

UDC 69.057

Methods of increasing the input capacity of industrial housing construction enterprises

Input capacity of the industrial housing construction enterprise (IHCE) reflects the maximum volume of finished construction products that the enterprise is able to produce over a period of time. It is expedient to increase the input capacity of IHCE by intensification of its production. It becomes possible with a deep understanding of work of its production system (PS), and taking into account its peculiarities: firstly, due to the complexity of formulating and solving in analytical form the problem of making an optimal decision within the framework of production management, it is advisable to resort to the variant approach. This approach implies the use of various management strategies and tactics depending on the specific situation, operating conditions and objectives of the enterprise; secondly, production technologies and its material and technical base are constantly updated following the progressive development of scientific and technical progress. Consequently, there is the emergence of more and more advanced forms of organization and management of production processes, as well as changing methods of planning business processes of the enterprise; thirdly, the production system of IHCE should be analyzed systematically. The system approach to production analysis is a methodology that allows analyzing production processes as a single interconnected system rather than as a set of individual elements or operations. Growth of input capacity during intensification of IHCE production by various methods, including by increasing labour productivity, adapting the means of labour and proper adjustment of production flows, in which specialization, proportionality, parallelism, directness, continuity, rhythmicity and automation are achieved. This in turn increases the input capacity of the enterprise.

Keywords: industrial housing construction enterprises, production system, input capacity, production intensification, labour productivity, potential, flow production

INTRODUCTION

The input capacity of an industrial housing construction enterprise as one of the states of potential intensity of its production system (PS) [1] reflects the maximum volume of finished construction products that the enterprise is able to produce over a period of time [2, 3]. Increasing the input capacity of IHCE can be achieved using two approaches: extensive and intensive. The first direction is provided and is characterized by the growth of finished construction products output at the expense of quantitative increase of living labour and means of labour without changing the technical characteristics and production technology. The second — at the expense of qualitative changes in the elements of production and technological processes by improving the technique and technology of production. This paper considers the methods of intensive increase in input capacity as the most effective.

IHCE PRODUCTION INTENSIFICATION

Intensification of IHCE production is a systematic application of scientific and technical achievements in its economic activity, contributing to the increase of efficiency of its production system. To make optimal decisions on intensification of PS, the management of the enterprise should have an understanding of all production processes, sufficient for complex analysis of PS as a whole and its individual components through a system of relevant indicators, which can be subsequently compared with those of the leading enterprises of the industry.

When considering methods of intensification of IHCE production, it is necessary to take into account the peculiarities of its PS functioning.

Firstly, due to the complexity of formulating and solving in analytical form the problem of optimal decision-making within the framework of production management, it is advisable to resort to the variant approach. This approach involves the use of various management strategies and tactics depending on the specific situation, conditions of activity and objectives of the enterprise [4]. The main advantages of using the variant approach include management flexibility, adaptability to changing conditions of external and internal environment, the ability to switch between different management strategies. At the same time, the variant approach requires high qualification, the ability for deep analysis and strategic thinking from the managerial level.

Secondly, production technologies and its material and technical base are constantly being updated following the progressive development of scientific and technological progress. As a consequence, there is the emergence of more and more advanced forms of organization and management of production processes, as well as changing methods of planning business processes of the enterprise.

Thirdly, the production system of IHCE should be analyzed systematically. The system approach to production analysis is a methodology that allows analyzing production processes as a single interconnected system rather than as a set of individual elements or operations. Within the systems approach, each element of the production process is not considered by itself, but in the context of how it affects other elements and the system as a whole [5, 6]. The whole production process is considered as a unity that has its own goals, structure, functions and regularities of development. In the framework of

Spirin A. S.



Spirin Alexander Sergeevich,
graduate student of the Department of Construction Organization and Real Estate Management; Moscow State University of Civil Engineering (National Research University) (MGSU); 26 Yaroslavskoe shosse, Moscow, 129337, Russian Federation; Scopus: 58565475400, ResearcherID: JNE-8074-2023, ORCID: 0009-0007-1819-6477; spirincorp@yandex.ru



Exorise industrial exoskeleton

the system approach, the production system is usually differentiated into subsystems and elements, between which vertical and horizontal links are established.

The intensification of IHCE production can be carried out in various ways, among which are the increase in labour productivity, adaptation of labour tools and improvement of production flows.

INCREASE IN LABOUR PRODUCTIVITY

The main directions for increasing labour productivity at production facilities are improving the qualifications of the enterprise's personnel and improving their working conditions.

Professional development of employees involves improving their professionalism by acquiring new and deepening existing knowledge. For this purpose, both internal (coaching, mentoring) and external (lectures, seminars, trainings) methods can be used.

Improving the working conditions of employees involves ensuring their physical and mental comfort, which, in turn, leads to a reduction in their fatigue — the process of decreased productivity due to the performance of hard and long work. Mental comfort is ensured by friendly relations within the team, its cohesion, as well as the availability of recreational infrastructure. Physical comfort is ensured, first of all, by the creation of a microclimate at the enterprise that meets all regulatory requirements. Secondly, it is ensured by introducing technologies that reduce physical strain into production practice. Advanced solutions in this direction include industrial exoskeletons [7–9] (Fig.).

ADAPTATION OF THE MEANS OF WORK

Adaptation of means of labour, as a part of the enterprise potential, is aimed at increasing their compliance with the characteristics of manufactured products, selected production technology and capacity of private technological processes in order to increase overall productivity.

As a rule, it is carried out in the form of technical re-equipment of the enterprise. Technical re-equipment of an industrial housing construction enterprise is a process of renewal and modernization

of the technical base of the enterprise. It may involve the acquisition and introduction of modern equipment, improvement of process automation systems, as well as the introduction of innovative production technologies. The application of technical re-equipment is aimed at increasing the efficiency and productivity of work, improving the quality of products, optimizing costs and improving working conditions for personnel.

IMPROVEMENT OF PRODUCTION FLOWS

Flow production is the main way of production organization at the enterprise of industrial housing construction. It is based on the principles of specialization, proportionality, parallelism, directness, continuity, rhythmicity and automation [10]. Its advantages include increased productivity, reduction of time and costs of work, better organization of labour and the possibility of using modern technologies.

Specialization of a production flow is characterized by the involvement of a group of production elements of a given flow in the performance of specific operations only. This allows for more efficient utilization of production elements due to optimal modes of their operation.

Process flow proportionality is the consistency and coherence of interrelated operations during the production process. This means that each step in the process must be balanced and coordinated with the other steps. For example, if one operation is performed faster than the next, this can lead to a build-up of production and unnecessary downtime. On the other hand, if one operation is slower, it can cause delays in the entire process. To determine the proportionality of the entire process, the ratio of the private to the total cycle of the process line should be used. The time required to complete the process T_{ip} is determined by the formula:

$$T_{ip} = \frac{(t_A + t_B + t_C + \dots + t_D)}{R'} = \frac{\sum t}{R'}, \tag{1}$$

where t_A, t_B, t_C, t_D — duration of operations of the stage process, min; R' — cyclicity coefficient.

Then the ratio of partial cycles over the whole process will be equal to:

$$\frac{t_A}{T_{ip} R'} = 1 - \left(\frac{t_B}{T_{ip} R'} + \frac{t_C}{T_{ip} R'} + \dots + \frac{t_D}{T_{ip} R'} \right). \tag{2}$$

Parallel production flow refers to the simultaneous execution of several operations during the production process. That is, different elements of a product are processed in different areas or production lines and then combined to create the final product. This helps in improving the efficiency of production by speeding up the process and increasing output per unit of time.

Parallelism is the parallel execution of works of a dismembered technological process. It allows to reduce the duration of the technological cycle. Parallelism of operations at technological stations is mandatory when $t_A, t_B, \dots, t_D$ exceeds the value of r cycle of the line. The number of parallel stations is equal to the multiplicity coefficient:

$$K_{mlt} = \frac{t_A}{r} + \frac{t_B}{r} + \dots + \frac{t_D}{r}. \tag{3}$$

Cycle is the time interval between the production of two products. With actual time F_D , min, and line capacity N , m^3 , cycle r is equal to, min/m^3 :

$$r = \frac{F_D}{N}. \tag{4}$$

Straightforward production flow means that the production process is organized in such a way that manufactured products pass through the production stages sequentially, without gaps. That is, the items of labour move along the production line in one direction, from the beginning to the end. This helps to minimize the time and resources spent on moving items of labour between operations.

Continuity of production flow means that the production process is organized in such a way that production operations are carried out without interruption or delay [11]. That is, as soon as one operation is completed, the next one begins, so that the objects of labour move uninterruptedly along the production line. This reduces downtime costs and increases overall labour productivity.

The rhythmicity of the technological process determines the output of products strictly according to the schedule and at certain intervals. Rhythmicity is assessed by the correspondence of the duration of the technological cycle of a stage process to the tact, rhythm and pace of the complete process, which predetermines the best conditions for its management [12]. If one group of operations is performed simultaneously at two or more stations, then the time interval required to perform n operations will be called the rhythm R , min/m³:

$$R = rn; \quad (5)$$

$$K_{mlt} = \frac{R}{r}. \quad (6)$$

One of the main conditions for rational organization of a process is its synchronization, i.e. equalization of the duration of process execution. In case of full synchronization $t_A, t_B, \dots, t_D$ are equal or multiple of K_{mlt} cycle and such a process is intermittent-flow. In the case when:

$$t_A \neq R; t_B \neq R; \dots, t_D \neq R, \quad (7)$$

the multiplicity condition can be written:

$$\begin{aligned} t_A &= K_{mlt}r \pm \Delta t_A = \frac{R}{r} \pm \Delta t_A; \\ t_B &= K_{mlt}r \pm \Delta t_B = \frac{R}{r} \pm \Delta t_B; \\ t_D &= K_{mlt}r \pm \Delta t_D = \frac{R}{r} \pm \Delta t_D, \end{aligned} \quad (8)$$

where Δt_i — time is shorter than a cycle r .

Production flow automation is the application of various kinds of automatic systems and equipment at each stage to reduce human involvement, increase productivity, efficiency and quality of output. It may include the use of software for planning and control, including artificial intelligence [13–15], robots for physical work, automated systems for transferring products between workstations, automated machines for quality control, and so on.

CONCLUSION

Deep understanding of IHCE production system operation allows to intensify its work — to increase the degree of correspondence of the enterprise potential characteristics to the characteristics of its product; to increase labour productivity by increasing the qualification of personnel and improving working conditions; to establish production flows properly, in which specialization,

proportionality, parallelism, directness, continuity, rhythmicity and automation are achieved. This in turn increases the input capacity of the enterprise — its maximum achievable capacity to produce finished construction products.

REFERENCES

1. Prykin B.V. *Technical and economic analysis of production*. 2 ed., rev. and supplement. Moscow, UNITI Publ., 2003 (GUP IPK Ulyanovsk House of Press); 475. (rus.)
2. Grabovyy P.G., Grebenshchikov V.S. *Assessing the potential of a construction system for the delivery of large investment projects*. *Real Estate: Economics, Management*. 2017; 2:76-81. URL: <https://elibrary.ru/item.asp?id=30775540> (rus.).
3. Grabovyy P.G., Zhikharev D.F. *The productivity of an industrial housing construction enterprise as the main indicator of the potential intensity growth of the production and construction system*. *Real estate: economics, management*. 2022; 2:11-17. DOI: 10.22337/2073-8412-2022-2-11-17
4. Monfred Y.B., Prykin B.V. *Organization, planning and management of construction industry enterprises*. Moscow, Stroyizdat Publ., 1989; 506. (rus.).
5. Rodionova V.N. *System approach as a general methodological principle of research into the organization of production systems*. *Organizer of Production*. 2008; 38:12-13. URL: istemnyy-podhod-kak-obschemetodologicheskii-printsip-issledovaniya-organizatsii-proizvodstvennyh-sistem (rus.).
6. Namestnikova L.S., Pakhomova A.A. *System approach to the management of production systems efficiency*. *Bulletin of Platov South-Russian State Polytechnic University (NPI). Series: Socio-economic sciences*. 2016; 3:86-91. URL: <https://vestnik.npi-tu.ru/index.php/vestnikSRSTU/article/view/759/760> (rus.).
7. Zhu Z., Dutta A., Dai F. *Exoskeletons for manual material handling : A review and implication for construction applications*. *Automation in Construction*. 2021; 122:103493. DOI: 10.1016/j.autcon.2020.103493
8. Golabchi A., Riahi N., Fix M., Miller L., Rouhani H., Tavakoli M. *A framework for evaluation and adoption of industrial exoskeletons*. *Applied Ergonomics*. 2023; 113:104103. DOI: 10.1016/j.apergo.2023.104103
9. Ralfs L., Hoffmann N., Glitsch U., Heinrich K., Johns J., Weidner R. *Insights into evaluating and using industrial exoskeletons: Summary report, guideline, and lessons learned from the interdisciplinary project "Exo@Work"*. *International Journal of Industrial Ergonomics*. 2023; 97:103494. DOI: 10.1016/j.ergon.2023.103494
10. Ivanov A.S. *Planning and organization of production. From industrial economy to knowledge economy*. Moscow; Berlin, Direct-Media, 2016; 203. (rus.).
11. Naumenko I.H. *Design of flow organization of construction works production*. Moscow, ASV Publ., 2008; 118. (rus.).
12. Lebedev V.M. *System engineering of flow methods of construction*. LAP LAMBERT Academic Publishing, 2016; 248. (rus.).
13. Nguyen T.T., Dinh K. 2020. *An artificial intelligence approach for concrete hardened property estimation*. *Journal of Science and Technology in Civil Engineering (JSTCE)* — HUCE. 2020; 14(2):40-52. DOI: 10.31814/stce.nuce2020-14(2)-04
14. Waqar A., Bheel N., Tayeh B.A. *Modelling the effect of implementation of artificial intelligence powered image analysis and pattern recognition algorithms in concrete industry*. *Developments in the Built Environment*. 2024; 17:100349. DOI: 10.1016/j.dibe.2024.100349
15. Wang Q., Hussain A., Farooqi M., Deifalla A. *Artificial intelligence-based estimation of ultra-high-strength concrete's flexural property*. *Case Studies in Construction Materials*. 2022; 17:e01243. DOI: 10.1016/j.cscm.2022.e01243

Методы повышения входной мощности предприятий индустриального домостроения

Входная мощность предприятия индустриального домостроения (ДСК) отражает максимальный объем готовой строительной продукции, который предприятие способно произвести за определенный период времени. Повышать входную мощность ДСК целесообразно путем интенсификации работы его ПС. Интенсификация производства ДСК — планомерное внедрение в его практику достижений научно-технического прогресса, обуславливающее лучшее использование производственных ресурсов и рост эффективности производства. Она становится возможна при глубоком понимании работы его производственной системы (ПС) и учете ее особенностей: во-первых, из-за сложности формулирования и решения в аналитическом виде задачи принятия оптимального решения в рамках управления производством целесообразно прибегать к вариантному подходу. Данный подход предполагает использование различных стратегий и тактик управления в зависимости от конкретной ситуации, условий деятельности и целей предприятия; во-вторых, технологии производства и его материально-техническая база постоянно обновляются вслед за поступательным развитием научно-технического прогресса. Вследствие этого наблюдается появление все более совершенных форм организации и управления процессами производства, а также изменяются методы планирования бизнес-процессов предприятия; в-третьих, производственную систему ДСК необходимо анализировать системно. Системный подход к анализу производства — это методология, которая позволяет анализировать производственные процессы как единую взаимосвязанную систему, а не как набор отдельных элементов или операций. В рамках системного подхода каждый элемент производственного процесса рассматривается не сам по себе, а в контексте того, как он влияет на другие элементы и на систему в целом. Рост входной мощности при интенсификации производства ДСК различными методами, в том числе за счет повышения производительности труда, адаптивирования средств труда и правильной наладки производственных потоков, в которых достигаются специализация, пропорциональность, параллельность, прямооточность, непрерывность ритмичность и автоматизация. Это в свою очередь повышает входную мощность предприятия.

Ключевые слова: предприятия индустриального домостроения, производственная система, входная мощность, интенсификация производства, производительность труда, потенциал, поточное производство

СПИСОК ИСТОЧНИКОВ

1. Прыкин Б.В. Техничко-экономический анализ производства. 2-е изд., перераб. и доп. М. : ЮНИТИ, 2003. 475 с.
 2. Грабовый П.Г., Гребенщиков В.С. Оценка потенциальности производственной строительной системы при реализации крупных инвестиционных проектов // Недвижимость: экономика, управление. 2017. № 2. С. 76–81. URL: <https://elibrary.ru/item.asp?id=30775540>
 3. Грабовый П.Г., Жихарев Д.Ф. Производительность предприятия индустриального домостроения как главный индикатор роста потенциальности производственно-строительной системы // Недвижимость: экономика, управление. 2022. № 2. С. 11–17. DOI: 10.22337/2073-8412-2022-2-11-17
 4. Монфред Ю.Б., Прыкин Б.В. Организация, планирование и управление предприятиями стройиндустрии. М. : Стройиздат, 1989. 506 с.
 5. Родионова В.Н. Системный подход как общеметодологический принцип исследования организации производственных систем // Организатор производства. 2008. № 3 (38). С. 12–13. URL: istemnyy-podhod-kak-obshchemetodologicheskii-printsip-issledovaniya-organizatsii-proizvodstvennyh-sistem
 6. Наместникова Л.С., Пахомова А.А. Системный подход к управлению эффективностью производственных систем // Вестник Южно-Российского государственного технического университета (НПИ). Серия: Социально-экономические науки. 2016. № 3. С. 86–91. URL: <https://vestnik.npi-tu.ru/index.php/vestnikSRSTU/article/view/759760>
 7. Zhu Z., Dutta A., Dai F. Exoskeletons for manual material handling : A review and implication for construction applications // Automation in Construction. 2021. Vol. 122. P. 103493. DOI: 10.1016/j.autcon.2020.103493
 8. Golabchi A., Riahi N., Fix M., Miller L., Rouhani H., Tavakoli M. A framework for evaluation and adoption of industrial exoskeletons // Applied Ergonomics. 2023. Vol. 113. P. 104103. DOI: 10.1016/j.apergo.2023.104103
 9. Ralfs L., Hoffmann N., Glitsch U., Heinrich K., Johns J., Weidner R. Insights into evaluating and using industrial exoskeletons: Summary report, guideline, and lessons learned from the interdisciplinary project “Exo@Work” // International Journal of Industrial Ergonomics. 2023. Vol. 97. P. 103494. DOI: 10.1016/j.ergon.2023.103494
 10. Иванов А.С. Планирование и организация производства. От индустриальной экономики к экономике знаний. Москва ; Берлин : Директ-Медиа, 2016. 203 с.
 11. Науменко И.Х. Проектирование поточной организации производства строительных работ. М. : Изд-во АСВ, 2008. 118 с.
 12. Лебедев В.М. Системотехника поточных методов строительства. Saarbrücken, Germany : LAP LAMBERT Academic Publishing, 2016. 248 с.
 13. Nguyen T.T., Dinh K. An artificial intelligence approach for concrete hardened property estimation // Journal of Science and Technology in Civil Engineering (JSTCE) — HUCE. 2020. Vol. 14. Issue 2. Pp. 40–52. DOI: 10.31814/stce.nuce2020-14(2)-04
 14. Waqar A., Bheel N., Tayeh B.A. Modeling the effect of implementation of artificial intelligence powered image analysis and pattern recognition algorithms in concrete industry // Developments in the Built Environment. 2024. Vol. 17. P. 100349. DOI: 10.1016/j.dibe.2024.100349
 15. Wang Q., Hussain A., Farooqi M., Deifalla A. Artificial intelligence-based estimation of ultra-high-strength concrete's flexural property // Case Studies in Construction Materials. 2022. Vol. 17. P. e01243. DOI: 10.1016/j.cscm.2022.e01243
- Об авторе: **Спирин Александр Сергеевич** — аспирант кафедры организации строительства и управления недвижимостью; **Национальный исследовательский Московский государственный строительный университет (НИУ МГСУ)**; 129337, г. Москва, Ярославское шоссе, д. 26; Scopus: 58565475400, ResearcherID: JNE-8074-2023, ORCID: 0009-0007-1819-6477; spirincorp@yandex.ru.
- For citation: Spirin A.S. Methods of increasing the input capacity of industrial housing construction enterprises. *Real Estate: Economics, Management*. 2024; 1:47–50.
- Для цитирования: Спирин А.С. Methods of increasing the input capacity of industrial housing construction enterprises // Недвижимость: экономика, управление. 2024. № 1. С. 47–50.