ALGORITHM FOR THE AUTOMATED FORMATION OF ORGANIZATIONAL AND TECHNOLOGICAL SOLUTIONS FOR CONSTRUCTION WORK WITH A TRIAL DESIGN BASIS

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The article reveals the approach to the automated design of construction processes with a trial design basis. The essence of the approach is in the automated formation of a set of all feasible organizational and technological solutions for the construction work at each design stage, basing on the capabilities of a particularconstruction and installation contractor, theworking conditions, the construction object characteristics, followed by the selection of the best solution according to the given criteria. The choice of the best solution for the implementation of the construction process occurs after the whole complex of technological and organizational solutions for each of the alternativesis formed, which helps to fully realize the systematic approach in the design of construction production. The main methods in the development of the algorithms, presented in this article, are logical and mathematical modeling, as well as a combinatorial approach for the formation of alternative solutions for construction work. As a result, a logical-mathematical model (algorithm) was created, designed for multivariable design of construction processes. The presented algorithm can be used in the framework of thedesign automationfor construction production, that is to say for creating software systems designed to support the activities of specialists involved in the organizational and technological design of construction production (development of construction methodstatement (CMS) and work execution plan (WEP)).
Keywords: modeling, computer technology, algorithms for construction workwith a trial design basis, multi-criteriaevaluation of alternatives

Introduction

Existing approaches to trial design often involve optimization and selection of the best options at each design stage, for example, comparing and selecting a construction crane at the stage of selecting construction machines; optimization of a linear or network calendar at the stage of scheduling [1]. Our approach fundamentally differs in the generation of alternatives at each design stage with the choice of the best option only after the end of all design stages, which helps to evaluate the effectiveness of decisions made at certain design stages for the whole complex of decisions at all design stages, in other words, systemically. Consideration of all possible combinations of technologies, alternatives in the composition of the used organizational and technological resources, options for the calendar model of the construction process provides the greatest opportunities in finding the best solution (the task of choosing the best option from all possible ones) [2].

Materials and methods

As the main methodological toolkit for the development of algorithms for the automated design of construction processes, including those with a trial design basis, a logical-mathematical modeling is used, which involves a description of the design and decision-making procedures based on mathematical expressions and logical operations. Thanks to a logical-mathematical modeling, we determine the relationship between the organizational and technological parameters of the construction system and the design sequence, which allows us to model the required parameters of the construction system. So,basing on the given initial values of the indicators we determine alternative options for the organizational and technological solutions of the construction work, the composition of the required organizational and technological resources, the intensity, duration, cost of work, the best combination of predetermined criteria for making construction works. A combinatorial approach is used to generate alternative solutions at all stages of modeling, [7], which involves finding all feasible combinations of alternative work solutions,taking into account the established capabilities and limitations.

Results

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The process of creating construction products is multi-level. Each of the levels is aimed at performing work that is part of a higher leveledconstruction volume: structural element - structure - part of a building - building or structure - a complex of buildings or structures [3]. Most of the construction work is a complex technological process, including sub-processes of varying complexity. A complex technological process consists of a set of simple technological processes, which in turn consist of technological operations.

As a rule, technological design is carried out precisely at the level of simple technological processes, considered as the level of elementary technological processes. Accordingly, scheduling and the tasks for organizing construction production are carried out at the level of complex technological processes (stages, work packages).

To describe the functioning of elementary technological processes, the following initial indicators are used [4]:

- time ($H_{вр}$) –theproductive time cost for the production of a unit volume of work;

- productivity (P) – the volume of production (performance) per unit of time;

- unit consumption rates of material resources– the cost of material resources (building materials, products, structures, etc.) per unit volume of work;

- unit prices ($C_{ЕД}$) – the price for resources costs per unit volume of manufactured products (performed works);

- time-based costs(cost per machine-hour - $C_{маш.-ч.}$, cost per man-hour$C_{чел-ч.}$, or costsfor construction machines operated by workers per unit of time.

To determine the values of the initial indicators for organizational and technological design, normative and reference documents are used as information sources (GESNs - state itemized cost estimate standards,FERs - Federal Unit Rates, TERs - Regional Unit Prices, ENiRs - Unified Norms and Prices, etc.).

The sequence of trial design for organizational and technological solutions of the construction work in an enlarged form includes the solving of the following tasks (Figure 1):

1) Decomposing complex technological processes to the level of simple technological processes (determination of the scope of work at the level of elementary technological processes);

2) Determining alternative technology options for the implementation of construction processes;

3) Determining alternative organizational and technological solutions (hereinafter referred to as OTS) for the implementation of construction processes for each version of the production technology (all possible options for integration with organizational and technological resources are formed based on the available resources of the construction contractor);

4) Calculating the intensity, duration, work costs for eachOTS;

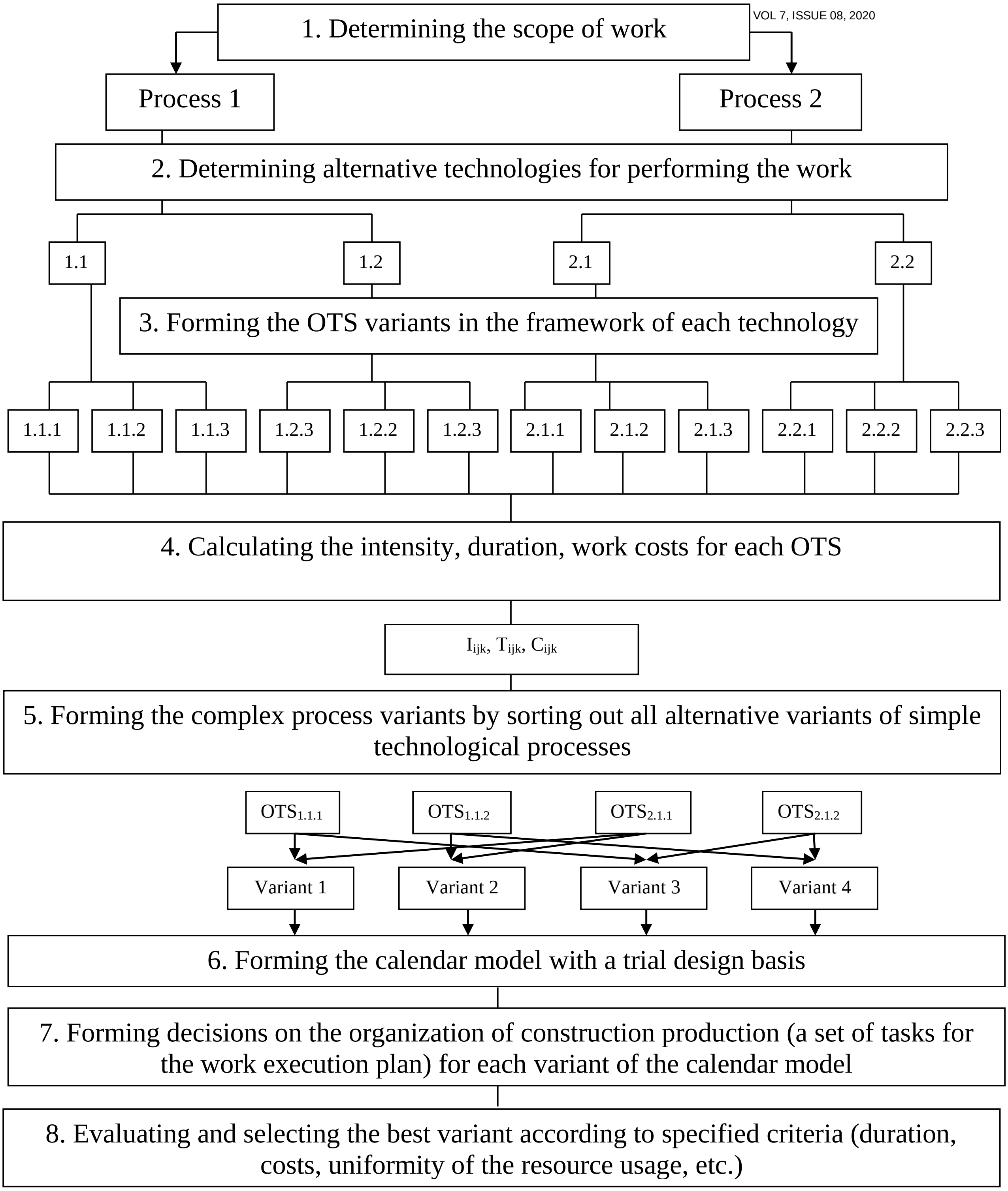
5) Forming the complex process variants by sorting out all possible combinations of the construction processes at the level of simple technological processes (alternative technologies and OTSfor works).

6) Forming the calendar model for the production of works with a trial design basis for each complex process variant (all possible feasible options for combining processesare considered).

7) Forming decisions on the organization of construction production (a set of tasks for the work execution plan) for each obtained variant of the construction process (a combination of technologies, OTS and the calendar model of the construction process).

8) Evaluating and selecting the best variant according to specified criteria (duration, costs, uniformity of the resource usage, etc.), taking into account the significance of the criteria.

VOL 7, ISSUE 08, 2020



Legend: I_{ijk} – the intensity of the (i) construction process implementation in the framework of (j) technology with the (k) variant of the organizational and technological solution (according to the composition of the involved resources); T_{ijk} – the duration of the (i) construction process in the framework of the (j) technology with the (k) variant of its implementation; C_{ijk} – direct costs for the implementation of the (i) construction process in the framework of the (j) technology with the (k) variant of its implementation

Figure 1. Schematic diagram of the OTS automated formation for construction work with a trial design basis

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For the purpose of automation and the tasks for the variable formation of OTS, we highlighted three types of technologies:

1) Non-mechanized (using only manual labor);

2) Mechanized (using manual labor and construction machines);

3) Fully mechanized (using only construction machines).

Suchgrouping of technological processes helps to take into account the specifics of each of the technological processes type during modeling, in particular, for non-mechanized processes, the variable solution is determined by the variantsof organization, teams and units supply; for fully mechanized ones it is determined by the variants ofavailablemachines supply by the construction contractor; for mechanized ones it is determinedby the variants for rational organization of the construction machines and workers joint work. Let'sconsider the order of the OTS automated variant formation at the level of simple technological processes.

Despite the main task in the framework of this study - the multivariate automated formation of OTS for construction work, it is proposed to expand the range of the considered modes of operation for the computer program described by the developed algorithm. In particular, depending on the conditions for the formation of decisions, the imposed requirements and restrictions, the followinguser basic modes of the computer program are proposed when forming decisions on the production of construction works:

- the OTS forming in the presence of time limits for completion of the work;
- the OTS forming based on the user's data input on the composition and quantity of resources with a non-alternative basis.
- the OTS forming on a multivariate basis;

So, for non-mechanized (manual) processes with time limit, when the maximum term for the construction process is set (T_{max}), we calculate the number of workers required to complete the process in the following way:

basing on the expression for calculating the duration of the construction process:

$$T = \frac{V \times H_{BPp}}{N \times 8 \times \kappa_{cм}} \tag{1}$$

with a given time limit (T_{max}), the minimum number of workers is calculated by the formula:

$$N = \left\lceil \frac{V \times H_{BPp}}{T_{max} \times 8 \times \kappa_{cм}} \right\rceil \tag{2}$$

In casewhen a team of workers is formed link-by-link (in multiples of the number of workers in one link), then the number of workers is adjusted taking into account the composition of the link and the required minimum number of links to complete the work in a given period:

The minimum number of therequired links is calculated by the formula:

$$K_{ЗВмин} = \left\lceil \frac{N}{N_{зв}} \right\rceil \tag{3}$$

And the number of workers corresponding to the minimum number of the required links is calculated by formula:

$$N = K_{ЗВmin} \times N_{зв} \tag{4}$$

Where:

N – the number of workers;

H_{BPp}– the costs ratefor working time per unit volume of work;

T_{max}– the maximum time limits for the construction process;

K_{cm}– the number of relays per day;

V –the amount of works;

8 – the duration of the relay, hours;

⌈ ⌉–the sign of rounding the value up;

$K_{ЗВmin}$– the minimum required number of links to perform work in a given time limit;

$N_{зв}$– the number of workers in one link.

If the user independently sets the amount of resources that are planned to be used when performing work with the trial design basis (for example, the number of workers), the system will use the amount of resources indicated in the initial data for all calculations and, based on this, carry out all calculations ($N = N_{max}$, where N_{max} is the number of workers entered by the user, N –the number of workers used by the system in the formation of OTS).

If it is supposed to carry out designing on a multivariate basis, the variability of OTS for performing non-mechanized technological processes is determined by the number of units in the brigade that the construction

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contractor can form, based on the available number of workers of the corresponding specialty and qualification, as well as the security,technological equipment, devices, etc., necessary for their work. The smallest number of workers in the brigade corresponds to the minimum composition of one link of workers, the largest one corresponds to the maximum number of links that a construction contractor can equip, that is to say the total number of workers in the relevant specialty and qualifications available to perform this process.

Then the number of variants generated for the non-mechanized technological process will be equal to:

$$n = N/N_{зв} \quad (5)$$

N – the total number of workers of the corresponding specialty and qualificationsavailable for the construction contractor to perform a certain type of work;

$N_{зв}$– the number of workersin one link for the performance of work (the recommended number of workers in a link is given in the corresponding collections of the ENiR regulations).

The number of workers for each option is calculated in the following:

$$N_i = n_i * N_{зв}, \text{ where} n_i = 1 \ldots n \quad (6)$$

For example, if the number of workers in the required specialty of the construction contractor is 6 people, the amount of the workers'link is 2 people, then the number of variants for performing this process will be:

$n_{max} = 6/2 = 3$

The number of workers for the generated OTSvariants for performing a non-mechanized process will be equal to:

$N_1 = 1*2 = 2$ people (one link works);

$N_2 = 2*2 = 4$ people (2 links work);

$N_3 = 3*2 = 6$ people (3 links work)

Further, regardless of the user-defined design mode (by themaximum time limit, by the number of workers set by the user, on a multivariate basis), the system determines the intensity of the construction process.

The intensity of work is understood as the speed of thebuildings and structures construction with technological systems thatinclude construction machines and workers. At the same time, some technological processes can be performed only by machines (earthworks) or only by workers (brickworks). However, the majority of technological processes in construction are characterized by the use of technological complexes that involve the joint work of construction machines and workers. Like productivity, intensity is defined as the volume of production (performed work) per unit of time.

The intensity of non-mechanized (manual) technological processes is determined basing on the total productivity of workers involved in this process, using the expression:

$$I = N / H_{BPp}, \text{ where} \quad (7)$$

N – the number of workers involved in the process;

H_{BPp}– rate of working time for the corresponding process.

The duration of a non-mechanized technological process is calculated as follows (in hours):

$$T_{ij} = \frac{V_i}{I_{ij}}, \text{ where} \quad (8)$$

Vi–the amount of work for the (i) technological process;

I_{ij}– the intensity of work for the (j) OTSvariant of the (i) technological process;

The cost of construction and installation works is determined by the cost of themain organizational and technological resources (working time and machine time, building materials and products, tools and accessories, etc.), in other words, the so-called direct costs of the construction contractor, as well as the amount of indirect costs, usually associated with the concentration of resources of the construction contractor at the construction site. Indirect costs are associated with ensuring the normal functioning of the main technological process, like the construction of temporary buildings and structures, the laying of communications for the construction period, the provision of workers with living conditions, management costs, etc. These costs depend on the number of workers and machines at the construction site, some of them are calculated directly, for example, basing on the maximum concentration of labor resources at the construction site.

ISSN- 2394-5125 VOL 7, ISSUE 08, 2020

To calculate the direct costs associated with the construction work, it is proposed to use the following expression (on time-based rates):

$$C = T\sum_{i=1}^{n} C_{P_i} N_i + m_k C_{m_k} V \tag{9}$$

C_{Pi}– the cost of one man-hour for a specialist of the (i) specialty and category;
N_i– the number of workers of the (i) specialty and category;
m_k–the consumption rate of the (k) material, structure, product;
C_{mk}–the unit cost of the (k) material, structure, product;
V – the amount of work for the corresponding process;
T – the duration of the works' delivery, hours.

Also, to determine the cost of construction works it is possible to use the following expression (basing on unit prices):

$$C = C_{Pi} \times V_i + m_k C_{m_k} V \text{ , where} \tag{10}$$

C_{Pi}– the rate of labor costs per unit volume of work for the (i) process.

Figure 2 presents an algorithm (schematic diagram) for making the decisions on the production of construction works for non-mechanized (manual) processes, including production on a multivariate basis.

ISSN- 2394-5125 VOL 7, ISSUE 08, 2020

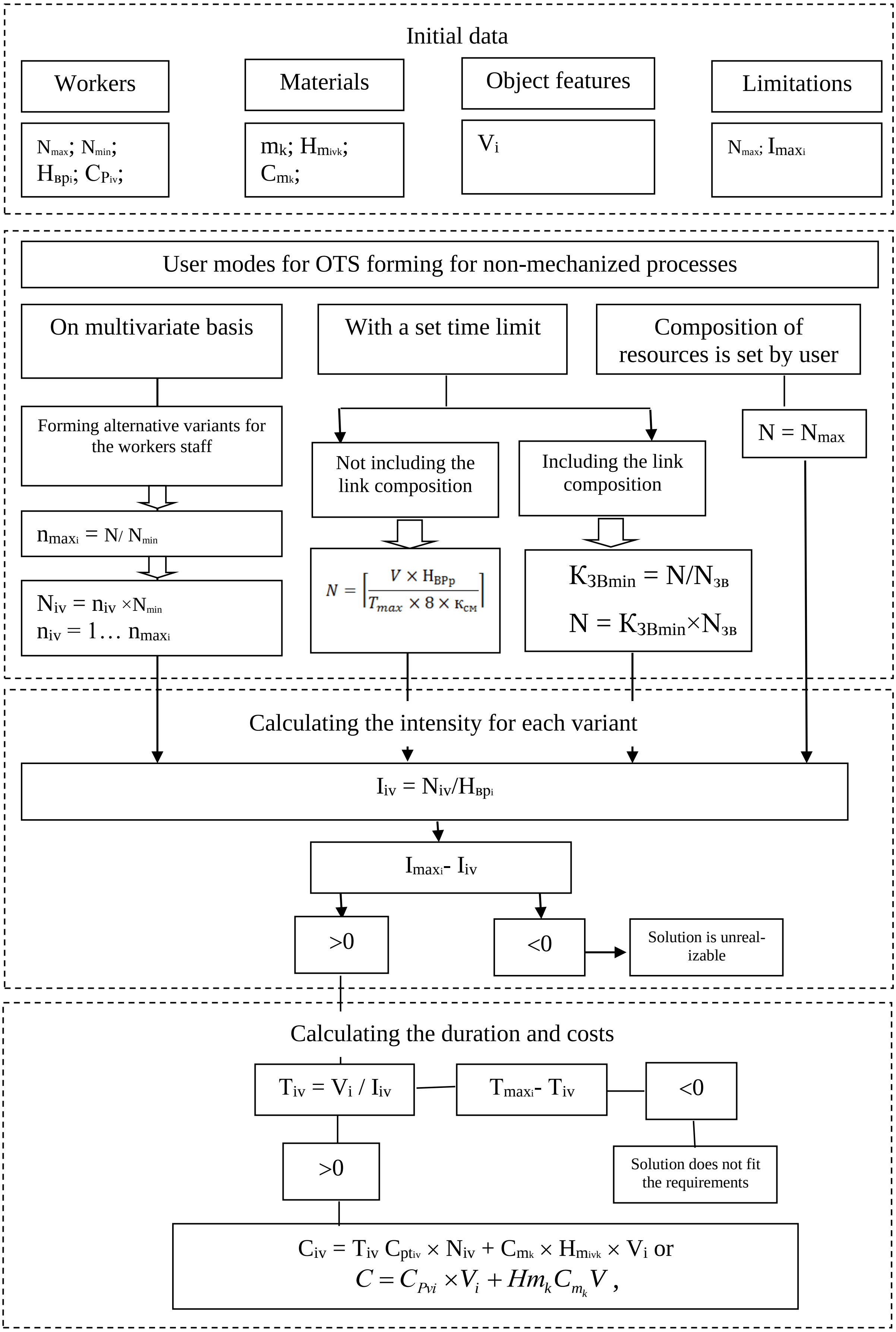

Figure 2. Schematic diagram of the OTS automated formation for non-mechanized (manual) technological processes

ISSN- 2394-5125 VOL 7, ISSUE 08, 2020

The formation of solutions for various user modes for mechanized processes is possible in the same way:
- the OTS forming in the presence of time limits on the work;
- the OTS forming basing on the user's data input on the composition and quantity of resources on a non-alternative basis.
- the OTS forming on a multivariate basis;

So, for fully mechanized processes (only construction machines are involved, without the participation of workers), if a time limit is set, then the maximum term for the construction process (T_{max}) and the number of construction machines needed to complete the process are calculated in the following ways:

basing on the expression for calculating the duration of the construction process:

$$T = \frac{V \times H_{BP_M}}{\kappa_M \times 8 \times \kappa_{CM}} \tag{11}$$

or if the operational performance of a construction machine is used to calculate the duration:

$$T = \frac{V}{P_M \times \kappa_M \times 8 \times \kappa_{CM}} \tag{12}$$

For a set maximum period (T_{max}), the minimum number of construction machines required for the completion of the works on time is calculated according to the formula (using the norm of the cost of machine time per unit volume of work):

$$\kappa_M = \left[\frac{V \times H_{BP_M}}{T_{max} \times 8 \times \kappa_{CM}}\right] \tag{13}$$

For a set maximum period (T_{max}), the minimum number of construction machines required for the completion of the works on time is calculated according to the formula (using the operational performance of construction machines):

$$\kappa_M = \left[\frac{V}{T_{max} \times P_M \times 8 \times \kappa_{CM}}\right] \tag{14}$$

Where:

K_M– the required number of construction machines;

H_{BP_M}– the expenditure rate of machine time per unit volume of work;

P_M– operational performance of a construction machine.

If a user independently sets the amount of resources that are planned to be used when performing work on a non-alterative basis (the composition of construction machines), the system will use the amount of resources indicated in the initial data for all calculations and, basing on it, it will carry out all calculations ($M_{ij} = \{M_{ij}\}$, where $\{M_{ij}\}$ is the composition of machines introduced or selected for the construction process, M_{ij} is the composition of the machines used by the system for the formation of OTS).

In the multivariate design mode of solutions for fully mechanized technological processes, the variation is determined by the composition of the construction machines that are available to the construction contractorfor carrying out this technological process [5]. Variant formation of fully mechanized technological processes is carried out by determining all feasible options for completing the process with construction machines.

For example, if a construction contractor has three construction machinesfor the construction process (M_1, M_2, M_3), then it is possible to form the following variants for equipping the process with machines:

1. M_1
2. M_2
3. M_3
4. $M_1 + M_2$
5. $M_1 + M_3$
6. $M_2 + M_3$
7. $M_1 + M_2 + M_3$

The intensity of the fully mechanized process is determined by the total operational performance of the construction machines used in this process:

$$I_M = P_M = P_1 + P_2 + \ldots + P_n \tag{15}$$

The duration of the process is calculated in the following way (in hours):

ISSN- 2394-5125 VOL 7, ISSUE 08, 2020

$$T_{ij} = \frac{V_i}{I_{ij}}, \text{ where} \quad (16)$$

V_i– the volume of work for the (i) technological process;

I_{ij}– the intensity of work for the (j) OTS variant of the (i) technological process;

To calculate the direct costs associated with the construction work on the basis of time-based rates, the following expression is used:

$$C = T\sum_{j=1}^{k} C_{M_j} k_j) + m_k C_{m_k} V \quad (17)$$

C_{Mj}– the cost of one machine hour for a (j)-typemachine;
k_j– the number of simultaneously working construction machines of the(j)-type;
m_k– the consumption rate of the (k) material, structure, product;
C_{mk}– the unit cost of the (k) material, structure, product;
V – the amount of work for the corresponding technological process;
T – the duration of the works'delivery, hours.

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ISSN- 2394-5125 VOL 7, ISSUE 08, 2020

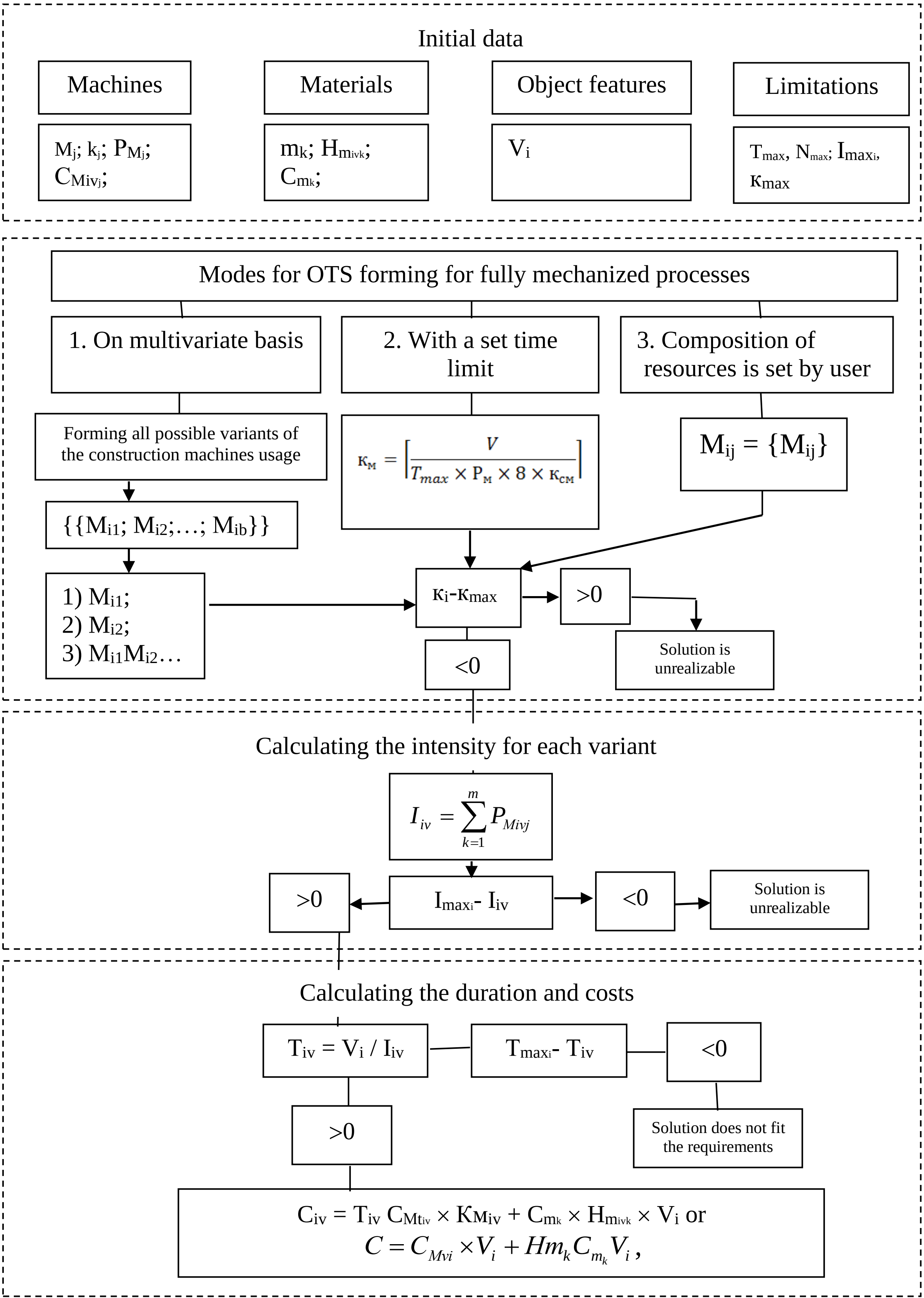

Figure 3. Schematic diagram of the OTS automated formation for fully mechanized technological processes

To determine the costs of construction works on the basis of unit prices, it is possible to use the following

ISSN- 2394-5125 VOL 7, ISSUE 08, 2020

expression:

$$C = C_{Mi} \times V_i + m_k C_{m_k} V \text{, where} \tag{18}$$

C_{Mj}–the costs rates of operating the machine per unit volume of work for the (i) process.

Figure 3 presents an algorithm for the automated formation of organizational and technological solutions for the implementation of a fully mechanized process.

For mechanized processes (with the participation of both construction machines and workers in the technological process), the composition of the construction machines planned for use is determined first (similar to the above-mentioned methodology for fully mechanized processes), and then the number of workers is determined, taking into account the need to ensure coordinated operation of machines and workers. To prevent technological downtime in the work of construction machines and workers due to the back-log in the implementation of the relevant technological operations by machines or workers, we can ensure equal intensity of their work using the following expression:

$$N = P_M / P_R = P_M \times H_{BP} \tag{19}$$

Where:

P_M– the total operational performance of construction machines for the corresponding process implementationvariant:

$$P_M = P_1 + P_2 + \dots + P_n \tag{20}$$

H_{BP}– the rate of time spent for a given technological process;

P_R– the productivity of one worker.

As the obtained number of the expression (19) can be rounded up or down to an integer value, then two variants are possible for the formation of the technological system with machine(s)and workers:

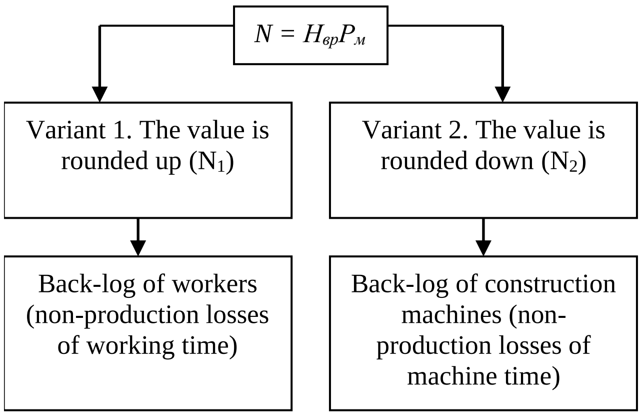

Figure 4. Variants for the formation of the technological system with machine(s) and workers depending on the rounding of the number of workers

These variants can be both acceptedin the organizational and technological design as alternative OTSvariants for performing a simple process.

The speed of creating construction products with a mechanized process (with the participation of both construction machines and workers) is determined by comparing the total productivity of workers with the total operational productivity of construction machines. The speed (intensity) value of the work is calculated by the smallest values of the operational productivity of machines or the total productivity of workers:

$$\frac{N}{H_{BP}} - P_M > 0 \Rightarrow I = P_M$$

$$\frac{N}{H_{BP}} - P_M < 0 \Rightarrow I = \frac{N}{H_{BP}} \tag{21}$$

$$\frac{N}{H_{BP}} - P_M = 0 \Rightarrow I = \frac{N}{H_{BP}} = P_M$$

Where:

ISSN- 2394-5125 VOL 7, ISSUE 08, 2020

I – the production intensity of construction works for the mechanized process;
P_M – the total operational performance of construction machines;
N – the number of workers;
H_{BP} – the norm of time for labor costs per unit volume of work;
$N/H_{вр}$– total productivity of workers.
The duration of the process is calculated with the formula (in hours):

$$T_{ij} = \frac{V_i}{I_{ij}}, \text{ where} \tag{22}$$

V_i– the volume of work for the (i) technological process;
I_{ij} – the intensity of work for the (j) OTSvariant of the (i) technological process;
The following expression is used to calculate direct costs with time-based rates:

$$C = T(\sum_{i=1}^{n} C_{P_i} N_i + \sum_{j=1}^{k} C_{M_j} k_j) + m_k C_{m_k} V \tag{23}$$

C_{Pi} – the cost of one man-hour of work for a specialist of the (i) specialty and category;
N_i – the number of workers of the (i) specialty and category;
C_{Mj} – the cost of one machine hour for a (j)-type machine;
k_j– the number of simultaneously working construction machines of the (j)-type;
m_k – the consumption rate of the (k) material, structure, product;
C_{mk} – the unit cost of the (k) material, structure, product;
V – the amount of works for the corresponding process;
T – the duration of the works' delivery, hours.

ISSN- 2394-5125 VOL 7, ISSUE 08, 2020

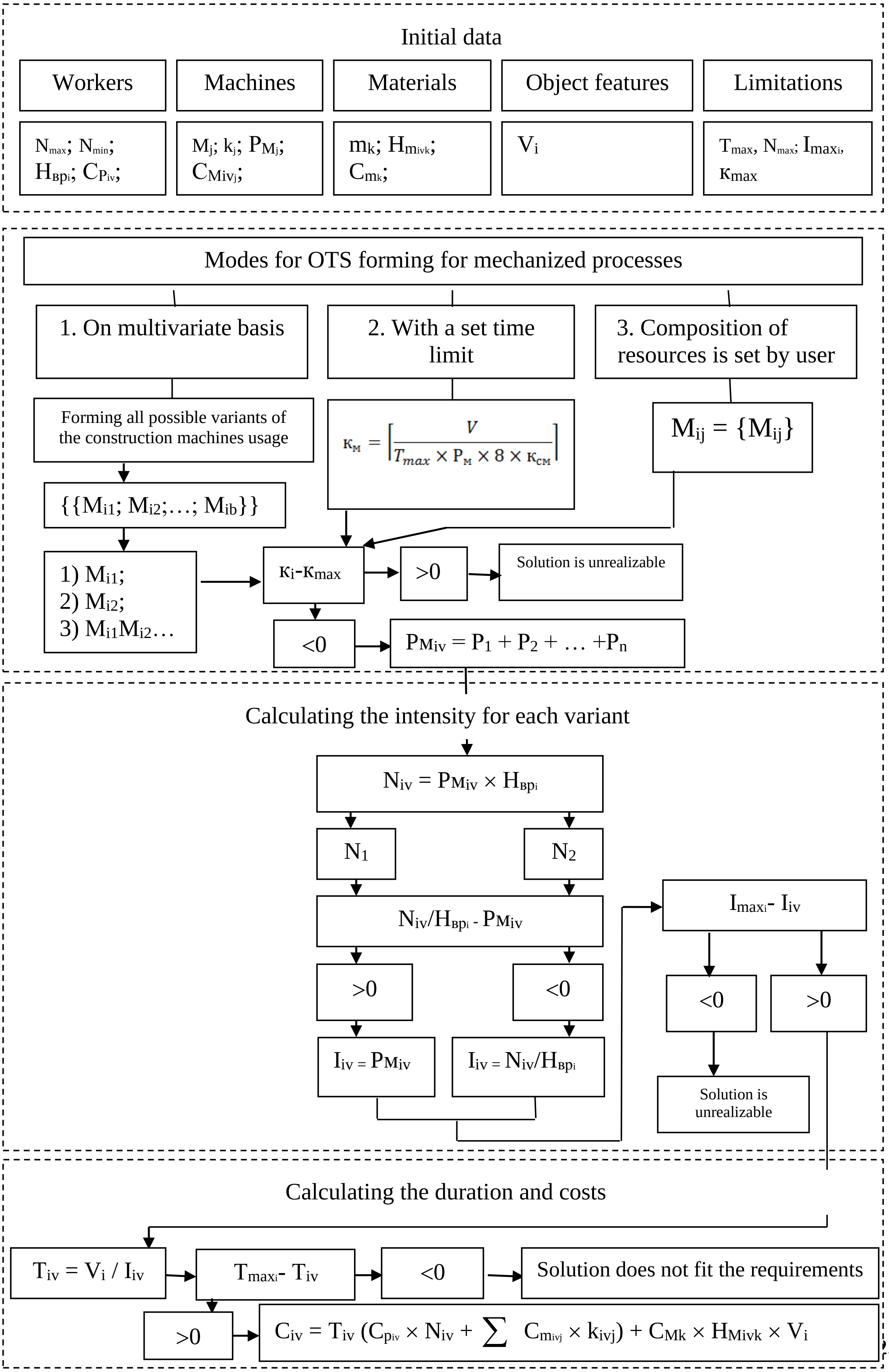

Figure 5. Schematic diagram of the OTS automated formation for mechanized technological processes

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It is possible to use the following expression to determine the costs of construction works on the basis of unit prices:

$$C = C_{Pi} \times V_i + C_{Mi} \times V_i + m_k C_{m_k} V \text{, where} \qquad (24)$$

C_{Pi}–labor costs ratefor workers per unit volume of work for the (i) process;

C_{Mj}–operating costs rate for the machine per unit volume of work for the (i) process.

Figure 5 shows the algorithm for the OTS automated formation for mechanized technological processes (construction machines and workers are involved).

The formation of variants for the implementation of the integrated process is carried out on the basis of a complete sorting out of possible OTSvariants for simple technological processes that make up the complex process.

Sorting out of variants for performing simple technological processes as part of the complex technological process can be carried out in the form of a sorting matrix, which is presentedin Table 1 (the following process parameters are usedin the example: the number of components for simple technological processes is 3, the number of OTSvariants for each simple technological process is 2):

Table 1. Sorting matrix

Variants of complex technological processes	Process 1	Process 2	Process 3
1	1.1	2.1	3.1
2	1.2	2.1	3.1
3	1.1	2.2	3.1
4	1.2	2.2	3.1
5	1.1	2.1	3.2
6	1.2	2.1	3.2
7	1.1	2.2	3.2
8	1.2	2.2	3.2

Note: 1.1, 1.2, 2.1, etc. arelegendsfor alternative variantsof performing simple technological processes.

To compare variants and choose the preferred one, it is proposed to use the vector method.It is very convenient for visual representation andcomparison of alternative variantsfor the construction process(Figure 6).

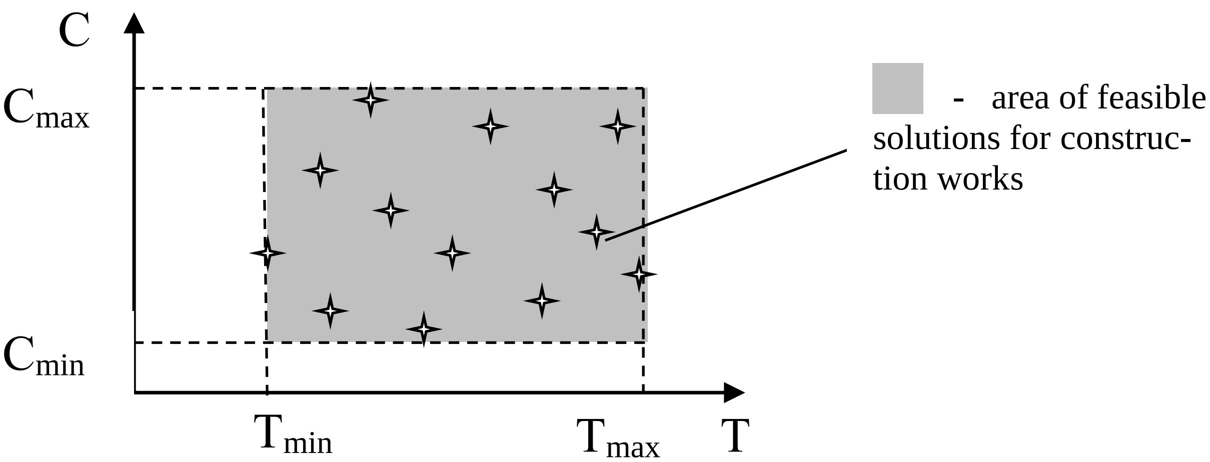

Figure 6. Area of feasible solutions for construction works

The vector model for adouble-criteria task (it is proposed to use the duration and costs of construction as criteria for evaluating and choosing the best variant):

$$V_i = \sqrt{T_i^2 + C_i^2} (25)$$

Where:

T – the duration of construction for the corresponding variant of the construction process;

ISSN- 2394-5125 VOL 7, ISSUE 08, 2020

C – the construction costs for the corresponding variant of the construction process;
V – the integral index for the corresponding variant.
Weight coefficients can be used to control the significanceof the criteria in expression (25).

Regardless of the chosencalculating mode for the integral index, it is necessary to carry out the normalizing procedure for the criteriavaluesto ensure their proportionality (the same dimension). Otherwise, criteria with a smaller dimension will have less influence or will not affect the integral index at all. To do this, we use one of the normalization methods, which involves obtaining the relative values of the criteria, dividing the initial values by the arithmetic mean for a series of data of the corresponding criterion:

$$T_i' = \frac{T_i}{T_{cp}}, C_i' = \frac{C_i}{C_{cp}} \quad (26)$$

Where T ’and C’ are the normalized (reduced to a comparable view) values of the criteria for evaluating variants for the implementation of the construction process.

Discussion

It should be noted that existing studies in the field of construction production with a trial design basis, as a rule, consider only separate particular aspects of variable solutions. For example, the issues of forming alternative sets of construction machines and choosing the best set at a reduced cost for use in a certain area of construction, etc. [3]. This study is based on the methodological developments of Professor Kabanov V.N. in the field of the variant formation of decisions on the production of construction works [6]. In the development of theapproach proposed byKabanov V.N., the range of thetechnological process typeswas expanded, an algorithm for the variant formation for non-mechanized technological processes was added, andthe multiplicity of the link composition was taken into account when calculating the required number of workers, etc.

Conclusion

The proposed approach to the design of construction processes on a multivariate automated basis allows us to expand the capabilities of a specialist in the field of the construction production organization, to provide the entire spectrum of possible alternatives for the implementation of the construction production with the choice of the best variantunderthe given criteria. Using the proposed model, makes it possible to find alternative variants for the implementation of construction production in the event of a malfunction in the system. Now it can be made by adjustingthe system parameters in cases of the destabilizing factors, the change in the system parameters or in the requirements for the building system functioning. The traditional approach to the design of building systems does not involve all feasible alternatives for the functioning of construction production, which significantly limits the efficiency of the organizational and technological design of the process, the possibility of finding the best complex of organizational and technological solutions for the construction work. As experience shows, thanks toour approach and the corresponding algorithms for the design of construction production, which serves as basis for prototypes of software systems for automating the workplace of an engineer-designer for OTSof the construction work,the number of alternative solutions for the construction work, even at the level of the single structure(for example, making the foundation for the building), reaches thousands of variants, which makes it possible to choose the best solution for certain working conditions, taking into account the requirements of the customer and economic efficiency for the contractor.

References

[1]. Gusakov A.A., Bogomolov Y.M., Brekhman A.I.2004. *Construction system engineering: encyclopedic dictionary*. Second Ext.and Rev. Ed. by Gusakova.A.A. Moscow: ASB Publishing, p.37.
[2]. Nikolaev Y.N.2015. *Computer technologies for designing construction production: training and workshop manual*.Ministry of education and science of theRussian Federation, VolgogradState Technical University, Volgograd:VolgGASU, pp. 7-9.
[3]. Oleynik P.P.2010. *Organization of construction production*. Moscow: Construction Universities Association Publishing, p. 26.
[4]. 2013. *Project Sustainability Management. Applications manual*. Second edition. Published by International Federation of Consulting Engineers (FIDIC),pp. 11-12.
[5]. Kuznetsov S.M., Kuznetsova K.S., Suvorov A.D., Maslov I.A. 2007. Automated system for building a park of construction machines. *Housing construction*, *3*:8-10.
[6]. Kabanov V.N.1993. *Guidelines for the use of thecomputer system “Technologist” in the development of optimal organizational and technological solutions for construction and installation works, for students of the specialty: Industrial andPublic Construction*. Volgograd: VolgGASU, p. 32.
[7]. Glazunov V.N.2018. *Conceptual design: theory of invention*.URSS, pp. 12-15.