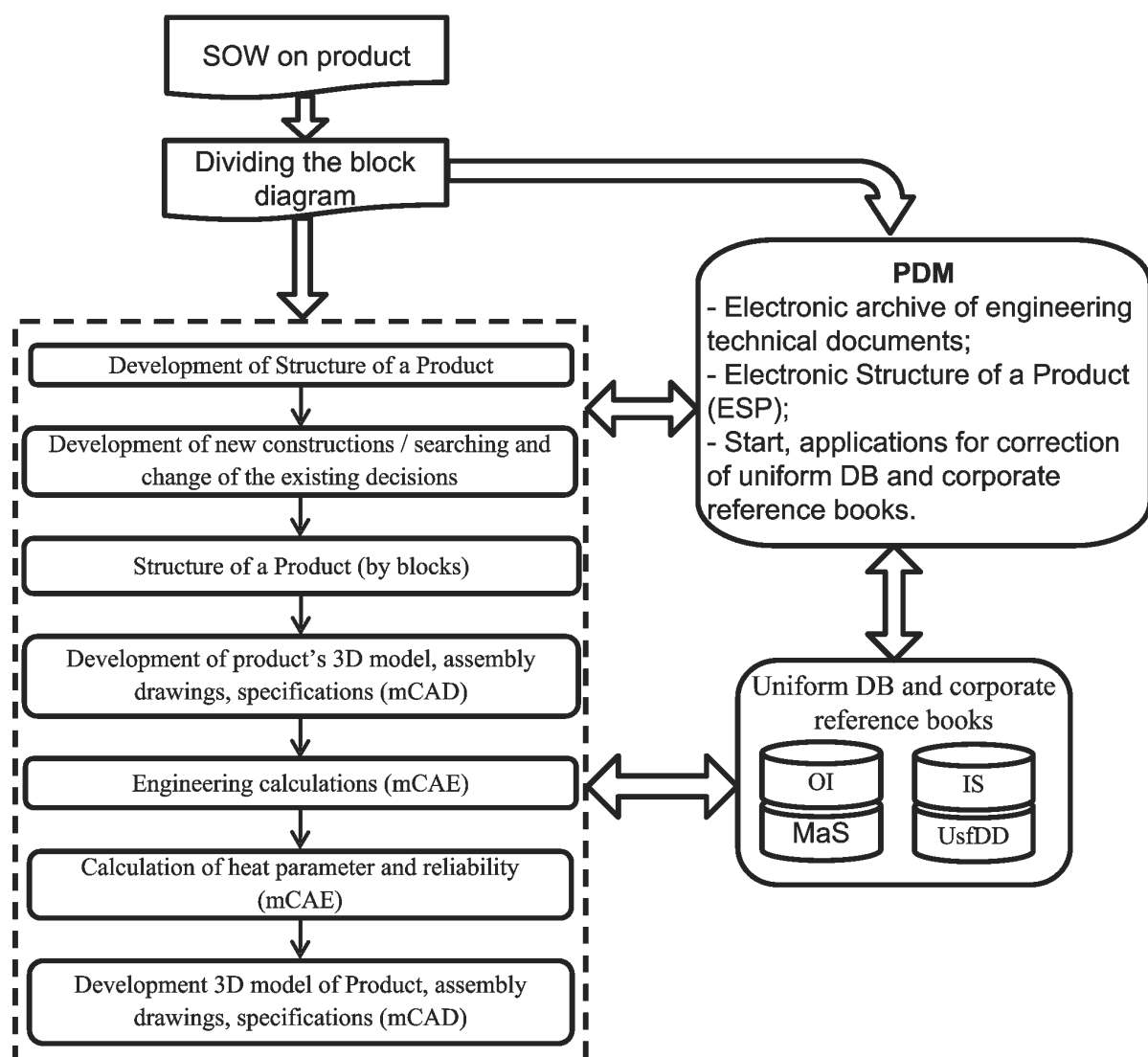


Figure 1. Scheme of processes of design-technology preparation of production.

he principle of action according to the scheme of processes consists in work in PDM-system with an array of the corporate reference books (directory system, reference products, materials and ranges) and the ESKD qualifier).

The main theme of the article is development of mathematical model of system of design and technological preparation and production in branch of the industrial enterprise, and also statistical processing of estimated results of application of the developed mathematical model in branch, and demonstration of its advantages at application at this plant.

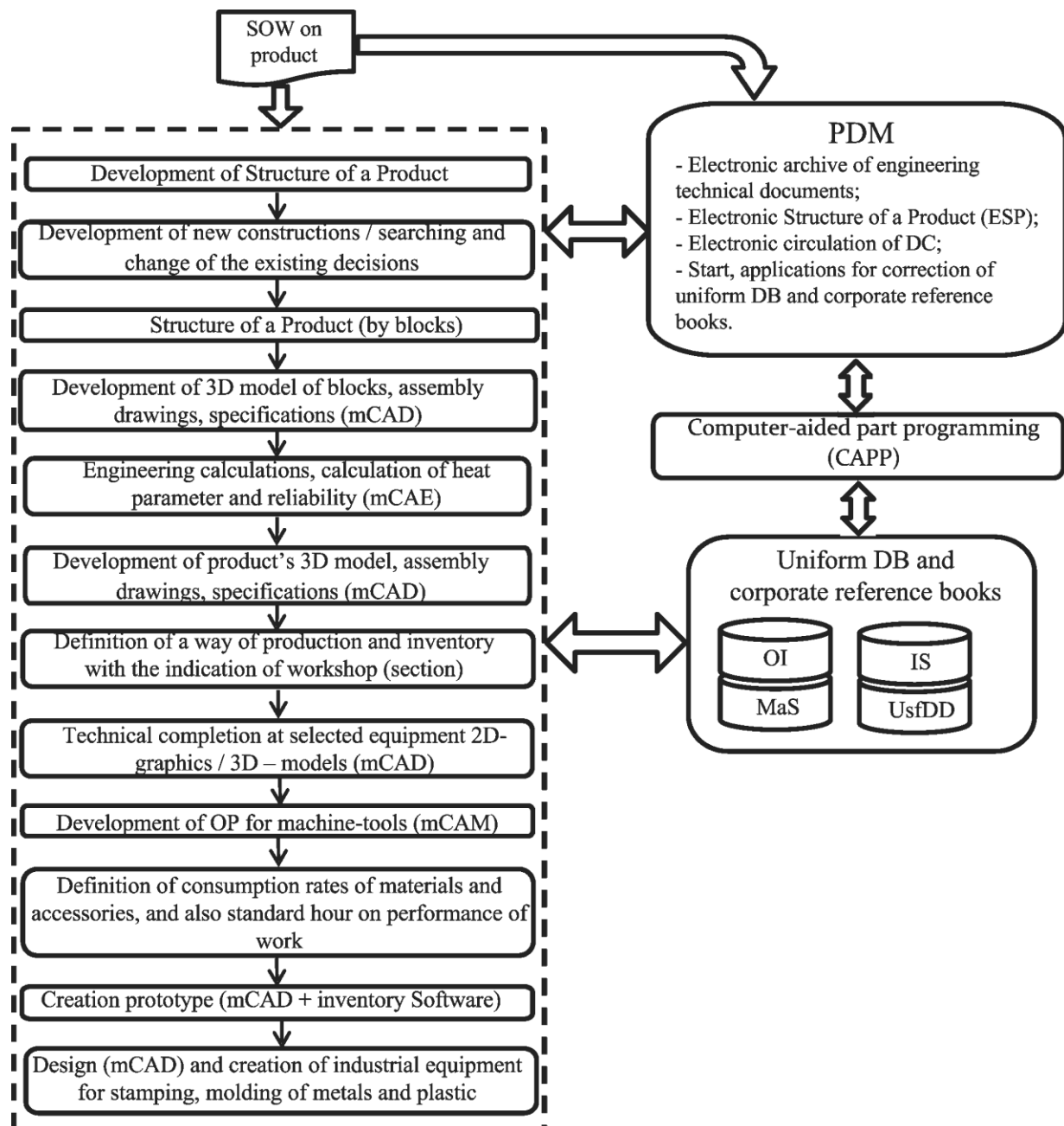


Figure 2. The scheme of processes of design preparation in branch.

3. Theory

The mathematical model of the DTPP system at any branch is under construction on the basis of theory of probability postulates, in particular, of the theory of a queuing and mathematical statistics [4].

The random process which proceeds in system S is considered as Markov if it proceeds without after-

action. In this process future state does not depend on the past, and last state does not influence the future [5].

It is possible to define probabilities of states by the marked state graph

$$p_1(t), p_2(t), \dots, p_n(t)$$

as functions of time. These probabilities satisfy to Kolmogorov's equations. In these differential equations probabilities of states will be unknown functions. Therefore, having solved these equations, it is possible to calculate probabilities of conditions of production as functions of time.

We will take a route list on printed circuit boards, details and clusters for unit of fluency of events λ which switches the services from state x_i to state x_j .

Today in branch the technology of a turn of route lists is not functioning yet. The engineering service is presented by one design-technology department, blanking shops – by third-party contractor, and assembly shops – by one assembly site. In this regard the offered classification of groups for branch is represented in fig. 3.

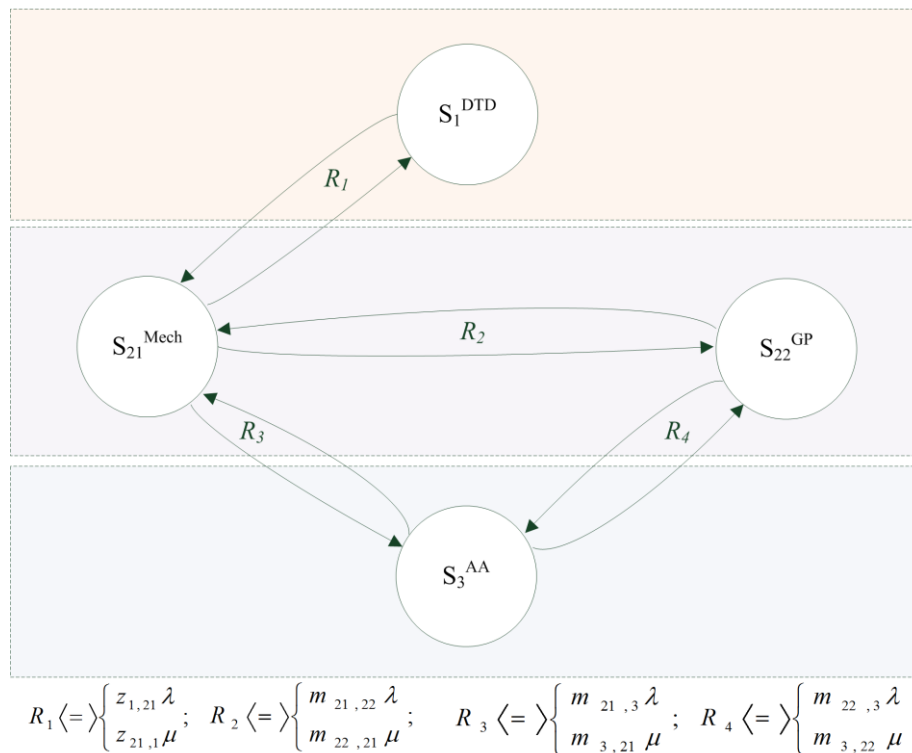


Figure 3. The marked state graph of design preparation of production and production at the branch with the description of transitions.

1. *Design and Technological Department (DTD)*. This department is performed design preparation of production and technological study of products. This activity is not performed yet.

2. *Third-party contractors*. These organizations are manufacture the printboards (PCB), details (Mech), perform galvano-paintings (GP) work.

3. *Assembly Area (AA)*. On this area installation of modules and blocks, assembly, run, adjustment, tests and delivery of blocks and products is performed.

At acceptance of a median number of the events written in one standard primary document or a kit of parts or modules (with the relevant document accompanying them - a route list), for λ , the complete flow of documents, getting to system for their after-treatment, is defined by dependence $x \cdot \lambda$, where x equals z, m в state graph (see figure 4). In our case λ constant value ($\lambda = const$), thus it is about the

elementary stream.

After that:

z – orders for performance of work by third-party contractors;

m – primary documents accompanying details, modules, blocks and products at each production phase - route lists;

μ - stream, constantly serving the applications coming from other departments. The resultant common flow of such documents can be expressed dependence $x \cdot \mu$. For each of the five states of systems S of the count we will find the limiting states probabilities and we will work out Kolmogorov's equations:

$$S_1 : \frac{dp_1}{dt} = -z_{1,21}\lambda p_1 + z_{21,1}\mu p_{21} \quad (1)$$

$$S_{21} : \frac{dp_{21}}{dt} = z_{1,21}\lambda p_1 - z_{21,1}\mu p_{21} - m_{21,22}\lambda p_{21} + m_{22,21}\mu p_{22} - m_{21,3}\lambda p_{21} + m_{3,21}\mu p_3 \quad (2)$$

$$S_{22} : \frac{dp_{22}}{dt} = m_{21,22}\lambda p_{21} - m_{22,21}\mu p_{22} - m_{22,3}\lambda p_{22} + m_{3,22}\mu p_3 \quad (3)$$

$$S_3 : \frac{dp_3}{dt} = m_{21,3}\lambda p_{21} - m_{3,21}\mu p_{21} + m_{22,3}\lambda p_{22} - m_{3,22}\mu p_{22} \quad (4)$$

For each repartition (design and technological preparation, third-party contractors and an assembly site) we will make equation system of Kolmogorov.

Condition of design-technology preparation:

$$\frac{dp_1}{dt} = z_{21,1}\mu p_{21} - z_{1,21}\lambda p_1 \quad (5)$$

State of procuring production – third-party contractors:

$$\begin{cases} \frac{dp_{21}}{dt} = (z_{1,21}p_1 - (m_{21,22} + m_{21,3})p_{21})\lambda + (m_{22,21}p_{22} - z_{21,1}p_{21} + m_{3,21}p_3)\mu \\ \frac{dp_{22}}{dt} = (m_{21,22}p_{21} - m_{22,3}p_{22})\lambda + (m_{3,22}p_3 - m_{22,21}p_{22})\mu \end{cases} \quad (6)$$

State of an assembly area:

$$\frac{dp_3}{dt} = (m_{21,3}p_{21} + m_{22,3}p_{22})\lambda - (m_{3,21} + m_{3,22})\mu p_3 \quad (7)$$

Integration of the received equation system allows to define state probabilities of design and technological preparation and production as functions of time in each instant [4].

4. Results of experiments

On the basis of monitoring of activity of the divisions involved in production process, authors investigated loading and rhythm of work of services of branch in the course of manufacture of a standard product. Coefficients according to transitions of a state graph of design and technological preparation of production and production were experimentally calculated. For averaging of indexes basic accepted the beginning, the middle and the end of month. Results of researches are given in the Tab. I.

TABLE I
LOADING AND RHYTHM OF WORK OF SERVICES OF BRANCH WITHIN A MONTH

№	Transitions	Coefficients	Indexes within a month		
			Beginning of month	Middle of month	End of month
1	R_1	$z_{1,21}$	10	10	8
2		$z_{21,1}$	1	1	1
3	R_2	$m_{21,22}$	8	10	10
4		$m_{22,21}$	6	8	8
5	R_3	$m_{21,3}$	2	2	2
6		$m_{3,21}$	1	1	1
7	R_4	$m_{22,3}$	2	2	2
8		$m_{3,22}$	1	1	1
9		λ	22	24	22
10		μ	9	11	11

Using the calculated coefficients in equation system (5-7) taking into account that at constant probabilities their derivants are equal 0, and also applying a normalizing condition (8):

$$p_1 + p_{21} + p_{22} + p_{23} + p_3 = 1 \quad (8)$$

state probabilities of system for the given stages of month were calculated. Results of calculations are presented in the Tab. II. For descriptive reasons they are brought in graphics in Fig 4.

Table II
PROBABILITIES OF CONDITIONS OF SYSTEM WITHIN A MONTH

№	Groups	Probabilities of conditions	Probabilities of conditions of system within a month		
			Beginning of month	Middle of month	End of month
1	DTD	p_1	0,0033	0,0043	0,0065
2	OI	Mec h p_{21}	0,0802	0,0932	0,1035
3		GP p_{23}	0,2090	0,2197	0,2277
4	AA	p_3	0,745	0,7075	0,6828

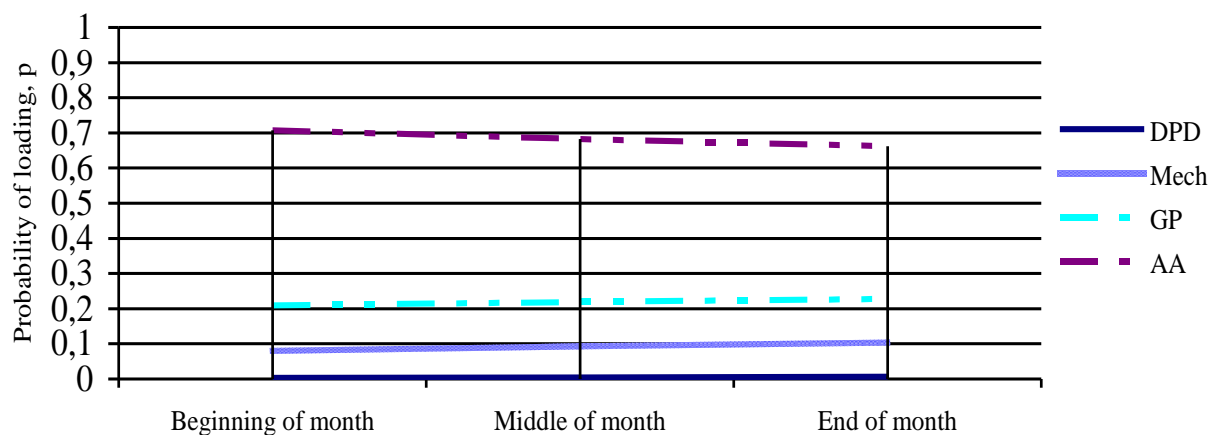


Figure 4. The schedule of probability of loading of divisions of branch within a month

In the course of the analysis of the developed mathematical model, and application of the explained methods and the principles, authors were it is offered to make essential changes to the current business processes of design and technological preparation and production of the enterprise. These changes led to the larger transparence of production consisting in expeditious emergence of actual information about the course of production process to chiefs of divisions of all ranks and persons, responsible for a condition of production, and also to reduction of time and decrease of probability of inaccurate information transfer, details and blocks. It, in turn, positively affected dynamics of implementation of the production schedule, and also prime cost of products. In general, it depend, including, from padding expenses, the bound to losses of time and financial resources on elimination of consequences from irregularly or not in time the made decisions and actions of personnel.

Thereby, proceeding from results of the conducted researches, it becomes apparent that application of the developed DTPP mathematical model and production allows to increase in general loading of services that increases rhythm of their work and, as a result, labor productivity.

5. Discussion of results

From data of research it is visible that probability of loading DTD within a month is step by step increases (from 0.0033 to 0.0065). The probability of loading of the third-party contractor - manufacturer of details (Mech) increases during the month from 0.0802 to 0.1035. The probability of loading of the third-party contractor of galvano-paintings (GP) within a month from value 0.2090 increases to 0.2277. The probability of loading of an assembly site from value 0.7075 decreases to the end of month to 0.6623.

6. Summary and conclusions

The developed mathematical model of system of design and technological preparation and production can be applied to definition of state probabilities of activity of divisions and production as function of time in each instant that will allow to keep account of loading of performance of work in branches of the plant.

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References

- [1] GOST 2.103-68 Uniform System of Design Documentation (USDD). Development stages.
- [2] Sim R M 1986 *Recent developments in computer-aided design and engineering*. CAD International Directory, ScienceDirect, p. 11–15. [Electronic resource] - Access mode: <http://www.sciencedirect.com/science/article/pii/B9780408255554500056>.
- [3] Qun Gao 2012 *The Research and Application of the Integration Pattern of PDM and CAD in Aerosun*. (Dept. of Ind. & Commercial Manage., Nanjing Inst. of Ind. Technol., Nanjing, China. Computer Science & Service System (CSSS), International Conference. [Electronic resource] – Access mode: <http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=6394276&newsearch=true&queryText=pdm>.
- [4] Sosedko V V and Yanishevskaya A G 2012 *Mathematical model of uniform system of design-technology preparation and production at the production enterprise*. Engineering bulletin of Don. Electronic magazine. - No. 4. - Access mode: <http://www.ivdon.ru/magazine/archive/n4p2y2012/1404>.
- [5] Venttsel E S 1972 *Operations research*. (Moscow: Soviet radio). 552 pages.