Managing Micrologistic System Operation Flexibility for Make to Order Manufacturing

G A Khachatryan¹, A V Kholodnova¹

¹Department of Management and Logistics, Yuri Gagarin State Technical University of Saratov, Russia
²Department of Management and Logistics, Yuri Gagarin State Technical University of Saratov, Russia

E-mail: hachatryanga68@gmail.com, XolodnovaAV@yandex.ru

Abstract. Under conditions of make to order manufacturing in the micrologistic system of the enterprise, problems arise due to inefficient use of production capacities due to irrational use of productive labor resources. In order to solve the problem of material flow parameters of logistical optimization by increasing production «flexibility» in the production chain, we propose an algorithm of operational control through redistribution of industrial labor resources of an industrial enterprise. Practical application of this algorithm allows increasing flexibility of the enterprise to meet the market demand for products on individual orders, and to increase the efficiency of its activities.

1. Introduction

Modern production is characterized by extensive use of universal equipment and flexible reconfigurable production systems, which is conditioned by changing requirements of consumers to product quality and production time. Such conditions require continuous improvement of the process of production management based on logistics, which presupposes rational distribution and movement of material, labor and other accompanying flows between the production stages of the technological process. In a random situation of incoming flow of consumer orders, the issue of organizing the movement of labor flows is very relevant, since inefficient distribution of labor resources among the production stages of the technological process leads to an increase in its duration, both for individual operations and throughout the entire production process starting from procurement and up to the stage of packaging end products.

To guarantee effective functioning of the micrologistic system, it is necessary to ensure the greatest possible flexibility of the production system, which implies the ability of the enterprise to satisfy any exceptional demands of customers.

In the course of work on the present study, we used fundamental works on logistics, i.e. works where solution of problems close to the problem under study is proposed; works related to evaluation of economic efficiency of logistic systems; works devoted to problems of economic and mathematical modeling [1-20]. Moreover, we examined works, which viewed the problem of controlling flexibility of micrologistic systems’ functioning using various sources, and proposed tools for achieving flexibility of operation of the production and logistics systems, i.e. flexibility of the machine system (flexibility of equipment), product range flexibility, technological flexibility, volume of production flexibility,
flexibility of system expansion, and system versatility [11, 16, 20].

2. Ease of use

2.1. Problem statement

We have chosen material and accompanying flows of the steel doors production enterprise as the subject of the study. The incoming order flow consists of the requirements for the production of individual products, which differ according to the following characteristics:

– affiliation to certain series (product design principle);

– affiliation to a certain model type (types of configuration and finishing within the framework of every series).

At the time of data collection, the company was producing six series of products and more than 50 models of products. The technological process of production is distributed among 12 production stages according to the type of technological operations performed, with consideration of individual specifics of production organization at the enterprise.

Features of the products’ manufacturing technology for various series and models predetermine the study's most important characteristics of the input flow, i.e. total labor intensity in man-hours. The total labor intensity is the sum total of labor-intensities of technological operations performed at individual technological stages in the process of manufacturing products of a particular type.

The list of basic models of products and their total labor intensities, as well as labor intensity for each of the technological stages are presented in Table 1.

Table 1. Labor intensities for product manufacturing.

| Series | Models | preparation | CNC | welding locks | MDF | finishing | painting | Mineral wool board | total |
|--------|--------|-------------|-----|---------------|-----|-----------|----------|--------------------|-------|
| Euro-Light | Stel 1 | 0.53 | 0.84 | 1.54 | 0.77 | 0 | 0.93 | 0.84 | 5.45 |
| Euro-Light | Stel 1+ | 0.55 | 0.84 | 1.54 | 1.03 | 0 | 0.93 | 0.95 | 5.84 |
| Euro-Light | Stel 2 | 0.52 | 0.84 | 1.54 | 0.77 | 0 | 0.93 | 1.01 | 5.61 |
| Euro-Light | Stel 2+ | 0.55 | 0.84 | 1.54 | 1.03 | 0 | 0.93 | 1.12 | 6.01 |
| Euro-Light | Stel 3 | 0.53 | 0.84 | 1.54 | 1.03 | 1.07 | 0.93 | 1.38 | 7.32 |
| Euro-Light | Stel 3+ | 0.55 | 0.84 | 1.54 | 1.03 | 1.07 | 0.93 | 1.55 | 7.51 |
| Euro-Light | Skin 1 | 0.53 | 0.84 | 1.54 | 0.77 | 0 | 0.93 | 0.89 | 5.5 |
| Euro-Light | Skin 1+ | 0.55 | 0.84 | 1.54 | 1.03 | 0 | 0.93 | 1.01 | 5.9 |
| Euro-Light | Skin 2 | 0.52 | 0.84 | 1.54 | 0.77 | 0 | 0.93 | 1.06 | 5.66 |
| Euro-Light | Skin 2+ | 0.55 | 0.84 | 1.54 | 1.03 | 0 | 0.93 | 1.18 | 6.07 |
| Euro-Light | Garant 01 | 0.55 | 0.84 | 1.54 | 2.06 | 0 | 0.93 | 1.44 | 7.36 |
| Euro-Light | Garant 02 | 0.55 | 0.84 | 1.54 | 2.06 | 1.07 | 0.93 | 1.87 | 8.86 |
| Euro-Light | Garant 03 | 0.55 | 0.84 | 1.54 | 2.06 | 2.36 | 0.77 | 2.64 | 10.76 |
| Euro-Light | Top Light | 0.53 | 0.84 | 1.54 | 1.09 | 1.07 | 0.93 | 1.61 | 7.61 |
| Euro-Light | Top Light+ | 0.53 | 0.84 | 1.54 | 0.77 | 0 | 0.93 | 0.89 | 5.5 |
| Euro-Light | Top Light 4 | 0.53 | 0.84 | 1.54 | 1.09 | 0 | 0.931 | 1.18 | 6.11 |
| Euro-Light | Top Light 4+ | 0.56 | 0.84 | 1.54 | 1.31 | 0 | 0.93 | 1.29 | 6.47 |
| Euro-Light | Premium Light | 0.53 | 0.84 | 1.54 | 1.09 | 2.34 | 0.77 | 2.38 | 9.51 |
| Euro-Light | Premium Light+ | 0.56 | 0.84 | 1.54 | 1.31 | 2.36 | 0.77 | 2.49 | 9.87 |
The data in Table 1 shows that products of different series and models have different manufacturing labor intensities, both general and by stages. Analysis of the pattern of movement and the structure of incoming orders revealed their significant irregularity, which allowed assuming the presence of the irregular nature of production capacities’ loading level in the micrologistic system, both at individual stages of the technological process and in the enterprise as a whole.

To illustrate the analysis results regarding the ratio of available production capacities to the complexity of incoming orders, we used data for the period where the volume of orders is at least sufficient to load the production. This approach is justified by the fact that during the period of orders shortage flexibility of the micrologistic system is an insignificant factor for ensuring completeness of their service. Presence of the number of orders, which is equal to or greater than the production capacity of the micrologistic system is the situation when its flexibility becomes a significant characteristic for ensuring processing of the flow of orders with the highest level of efficiency.

The analysis data regarding the ratio of available production capacities to the standard labor intensity of incoming orders for the most characteristic stages of the technological process in the period
under study are shown in the form of graphs (see Fig. 1, 2, 3, 4, 5).

**Figure 1.** Correlation between the production capacity of the «preparation» stage and labor capacity of the incoming orders.

**Figure 2.** Correlation between the production capacity of the «locks» stage and labor intensity of the incoming orders.

**Figure 3.** Correlation between the production capacity of the «MDF» stage and labor intensity of the incoming orders.
Figure 4. Correlation between the production capacity of the «welding» stage and labor intensity of the incoming orders.

Figure 5. Correlation between the production capacity of the «finishing» stage and labor intensity of the incoming orders.

The graphs above show that, based on the analysed stages, the value of the standard labor intensity for the production of received orders, as a rule, does not coincide with the value of production capacity.

Sections of the graphs of labor intensity for received orders, which are lower than the graphs of the production capacity of production stages, indicate under-loading (simple) of the production capacity at these points of time. Sections of the graphs of labor intensity for received orders, which are higher than the graphs of the production capacity of production stages, determine the volume of orders, which cannot be made on time by a certain production stage at the expense of its own resources. Quantitative estimate of the loading level of the production capacity of major stages of the technological process is given in Table 2; based on this data it can be concluded that there is an imbalance of production capacity at individual stages of the technological process.

This conclusion is based on the fact that the level of production capacities loading at different stages of the technological process varies, with the lowest production capacities loading level at the MDF stage, which is characterized by the greatest dispersion of incoming orders' labor intensity over time.
Table 2. Utilization of production capacity of «TOREX» LLC at various stages of the technological process (in per cent).

| Stage of the technological process | 1\textsuperscript{st} half of 2015 | 2\textsuperscript{nd} half of 2015 | 1\textsuperscript{st} half of 2016 | 2\textsuperscript{nd} half of 2016 | 1\textsuperscript{st} half of 2017 |
|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|
| Preparation                       | 82.1                              | 83.4                              | 86.2                              | 86.4                              | 87.7                              |
| Locks                             | 80.2                              | 81.9                              | 85.8                              | 86.3                              | 87.1                              |
| MDF                               | 40.3                              | 44.9                              | 47.4                              | 48.7                              | 50.6                              |
| Welding                           | 82.5                              | 84.9                              | 89.4                              | 90.6                              | 93.2                              |
| Finishing                         | 83.8                              | 86.4                              | 89.9                              | 91.6                              | 94.3                              |

This is happening due to the fact that this stage is mainly involved in the production of premium class products, which have a small and unevenly distributed share in the order flow.

Due to uneven distribution of the load along the stages of the technological process, over certain periods of time there is partial employment of labor resources due to the fact that there is a smaller incoming material flow into the production stage. This leads to a decrease in hourly output at the stages under study and an increase in the loss of working time. The situation is increasingly worsened due to the growing flow of demands for product manufacturing.

The uneven loading of technological process stages makes it possible to propose reasonable redistribution of labor resources from the unloaded stages to the overloaded ones.

The viability of this assumption is also confirmed by the correlation analysis of the production capacity and the labor intensity of the fulfillment of incoming orders along the micrologistic system as a whole (see Fig. 6).

![Figure 6](image)

Figure 6. Sample of uneven loading of production capacities at the «preparation» stage.

On average, the enterprise's level of production capacities' under-loading of is 6.2 %. At the same time, the volume of unprocessed orders (overload) is 3.5 % of production capacity per day.

The total loss of the micrologistic system due to the lack of effective mechanism that can provide flexibility of functioning, the lost profit inclusive of penalties for slow delivery is 19,1 thousand rubles per day or 4,83 million rubles a year.

2.2. Purpose of the study

The purpose of the study is to develop an algorithm for managing flexibility of functioning for the micro-logistic system of the make to order production. To achieve the goal we formulated the following tasks in the study:

- to determine the structure of the incoming flow of individual requirements for product manufac-
turing, which are to be produced;
- to solve the problem of rational distribution of the labor resources through their operational maneuvering among the stages of the technological process of product manufacturing;
- to develop an algorithm for increasing the adaptation of the production capacities of the micrologistic system to a random flow of incoming orders due to flexible maneuvering of labor resources.

2.3. Research methods
The research is based on statistical analysis of data related to business processes of the enterprise. We investigated the dynamics of order intake; seasonality of orders intake; loading of production capacities. We used data concerning the latest three years of enterprise's operation for our analysis.

2.4. Findings
Analysis of statistical data collected at the enterprise allowed to come to the following conclusions:
1) structure of the flow of incoming orders is non-homogeneous based on the product type;
2) values of individual general labor intensities for production of different types of products differ from each other significantly;
3) structures of labor intensities for different operations are individual and differ from each other significantly;
4) volume of incoming orders has a steady tendency towards growth;
5) flow of incoming orders quantity-wise has well-expressed seasonal fluctuations;
6) seasonal fluctuations of the incoming orders very precisely coincide with fluctuations of the major industry (construction) which is the consumer of the manufactured goods;
7) growth of the incoming orders conditions the accompanying growth of general labor intensity for such orders;
8) growth rate of the total labor intensity of incoming orders advances the growth rate of the number of incoming orders due to an increase of the average per unit labor intensity of one product;
9) there are certain types of work at the stages of technological process, where the growth rate of labor intensity differs from the growth rate of total labor intensity;
10) dynamic series of labor intensity at different stages of production, growth rate of which differs from the growth rate of the total labor intensity, have the largest range of variations;
11) heterogeneity of the flow of incoming orders for various types of products and the structure of work performed causes significant fluctuations in the per unit labor intensity of work performed at different stages of the technological process;
12) heterogeneity of the structure of incoming orders for products causes uneven distribution of the total labor intensity among the stages of technological process, which, in turn, is the reason for uneven loading of production capacities of the technological process stages;
13) order flow under study can be recognized as a flow with random demand for products;
14) actual structure of the order flow requires development of the management system that ensures balance of capacity utilization of technological process stages as well as qualitative and quantitative flexibility of production.

To increase functioning flexibility of the micrologistic system of an industrial make to order enterprise, we propose an algorithm for adapting production capacities of the micrologistic system to a random flow of incoming orders, i.e. to conditions of unstable demand.

The algorithm for ensuring balance of the incoming orders flow and total production capacity of the micrologistic system according to the total labor intensity can be represented in the form of the following enlarged scheme (see Fig. 7). Its structure includes the system for assessing the workload of the enterprise (1) and the model of incoming orders ranking (2).
Figure 7. Enlarged scheme of the algorithm for balancing the random flow of incoming orders and production capacities of the micrologistic system.

1. System of enterprise’s workload assessment presupposes calculation of the following parameters:

1.1. Enterprise’s workload coefficient:

\[ K^e = \frac{\sum_{i} \sum_{j} (Q^i_j \cdot T^i_j)}{\sum_{i} P^i_i}, \]  

(1)

where

- \( \sum_{i} \sum_{j} (Q^i_j \cdot T^i_j) \) – is the total capacity of the declared normative labor intensity of the order flow over period \( \tau \), man hours;
- \( J \) – current number of the order type;
- \( J \) – number of order types;
- \( \tau \) – number of analyzed period;
- \( i \) – stage (operation) of the technological process number;
- \( I \) – number of stages (operations) of the technological process;
- \( Q^i_j \) – flow capacity of the \( j \)-type of orders over period \( \tau \), units;
- \( P^i_i \) – industrial capacity (productivity) of the i-stage, which performs a certain operation of the technological process over analyzed period \( \tau \), man hours.

Industrial stage \( P^i_i \) capacity:

\[ P^i_i = \sum_{k=1}^{K} V^i_{k} \],

(2)

where

- \( V^i_{k} \) – is normative industrial capacity of the machine of a certain type at an i-stage of the technological process, man hours;
- \( \kappa \) – number (type) of machine;
- \( K \) – number of machines of the
1.2. Coefficient of stage loading:

\[
E_{\tau} = \frac{\sum_{j=1}^{J} (Q_j^\tau \cdot T_j^\tau)}{P_i^\tau},
\]

where \( \sum_{j=1}^{J} (Q_j^\tau \cdot T_j^\tau) \) is the general demand for operations of the i-type for the incoming flow of orders over the analysed period \( \tau \), or the required power of the i-stage over period \( \tau \), man hours; \( Q_j^\tau \) – is normative labor intensity of the operation (at i-stage), which can satisfy the j-type of demand at an i-stage, man hours.

2. To compile an operational production plan, we need to form the flow of proposals, which are to be included into the plan. To this end, a ranking model of incoming orders is proposed, which assigns private and full ranks to candidate orders for inclusion in the production queue. The priority function for period \( \tau \) is calculated as the sum of the product's normative profit and penalties:

\[
E_{\tau} = I_j + C_j
\]

where \( I_j \) is the sum of profit within the price of the product (profitability of j-th product); \( C_j \) – sum of penalties from an individual customer ordering a production batch of j products for non-fulfillment of the terms of the contract regarding the delivery term and other factors.

Based on the value of this function, products in the queue are ranked. Based on the product rank, decisions are made regarding their further progress along the production cycle. The higher the value of the priority function, the more preferable is the product’s progress in the wait line for production. The priority function reflects, on the one hand, the economic interest to receive a bigger profit from product manufacturing, on the other hand, it helps to reduce penalties due to nonfulfillment of the contract terms.

The wait queue can contain both batches and individual products, the production of which can be delayed indefinitely according to the algorithm decision. To prevent this, it is necessary to evaluate these orders using a full priority function, which also takes into account storage costs for already manufactured products from the "broken" batches.

The full priority function at the point of time \( \tau \) is calculated as follows:

\[
\hat{E}_{\tau} = \hat{E}_{\tau} + \frac{\left( \sum_{j=1}^{J} C_{\tau,j} \right) \cdot \Delta t}{J_{\tau,e}},
\]

where \( \hat{E}_{\tau} \) – is the priority function over period \( \tau \); \( \sum_{j=1}^{J} C_{\tau,j} \) – storage and part of the “broken batch” order processing expenses, in RUR.; \( J_{\tau,e} = J - J_{\tau,b} \) – is the size of the “waiting” batch, in units; \( J_{\tau,b} \) – is the size of the “broken” batch, in units; \( \Delta t \) – number of waiting days, in days.

Having evaluated the priority function for all products in the wait queue and the products that were “broken off” from their batches, we can form the corrected list of products, which are excluded from the compiled operational production plan for the product flow production for a current period.

Analysis of labor distribution for the orders takes by the micrologistic system for different stages of the technological process (see Fig. 8).
Figure 8. Enlarged scheme of analysis for distribution of the labor capacity for the flow of incoming orders taken to production by the micrologistic order system for various stages of the technological process.

The algorithm for solving the problem of free resources distribution between donor-stages and acceptor-stages makes up the deficit of production capacities and provides for achievement of more balanced loading of the stages of technological process.

Here is the economic and mathematical model and algorithm for solving the problem of redistribution of "excess" labor resources among the stages of technological process that are experiencing deficit:

1) a number of labor resources, which equals the deficit of labor resources at acceptor-stage \( aj \) has to be moved to \( j \) acceptor-stage from all \( i-x \) donor-stages:

\[
\sum_{i=x}^{N} x_{ij} = a_j, \; j = 1, 2, ..., N
\]  \hspace{1cm} (6)

2) the number of labor resources, which equals their excess at donor-stage \( bi \) has to be moved from \( i \) donor-stage to all \( j \) acceptor-stages:

\[
\sum_{i=x}^{N} x_{ij} = b_i, \; j = 1, 2, ..., M
\]  \hspace{1cm} (7)

3) at that, the general productivity of the moved labor resources at the new places has to be maximal:

\[
\sum_{i=x}^{M} \sum_{j=1}^{N} (C_{ij} \cdot x_{ij}) \rightarrow \max
\]  \hspace{1cm} (8)

4) conformity of the incoming flow of orders accepted by the micrologistic system for production with the production capacities of the micrologistic system achieved at the first stage of the algorithm’s implementation provides for the balance:

\[
\sum_{i=x}^{M} b_i = \sum_{j=1}^{N} a_j
\]  \hspace{1cm} (9)

5) economic content of variables imposes the following restrictions on their values:

\[-a_j \geq 0; \; -b_j \geq 0; \; -C_{ij} \geq 0; \; -x_{ij} \geq 0; \; -C_{ij} = C_{ji} = 0\]  \hspace{1cm} (9)
The problem turns into a type of the linear programming transportation problem (Table 3) and can be solved by any of the known methods.

**Table 3.** The donor-acceptor matrix of labor resources distribution among stages of the technological process.

| Stages-Acceptors | Donor-stages | Deficit of production capacities |
|------------------|--------------|---------------------------------|
|                  | $B_1$        | $B_2$                           |
|                  | $\ldots$     | $B_i$                           |
|                  | $\ldots$     | $\ldots$                        |
|                  | $B_M$        |                                 |
|                  | $\hat{A}_1$  | $\hat{N}_{11}$                 |
|                  | $\hat{A}_2$  | $\hat{N}_{12}$                 |
|                  | $\ldots$     | $\hat{N}_{i1}$                 |
|                  | $\ldots$     | $\ldots$                       |
|                  | $\hat{A}_j$  | $C_{j1}$                       |
|                  | $\hat{A}_N$  | $C_{N1}$                       |
|                  |               |                                 |
| Excess of produc- | $b_1$        | $b_2$                           |
| tion capacities   | $\ldots$     | $\ldots$                       |
|                   | $b_j$        | $\ldots$                       |
|                   | $\ldots$     | $\ldots$                       |
|                   | $b_M$        | $\sum_{j=1}^{M} b_j = \sum_{j=1}^{N} a_j$ |

Thus, in the course of practical application of the developed algorithm at an industrial enterprise, it becomes possible to do the following:

- reduce the losses of the micrologistic system as a result of ranking the flow of incoming orders and priority production of orders with the highest rank;
- increase the productivity of labor resources;
- increase the volume of orders accepted for production;
- shorten the production terms.

3. Discussion

One of the central problems of logistics efficiency is the problem of reducing the level of stocks when delivering goods "just in time." It is estimated that the size of “dead” capital, which is kept in reserve is over one-third. Maintenance of stocks requires 20-40% of all expenses of the consumer, including expenses for transportation and warehouse operations. As a result of the implementation of the logistics principles, the delivery time of Citroen cars to its customers had been reduced from 53 days in 1985 to 25 days in the year 1990. The need for warehouse space and the cost of cargo operations decreased by 50%. In addition, equipment productivity increased by 25% due to reduction in the volume of goods processing [10, 11]. Implementing the “just in time” principle, Citroen ensures the delivery of materials within an hour interval of their planned arrival.

Analysis of more than 80 firms in the Federal Republic of Germany showed that with the use of the Kanban system, production reserves are on average reduced by 50%, labor productivity increased by 20-50%. For example, in the course of implementation of the “just in time” delivery principle the supplies of materials in the German car industry, which has a cost of 15 billion DM, are reduced by 4 times. The use of this principle at Audi plants has reduced the need for warehouse space by 80%, and the cost of handling operations by 15% [10, 17].

According to experts, use of informatics in the field of goods circulation control raises the level and quality of services in 43-45% of the cases and reduces distribution costs in 40% of the cases. Logistics costs account for 10 to 30% of the total company’s costs spent of product manufacturing [19, 20].

If the logistics expenses are 100%, individual components are distributed as follows: transportation 20-48%, storage handling operations and storage of goods 25-46%, packaging 5-18%, management 4-15%, others, including order processing, 5-17% [19-21].

According to statistics (analytical reviews of the American Production and Inventory Control Society) and the Handbook of Material Capacity Requirements by Howard W. Oden, McGrown Hill Inc., implementation of the modern logistical system can have the following effect (Table 4).
Introduction of the developed algorithm at the enterprise under study made it possible in practice to prove the possibility of more efficient use of production capacities through redistribution of productive labor resources.

Table 4. Effect from implementation of logistical systems.

| Parameter                                      | Average by industry branches |
|------------------------------------------------|-----------------------------|
| Increase in stocks turnover                    | +65%                        |
| Increase in just-in-time supplies              | +80%                        |
| Reduction of manufacturing defects             | -35%                        |
| Reduction of delays in dispatch of finished products | -45%                        |
| Elimination of manual preparation and document maintenance | + 90%                        |

The results are as follows.

1. As a result of ranking the incoming orders and priority processing of orders with the highest rank, the losses of the micrologistic system related to demands satisfaction failure decreased by 3.2%.

2. As a result of redistribution of free production capacities we observed the increase of efficiency of their utilization by 6.2%.

3. The designed economic and mathematical model for solving the problem of logistic labor resources maneuvering at an industrial enterprise was developed as a result of scientific study of the production stages of a large industrial metal doors production enterprise.

4. Conclusion

In the course of the study we identified problems concerning balancing of the labor force's load with the flow of incoming orders at various stages of the technological process at the make-to-order enterprise that produces products according to individual requirements of its customers. The imbalance of the load was caused by the unevenness of the flow of incoming orders, according to both its qualitative and quantitative characteristics, which is conditioned by different labor intensity for each technological operation and each product as well. This problem was especially significant during the periods of seasonal fluctuations, when the number of incoming orders dropped or increased dramatically, thereby causing sharp fluctuations in the total daily labor intensity for meeting the individual requirements of customers.

To ensure balanced loading of labor resources at different stages of technological process, we carried out comparative analysis of production capacity of the enterprise as a whole, of each technological stage separately, and of the capacity of the incoming flow of individual customer requirements. As a result of this analysis, we identified 12 stages of the technological process with a total of 200 workers, which are faced with deficit or excess of labor resources. The number of stages with a shortage of labor resources was 5. The deficit was about 30% (22 people). The number of stages with excess labor resources was 8, where 43% (52 people) of the total number of workers were not loaded.

The process of analyzing distribution of labor intensity for the company's orders made it possible to form the "donor-acceptor" matrix for allocation of labor resources among the stages of technological process, which allowed to provide for stages with shortage of labor resources, and, thus, to balance the load distribution among the stages of technological process, which resulted in reduction of losses of the enterprise due to failure to satisfy the requirements of capacities and meet the general term of order manufacturing and increase the efficiency of the production capacity use. As a result of redistribution of labor resources, effectiveness of work of stages with deficit increased by an average of 22%.

Introduction of the developed algorithm into the work of the industrial make-to-order enterprise will reduce the losses of the micro-logistic system and save it from disrupting satisfaction of the capacities' requirements and total production lead-time; it will increase the efficiency of production capacities utilization, which is expressed in the increase in labor productivity by 15.4% and reduction in
losses on the whole by 10.2%.

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Acknowledgments

The authors of the article would like to express special gratitude to the founder of Torex LLC Mr Sedov Igor Vasilevich for his support in conducting this research; head of the Information Technology and Industrial Logistics Service of Torex LLC, Mr Alexeyev Vladimir Lvovich. The authors of the article also express their gratitude to Doctor of Economic Sciences, Professor Sankov Victor Grigorievich.