INFORMATION TECHNOLOGY

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THE METHOD OF ANALYSIS AND PERFORMANCE MANAGEMENT OF DISPERSED PRODUCTION PLANNING

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Abstract. *The article presents a calculation method of management index, and offers a calculation model of the required number of experts for effective production planning. There was created a method of analysis and performance management of dispersed production planning.*

Keywords: performance management; information technology; production planning.

1. Introduction

The problem of determining management efficiency of Production Planning (PP) at domestic industrial enterprises is very important and requires an immediate solution.

The use of modern information technologies and management approaches serves to improve the efficiency of PP system.

At present time there are no means for analyzing and determining the efficiency of PP systems before and after the introduction of computer-aided management systems of PP.

2. Objectives

To present the results of theoretical and methodological researches on development of management tools of PP and define its efficiency at industrial enterprises.

3. Research results

Solving the problem of scientific analysis method development and performance management of production planning requires the implementation of several generalized stages. We will introduce the given stages in brief:

4. Calculating the span of control

PP management is a complex dynamic process which involves information, material and human resources. Their number and usage rate depends on the efficiency of PP.

However, the existing calculation rates of resources and their control are out of date with the development of information technologies and do not meet the needs of time. To solve the problem of calculating the rate for PP processes control we used a structural approach. The structural approach provides using of many concepts [5], but we distinguish two main concepts: division of labor and control coverage as critical ones for performance indices of subdivision work involved in PP and which have a direct impact on key performance index such as an average cost of developing a Design-Engineering Documentation (DED) set.

As the components of this index is the number of relevant experts and indirectly the number of control levels that affects the rate of approval of documents and errors caused by a human factor.

The study of existing schemes of formal organizational structures of PP allowed to define main levels of horizontal and functional division of labor (Fig. 1).

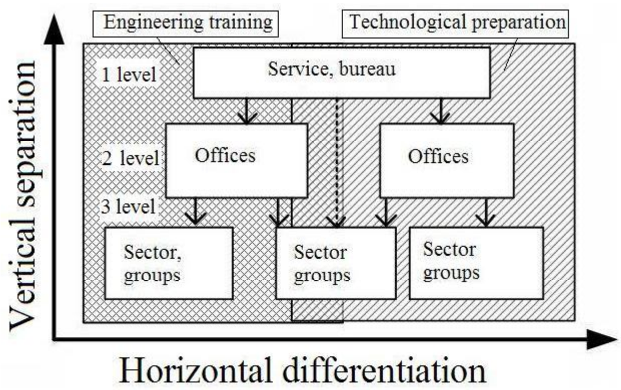

Fig. 1. The division of labor when performing a function of production planning

The purpose of vertical division of labor in the system of PP – is the formalization of relationship flow and authority which structure is used in PDM systems for workflow within the limits of mechanisms for approving PP documents.

Horizontal differentiation reflects the degree of division of labor between individual structural units within the upper level of PP functions, such division is presented by designing and technological preproduction.

In modern PP systems an average degree of vertical division is equal to 3, and horizontally it can range from 5 to 15 organizational units.

For describing the division of labor, we introduce a concept of organizational graph (Fig. 2) and organizational matrix (Table 1).

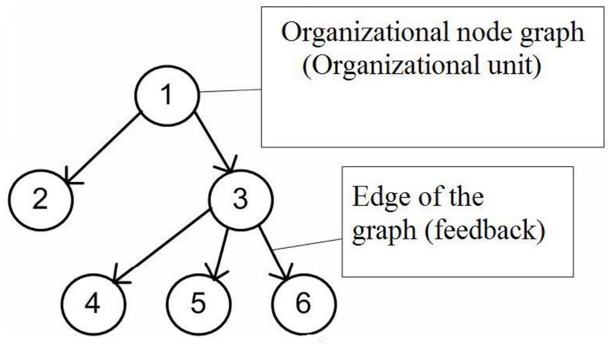

Fig. 2. Organizational graph

Formation of the organizational matrix is according to the rules of graph theory [1]:

1. Rectangular matrix, its dimension is determined by the number of organizational units

$O_i, i = \{1 \div n\}$.

2. Main diagonal elements of the matrix are equal to zero $O_{ij} = 0, i = j$.

3. Elements that are at the intersection of organizational units, and which have a connection, equate to one.

Table 1. Organizational matrix

	O_1	O_2	O_3	O_4	O_5	O_6
O_1	**0**	1	1	0	0	0
O_2	0	**0**	0	0	0	0
O_3	0	0	**0**	1	1	1
O_4	0	0	0	**0**	0	0
O_5	0	0	0	0	**0**	0
O_6	0	0	0	0	0	**0**

And horizontally there are elements above the level of subordination, that is we consider the connection from the first to the second and third one, from the third to the fourth one.

4. Number of connections – K_C (one directional) in the organizational structure is equal to a half of the number of organizational matrix elements K_E which have the value - 1,

$$K_C = K_E, \{O_{ij} = 1\}.$$

5. Number of control levels - (main index for building a workflow system using PDM systems) is the number of matrix rows $\kappa_o\{O_{ij} = 1\}$ in which there is at least one unit increased by one,

$$K_{CL} = \kappa_o\{O_{ij} = 1\} + 1.$$

Control rate or control coverage is a quantitative index that describes the number of employees (size of the Organizational Unit) that are subordinated to one Manager/Head.

The most significant works in the field of control rates belong to B.Z. Mylner [3], who offered the following formula (1) to determine the number of potential relationships (contacts) of Manager/Head, depending on the number of subordinate employees (n):

$$K_R = \frac{n \cdot 2^n}{2} + n - 1.$$

However, formula application gives an idea of possible number of relationships and does not characterize their complexity, therefore we suggest to introduce the concept of management index I_K, which would take into account these aspects under the conditions of dispersed enterprises PP.

The model of interrelation "Manager/Head of the organizational unit – subordinate employee " can be considered as a combination of factors which describe the level of complexity of these interrelations.

Taking into consideration the peculiarities of extended enterprises and analysis of corresponding models we suggest using the following factors on the definition of rating scales:

1. Geographical distance of subdivisions. Modern extended enterprise (or some of their subdivisions that fulfill the functions of PP) can be separated both within one enterprise and within the city, which greatly complicates the management process.

2. The uniformity of functions that should be controlled by Manager/Head of the organizational unit of PP.

3. The complexity of functions. Management is considered in terms of Manager's possible analysis of typical, standardized functions of subordinate employees, that is we examine the required level of competence and time necessary for management.

4. Management and control. The factor reflects the time spent by Manager/Head on management of subdivisions.

5. Coordination. We consider the aspect that takes into account Manager's load to coordinate the work of his/her subdivisions with other organizational units within technological process.

6. Planning. The factor considers management in terms of independence of divisional Manager concerning work planning of the organizational unit.

Management index is calculated according to the formula:

$$I_M = \sum_{i=1}^{6} g_i f_i \, , \qquad (1)$$

where g_i – weighting factors which are calculated using the pair-wise comparison [4];

f_i – points, assigned to each factor by experts $f_i = \{1 \div 5\}$ [4].

The level of control coverage is determined using management index (Table 2).

Table 2. The level of control coverage depending on the management index

Management index I_M	Standard coverage control, man	Number of potential relationships K_R	Times , spent in leadership positions, %
1	7-9	454-2312	50
2	6-8	197-1431	40
3	5-7	84-454	35
4	4-6	35-197	30
5	3-5	14-84	25

Data concerning percentage of time used to organize the work of subordinate employees (management of the organizational structure) is used in the simulation model of experts interrelation in PP system of the expanded production as statistical data for modeling of information flows, processes for documents approval in PDM system in the course of mathematical description of corresponding functions by means of statistical models.

Input data for these calculations is the number of experts involved in PP as one of the key performance index.

This number shall be calculated in accordance with the standards of designing and process flow documentation development.

5. Development of a calculation model to define the required number of experts in PP

The number of employees engaged in PP depends on a number of factors: production volume, rate of introducing new product specimens to the market, condition of single information environment and software and hardware used to develop DED.

Majority of machine manufacturing companies during the period of late 90 's - early 2000's (approximately until 2006) in the framework of dynamic market practically abandoned planned management of economic and financial activity and, as a consequence work measurement of experts involved in PP in compliance with the standards established on the basis of industry-specific standards.

Planning was carried out mainly by means of managing salary budget, when some certain percentage from production volume was allocated for PP direction, and staff formation was based on the market value of experts (design engineer, production engineer).

However, processes of entering into overseas markets, introduction of modern information technologies, creation of united information space of PP within the framework of expanded production on the one hand created necessary conditions for the revision of planning approaches, and on the other hand allowed to use a new approach to this matter in connection with such possibilities, as documented "Work Flow" procedures in PDM systems that simplifies time tracking procedures required for the development of DED sets.

Let's examine a model to determine the required amount of experts for product design and production engineering planning, on the basis of company planned target in respect of production output, taking into account inter-industry time standards for the development of design-engineering documentation.

The number of experts involved in product design and production engineering planning is calculated according to the formula:

$$C_{DEB} = C_D + C_E + C_O \, . \qquad (2)$$

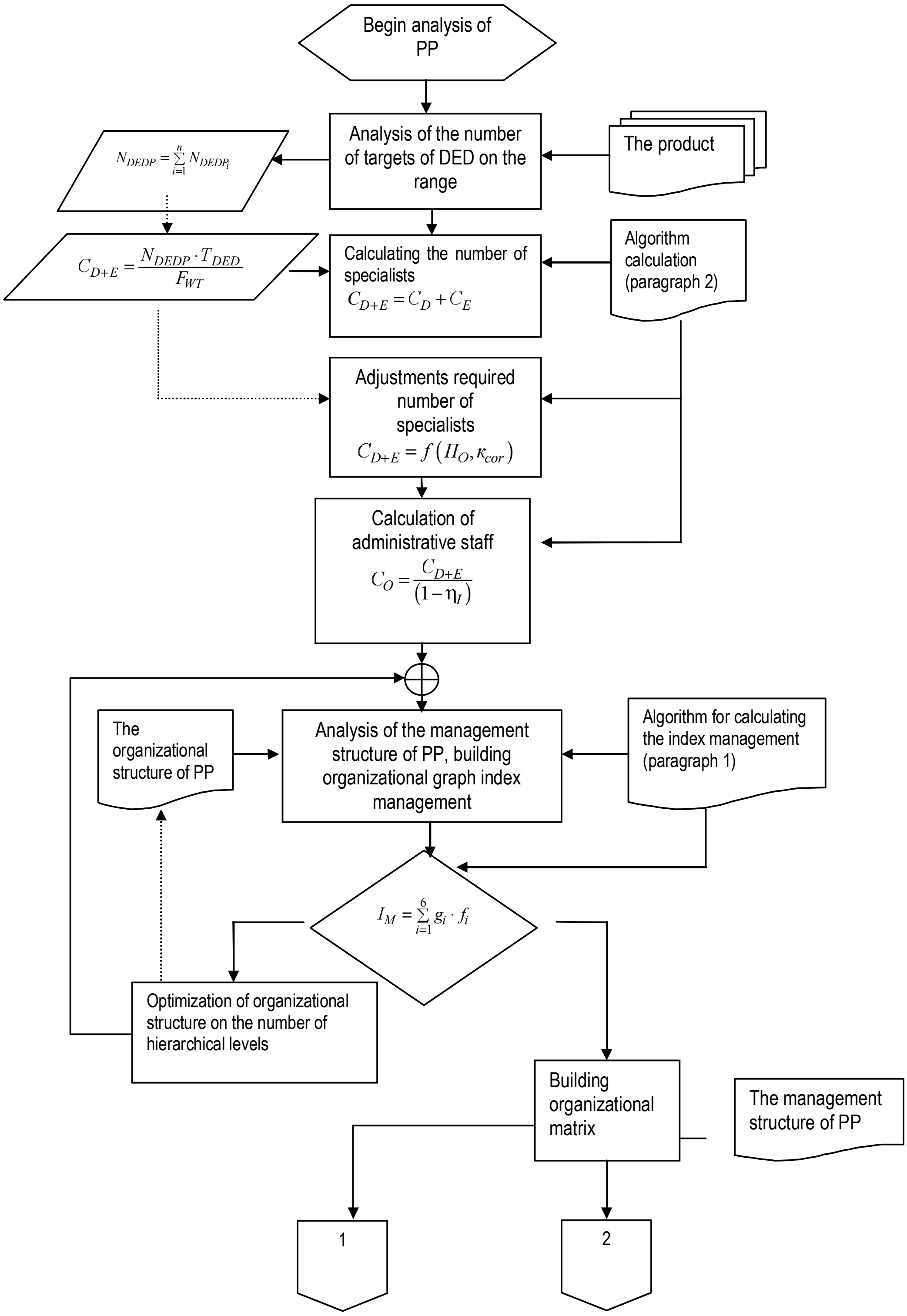

Fig. 3. Algorithm of method of analysis and performance management of PP (Part 1)

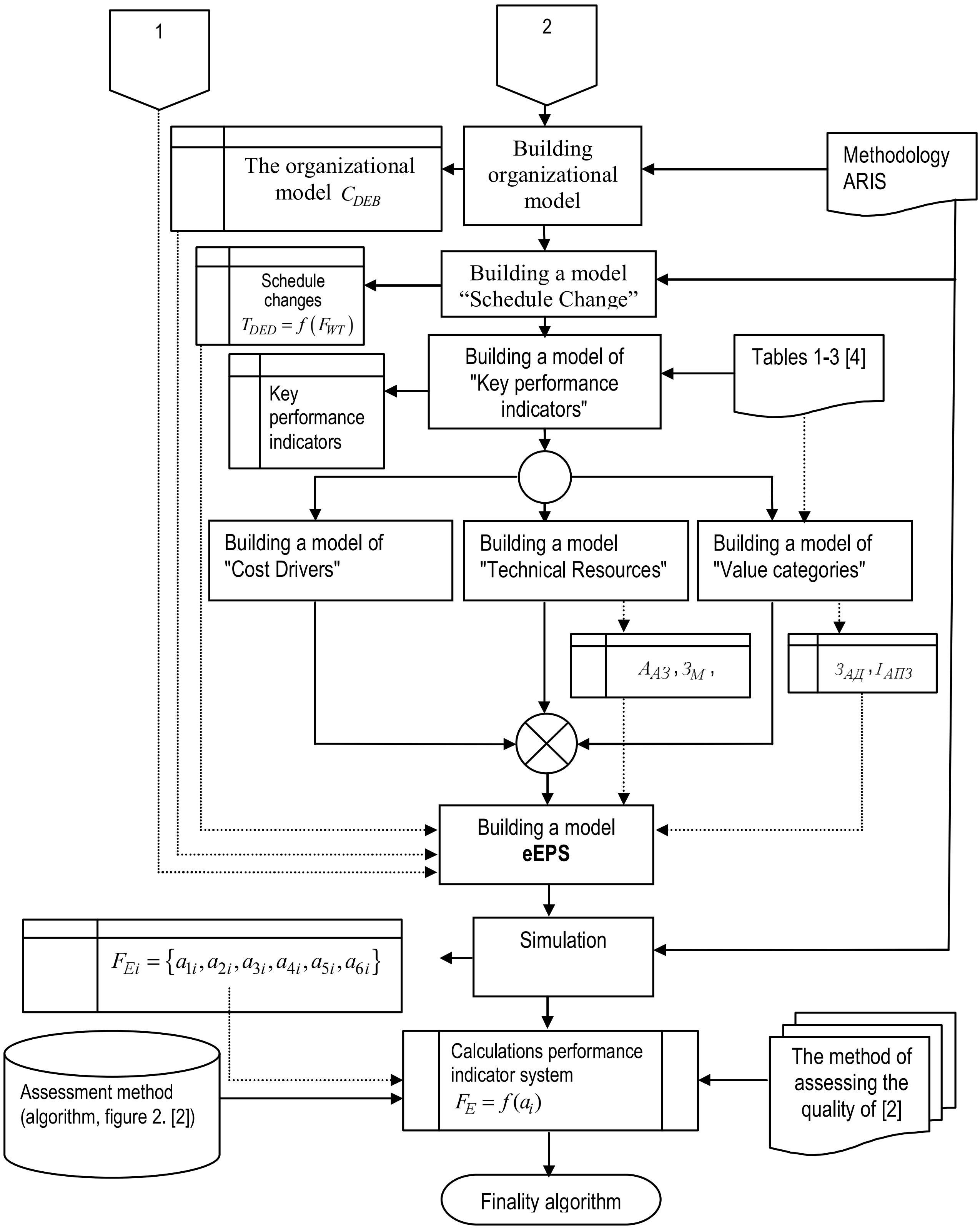

Fig. 3. Algorithm of method of analysis and performance management of PP (Part 2)

Based on the formula 3 the number of employees who participate in documentation development can be conditionally divided into two groups: employees who are directly involved in the development of DED (4) and employees who perform managerial and administrative functions:

$$C_{D+E} = C_D + C_E .$$

Rate indices C_{D+E} and C_O o are connected by the coefficient η_2, which in practice takes values from 0.10 to 0.20 that is weight rate percentage of employees engaged in performance management and administrative functions in the total number of employees of Bureau for Design and Technology is equal to 10–20 %:

$$\eta_I = \frac{C_O}{C_D + C_E + C_O} = \{0,1 \div 0,2\} . \quad (3)$$

As a rule, calculation of employees number required for DED development is based on the nomenclature plan of products per year or the planned number of DED sets

$$N_{DEDP} = \sum_{i=1}^{n} N_{DEDP_i}$$

and time of their development $T_{DED} = T_{DD} + T_{ED}$:

$$C_{D+E} = \frac{N_{DEDP} T_{DED}}{F_{WT}} , \quad (4)$$

where F_{WT} – fund of annual working time.

Further, according to the established company coefficient η based on the formulas (3), (4) we determine the required number of employees engaged in managerial and administrative functions:

$$C_O = \frac{C_{D+E}}{1 - \eta_I} .$$

It should be noted that this approach gives a general idea about the required number of staff taking into account only working time standard and does not take into consideration the complexity of documentation, automating development aids and many other factors.

A model for determining the required number of experts, as a function of several variables can be represented as follows:

$$C_{D+E} = f(\Pi_O, \kappa_{cor}) , \quad (5)$$

where Π_O – basic parameters of the project, which is being developed (Table 3);

κ_{cor} – correction coefficients (Table 4).

Table 3. Basic project parameters

Name parameter	The range of the parameter
Object design	Card numbers
Design stage	According to the stages
Category novelty	A-D
The actual format	A0-A4
Whole leaves	The actual value
Group collapsible	I-IV

It should be noted that basic project parameters Π_O define time rates t_H for developing documentation in accordance with the regulatory tables.

Table 4. Correction coefficients

Name of factor	The range of the factor
1. Seriality production	1,0 – 1,2
1. Adjustment (modification), %	0,1 – 1,0
2. Experience an employee	1,2 – 1,0
3. Related work	1,0 – 2,1
4. Features of Product	1,0 – 1,2
5. Performance of frames and stamps	1,2 – 0,8
6. Software	1,2 – 0,72
7. Scale drawings	1,0 – 1,15
8. Readiness drawings	0,6 – 1,0
9. Density filling drawings	0,8 – 1,2
10. Using the basic version, %	1,0 – 0,2
11. Language requirement	1,0 – 1,5
12. Using applications	0,15 – 1,0
13. Combining drawings	1,0 – 1,15

Correction coefficients are used to take into account all design environment and formula 8 can be written as follows:

$$C_{D+E} = \frac{\sum_{i=1}^{14} t_H \cdot k_{cor_i}}{F_{WT}} .$$

It is important to note that the abovementioned coefficients do not take into account work features of experts involved in DED development in a single information field, which can significantly adjust coefficients 4,7, which have one of the largest variation range.

6. Developing a method implementation algorithm

Due to a large number of models, algorithms and approaches that are used for modeling and analysis of key performance indices in the course of PP within the framework of coordinated interaction between experts, the method of analysis and performance management of dispersed production planning was developed (Fig. 3). This method logically combines the indicated interrelated modeling tools to assess the quality of PP management system. The method is presented in a graphical form as an algorithm of successive steps in the process of PP condition analysis, and building models for simulation modeling (Fig. 3).

The method provides a preliminary analysis of enterprise production program and planned number of DED sets required in the reporting year according to the production program.

The next step is to analyze and calculate the required number of experts involved in PP in terms of direct development of DED sets. The analysis is done using two types of calculations, described in detail in section 2.

It should be noted that the coefficients of the model (2) should be corrected after the simulation modeling and processing of statistical data regarding the time required for approval of documents, depending on the selected approach to its life cycle.

After complete calculation of the required number of experts involved in PP, it is necessary to make calculation and analyze control standards in the existing management system in accordance with the approved structure of subordination and interrelations, which are described in section 1.

As a result of calculations we obtain the management index and optimize the organizational structure of PP.

Management index also allows to determine the statistical data regarding time of employment in the processes of approving documents and use them in simulation models taking into account daily schedule.

The following steps involve the development of six models which supplement each other and are the basis for filling attributes of seventh model eEPS.

Exactly attributes of eEPS model allow to get value in the time of key performance indices and use them for calculating the efficiency of PP management system.

According to the algorithm of evaluation method for the quality of management system [2], which is added to general method of analysis and performance management (Fig. 3), simulation modeling can be carried out both directly for

determining the quantitative and qualitative changes in the system after the implementation of measures its optimization and permanently to monitor the dynamics of efficiency index change in time for managerial decision-making.

7. Conclusions

We have developed the calculation method of control standards and management index, and offered the calculation model of the required number of experts for effective planning of dispersed production.

We have created and presented in the form of algorithm the method of analysis and performance management of dispersed of production planning.

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П.М. Павленко[1], А.О. Хлевний[2]. Метод аналізу та управління ефективністю технологічної підготовки розосередженого виробництва
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Наведено результати досліджень із розробці інструментальних засобів управління технологічною підготовкою виробництва та визначення її ефективності на промислових підприємствах. Розглянуто спосіб розрахунку індексу керівництва. Запропоновано модель розрахунку необхідної кількості фахівців для ефективної технологічної підготовки виробництва. Створено метод аналізу та управління ефективністю технологічної підготовки розосередженого виробництва.
Ключові слова:; інформаційна технологія; технологічна підготовка виробництва; ефективність управління.

П.Н. Павленко[1], А.А. Хлевной[2]. Метод анализа и управления эфективностью технологической подготовки рассредоточенного производства
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Приведены результаты исследований по разработке инструментальных средств управления технологической подготовкой производства и определения ее эффективности на промышленных предприятиях. Представлен способ расчета индекса руководства. Предложена модель расчета необходимого количества специалистов для эффективной технологической подготовки производства. Создан метод анализа и управления эффективностью технологической подготовки рассредоточенного производства.
Ключевые слова: информационная технология; технологическая подготовка производства; эффективность управления.

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