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SYSTEM OF REDISTRIBUTION OF NON-USED RESOURCE WORK IN NON-RHYTHMIC FLOW-LINES

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The article proposes to reduce the duration of non-rhythmic flow lines on technologically identical processes by using the resource of "flow-line non-critical" divisions on interdependent works.

In non-rhythmic flow-line construction, there are processes with a reserve of non-used resources with adjacent works ("flow-line non-rhythmic" works). As a result of the system study, it is proposed to characterize "flow-line non-critical" works as having an increased period of deployment or convolution of flow lines.

The work volume is redistributed on technologically identical processes, for which interdependent divisions are determined. General new working deadlines are limited by the target function. Additional restrictions determine the limits of change in the term of work on intermediate divisions.

Optimized works are performed in two variants for three and two shifts. This method is more effective in reducing construction and complements the optimization method by reducing the deployment period.

Key words: non-rhythmic flow-lines, "flow-line non-rhythmic" works, deployment and convolution periods, sequentially parallel method, technologically identical works, flow-lines optimization.

Introduction

For energy-saving building construction technologies, harmoniously balanced systems should be introduced by adopting rational constructive, organizational and technological decisions (COTD) based on variant design. Variant design involves reducing the construction period by using the reserves of "flow-line non-critical" works on the building (Determination of the construction duration of objects, NSU, 2014).

Today, construction requires a reduction in labor resources with a large amount of work (Ivaneiko, Mudryi, Oleksiv, 2017). NULP has developed a methodology for reducing the construction period by reducing the deployment periods of non-rhythmic flow-lines on two processes using the available resource. (Ivaneiko, Oleksiv, 2022). The proposed system of redistribution of non-used resources is a continuation of preliminary research on more technologically identical processes.

Reduction of construction is achieved by constructive, organizational, and technological measures. For constructive reasons, it is achieved by choosing the type of materials and reducing the number of elements (Hicks, Lawson, Rackham, Fordham, 2004; Ivaneiko, Oleksiv, 2017; Mudryi, 2011, Shvydenko, 1983; Egnus, 1975). And for technological – changes in labor productivity, the number of machines in the process and application of technology transport machines (Shumakov, 2015; Mudryi, 2017, Ivaneiko, 2021), and the replacement of simple manual works by mechanized by the use of hybrid, universal and mini machines (Chebanov, 1994, Stilets, 1999; Ivaneiko, Ivaneiko, Vyshnevetsky, 2021). In the organization of construction to reduce the term of construction solve optimization problems and apply flow-line construction methods (Maj, 2007; Ushatsky, 2007) and many more changes.

One of the necessary optimization tasks is to solve the problem of reducing the construction period for the system with a limited number of resources. For a certain resource and division into parts, the algorithm for finding the optimal sequence of mastering fronts (species of works), proposed by S. M. Johnson is applied (Pan, 2002; Schaller, 2005). One way to reduce the construction period of a given resource system is to search for an organizational and technological sequence of work by the method of branches and boundaries (A. H. Land and A. G. Doig, 1960).

In the organization of construction to reduce the term of the building process, a parallel flow-line method is used:

a) obtaining the same duration of all types of work (proposed in 1959 in the Kyiv Engineering and Construction Institute by A. M. Clinduh);

b) achieving directive duration of construction using additional resources on works:

– critical, on the flow-line division (Kelley, Walker, 1959);

– the most time-consuming (proposed in 1965 by V. P. Hibukhin);

– he largest in terms of duration (proposed in 1982 A. V. Afanasiev).

It should be noted that the organization of works using parallel execution requires the involvement of additional labor resources in the structure.

Studies of non-rhythmic flow-lines show that in the system of duration of work they decrease due to a change in (greater or less) intensity of processes. One way for efficient processes selected for a given amount of work is to change productivity, which introduces from an economic point of view to increase costs (Ivaneiko, Mudryi, 2011). In some cases (with reduced intensity of work), it is enough to introduce planned organizational downtime at work to obtain a shorter duration of construction. Such works in the system have a reserve of non-used resources – "flow-line non-critical" works.

Optimization methods to reduce the flow-line deployment period allowed the use of duration reserves "flow-line non-critical" divisions with intensity on "flow-line critical" operation, and reduce its volume and duration of construction (Ivaneiko, Oleksiv, 2022). This procedure can be used for all unbalanced pairs at the facility but cannot be used for technologically incompatible processes. A study of the flow-line construction performance showed that from a mathematical point of view, with a large number of divisions, there are more than two interdependent divisions (Ivaneiko, Ivaneiko, 2020), which may be technologically compatible and among which there are "flow-line non-critical" works not related to the flow-line deployment period.

The article proposes dependencies to determine "flow-line non-critical" works, the criterion of the effectiveness of redistribution of non-used resources and the term of work on interdependent divisions.

Development of theory and improvement of flow-line non-rhythmic construction for technologically identical processes by redistribution of volumes of works "flow-line non-rhythmic" divisions on interdependent divisions using a sequential-parallel method to reduce the duration of work without attracting additional resources.

Material and Methods

Sequential-parallel methods in the flow-line organization of works are used to balance the duration of two or more processes in order to obtain a reduction in the construction period.

As a rule, there is a variable number of divisions and types of work in construction. The maximum number of interdependent divisions f_{max} is equal to the minimum size of fronts and types of work:

$$f_{max} = \min(m, n) , \quad (1)$$

where m is the number of divisions (fronts of works) during the flow-line of the building; n – number of types of work.

To be able to implement a sequential-parallel method in the flow-line organization of works on interdependent divisions (placed on one rank) they must be technically and technologically compatible in characteristics.

For calculation, consider the matrix in the OTW system (organization of types of work). The number of interdependent divisions equal to the value of the works, is determined by the matrix in the ROTW system by moving the tapes per unit. For the system $n \times m = 6 \times 7$ matrices are defined in the OTW system (Table 1) and ROTW (Table 2) with the calculation of the number of interdependent divisions for rank (f) and technologically combined works (q).

Table 1

OTW matrix for the number of works *n=6* on divisions *m=7*

OTW			Divisions and duration of work						
			1	2	3	4	5	6	m= 7
Types of works	А	1	t_{11}	t_{12}	t_{13}	t_{14}	t_{15}	t_{16}	t_{17}
	Б	2*	t_{21}	t_{22}	t_{23}	t_{24}	t_{25}	t_{26}	t_{27}
	В	3*	t_{31}	t_{32}	t_{33}	t_{34}	t_{35}	t_{36}	t_{37}
	Г	4*	t_{41}	t_{42}	t_{43}	t_{44}	t_{45}	t_{46}	t_{47}
	Е	5*	t_{51}	t_{52}	t_{53}	t_{54}	t_{55}	t_{56}	t_{57}
	Д	n=6	t_{61}	t_{62}	t_{63}	t_{64}	t_{65}	t_{66}	t_{67}

Table 2

ROTW matrix *n x m=6 x 7* with technologically identical processes 2–5

ROTW			Ranks and duration of work											
			1	2	3	4	5	6	7	8	9	10	11	p=12
Types of works	А	1	t_{11}	t_{12}	t_{13}	t_{14}	t_{15}	t_{16}	t_{17}	0	0	0	0	0
	Б	2*	0	t_{22}	t_{23}	t_{24}	t_{25}	t_{26}	t_{27}	t_{28}	0	0	0	0
	В	**3***	0	0	t_{33}	t_{34}	t_{35}	t_{36}	t_{37}	t_{38}	t_{39}	0	0	0
	Г	4*	0	0	0	t_{44}	t_{45}	t_{46}	t_{47}	t_{48}	t_{49}	t_{410}	0	0
	Е	5*	0	0	0	0	t_{55}	t_{56}	t_{57}	t_{58}	t_{59}	t_{510}	t_{511}	0
	Д	n=6	0	0	0	0	0	t_{66}	t_{67}	t_{68}	t_{69}	t_{610}	t_{611}	t_{612}
f			1	2	3	4	5	6	6	5	4	3	2	1
q (for Б …Е)			0	1	2	3	4	4	4	4	3	2	1	0

* Technologically interdependent works (four combined works – Б…Е).

Non-rhythmic flow-lines differ in time and time of work. To search for critical and non-critical works in Critical Path Method, the calculation of early beginnings and late endings and their comparison by time reserves is made.

It is possible to pre-determine small works as critical, in accordance with the principle of increasing the flow-line deployment period. That is, the first sign of non-critical work in the system is less than the value of the duration of work compared to the neighbouring ones and its less value from the average value of interdependent divisions. At the same time, studies have shown that "flow-line non-critical" work is increased during periods of deployment or convolution of flow-lines.

The flow-line deployment period is calculated by the direction calculation and non-critical works are determined in which the deployment period of the T_j^p flow-line is greater than the duration (*j-1*)-work on the first division (front works):

$$T_j^p > t_{(j-1)1} \,, \qquad (2)$$

$$T_j^{\mathrm{p}} = \max(\sum_{i=1}^{\mathrm{k}} t_{(j-1),i} - \sum_{i=1}^{\mathrm{k}-1} t_{ji}) \qquad 1 \le k \le m \,, \tag{3}$$

where T_j^{p} is the period of deployment of the *j* flow-line (processes); $T_{1(j-1)}$ – the duration of the first capture for (*j-1*) stream (robots); t_{ji} – duration of the *j* flow-line (processes) on the *i* front; $1, 2, ..., j, ..., k, ..., n$ – partial flow-lines (processes); $1, 2, ..., i, ..., m$ – partial fronts of works.

The convolution period is calculated in the opposite direction of calculation and non-critical works (*j-1*) are determined, in which the convolution period of the flow-line $T_j^{зг}$ is longer than the duration of the *j* work on the last division:

$$T_j^{зг} > t_{jm} \,, \tag{4}$$

$$T_j^{зг} = \max(\sum_{i=m}^{\mathrm{k}} t_{j,i} - \sum_{i=m}^{\mathrm{k}+1} t_{(j-1)i}) \qquad m \ge k \ge 1 \,, \tag{5}$$

where $T_j^{зг}$ is the period of deployment of the *j* flow-line (processes); T_{mj} – duration of the *m* division (front of works) for *j* flow-line (processes); t_{ji} – duration of the *j* flow-line on the *i* front; $1, 2, ..., j, ..., k, ..., n$ – partial flow-lines; $1, 2, ..., i, ..., m$ – partial fronts of works.

The work is non-critical if one of the conditions (2) or (4) is met.

To be able to implement a sequential-parallel method in the flow-line organization of works on interdependent divisions (placed on one rank) they must be technically and technologically compatible in characteristics and for them the average value on the division is determined:

$$\tau^*_{gcep} = \sum_{j=x}^{y} t^*_{jg} / q \,, \tag{6}$$

$$\tau^*_{jgcep} \approx \tau^*_{jg} = \tau_{ji} \,, \tag{7}$$

$$i = g - j + 1 \,, \tag{8}$$

where τ^*_{jgcep} is the average value on interdependent divisions (*q*) on the rank *g*; t^*_{jg} – the accepted duration of the *j* work on the g-th rank; τ_{ji} – accepted duration of the *j* work on the *i* division; *1... g ...p* – partial ranks of works; *q* – number of interdependent divisions (Table 2); *x* and *y* – numbers of the first and last work on interdependent divisions.

The main purpose of dividing the duration of work (in integers) by average values is to achieve a total difference between all dependent divisions within:

$$0 \ge \Delta T_j^m = \sum_{i=2}^{\mathrm{k}} \tau_{(j-1),i} - \sum_{i=1}^{\mathrm{k}-1} \tau_{ji}) \ge -1 \qquad 1 \le \mathrm{k} \le \mathrm{m} \,, \tag{9}$$

where ΔT_j^m is the difference in duration between dependent divisions, which show how much non-used time reserves in "flow-line non-critical" works. Time reserves are used 100 % with an odd difference of – 1, and odd – 0.

The additional difference in values for intermediate divisions may be less than – 1, but in any case must be less than zero:

$$\Delta T_j^h = \min(\sum_{i=2}^{h} \tau_{(j-1)i} - \sum_{i=1}^{h-1} \tau_{ji}) \le 0 \qquad ......1 \le h \le m-1 \,, \tag{10}$$

where *h* is the number of work divisions in the matrix of OTW within $1, 2, ..., i, ..., h \ldots (m-1)$; $\Delta \mathrm{T}_j^{\mathrm{h}}$ – the difference in the duration of work (*j-1*) and *j* on (*m-1*) divisions.

For each division, the number of changes required to perform the work is determined:

$$W_{ji} = \frac{t_{ji}}{\tau_{ji}}, \tag{11}$$

where W_{ji} is the number of changes at the work of the j flow-line on the i division (front works); τ_{ji} – the accepted duration of the j flow-line on the i division (front works).

Within the framework of solving the problem it is possible to adjust the duration of τ_{ji} work, to reduce the number of changes in performance.

Results and discussion

To compare the terms of work, a matrix model (Ivaneiko, Oleksiv, 2016) was taken (Table 3). The table calculates the timing of work, periods of deployment and convolution of flow-lines according to the formulas (3), (4) and defines "flow-line critical and non-critical" works by the formulas (2) and (4).

Table 3

Output data for the calculation of non-rhythmic flow-lines

Grippers	Technological processes and duration of work					
	Earthworks	Installation of foundations	Installation of a frame and walls	Roof adjustment	Installation of technological equipment	Disposal works
	А	Б	В	Г	Е	Д
I	1	10	12	5	10	12
II	3	6	10	6	20	8
III	4	5	6	4	8	18
IV	3	3	8	3	11	9
V	1	2	14	2	17	7
VI	2	4	7	8	12	4
VII	3	1	9	7	16	5
Amount	17	31	66	35	94	63
T^{p}	1		10	38	5	36
$T^{зг}$	15	45	7	54	5	
Works*	NC	NC	C	NC	C	NC

* To the "flow-line critical" works belongs C, D (C), and to the "flow-line non-critical" – A, B, E and F (NC).

Process analysis shows that they are technologically identical processes: A and B – as union by a universal machine; B, C, D, F – are combined by installation of elements with professional workers and partially specialized machines.

Systemic association of all works (B, C, D, F) is included in the matrix of OTW (Table 4).

We combine the data of these processes in time (in different shifts).

For calculation we need to determine:

a) average values of works by option B–E (j=2 ...j=5) for ranks g= 2 ...10 number of interdependent divisions ((6), Table 2) are:

$\tau^*_{2cep} = (10)/1 = 10$; $\tau^*_{3cep} = (6+10)/2 = 9$; $\tau^*_{3cep} = (5+10+5)/3 = 6.67$; $\tau^*_{4cep} = (3+6+6+10)/4 = 6.25$; $\tau^*_{5cep} = (2+8+4+20)/4 = 8.25$; $\tau^*_{6cep} = (4+14+3+8)/4 = 7.25$; $\tau^*_{7cep} = (1+7+2+11)/4 = 5.25$; $\tau^*_{8cep} = (9+8+17)/3 = 11.33$; $\tau^*_{9cep} = (7+12)/2 = 9.5$; $\tau^*_{10cep} = (16)/1 = 16$;

b) by (7) taking into account the target function in (9) determine the duration of work on ranks (duration $T_{Б2}...T_{Е2}$) – $(\tau_{2g}, \tau_{3g}, \tau_{4g}, \tau_{5g})$: and divisions $(\tau_{j1}, \tau_{j2}, \tau_{j3}, \tau_{j4})$ (7), (9);

c) define the construction period of T=97;

d) determine the number of changes in the performance of works (11). For divisions E2 and E4 it is necessary to perform works in three shifts, because $W_{52} = 20/9 = 2.22 \rightarrow 3-shifts$ and $W_{52} = 11/5 = 2.2 \rightarrow 3-shifts$.

Table 4

Redistribution of volumes of works by sequentially parallel method in technologically compatible processes

ОВР			Fronts and duration of work							Option 1				Option 2			Option 3		
										Output data				Б+В+Г+Е			Б+В+Г+Е		
			I	II	III	IV	V	VI	VIII	T_j^p	$T_j^{зг}$	$T_{чп1}$	$\frac{T_1^п}{T_1^в}$	$T_6^р$	$T_{чп2}$	$\frac{T_2^п}{T_2^в}$	$T_1^р$	$T_{чп3}$	$\frac{T_3^п}{T_3^в}$
Types of works	А	1	1	3	4	3	1	2	3	1	15	17	$\frac{0}{17}$	1	17	$\frac{0}{17}$	1	17	$\frac{0}{17}$
	Б	1	10	6	5	3	2	4	1										
		2	***10***	***9***	***6***	***6***	***8***	***7***	***6***		45	31	$\frac{1}{32}$		52	$\frac{1}{52}$		52	$\frac{1}{52}$
		3	10	9	6	6	8	8	5										
	В*	1	12	10	6	8	14	7	9										
		2	***9***	***7***	***6***	***8***	***8***	***5***	***11***	10	7	66	$\frac{11}{77}$	10	54	$\frac{11}{65}$	10	54	$\frac{11}{66}$
		3	9	7	6	8	7	5	12										
	Г*	1	5	6	4	3	2	8	7										
		2	***7***	***6***	***9***	***7***	***5***	***11***	***10***	38	64	35	$\frac{49}{84}$	9	55	$\frac{20}{75}$	9	55	$\frac{20}{65}$
		3	7	6	8	7	5	12	10										
	Е*	1	10	20	8	11	17	12	16										
		2	***7***	***9***	***7***	***5***	***12***	***9***	***16***	5		94	$\frac{54}{148}$	7	65	$\frac{27}{92}$	7	65	$\frac{27}{91}$
		3	7	10	7	6	10	9	16		5								
	Д	1	12	8	18	9	7	4	5	36		63	$\frac{90}{153}$	7	63	$\frac{34}{97}$	7	63	$\frac{34}{97}$
Deployment period										90				34			34		

* Technologically identical processes.

Table 5

Purpose function and additional difference of values on divisions

Options	Purpose function			Additional difference in values on grips		
	ΔT_3^m	ΔT_4^m	ΔT_5^m	ΔT_3^h	ΔT_4^h	ΔT_5^h
Option 2	-1	0	-1	-2	-1	-2
Option 3	0	0	-1	-1	0	-4

To perform all the work on two divisions, a third version of the duration distribution has been developed, in which the greater required values of the execution of the E-job on 2 and 4 divisions

($\tau_{52} = 10$ ($W_{52} = 20/10 = 2$ shifts), $\tau_{54} = 6$ ($W_{52} = 11/6 = 1.83$)) followed by redistribution of terms according to the (9) and (10).

The purpose function and the additional difference in values on divisions are shown in Table 5.

The duration of flow-line is less than or equal to division planning. For data developed options for the duration of flow-line work and Critical Path Method coincide and are equal to 97 days. The duration of option 1 is 128 days when calculating Critical Path Method.

According to the system of redistribution of the resource of works, the duration decreases the more the combined technologically identical works. The introduction of this sequential-parallel method with coordination of works in time should take into account the cost of machines and working tools.

Conclusions

1. The proposed system method of redistribution of non-used work resources on technologically identical processes with the introduction of a sequential-parallel flow-line method of the construction organization. Non-used work resources have "flow-line non-critical" work with increased deployment or convolution periods. This method will reduce construction times.

2. The implementation of this organizational method of work should be carried out with coordination with structural elements and means of mechanization with a justification of economic expediency.

3. The use of non-used resources of non-critical works in network planning (Critical Path Method) was investigated.

References

Determination of the duration of construction. DSTU B A.3.1-22:2013. National Standard of Ukraine. (2014). Kyiv: Ministry of Regional Development and Construction of Ukraine [in Ukrainian]. URL: https://dbn.co.ua/load/normativy/dstu/dstu_b_a_3_1_22/5-1-0-1109.

Ivaneiko, I. D., Mudryi, I. B., Oleksiv, Y. M. (2017). Method of forming effective sets jib cranes in conditions limiting the construction term. Modern technologies and methods of calculations in construction, 8, 87–94 [in Ukranian]. URL: https://eforum.lntu.edu.ua/index.php/construction/issue/view/13/12.

Ivaneiko, I., Oleksiv, Y. (2022). Optimization of deployment periods of non-rhythmic flow-lines by complex mechanized machines / Theory and Building Practice. Vol. 4, No. 2, 75–82. DOI: https://doi.org/10.23939/jtbp2022.02.075.

Hicks, S. J., Lawson, R. M., Rackham, J. W., Fordham, P. (2004). Comparative Structure Cost of Modern Commercial Buildings (Sec. Ed.) SCI P137, 85 p. URL: https://www.steelconstruction.info/images/d/df/SCI_P137.pdf.

Chebanov, L. S., Frolov, A. V. Universal use of machines in construction / L. S. Chebanov, A. V. Frolov. K.: Budivelnyk, 1994. 250 p. URL: https://scholar.google.com/citations?view_op=view_citation&hl=uk&user=RBR31bUAAAAJ&citation_for_view=RBR31bUAAAAJ:eQOLeE2rZwMC.

Strylets, F. (1999). Technology of Cumulative Works Production for Lay the Underground Conditions jf Reconstruction of the Enterprises. (Ph. D. dissertation abstract) [in Ukranian]. URL: http://irbis-nbuv.gov.ua/cgi-bin/irbis_nbuv/cgiirbis_64.exe.

Ivaneiko, I. D., Ivaneiko, M. M., Vyshnevetsky, R. M. (2021). Construction of prefabricated foundations in complex excavation sites. Modern technologies and methods of calculations in construction, 16, 53–61 [in Ukranian]. DOI: https://doi.org/10.36910/6775-2410-6208-2021-6(16)-07.

Maj, T. (2007). Organszacja budowy. Warszawa. URL: https://books.google.pl/books?id=jO-GGbZsFEsC&printsec=copyright&hl=pl#v=onepage&q&f=false.

Ushatsky, S. A., Sheiko, Y. P., Triger, G. M. (2007). Organization of construction [in Ukranian]. URL: https://www.yakaboo.ua/ua/organizacija-budivnictva.html.

Chao-Hsien Pan, J., Chen, J.-Sh., Chao, Ch.-M. (2002). Minimizing tardiness in a two-machine flow-shop. Computers & Operations Research, 29, 869–875. DOI: https://doi.org/10.1016/S0305-0548(00)00090-3.

Schaller, J. (2005). Note on minimizing total tardiness in a two-machine flowshop. Computers & Operations Research. 32(12), 3273–3281. DOI: https://doi.org/10.1016/j.cor.2004.05.012.

Land, A. H., Doig, A. G. (1960). An automatic method of solving discrete programming problems. In: Econometrica 28. Pp. 497–520. URL: https://www.jstor.org/stable/1910129.

Kelley, J. E., Walker, M. R. (1959). Critical-path planning and scheduling. In Papers presented at the December 1–3, 1959, eastern joint IRE-AIEE-ACM computer conference (IRE-AIEE-ACM'59 (Eastern)). Association for Computing Machinery, New York, NY, USA, 160–173. DOI: https://doi.org/10.1145/1460299.1460318.

Afanasiev, V. A. (1990). Flow-line organization of construction. Leningrad [in Russian]. URL: http://aleph.lsl.lviv.ua:8991/F/?func=direct&doc_number=000275862&local_base=LSL01.

Ivaneiko, I. D., Mudryi, I. B. (2011). Study of the small volume of work for jib cranes during the construction of foundations in urban development. Urban development and spatial planning. Pp. 41, 178–183 [in Ukranian]. URL: http://nbuv.gov.ua/UJRN/MTP_2011_41_26.

Ivaneiko, I. D., Ivaneiko, M. M. (2020). Theoretical research into shortening construction times using integrated processes. Scientific bulletin of civil engineering, 100(2). Pp. 119–126 [in Ukranian]. URL: http://nbuv.gov.ua/UJRN/Nvb_2020_100_2_21.

Ivaneiko, I. D., Oleksiv, Y. M. (2016). Balancing non-rhythmic flow-lines by complex mechanized brigades. Urban development and spatial planning. Pp. 62, 222–227 [in Ukranian]. URL: http://nbuv.gov.ua/UJRN/MTP_2017_62%281%29__34.

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СИСТЕМА ПЕРЕРОЗПОДІЛУ НЕВИКОРИСТАНОГО РЕСУРСУ РОБІТ У НЕРИТМІЧНИХ ПОТОКАХ

Запропоновано зменшити тривалість виконання неритмічних потокових робіт на технологічно однотипних процесах шляхом використання ресурсу "потоково некритичних" захваток на взаємозалежних роботах.

Розрахунки Critical Path Method включають критичні роботи, які розраховуються за раннім початком та пізнім закінченням і не мають резервів часу. Попередні дослідження показали, що "потоково некритичні роботи" визначаються періодом розгортання потоків.

У неритмічному потоковому будівництві існують процеси із запасом невикористаного ресурсу з суміжними роботами ("потоково неритмічні" роботи). З дослідження системи запропоновано характеризувати "потокові некритичні" роботи як такі, які мають збільшений період розгортання або згортання потоків.

Обсяг робіт перерозподіляється на технологічно однотипні процеси, для яких визначаються взаємозалежні захватки. Загальні нові терміни роботи обмежені цільовою функцією. У додаткових обмеженнях визначаються межі зміни терміну виконання робіт на проміжних захватках.

Для порівняння варіантів вибрано шість процесів із виконанням робіт на семи захватках. Визначено технологічно однакові процеси. Розрахунок виконується у матрицях ОВР і ОВРР для варіанта на чотирьох технологічно однакових процесах.

Нові та старі тривалості на захватках встановлюють на "потоково критичних" роботах кількість змін. Для зменшення кількості змін на захватці можуть уводитися нові терміни, більші за середні, і з цими значеннями за методикою досягається цільова функція.

Оптимізоване виконання робіт здійснюється у двох варіантах на три та дві зміни. Найбільше скорочення терміну будівництва досягається зі збільшенням взаємозалежних захваток на технологічно однакових процесах. Цей метод є ефективнішим і доповнює метод оптимізації зі зменшенням періоду розгортання потоків.

Ключові слова: неритмічні потоки, "потоково некритичні" роботи, періоди розгортання і згортання потоків, послідовно-паралельний метод, технологічно однакові роботи, оптимізація потоків.