ANALÝZA ENERGETICKEJ NÁROČNOSTI TECHNOLOGICKÉHO ZARIADENIA V STRATÉGII ŠTRUKTÚRY STROJÁRSTVA

ANALYSIS OF ENERGY EFFICIENCY OF TECHNOLOGICAL EQUIPMENT IN STRUCTURE OF ENGINEERING

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Abstract: *This article describes the current problem - increasing efficiency in terms of reducing the energy intensity of production systems in mechanical engineering. It is based on the original approach to technical-economic analysis of production systems in mechanical engineering. Due to morale and diligence, the technical park at the level of production system automation in companies is relatively low. This situation forced companies to become interested in programmatic development of technical progress in their own production systems. Such a task requires scientifically based motivation. In order to develop the strategy of the technical progress structure in a company responsibly, it must be based on a technical-economic analysis of the conditions and operation of each element of the production system structure.*

Abstrakt: *Článok opisuje aktuálny problém – zvyšovanie účinnosti z pohľadu znižovanie energetickej náročnosti výrobných systémov v strojárstve. Vychádza z pôvodného prístupu k technicko-ekonomickej analýze výrobných systémov v strojárstve. Kvôli morálke a pracovitosti je technický park na úrovni automatizácie výrobných systémov v podnikoch pomerne nízky. Táto situácia prinútila podniky začať sa zaujímať o programový rozvoj technického pokroku vo vlastných výrobných systémoch. Taká úloha si vyžaduje vedecky podloženú motiváciu. Aby sa zodpovedne rozvíjala stratégia štruktúry technického pokroku v podniku, je potrebné, aby vychádzala z technicko-ekonomickej analýzy podmienok a prevádzky každého prvku štruktúry výrobného systému.*

Key words: *energy efficiency analysis, structure, machine-building*
Kľúčové slová: *analýza energetická, technická, organizačná, stavba strojov*

1 INTRODUCTION

Modern manufacture of complex equipment means the coordinated work of many enterprises. As processes of designing and production management at the enterprises are carried out by means of the automated systems successful industrial activity means necessity of information interaction of such systems. And as the purpose of machine-building manufacture is creation of products of the demanded quality convenient in development and service while in service information interaction is necessary also between manufacturers and consumers of production.

The analysis of the existing automated systems has shown, that the complex system of an efficiency estimation of industrial systems in mechanical engineering does not exist. At the same time, a number of models and techniques, and the program complexes allowing partially to automate process of an estimation of efficiency is developed. The complex system of automation of an estimation of efficiency should include following stages:

- The economic analysis;
- The technical analysis;

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- The technical and economic analysis;
- The organizational-technical analysis.

Known strategies of estimation technical-economic efficiency consider the manufacturing system with positions of generalized factors, which calculate in general for manufacturing system a scale of enterprise [1,2,3]. But the efficiency of manufacturing system of machine building depends on the efficiency operation of each separate workplace. In other words, a workplace is a main section, which factors of work and it allows to value the real condition a manufacturing.

Thereby, for organization of efficient technical advances of enterprise, as well as for decision a problem of qualitative and quantitative estimation of technical-economic factors of separate workplace it is necessary to develop a technique, which take into account the features of equipment, qualification, experience of functioning (working) the performer and constructive-technological parameter of detail. For efficient monitoring the different stages of life cycle within the framework of enterprise it is necessary to develop the information database, on base which are automated the processes a decision making on each stage of life cycle developed manufacturing system.

2 THE PURPOSE AND RESEARCH PROBLEMS

The main purpose of work is development of mathematical model of a complex efficiency estimation of manufacturing systems in the mechanical engineering, that will consider parameters of functioning of each separate workplace: characteristics of the equipment, qualification, an operational experience of the executor and design data-technological of a detail; creation on its basis of the automated system of technical audit of industrial systems in mechanical engineering.

For achievement purposes it is necessary to decision following problems:

1. Determination of test objects in terms a theory of sets;

3. Formalization a worker of place in terms a theory of sets;

4. Development an algorithm a data acceptance and undertaking the estimation efficiency of manufacturing systems of machine building;

5. Development of strategy of determination of the main fund (the active part), residing in critical condition (the rules a selection).

3 DEFINITION OF A MANUFACTURING STRUCTURE

The industrial structure of the machine-building enterprise is defined by character of let out production, its complexity, type of manufacture, first of all the nomenclature and volume of release, forms of interrelation with other enterprises [4,5,6]. Depending on the end production which is let out by the enterprise, distinguish the enterprises specializing on release of finished articles, details and units or preparations. According to it they have subject, central and detailed or technological specialization. The enterprises of subject specialization can have a full work cycle and include procuring, processing, assembly shops or manufactures.

Traditionally industrial structure of the enterprises of mechanical engineering it is possible to present divisions of the core, auxiliary, productions of services. In structure of the

basic manufacture procuring, processing and assembly shops are allocated [7,8]. On the basis of industrial structure, the general plan of the enterprise, i.e. a spatial arrangement of all shops and services, and also ways and communications in territory of a factory is developed. Shops settle down in sequence of performance of production.

4 DEFINITION OF A WORKPLACE

Existing methods of an estimation of a production efficiency of the enterprises as systems are considered in works of authors [9] etc. from positions of the general theory of systems and its component – theories of management – such industrial systems as the enterprises (shops), concern to the category greater and complex. Thus the industrial system can be decomposed into separate elements, and its efficiency can be estimated through the description of each of these elements, for example, a workplace which is a part of such system.

In many sources [10,11] workplace is considered, as a producing unit which includes the part of a floor space adapted for performance of a production target, the core and auxiliaries (machine tools, mechanisms, etc.), raw material, materials, the items completing products, energy, the information from the documentation (design, technical, economic, etc.).

There is no standard complex definition of a workplace, and normative documents describe it from an organizational position: the site of the floor space equipped according to requirements of certain technological process by the equipment, the tool, the adaptation, etc. where the worker should be or where it is necessary for it to arrive in connection with its work according to the duty regulations in the written or oral form [12].

From told above it is possible to draw a conclusion, that the workplace is defined as set of two elements: the worker and the equipment which result of interaction is the detail.

Designing of technological process provides the plan and a method of processing of details, thus simultaneously specify, on what machine tool operations will be carried out. Thus, it is expedient to include a detail in system " Workplace ". The characteristic of a detail is a basis at a choice of the equipment. For example, processing of bodies of rotation is carried out on a lathe and cannot be made, for example, on the milling machine tool. The choice of type of the equipment means, first of all, is defined by its opportunity to provide performance of the technical requirements shown to a producing detail concerning accuracy of its sizes, forms and a class of a roughness of surfaces. If on character of processing these requirements can be carried out on various machine tools, choose this or that machine tool for performance of the given operation on the basis of following reasons:

1. Conformity of the basic sizes of the machine tool to overall dimensions of a detail
2. Conformity of productivity of the machine tool to quantity of details which need to be processed within a year
3. Probably fuller use of the machine tool on capacity and on time
4. The least expenses of time for processing of a detail
5. The least cost price of processing of a detail
6. The least cost price of the machine tool
7. Real opportunity of purchase of the machine tool
8. Necessity of use of available machine tools.

It is possible to draw a conclusion that it is necessary to consider a workplace as the system of higher order including not only traditionally defined workplace, but also detail or the list of operations which are made or carried out on the given equipment, and also a supply with information of a workplace.

5 THE FORMALIZED REPRESENTATION OF A WORKPLACE

For the analysis of efficiency of industrial system within the limits of the given work it is necessary to specify concept "Workplace".

Definition 1. As a workplace we shall understand the part of the industrial system consisting of four interconnected elements « the equipment – a detail – the worker – the information » (figure 1). Each of elements renders essential influence on efficiency of functioning of a workplace.

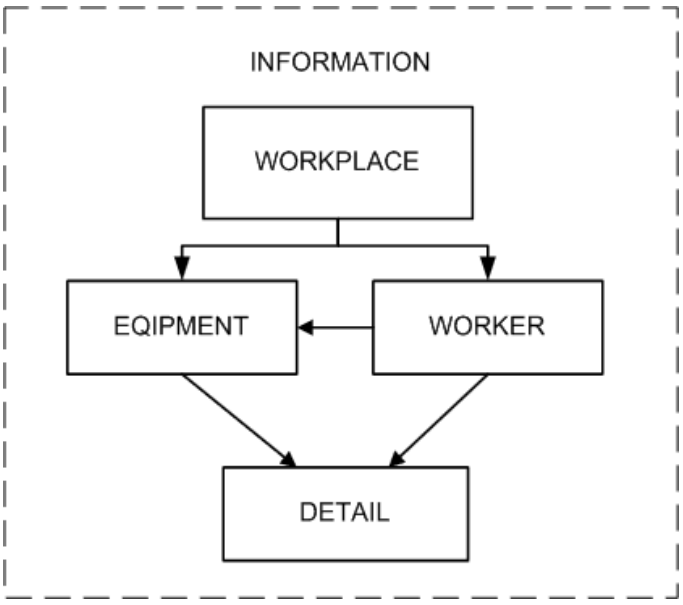

Figure 1. The block diagram of a workplace

The equipment. As the equipment we shall understand the machine for processing the various materials, used in manufacture, the adaptation necessary for performance of operation on the given machine tool, and also the necessary tool providing achievement of the greatest productivity, demanded accuracy and a class of a roughness of a working surface [13,14].

The Detail. The detail is a primary element of the product, describing which attribute is absence in it of the demountable and one-piece connections, made of a homogeneous material.

The information. As the information we shall understand a supply with information and support of all structural elements of a workplace

6 COMPLEX EFFICIENCY ESTIMATION OF MANUFACTURING SYSTEMS IN THE MECHANICAL ENGINEERING

Under an analysis of manufacturing system of machine building is understood the estimation of the current condition of manufacturing system and offers on its technical advances. For decision delivered problem in the first place follows to execute the formalization of test objects, which allows to do the findings on the leading indexes of operating the manufacturing system of machine building.

Analyzed objects are the worker a place and its element.

For decision a problem to automations analysis manufacturing systems of machine building a qualifier of details, made within the framework of analyzed manufacturing system, is characterized the ensembles, presented below.

$$D=\{d_1,d_2,d_3,..d_j,...,d_n\}$$

$$d_i=\{SH_D,I_D,K_D,M_D,T_G,L,D,B,H,G_c,O,C_d\}$$

$$G_C=\{C_{\min},C_{\max}\}$$

$$O=\{O_1,O_2,O_3,..O_j,...,O_n\}$$

$$O_i=\{T,JT,R_a,P_P,K\},$$

d_1 - a detail, made in considered manufacturing system a scale a shop

SH_D - a cipher of detail,

I_D - a name of detail,

K_D - a class of detail,

M_D - a material of detail,

T_G - labour content of annual program,

L,D,B,H - a dimensional sizes of detail,

G_C - a subset by elements which are an interval a difficulty

O - an elements this subset O are a type of work required for fabrication of concrete detail.

Type of functioning is characterized:

labour content of processing a surface *T*,

accuracy of processing a surface *JT*,

roughness processed surface *Ra*,

sizes of processed surfaces P_P,

code a type of processing *K*

C_d - a factor a complexity of detail

Proposed qualifier of equipment is based on qualifier metal-cutting machines. On the first level a qualifier of equipment is described the organizing structure of manufacturing system a scale of a shop. On this level can be calculated the general factors of a shop such as: technological prime cost, percent a wear-out of equipment in shop. Following level, a qualifier is an area of a shop, where can be calculated factor to automations of equipment, factor of loading the equipment. On the third level a qualifier is considered the type of

machines. Following level a qualifier distributes the machine on level of automations. Fifth level proposed qualifier describes the ensemble of machines which belong to concrete type. On this level are took into account the characteristic of separate machine. Such factors, as power, cost, accuracy of machine and maximum mass of stocking up are a passport features apart took unit of machine. The rest factors, such, as percent a wear-out, capacity and reliability are accounting.

On the last level a qualifier each unit an ensemble of machines of concrete type is described the ensemble executed operations on him.

For decision a problem to automations analysis of manufacturing systems of machine building a qualifier of equipment is presented in the manner of row an ensemble.

$$M = \{m_1, m_2, m_3, ..., m_j, ..., m_n\}$$
$$m_i = \{TS, U, B_c, T_c, PD_c, O_c\}$$
$$TS_i = \{ts_1, ts_2, ts_3, ..., ts_j, ..., ts_n\}$$
$$U_i = \{u_1, u_2, u_3, ..., u_j, ..., u_n\}$$
$$PD_c = \{M_c, I_c, P_c, C_c, H_c, Jt_c, M_z\}$$
$$JT_c = \{H, P, B, A, C\}$$
$$V = \{V_1, V_2, V_3, ..., V_j, ..., V_n\},$$

where:

m_i - machine considered production system a scale a shop,
TS_i - subset, which elements are a shop of manufacturing system,
U_i - subset, element which - an area considered shop of manufacturing system,
B_c - type of machine,
PD_c - passport machine data,
M_c – power,
I_c - percent a wear-out,
P – capacity,
C_c -cost,
H_c – reliability,
Jt_c – accuracy,
H - machine normal group accuracy,
P - machine to extended precision,
B - machine to pinpoint accuracy,
A - machine to specifically pinpoint accuracy,
C - specifically exact machine,
M_z - maximum mass of stocking up,
V - operations, which are executed on given machine,
V_i - operation executed on considered machine.

Under process of determination of critical conditions of the fixed capital (it's active part), is meant the determination of models of equipment, selected on rule a selection. This

rule can be described in the following words: from ensemble of the whole equipment is selected and confesses, as residing in critical condition the equipment which make most exact and most complex details, which has the largest wear-out and which is used on labor-consuming types of work themselves. On drawing (refer to. figure 2) this area, painted by dark color.

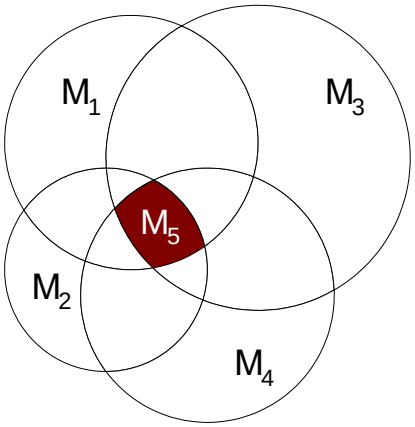

Figure 2. Determination of equipment, residing in critical condition, where:

M1 - an ensemble of equipment, with maximum percent a wear-out;
M2 - an ensemble of equipment, with maximum percent of loading;
M3 - an ensemble of equipment, on which are processed the most exact details;
M4 - an ensemble of equipment, on which are processed the most complex details;
M5 - an ensemble of equipment, residing in critical condition.

For carrying out of the analysis of manufacturing systems of machine building the algorithm has been created. It is represented on figure 3.

7 CONCLUSIONS

Thereby, there were determined and formalized main test object a structure-strategy of manufacturing systems in machine building. Approach to determination of critical conditions of the fixed capital (the active part) is in a certain sense general and can be used (after necessary revision) for other objects of studies.

For collection and automated data processing about equipment, subject of labor of under investigation manufacturing system, their characteristics and features was designed database “Audit of machine-building manufacturing” on base DB MS “Access”

At present necessary to develop offer and restructure variants of manufacturing system, in the manner of procedure a syntheses of manufacturing system on base combinatorial analysis. For decision this problem it’s necessary revision of existing and making the additional qualifiers such as Qualifier a worker, Qualifier CAD. On generated ensemble will be consecutively superimposed the restrictions, exclusive not having sense of combination. Also algorithm will contain the big amount of iterations (the repetitions). Conditions of completion a selection (the amount of elements of manufacturing system) will be defined by the user.

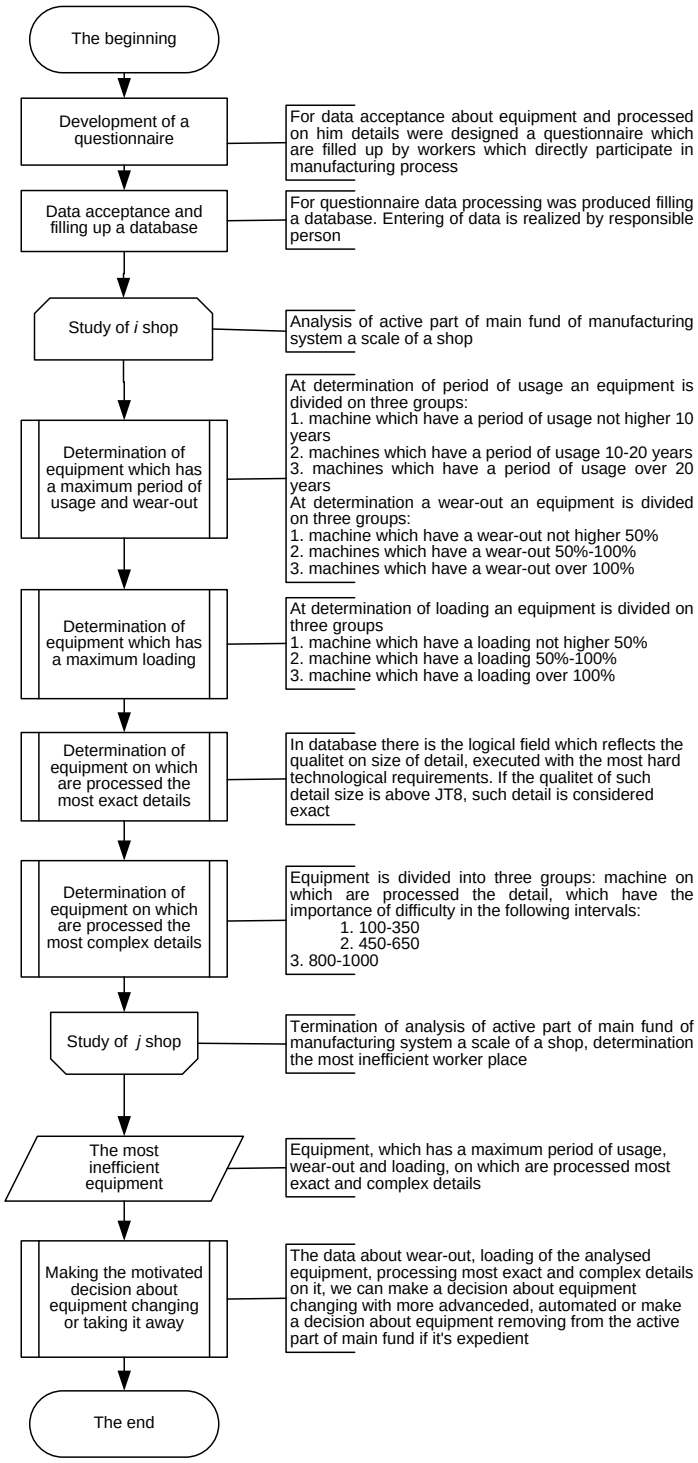

Figure 3. Algorithm a data acceptance and undertaking the estimation efficiency of manufacturing system of machine building.

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