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Technical and economic feasibility study of computer-simulation models of C++ Software Product

The research describes the methodology of the study of computer-simulation models of C++ software product. The interface of the developed computer program to simulate the random packing of the various particles of the mixture in a rectangular container is presented. The regularities of structure formation of materials with given size and shape (spherical, ellipsoidal, netamerica) of the structural elements of the charge of structurally inhomogeneous materials and correlation between the components, structure and properties of structurally inhomogeneous materials is reasonably predicted. The analysis of physical and mechanical properties of structurally inhomogeneous materials, the sequence of operations of technological process is made. It is defined that the basic properties and parameters of materials (density of the mold, the quality of contacts, grain size, content components) that should be controlled in the manufacturing process. It is proved that the developed computer-simulation model provides the opportunity to reduce the cost of operational memory of computer information systems, and conduct the bulk of research without setting up expensive and time-consuming field experiments, allowing for a near zero waste (from waste) manufacture of a wide purpose, to save energy and materials, to reduce labor costs by reducing the number of process operations, and process automation.

Keywords: *physical and mechanical properties of structurally heterogeneous materials; computer-simulation model; technical and economic feasibility study; C++ software product.*

Statement of the problem. Computer and information technology formulate technical and scientific progress and provide an informational foundation for the development of science. The use of modern software in the study of material structure has led to the emergence of a new direction in material science – computer material science. Production of materials with unique properties is possible with the help of traditional methods that use physical, chemical, and metallurgical technologies. In many cases, these techniques are labour-consuming, lengthy and energy consuming. To improve the efficiency of traditional technologies and also to introduce wasteless manufacture of products of wide purpose, to save energy and materials, to reduce labor costs by reducing the number of process operations and process automation allows the use of computer simulation in all stages of production of new materials. Thus, technical and economic feasibility study of computer-simulation models of C++ software product is an urgent task.

Analysis of recent publications. Worldwide, many scientists are engaged in the study of the structure of structurally inhomogeneous materials. In the analysis of the physical and mechanical properties of structurally inhomogeneous materials of their time quite a significant number of researchers are engaged, among which may be noted: Yu.N. Kriuchkova [2, p. 20], Yu.N. Kriuchkova, P.I. Poluhina [3, p. 65] A.A. Lebedieva [4, p. 10]. The results obtained in these studies, are of phenomenological nature and, therefore, the mechanical properties in most cases do not correlate with the structure of the materials. In turn, the study of regularities of formation of structure and properties of structurally inhomogeneous materials depend on geometrical factors of the powder particles. In addition, the analysis of advanced technological processes in powder metallurgy shows that the correlations between the components, structure and properties by all the operations of the process, where the initial stage is the filling of molds with the powder, which determines not only the size, shape, density, performance, security, and culture labour, but also affects a number of important properties of the finished product. It should be noted that each of these stages affects the quality of the final product. Therefore, among the new important technologies is the use of computer simulation in all stages of production of new materials, as well as to predict quality indicators of the final product. Therefore, an important role is played by technical and economic feasibility study of computer-simulation models of C++ software product, which poses new challenges to research requiring urgent and effective solutions.

Objective is to describe the technique of the technical and economic feasibility of computer-simulation model software of C ++.

The main results of the study. The progress in the economics, industry, science and technology and education depends at present largely on a massive introduction of computers. Any computer in the process of its work uses software. In turn, the development of software requires a certain intellectual and labor costs, as well as the mandatory use of computer technology that determines the characteristics of the workload of the software product.

It should be noted that the labour intensity of the product is reciprocal of the measure of labor productivity. It is defined as the ratio of the amount of labor expended in the sphere of material production to the volume of the produced products. If we talk about the definition of labor intensity of workers such as programmers [8, p. 120], the workload for this category can be carried out using the following formula:

$$T_{\sum programme} = T_{u} + T_{a} + T_{бс} + T_{п} + T_{нтп} + T_{д}; \quad (1)$$

where T_{u} − labour costs for the study of material, which is included to the developed program;

T_{a} − labour costs for the development of program algorithm;

$T_{бс}$ − labour costs for the development of flowchart of program;

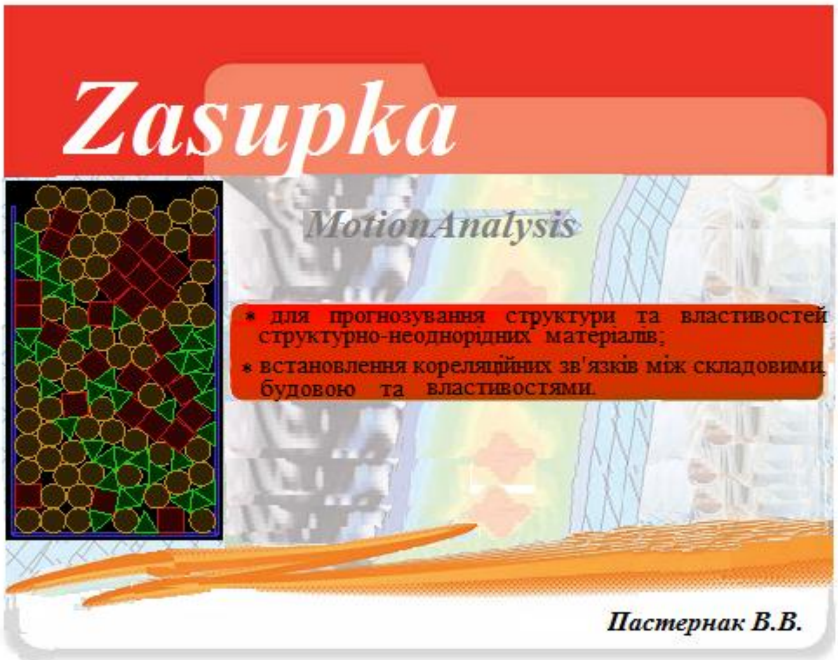
$T_{п}$ − labour costs for programming using algorithmic language;

$T_{нтп}$ − labour costs for the program debug;

$T_{д}$ − labour costs for preparation of documents in manuscript form.

The time spent on the labour intensity of the developed computer-simulation models (Fig. 1) is calculated by the time of actually work, and the time of the remaining stages is determined by the calculation method for the conditional number of teams Q.

Figure 1 shows the interface of the developed computer program used to model of filling of a rectangular container with particles of various shapes and sizes. It should be noted that the adequacy of the proposed models by comparison of computer and field experiments have shown their satisfactory convergence. Created software tools (computer simulation models) are used to enable the simulation of processes of filling powder materials. However, to obtain the necessary in the practice of the dependency of the properties of structurally inhomogeneous materials from the particle size, their shape, size of the hopper and the like we have to perform a series of experiments and found input parameters to build certain functional relationship using the least squares method [7, p. 230].



** made according to data of [7, p. 230]*

Fig. 1. The interface of the developed computer program to simulate the random packing of the various particles of the mixture in a rectangular container

It should be noted that the conditional number of teams Q of developed computer program is determined by the formula:

$$Q = q \cdot c; \quad (2)$$

where:

q − coefficient taking into account the number of conditional commands depending on the type of task;

c − coefficient taking into account the novelty and difficulty of the program.

The value of the coefficient q can be chosen from the table 1.

Table 1

The range of variation of the coefficient (q)

Type of task	The limits of changes in the coefficient
Optimization and modeling tasks	from 600 to 800
Objectives of operational management	from 800 to 1400
Planning tasks	from 1500 to 3500
Multiple tasks	from 4000 to 5000
Complex tasks	from 5000 to 5500

**made according to [6, p. 20]*

The time required for a description of the source text of the C++ software product is calculated by the formula:

$$T = \frac{Q}{\Pi \cdot K_{k\text{в}}} \cdot K_{\text{сл}}; \quad (3)$$

where:

Q – the conditional number of teams;

Π – performance of an artist;

$K_{k\text{в}}$ – qualification rate of artist;

$K_{\text{сл}}$ – factor that considers the load of the programmer during the day, and is within $K_{\text{сл}}$ = 0,5 –1,67.

To perform all of the terms of the description of the source text of the C++ software product it is necessary to adopt a ratio within q = 600 – 800.

It should be noted that a developed new software product according to the degree of novelty can be assigned to one of 4 groups (table 2), where:

– group A – the development of fundamentally new tasks;
– group B – the development of original programs;
– group C – development of programs using standard solutions;
– group D – single typical task.

For this software product degree of novelty and complexity of the program is group A. According to the complexity of a software product can be assigned to one of 3 groups:

1 – optimization algorithms and modelling systems;
2 – tasks of accounting, reporting and statistics;
3 – standard algorithms.

This software belongs to the 1st group of complexity. In turn, the coefficient C is defined by table 2 at the intersection of the groups of complexity and degree of novelty.

Table 2

The possible range of groups of complexity and degree of novelty of the C++ software product

Language of programming	Group of complexity	Degree of novelty			
		A	B	C	D
High level	1	1,38	1,26	1,15	0,69
	2	1,30	1,19	1,08	0,65
	3	1,20	1,10	1,00	0,60
Low level	1	1,58	1,45	1,32	0,79
	2	1,49	1,37	1,24	0,74
	3	1,38	1,26	1,15	0,69

** made according to [8, p. 120]*

In this case, the factor of novelty and complexity of the developed computer-simulation models is C = 1,38.

Now, according to the formula (3), it is possible to determine the total number of teams Q of the source program text. We get

$Q = 600 \cdot 1{,}38 = 828$ (total number of teams).

Time, required for preparation and study of materials of the software product will be calculated according to the formula:

$$T_u = Q \cdot K_{\text{сл}} \; / 50 \cdot K_{k\text{в}}; \quad (4)$$

where:

$K_{\text{сл}}$ – is constant and equals 1,1;

$K_{k\text{в}}$ – the value of the coefficient of qualification of executor, which is selected in the range from 0.8 to 1.5 depending on the experience of the programmer, i.e., the low level equals 0.8, the average level is 1.3, the high level is 1.5.

We get

T_u= 600 · 1,1 / 50 · 0,8 = 16,5 hours.

Labor costs that are required for the development of the algorithm of the program must be calculated according to the formula:

$$T_A = Q \; / \; 50 \; \cdot \; K_{кв}. \quad (5)$$

We get:

T_A = 600 / 50 · 0,8 = 15 hours.

Labor costs that are required to develop a flowchart of the program are calculated similar to the formula (1), and then we get:

$T_{бс}$ = 600 / 50 · 0,8 = 15 hours.

The effort required for programming (coding using algorithmic programming language) are calculated according to the following formula:

$$T_П = Q \; \cdot \; K_{сл} \; / \; 50 \; \cdot \; K_{кв}; \quad (6)$$

where:

$K_{сл}$ − is stable and equals 1,4.

After that we have:

$T_П$ = 600 · 1,4 / 50 · 0,8 = 21 hours.

Labor costs that are required to debug and test software product in C++ is defined by the formula:

$$T_{нтп} = Q \; \cdot \; K_{сл} \; / \; 50 \; \cdot \; K_{кв}; \quad (7)$$

where:

$K_{сл}$ − is stable and equals 1,5.

Substituting values in the formula 7 we have got the ratio:

$T_{нтп}$ = 600 · 1, 5 / 50 · 0, 8 = 22,5 hours.

The efforts required for the paperwork, instructions, explanatory notes, etc. taken according to the actual work time, which in turn is equal to:

$T_Д$ = 15 – 20 hours.

Then, knowing the time spent on each stage of the developed computer-simulation models of C++ software product we get $T_{\sum program}$ according to the formula 1.

Thus,

$T_{\sum program}$ = 16, 5 + 15 + 15 + 21 + 22,5 + 18 = 108 hours.

From the above material it is possible to calculate the number of days that were spent on the implementation of the C++ software according to the following formula:

$$Д = \; T_{\sum program} / \; 5. \quad (8)$$

We get

$Д$ = 108 / 5 = 22 (days).

Thus, the presented data suggest that the time and resources of developing and implementing a computer-based simulation modeling to study the structure of lobules of structurally inhomogeneous materials is much less than in the case of field experiments.

Conclusions. Analysis of the current state of modeling research in powder metallurgy indicates that the study and prediction of the structural characteristics of materials obtained by the combination of technological operations with known characteristics is possible with computer and information technology. In turn, computer and simulation models, including methods, algorithms and software, can be successfully applied in scientific and technological research. It should be noted that the implementation of the created computer simulation models allows to solve structural simulation problems in such areas:

- prediction of regularities of formation of structure of materials based on dimensions and shape (spherical, ellipsoidal, non-isometrical) of the structural elements of the charge of structurally inhomogeneous materials;
- establishing correlations between the components, structure and properties of materials.

The developed computer-simulation model provides the opportunity to reduce the cost of operational memory of computer information systems, and conduct the bulk of research without setting up expensive and time-consuming field experiments, set to zero waste (from waste) manufacture of wide purpose, to save energy and materials, to reduce labor costs by reducing the number of technological operations and automation processes.

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Scientific interests:
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