Methodology for the implementation of a technological solution, taking into account the optimization of production business processes based on simulation

I I Shanin

Voronezh State University of Forestry and Technologies named after G.F. Morozov, 8, Timiryazeva St., Voronezh, 394087, Russia

E-mail: kingoao@mail.ru

Abstract. The current production activity of modern commercial organizations is focused on the use of effective technological solutions. The main goal of any commercial organization that carries out production and sales activities is the release of a certain type of industrial product that meets certain consumer and quality characteristics. Any commercial activity is focused on improving the efficiency of technological processes using rational approaches to save production resources to further maximize profits. When building a technological production chain, it is necessary to analyze production business processes, taking into account both the individual needs of consumers in industrial products and taking into account the main goal of a commercial organization, taking into account the introduction of modern technological solutions. The study proposes to introduce an effective technological solution into the production process, based on the results of simulation (for example, furniture production). Therefore, to assess the performance of technological processes and the effectiveness of the use of machinery and equipment, it is necessary to apply an approach to the implementation of an effective technological solution. For this, it becomes necessary to develop an algorithm for the implementation of an effective technological solution, taking into account the optimization of production business processes based on simulation, based on increasing the efficiency of using machines and equipment and reducing downtime in the production process chain.

1. Introduction

It should be noted that the key task of any commercial organization that produces furniture products is to improve production business processes for further development of financial and production activities. It is necessary to improve production business processes on the basis of a reorientation of production towards the transition from serial technological processes to an optimized type of furniture production. The application of this approach will improve the efficiency of production business processes and the volume of products. Simulation methodology must be applied as a key component of a lean manufacturing approach. This approach involves the improvement of technological processes, in which a number of the most frequently used assortment units of parts and furniture components must be transferred to technological processes for the production of serial furniture products and their storage in a warehouse. Rarely used parts and components used for complex design features to order must be manufactured as part of an individual technological process based on modelling.
In modern scientific literary sources, there are no unified methodological foundations that would clearly distinguish between serial technological processes and technological production processes for individual orders. Production systems of mass, batch and unit types of production characterize only a part of production business processes, which do not take into account the indicators of volumetric and production criteria, as well as the specific features of the manufacture of furniture products by commercial organizations. In this direction, the most optimal one is a scientifically grounded approach to the application of an industrial-technological method, which requires optimization of serial technological processes and production processes for individual orders, in the aggregate of a single configuration of production business processes of a commercial organization. The proposed approach to the study is based on the construction of mathematical models using simulation modelling of technological processes of production and sales of products. A single industrial method involves the manufacture of furniture products on a large scale, by freeing up resources (material, raw materials, labour).

2. Materials and methods
The research methodology was based on developments on the research topic, tested and presented in modern scientific works of researchers in the area under study. We also took into account the empirical results of practical implementation at industrial enterprises and commercial organizations of methodological approaches to assessing the applied production business processes in the financial and production environment and the possibility of improving the ongoing technological processes [1, 2].

The study used methods of simulation, computer data analysis, mathematical modelling, systemic, economic and stochastic analysis, and a graphical method.

The efficiency of the flow of production business processes of a commercial organization, including furniture, is understood as a process in which technological processes proceed according to the planned indicators and the strategy of the commercial organization. The study, among other things, used an improved method for comparing the quality of technological processes based on the reporting documentation of a furniture commercial organization. The quality category of technological processes is of a comparative nature, therefore, it is expressed in quantitative terms and is determined by the formula (1) [3, 4]:

$$ S = \sum_{i=1}^{n} T_i X_i, $$

where $T_i$ is an indicator of the quality of a separate technological process of the i-th group; $X_i$ is the value of the coefficient of significance (weight) of the i-th group of quality indicators of technological processes.

3. Results and Discussion
The result of the study is an approach to improve the efficiency of production of products on the example of furniture enterprises, which combines all the necessary elements to ensure ongoing business processes in the production system of a commercial organization. This approach makes it possible to determine the reserves for increasing the efficiency of using all available resources in financial, economic, production and technological activities, as well as to determine possible ways aimed at achieving the maximum economic effect for a commercial organization and society as a whole.

Calculations of the passage of technological processes, carried out as part of a study of the financial and production activities of furniture commercial organizations in the Voronezh region of the Russian Federation, made it possible to determine the possibility of obtaining a potential economic effect in the process of implementing the proposed approach. As indicators-indicators of technological processes, indicators were used that determine the volume of production, indicators of the efficiency of using fixed assets, and also the ratio of the turnover of working capital was calculated according to a group criterion (Table 1).
The calculations shown in Table 1 were obtained based on the results of the study based on simulation modelling of technological production processes, as part of the analysis of the indicators provided in the reporting by the enterprise-object that produces and sells furniture products [5,6].

The results of calculations of simulation modelling (Table 1) made it possible to conclude that in a commercial organization for the production and sale of furniture products due to the improvement of technological processes, based on the transition to an optimized production process, it becomes possible to increase production by 25.9%.

Table 1. Comparative values of indicators of technological processes during the transition to an optimized production process of furniture products

| Indicator name                                                                 | Serial technological processes (first condition) - S1 | Technological processes on orders (second condition) - S2 | Optimized production process (third condition) – S_{opt} | Change of the third condition in relation to the first two, % |
|--------------------------------------------------------------------------------|------------------------------------------------------|----------------------------------------------------------|----------------------------------------------------------|----------------------------------------------------------|
| Time required for processing the technological process, h                      | 27.4                                                 | 32.8                                                     | 22.7                                                     | -20.7 - first condition; -44.5 - second condition         |
| The degree of utilization of production equipment                               | 0.58-0.69                                            | 0.47-0.51                                               | 0.73-0.78                                               | 25.9 - 1st condition; 55.3 - 2nd condition               |
| (workshop for cutting materials and manufacturing of blanks, assembly workshop)|                                                      |                                                          |                                                          |                                                         |
| The value of the average stagnation time of work pieces between production units, h | 16.3                                                 | 23.1                                                     | 12.9                                                     | -20.9 - 1st condition; -44.2 - 2nd condition             |
| The value of the average stagnation time of work pieces, % of the time required for processing the technological process | 59.5                                                 | 70.4                                                     | 56.8                                                     | -2.7 - 1st condition; -13.6 - 2nd condition             |
| Average production volume per year, units.                                     | 196                                                  | 112                                                      | 334                                                      | 138 - 1st condition; 222 - 2nd condition. On average by 25.9% |

On the basis of the methodology of simulation modelling, an algorithm for introducing an approach to improving technological processes is proposed, based on increasing the efficiency of production business processes and the volume of products.

In the process of constructing the algorithm in the study, the following tasks were set: reducing labour costs in the interval of stagnation of blanks between production units; increasing the degree of utilization of production equipment (workshop for cutting materials and making blanks, assembly workshop) with the number of new orders; reducing the cost of products. To solve the set tasks, it is necessary to optimize all technological processes in general, namely, to change all time tasks and
plans, using an imitation-mathematical approach to solving the tasks, aimed at increasing the possibility of fulfilling the number of orders [7,8].

Let us suppose that the vector in the data array $\vec{A} - \text{number of orders received}$, then:

$$\vec{S} = [S_i, t_{i1}, t_{i2}, T_{i3}, T_{i4}],$$

where $S_i$ is a vector that determines a set of parameters of the $i$-th type of resources used in the technological process (raw materials, materials, components): $t_{i1}$ - time required for loading and unloading operations of the $i$-th type of resources; $t_{i2}$ - minimum time of the technological process of the $i$-th part; $T_{i3}$ - value of the average execution time of the technological process for a specific nomenclature unit of the finished product; $T_{i4}$ - value of the average execution time of the technological process for a specific nomenclature unit of blanks and furniture components.

Changing the necessary temporary tasks and plans, using a simulation-mathematical approach to solving the tasks, aimed at increasing the possibility of fulfilling the number of orders, is performed in several levels:

At the first level, orders are sorted and distributed among departments that carry out a control function in production business processes of various levels, with the determination of the lead time for a specific order in conditions of optimal planning of all necessary resources [9, 10].

At the second level, adjustments are made to planned indicators associated with the possibility of reducing the order execution in time, within the order period. It is worth considering the need to group orders to reduce the time of presence in production plans of homogeneous types of used resources by leading technological processes. The selection of the required elements of the data array $\vec{S}$ must be carried out on the basis of the following criteria:

1) Strategic lead time for one order:

$$t_{i1}^l \in [t_{i}^{left}, t_{i}^{right}],$$

where $t_{i}^{left}$ is the value of the initial (left) border of the interval for selecting the required elements of the data array for a specific order with the serial number $i$:

$$t_{i}^{left} = t_{i}^{current} + T_{i}^{mean} - T_{i}^{safety stock},$$

$t_{i}^{current}$ – value of the current lead time for one order of the $i$-th product part; $T_{i}^{mean}$ – value of the average lead time of one order of the $i$-th part of the product; $T_{i}^{safety stock}$ – value of additional time with a possible increase in the lead time of one order; $t_{i}^{right}$ – value of the final (right) border of the selection interval for the data array elements for a specific order contained in the production plan;

$$t_{i}^{right} = t_0 + T_k;$$

$t_0$ – value of the initial lead time for one order; $T_k$ – optimal planning value, minutes;

$$T_{i3}^3 < t_{i}^{mean} - t_0 + T_{i}^{safety stock}, > T_{i4},$$

where $t_{i2} > t_0$.

2) Reducing the amount of resources in warehouses and production sites:

$$RWP(t) \Leftarrow RWP_{i}^{plan}$$

where $RWP(t)$ – amount of resources in warehouses and production sites at the current $i$-th part of the product; $PRWP_{i}^{plan}$ – amount of resources in warehouses and production sites according to the plan for the production of the $i$-th part of the product;

$$P_{making} \Leftarrow p_{making}^{plan}.$$
$P_{\text{making}}$ – actual value of all necessary resources required to complete the order in fact; $P_{\text{plan}}$ – standard value of all the necessary resources required to fulfil the order according to the plan.

Figure 1 shows an algorithm for the transition from serial technological processes to an optimized type of furniture production, based on the implementation of an approach to improve technological processes, using the methodology of simulation.

![Algorithm for the transition from serial technological processes to an optimized type of furniture production](image)

**Figure 1.** Algorithm for the implementation of an approach to improve technological processes based on simulation.

The proposed approach can be applied provided that all technological processes are carried out with the full availability of the necessary equipment, human resources, raw materials and materials, production areas have an appropriate capacity and the volume of orders does not exceed the production capacity. It should be noted that the time of order receipt and the order of the technological processes do not affect the processes in the algorithm.

When carrying out the optimal planning of all the necessary resources, as the basis for the optimality criterion, it is necessary to use the value of the minimum duration of the technological process of manufacturing a product, since on its basis most of the production indicators are calculated that affect the efficiency of production business processes and the volume of products, the speed of order fulfilment.
4. Conclusion

In the course of the implementation of the mathematical approach based on simulation modeling and the proposed algorithm, the search for optimality for finding the vector for solving the problem conditions can be represented as:

\[
(G_1, S_2, S_3, \ldots, S_i, \ldots, S_n; (x_1, x_2, x_i, \ldots, x_n); (t_1, t_2, xT_3, T_4))
\]

where \(x_i\) is the simulation indicator corresponding to the technological number of the production operation, determined in the \(i\)-th by the number in the technological process, while \(n\) is the total number of products sent to production. Where \(S_i\) is the parameters of a certain type of resources used in the technological process, \(T_{3,4}\) is the value of the average execution time of the technological process for a specific nomenclature unit of the finished product and blanks and furniture components, respectively.

The result of the study at furniture enterprises was the identification of the main ineffective production business processes and the possibility of optimizing current technological processes in the context of increasing the efficiency and innovation of the production of manufactured furniture products. Based on the results of the application of the developed algorithm, it is possible to identify technological processes that require their optimization to improve production efficiency. The proposed approach allows you to optimize the use of material resources and increase the level of technological processes in modern commercial organizations engaged in the production and sale of industrial products, including furniture.

References

[1] Drapalyuk M V, Bartenev I M, Midges M A, Druchinin D Yu, Markov O B and Klubnichkin E E 2012 Mathematic model of process of giving and emission of soil by working bodies of the combined car for suppression of forest fires Polymathematic network electronic scientific magazine of the Kuban state agricultural university 84 232-246

[2] Morkovina S S, Rezanov V K, Panyavina E A and Sukhova V E 2018 Function value analysis in forestry practice Innovation Management and Education Excellence through Vision 2020 Proc. of the 31st Int. Business Information Management Association Conf. (IBIMA) vol 1 pp 4419-4425

[3] Drapalyuk M V, Bezrukova T L, Shanin I I and Bezrukov B A 2019 Methodology of probabilistic modelling of the current activity of industrial enterprises J. of Phys.: Conf. Ser. 1333 072022

[4] de Melo F, Maslennikov V V, Popova E V, Bezrukova T L and Kyksova I V 2015 Quantitative analysis in economics based on wavelet transform: a new approach Asian Social Science 20 66-73

[5] Yakovleva E A and Subkhonberdiev A Sh 2019 Implementation of "green" economy principles in the forest sector IOP Conf. Ser.: Earth Env. 392 012016

[6] Bezrukova T L, Igolkin I S, Salikov Yu A, Smolyaninova I V and Akhmedov A E 2019 Innovation approach to diversification of activities of a modern university on the basis of remote education The Int. J. of Educational Management 33(3) 486-493

[7] Morkovina S S, Drapalyuk M V, Sibiryatkina I V and Torzhkov I O 2017 Priorities of diversification in forest complex growth Proc. of the 30th Int. Business Information Management Association Conf. (ed Khalid S Soliman) vol 1 pp 2856-2862

[8] Shanin I I 2019 Modeling of technological processes at enterprises of timber processing industry IOP Conf. Ser.: Mater. Sci. Eng. 560 012042

[9] Shanin I I and Boris O A 2018 Modeling operation of mechanism of holistic management of technological processes at enterprise IOP Conf. Ser.: Mater. Sci. Eng. 327 022095

[10] Vasiltsova V M, Dyatlov S A, Vasiltsov V S, Bezrukova T L and Bezrukov B A 2015 Methodology of management innovation hypercompetition Asian Social Science 20 165-169