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Ways to improve logistics system of the company

Metody doskonalenia systemu logistycznego przedsiębiorstwa

Abstract. The article deals with the ways of improving automotive enterprise logistics system by the improving the process of aggregate-module assembly according to the operating conditions of domestic automotive enterprises, taking into account the optimal number of assembly operations on the main conveyor and structured system suppliers, which help to increase output by reducing the duration of the production cycle of car assembly and increasingits productivity. In particular, the mechanism of improving the logistics system of automotive enterprises from domestic reserves, consisting of scientific and methodological, regulatory and contracting, technical and technological, organizational and economic components, logistics and evaluation of the effectiveness of the proposed measures are grounded in the article. Based on the characteristics of automotive companies in Ukraine was formed phase of transformation of the logistics system, which is logistics-oriented for the consumer, and was developed and adapted for today's conceptual approach to the management and planning of the logistics system of automotive enterprise,based on the principles of flexible production concept.

Key words: logistics, logistics system, automotive enterprise, mechanism, transformation of the logistics system, management, consumer

Synopsis. W artykule są rozpatrywane metody doskonalenia systemu logistycznego zakładów samochodowych na drodze doskonalenia procesu montażu agregatowo-modułowgo zgodnie z warunkami funkcjonowania krajowych zakładów samochodowych, z uwzględnieniem optymalnej liczby czynności montażowych na linii głównej i strukturyzowanego systemu dostawców, co sprzyja zwiększeniu zakresu produkcji poprzez skrócenie czasu trwania cyklu produkcyjnego montażu samochodów i podniesieniu wydajności. W szczególności w artykule uzasadniany jest mechanizm doskonalenia systemu logistycznego zakładów samochodowych kosztem wykorzystania rezerw wewnętrznych, do których należą komponenty naukowo-metodyczne, regulacyjne i umowne, techniczno-technologiczne i organizacyjno-gospodarcze, logistyka i oszacowanie skuteczności zaproponowanych przedsięwzięć. Na podstawie charakterystyk zakładów samochodowych Ukrainy został

sformowany etap transformacji systemu logistycznego zorientowany logistycznie na odbiorcę. Również zostało opracowane i przystosowane do współczesnych warunków podejście konceptualne do zarządzania i planowania systemu logistycznego produkcji samochodów z uwzględnieniem zasad koncepcji elastycznego systemu produkcji.

Słowa kluczowe: logistyka, system logistyczny, zakłady samochodowe, mechanizm, transformacja systemu logistycznego, zarządzanie, odbiorca

Introduction

Management schemes formed in Ukrainian automobile manufacturing companies provide ample opportunities for application of logistics practice with the purpose of electing business functioning patterns, expansion of influence areas and profitability improvement among variety of the possible most favourable ways. Mode and principles of activities of enterprises require implementation of logistic concepts with consideration of results of contemporary studies and analysis of market segments. Nevertheless, implementation of any contemporary approach of the logistics system management of an enterprise is encumbered by poor conceptual and methodical substantiation, as well as by insufficient adaptation level of practice and theory of logistic system creation to the conditions of today's automobile manufacturing.

The necessity of enhancing elaborations, implementing and applying the logistic concept in any production processes is demonstrated by works of such scientists as A.U. Albekov, B.A. Anikin, O.V. Arefieva, S.O. Arefiev, V.I. Berezhna, A.M. Gadzhynskyi, A. Yu. Yermakov, L.V. Zaburanna, A.G. Kalchenko, O.I. Klevlin. O.O. Kolobova, V.V. Kryveshchenko, I.M. Ktridych, D.D. Kostoglodova, N.K. Moisieieva, I.I. Savvidi, V.N. Stakhanov, Ye. V. Krykavskyi, R.R Larina, I.A. Lenshyn, I.M. Omelchenko, T.V. Sarycheva, Yu. I. Smolniakov, L.B. Mirotin, I.E. Tashbaiev, Yu. M. Nerush, M.A. Oklander. O.P. Khromov, Yu. V. Ponomarieva, A.N. Rodnikov, V.I. Sergeiev, L.E Khazanova, Kh.A. Faskhiev, N.B. Filipov and wester scientists such as Donald G. Bauersocks, David G. Kloss, G.R. Stock, D.M. Lambert, G. Coil, E. Bardi, S. Langley.

The aim and methods

Structure of the aggregate-modular assembly process conforming to functioning conditions of domestic automobile manufacturing enterprises is analysed with consideration of optimal number of assembly operations at the main conveyor and with consideration of structured system of suppliers; unlike the existing pattern, such structure is conducive to the production output increase owing to curtailment of duration of useful part in any automobile assembly production cycle and improvement of labour productivity resulting from reduction of the labour inputs.

Scientific elaborations of domestic and foreign scientists in the field of logistics, marketing, management and information technologies have been used as the theoretical and methodological basis to perform this research. To acquire information and to obtain and process the study results, the system of scientific research methods has been applied such

as systemic analysis for the logistics system perscrutation; methods of grouping, selective studies, questioning for appraisal of the logistics system conditions in automobile manufacturing enterprises; comparative and economic analysis for appraisal of economic and logistic activities of automobile manufacturing enterprises; expert evaluation method was used in the course of logistics system diagnostics, appraisal of production systems, quality of automobile production process, logistics service; computer technologies have been applied to process the completed research results.

Information basis of the research was formed by official data obtained from the State Statistics Service of Ukraine, Association of Automobile Manufacturers of Ukraine, financial statements of automobile manufacturing enterprises, legislative and regulatory acts of Ukraine, theoretical provisions elaborated by domestic and foreign scientists in respect of the problems related to theory and practice of management of logistic activities of enterprises, management, organisation and development of automobile manufacturing industries, materials of own study of production processes employed by automobile manufacturing enterprises.

The main material research

Efficient usage of production facilities is determined not only by saving working hours and increasing the added value, but also by the increase rate of said parameters [Bowersox and Closs 2008].

Thus, we may assert that the entire production result caused by application of the production facilities depends mainly on how their application is organised [Zaburanna and Hluschenko 2011].

Since production organisation is a system of organisation of such production elements as production (process) cycle, labour organisation and management organisation, the following items may be deemed to have been the sources of efficiency improvement:

- Increase of equipment productivity.
- Improvement of the production process allowing us to curtail the time of influence over a subject of labour in the course of its transformation from material to a product.

Any increase in production output owing to curtailment of the time required for conveyed assembly of an automobile is one among components of the economic benefits caused by implementation of principles of a flexible production concept. Prime cost and price of an automobile, its market success and financial success of the enterprise will depend on the production process perfectness.

Analysis of practical experience of conveyor operations at CJSC *ZAZ* has demonstrated that the concurrent mode of assembly operations is used in the production process: the conveyer has 140 (including 123 in the course of assembly) rigidly fixed mounting devices to suspend automobiles in-line [Glushchenko 2012b].

Analysis of the production process has also determined absence of any model determining the production cycle duration at such a conveyor. Therefore, we have adopted the following formulas and particular values for usage as characterising the in-line assembly process:

1) Duration of the production cycle at 1 line is 5 hours 24 minutes (324 minutes); assembly time step at 1 line is 1 minute 8 seconds (1.13 minutes); production output from one line during a day (2 shifts) is 742 units or 371 units per shift; duration of one shift is 8 hours (480) minutes; dinner hour duration is 48 minutes;
2) Concurrency coefficient

$$K_{pap} = \frac{T_c^i}{T_{c.seq}} \tag{1}$$

where:
T_c^i – stands for the production cycle duration for concurrent or concurrent-sequential movement of details in the course of their production;
$T_{c.seq}$ – stands for the production cycle duration for sequential movement of details in the course of their production;

3) Time step of the line (r) means the interval between sequential output of two articles of the same description

$$r = \frac{F_d \cdot 60}{N_l} \tag{2}$$

where:
F_d – stands for actual working time fund in hours equal to the difference between the efficient working time fund and specified losses of it;
N_l – stands for the programme for launch of an article into production;

4) Conveyor spacing (l) means the distance between centres of two neighbouring work places (6 m);
5) Conveyor length (L) is 738 m

$$L = l \cdot C_i \tag{3}$$

where:
l – stands for the conveyor spacing (m);
C_i – stands for the required number of machines (number of mounting devices at the conveyor in our case);

6) Production cycle duration

$$T_c = T_{usf} + T_{int} \tag{4}$$

where:
T_c – stands for the production cycle duration (minutes);
T_{usf} – stands for useful portion of the production cycle (processing time, prepration time, time for control, transport, packing) (minutes);
T_{int} – stands for idle time (between operations, between shifts) (minutes) [Kondratiuk, Vikarchuk, Gerasymchuk 2009].

Aggregation of the assembly process at an automobile manufacturing enterprise is a complicated multistage process.It is clear that any parts and details that shall be detached and removed from the assembly departments gradually. If that is the case, prioritization of parts and details to be so detached and delivered first shall be the task.

With this end in view, we have devised an economic-mathematical model describing formation process of component batches to be transferred to suppliers with the main task of such model being in determination of the transferring sequence of various automobile components from the lower production tier to suppliers.

To devise the economic-mathematical substantiation, we have taken the following assumptions [Glushchenko 2012a]:

1) We have detached T_{usf} from $T_c = T_{usf} + T_{int}$ formula (4), since idle time does not influence over the curtailment of any assembly operations;
2) In our model, we assume $T_{usf} = T_c$; considering composition of T_{usf} and peculiarities of the in-line assembly process, we shall represent the useful duration of production cycle for assembling automobiles at 1 line T_c as a sum of operations related to assembling with consideration of the concurrence coefficient;
3) Curtailment of the production cycle duration and switchover to principles of aggregate-modular assembly is possible in two ways;
4) Detachment and transfer to suppliers of the 1st tier of complexes of assembly operations that are performed at the main conveyor directly;
5) Transfer to suppliers of the 2nd and other tiers in the production of automobile components that are assembled today in the mechanical assembly departments of the automobile manufacturing enterprise.

The above-mentioned ways leading to improvement of the conveyor capacity can be used as individually so concurrently; it is quite clear that the last version will be more effective.The economic-mathematical substantiation of this model is based on the principle of detachment of an automobile component with the longest assembly time.

Process of detaching operations at CJSC *ZAZ* is based on the principle of transferring production of automobile components for models that are on the latest life cycles of the commodity to suppliers. This process is applicable only to automobile components that are assembled at mechanical assembly productions (MAP) and are not linked to the aggregation processes in automobile assembling process (Table 1).

Our model allows us to aggregate the assembly process not for automobiles only, but also for package units in the mechanical assembly production (MAP). The first process is the most effective since it allows us to increase the conveyor capacity and number of automobiles that are assembled.

First stages of the algorithm are of preparatory nature. Main task of these stages is to form a list of components to be transferred to component item suppliers in the mechanical assembly production based on analysis of the composition and labour inputs within the scopes of running production processes of automobile assembling and assemblage of components in the mechanical assembly production i.e. acquisition of source data for further analysis.

As a matter of fact, formation of the list of automobile components to be detached is based on data of analysis to be carried out at the preceding stage and on the practical experience in implementation of the aggregated assembly [Nayanzin 2006]. The list so

Table 1. Advantages of the author's model over the existing system
Tabela 1. Przewagi autorskiego modelu nad istniejącym systemem

Criterion	Author's algorithm	Existing system
Purpose	Increase of scope and improvement of diversity of manufactured products; improvement of assembly quality and labour conditions	Vacation of floor space that may be used for deployment of production of new automobile components for new automobile models
Principle	It works based on the principle of detachment of assembly operations of automobile component with the longest manufacture time.	It works based on the principle of transferring manufacture of automobile components for outdated automobile models to suppliers.
Opportunities	It allows us to aggregate to assembly process as in mechanical assembly production, so at the main conveyor.	It does not provide for any aggregation in automobile assembling

Source: overview of the authors based on their own research.

obtained may be divided into two subgroups. The first subgroup shall include assembly operations to be removed from the main conveyor, while the second group shall include assembly operations of components to be removed from the conveyor of the mechanical assembly production (in future, we recommend considering the process of aggregation of assembly operations in the mechanical assembly production from the viewpoint of the main conveyor aggregation).

Thus, let us consider economic-mathematical tools in terms of the above-explained algorithm.

Third step of the algorithm is in calculating duration of the automobile assembly cycle within the framework of available production process; such calculation shall be made with the formula:

$$T_c = k\sum_{n=l}^{N} t_n \tag{5}$$

where:
T_c – stands for useful duration of the automobile assembling cycle in-line prior to production process reforming (minutes);
k – stands for concurrency coefficient for automobile assembling operations;
t_n – stands for duration of *nth* operation of automobile assembling (minutes);
N – stands for the number of operations required to assemble an automobile;

Calculation of the duration of the cycle of operations to be removed T_{ci} at the fourth stage shall be made with the formula:

$$T_{ci} = k\sum_{i=l}^{l} t_i^v \tag{6}$$

where:
T_{ci} – stands for useful duration of the part assembly cycle to be removed;
t_i^v – stands for the number of *ith* operations in the assembly part to be removed;
l – stands for the number of operations to be removed from the main conveyor when manufacture of *ith* part is transferred to suppliers.

Calculation of duration of the automobile assembling cycle T'_{ci} after removal of *ith*-group of operations from the main conveyor (the fifth algorithm step) shall be made with the formula:

$$T'_{ci} = T_c - T_{ci}$$
$$T'_{ci} = k\left(\sum_{n=l}^{N} t_n - \sum_{i=l}^{l} t_i^v\right) \quad (7)$$

where: T'_{ci} – stands for useful duration of the automobile assembling cycle at automobile manufacturing enterprises after removal of *ith* group of operations from the main conveyor.

Purpose of the six algorithm step is to calculate the duration of operations aimed at installation of so removed part with the following calculations:

$$T_c^u = k\sum_{a=l}^{A} t_a^u \quad (8)$$

where:

T_c^u – stands for useful duration of the installation of finished part in-line;

t_a^u – stands for duration of *ath* operation aimed at installation of the finished previously removed part in-line;

A – stands for the number of operations related to installation of such finished part.

Calculation of automobile assembling cycle duration after removal and installation of assembly components is the task of the seventh step. Below we produce the formula for this step:

$$T_c^{new} = T'_{ci} + T_c^u = k\left(\sum_{n=l}^{N} t_n - \sum_{a=l}^{A} t_a^u\right) \quad (9)$$

where: T_c^{new} – stands for the duration of the assembly cycle after removal and installation of the assembly components.

The eighth step is the final stage of the algorithm. Main task of this step is in determining the high priority parts to be transferred to suppliers; such determination shall be made by arranging obtained values ΔT in the descending order of priority. To achieve this, changes in duration of cycle ΔT owing to the removal of *ith* group of assembly operations shall be calculated:

$$\Delta T = T_c - T_c^{new} \quad (10)$$

where: ΔT – stands for changes in the automobile assembling cycle duration after removal of *lth* group of assembly operations;

$$\Delta T = k\left(\sum_{s=l}^{l} t_i^v - \sum_{a=l}^{A} t_a^u\right) \quad (11)$$

Further, it is necessary to elect *ith*part, removal of which from the conveyor shall give maximum ΔT value. Just this part shall have the top priority to aggregate the assembly process; it must be transferred to suppliers of lower tier for manufacture first of all.

Effects to be obtained by the enterprise as a result of implementing the aggregate-modular assembly are:

1) Increase of production output to be obtained as a result of curtailment of the duration of useful part of automobile assembling production cycle;

2) Increase of profits to be earned owing to realisation of additional production volume;
3) Improvement of the labour productivity to be achieved owing to reduction of labour inputs to assembly process and increase of production volume.

Thus, the assembly scheme resulting from implementation of the aggregate-modular assembly in the production shall be outlined as follows (Fig. 1).

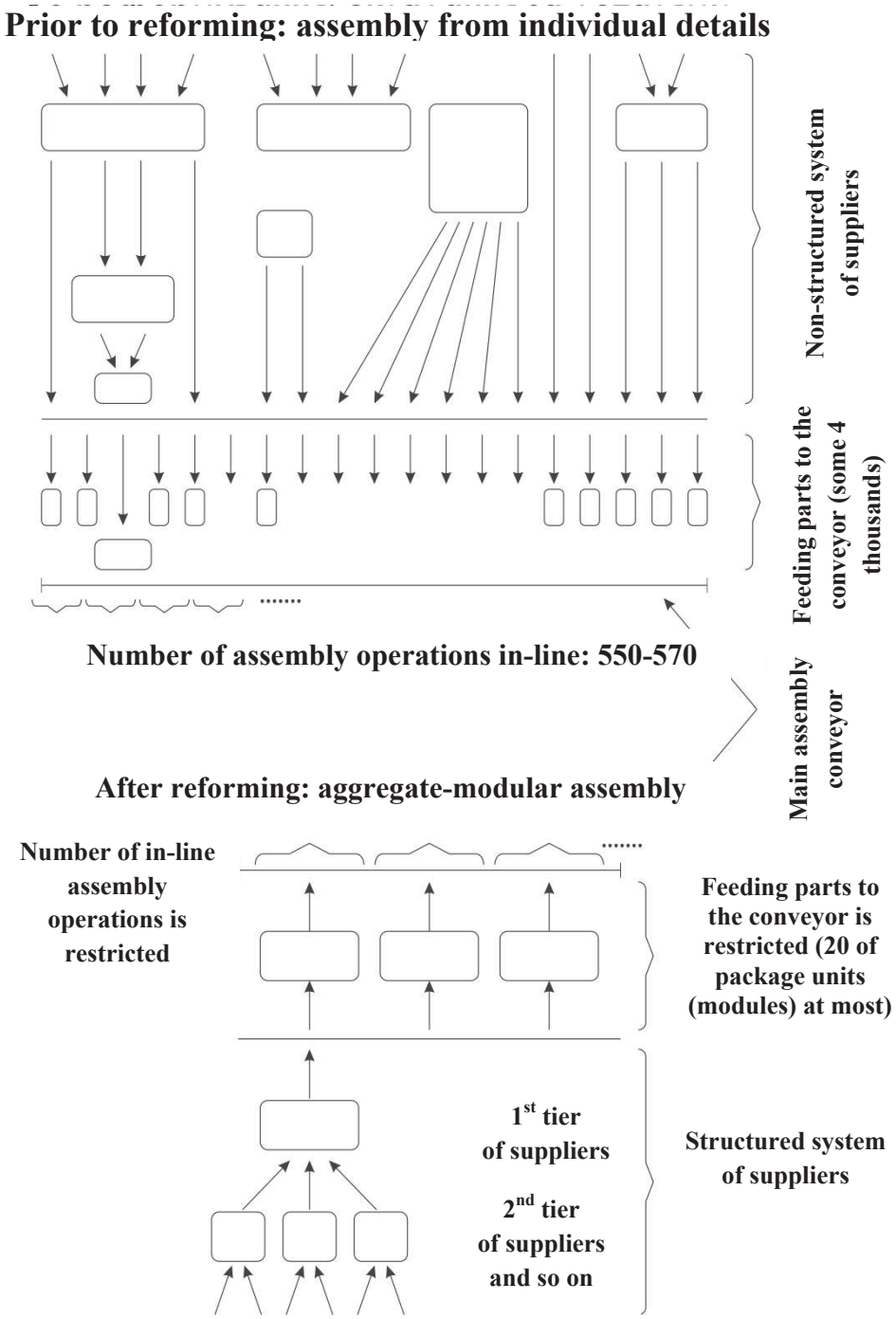

Figure 1. Automobile assembling scheme prior to and after reforming logistics system of the enterprise

Rysunek 1. Schemat montażu samochodów przed i po zreformowaniu systemu logistycznego przedsiębiorstwa

Source: own development of the author.

After elaboration of our model for improvement of the company's logistic system, its economic efficiency must be verified. Calculation of parameters characterising efficiency of the offered model is given in Table 2.

Table 2. Procedure for calculation of parameters reflecting effects caused by removal of the door assembly operations

Tabela 2. Procedura obliczania parametrów odzwierciedlających skutki spowodowane usunięciem operacji montażu drzwi

Conventional notations	Parameter description and calculation procedure	Meas. unit	Parameter value
T_c	Duration of the assembly production cycle at 1 conveyor line without consideration of work concurrency	minutes	720
W	Design capacity of the production	pcs.	365 000
α	Share of models assembled at conveyor line in the total production output of the enterprise	%	21.2
N_{output}	Production volume of models at the enterprise $N_{output} = W \cdot \alpha$	pcs.	77 380
T_{ci}	Duration of side door assembly operation (87.14·2)	minutes	174.28
T'_{ci}	Duration of operations after removal of the side door assembly operation	minutes	545.72
T_c^u	Duration of fastening operation of finished side doors	minutes	14
T_c^{new}	Production cycle duration after removal and fastening the finished part	minutes	559.72
N_{output}^{new}	Production output of automobiles assembled at 1 conveyor line after production process reforming	pcs.	99 488
ΔN_{output}	Increment of production output of models assembled at 1 conveyor line $N_{output}\left(\frac{T_c}{T_c^{new}} - l\right)$	pcs.	22 108
P_{av}	Average profits earned owing to sale of an automobile	UAH	3 720
P_y	Annual profit earned owing to realisation of said increased output: $P_y = \Delta N_{output} \cdot P_{av}$	Thousand UAH	82.2
Production output for all models after the production process reforming (99488/0.212)		pcs.	469 283
Labour inputs to manufacture of an automobile calculated using the production capacity of 365 000 (210 days · 16 hours · 45 000 persons (workers)/ 365 000		Man hours per 1 automobile	414
Labour inputs to manufacture of an automobile calculated using the increase output of 469 283 pcs. (210 days · 16 hours · 45 000 persons (workers)/469 283)		Man hours per 1 automobile	322
Reduction of labour inputs to manufacture of an automobile resulting from the removal of door assembly operations (414–322)		Man hours per 1 automobile	92

Source: own author work.

Aggregate-modular assembly of automobiles shall allow us to implement the synchronised feeding of component items to the main conveyor. It is caused by the fact that a restricted number of automobile package items must be fed to the assembly conveyor. The process of synchronised feeding of component items and delivery of the automobile body to assembly operation is of great economic significance, since warehouse areas occupied with details and articles are curtailed, the working space are being cleaned up, regularity of the pace of production processes is raised and the like.

Summary

A structural-logical scheme of optimisation of the automobile assembling planning system is elaborated thus allowing us to proceed to a new level of production planning quality. The planning system is based on the planning centre operation aimed at detailed data processing followed by sending the data with instantiation as of deadlines, models, modifications, delivery sets, additional individualising parameters to the planning centres of suppliers and structural units, which in turn, based on the aforesaid data, shall elaborate own production schedules and commence manufacturing details and then modules and package units for the main conveyor. The offered planning system is organised on the 'pulling-out' principle and demonstrates that the production pace, scope and nomenclature of details and parts in the production is determined not by the procurement structural unit, but by the output line of final processing.

Optimisation algorithm for duration of assembly processes is offered with the purpose of realising new concepts of management and planning for the productive-logistics system in the automobile production. Curtailment of the total time required to manufacture an automobile is the main optimisation criterion here.

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