

REDUCTION OF WASTE THROUGH REORGANIZATION OF THE COMPONENT SHIPMENT LOGISTICS

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Abstract: This paper analyses the operation of a company from the automotive industry in terms of the identification of waste in the production process. The aim of this study was to develop methods for eliminating the sources of waste, i.e. extensive work-in-progress inventories. There was used the Value Stream Mapping (VSM) method. It allowed finding sources of waste and enabled an analysis of the process. The VSM method allows observing processes exactly as they are, thanks to which it is possible to identify the actual problems occurring in them.

Paper type: Case Study

Published online: 30 April 2017

Vol. 7, No. 2, pp. 77–90

DOI: 10.21008/j.2083-4950.2017.7.2.2

ISSN 2083-4942 (Print)

ISSN 2083-4950 (Online)

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Keywords: *reduction of waste, shipping logistics, optimization, Value Stream Mapping*

1. INTRODUCTION

Value stream is "the set of all actions both value-added and non-value-added involved in the process of manufacturing a product or a group of products – from raw material to finished product" (Tapping, Luyster & Shuker, 2002, p. 152). The purpose of Value Stream Mapping is to support the identification of areas that require improvement. This method uses the lean approach. The awareness of the need to identify those areas can be noticed in the economic practice, which is emphasized by authors of papers on VSM, who write for example that "companies see opportunities for improvements, elimination of waste and resolution of problems through a flow of materials and information with the use of this tool. In addition, almost half of the respondents who responded that they did not use this tool in the analysis of the flow of materials and information, stressed that they would implement it in the near future" (Piasecka-Głuszak, 2014, p. 100). In the studies discussed in this paper, the value stream mapping was the initial step that allowed analyzing the sources of waste occurring in the company and proposing solutions to reduce their impact. The study was performed in a production company which manufactures, among other things, brake calipers. The aim of the study was to identify the sources of waste and propose a manner of streamlining the processes in the company. The scope of the paper covers an analysis of the process of production of brake calipers – from value stream mapping, through preparation of proposals for improving the processes, to assessing the potential benefits resulting from introduction of the improvements.

2. THE PROCESS COVERED BY THE STUDY

Improvement is an extremely important issue, which is confirmed in the scientific literature, where the following statement can be found: "to survive and develop, each organization must be continuously improved" (Zymonik, Hamrol & Grudowski, 2013, p. 63). Quality standard PN-EN ISO 9001:2009 also refers to the concept of improvement: "organizations should plan and implement processes (...) required for (...) continuous improvement of the effectiveness of the quality management system" (Polish Committee for Standardization, accessed in 2016). Thus it seems to be obvious that improvement is an extremely important issue both in the management of quality of products or services and in the management of the organization of the whole company. The improvement process consists, among other things, in elimination of waste.

2.1. Production process

A very important action to be performed before designing the maps is the selection of a product or a family of products. Products are divided into families based on the repeatability of the operations. For the analysis, there should be selected a family of products characterized by a similar or identical production process (Rother & Shook, 2003, p. 5).

Table 1. Brake caliper production process

Stage of the production process	Operations	Operation time [s]	Additional time [s]
Machining	CNC machining	188	1800
	Assembly of bushings	90	
	Final washing	90	
Quality control	Measurement of roughness	1200	300
	Measurement of special characteristics	1151	161
Painting	Process of painting in an external company	N/A	N/A
Assembly	Subassembly of the automatic control unit	116	600
	Assembly of the automatic control unit	52	
	Pressing the levers	18	
	Assembly of bellows and levers	65	
	Application of adhesive	17	
	Assembling the bushing and pressing the cover	48	
	Screwing the cover	58	
	Test of hysteresis and automatic control	63	
	Screwing the bracket to the caliper	32	
	Assembly of stoppers	24	
	Test of the profile and displacement	45	
	Assembly of brake shoes	60	
	Visual inspection and final assembly	38	
	Packing of products	65	

In this paper, the process of production of brake calipers for trucks has been analyzed. This choice was made due to the fact that at the time of performance of the studies, this was the main product manufactured by the factory. This caliper is made up of many components, out of which the most important and requiring the greatest labor input is the brake caliper housing. Mapping was performed along the route of this component. The company manufactures this component from the machining of

the casting supplied to the installation in the brake caliper. The processes taking place in the company represent the entire production. They can be generally grouped into machining, quality control and assembly. These are three main parts that consist of individual operations. They have been summarized in Table 1.

The extra time included in Table 1 is, respectively for machining and assembly, the time of changeovers and replacement of components, while for quality control – the time required to mount the component in the machine as well as any additional activities performed during laboratory measurements. The situation is different in the case of painting of the housings – this process will be discussed in more detail further in the paper.

2.2. Assumptions and additional information

Designing a map of the current state for an existing, real company requires adopting certain assumptions and simplifications. This results from the fact that the value stream mapping is a universal method and therefore its application to this specific case requires analyzing the data acquired, taking into account the needs of the VSM method. Approx. 75% of demand for brake calipers is satisfied by the factory discussed in this paper. The customer orders 2160 pcs of calipers per week (including 1080 pcs of the right variant and 1080 pcs of the left variant). Therefore, for the needs of the project, customer's demand for ready components was decreased by 25%, i.e. to the level of 1620 (calculated as 75% of total demand of 2160 pcs).

Table 2. Inventory levels and assumptions

Type of inventory	Inventory level	Unit
Inventory level before CNC – safety inventory level	2000	pieces
Inventory level after machining	648	pieces
Inventory – Quality Control	44	pieces
Inventory – assembly (blocked on QC)	958	pieces

The volume of shipment of components for painting ranges from 900 pcs to 1080 pcs. According to the data obtained, 8 pcs from each shift are subjected to control (approx. 220 pcs are made per shift). Therefore, an intermediary solution has been adopted in the project: 990 pcs transported for painting in an external company. In this case, the laboratory gets 36 pcs and this is the inventory level that can be accumulated before the quality control performed in the laboratory. The inventory level from the previous order identified in the company was added to this value, which gives in total 44 pcs. In this case, the remaining 954 pcs are blocked in the quality control area and are released to the process after making measurements on samples, if they do not deviate from the requirements. In addition, in the assembly process, 4 additional pcs were observed in inventories, which

was also taken into account. There were 958 pieces in total. Table 2 summarizes the above assumptions as well as the inventory levels in the company.

2.3. The process of painting the housings in an external company

The determination of the times of the painting process was more problematic. In more detail, this process consists in covering the housings with anti-corrosion coating. Therefore, it has primarily a functional aspect (protection of a caliper against corrosion) but also performs an aesthetic function (coating changes a color of the housing). The company outsources this operation to an external entity. After the housings have been painted, they are returned to the company. Then the quality control is performed and they are directed to the assembly process.

According to the surveys carried out in the company, 900 to 1080 pcs of the casts (the project assumed 990 pcs) that have been machined earlier are sent to the external company. The process of painting and transport from and to the external company takes in total two weeks, i.e. 10 working days (252,000 seconds). The housings that have been machined earlier are transported twice a week in packaging containing 36 pieces of components each.

In the scope of the studies performed, the process of painting (covering with anti-corrosion coating) cannot be broken down into the time of processing and the lead time based on the real values. Considering a lack of access to the data on the process of painting (covering with anti-corrosion paint), the data concerning the duration of such a process were found in the website of a manufacturer of anti-corrosion paints (Colorak Polska, accessed in 2016). According to the manufacturer's description, the time of drying, depending on the type of coating, ranges from 3 to 7 days. The time of the painting process in an external company is 10 working days. Thus, for the needs of this study, the average drying time of 5 days will be adopted.

The process of painting and the process of transport (in both ways) take remaining 5 working days. In order to estimate the time of transport, two factors should be considered: the distance between the external company and the factory (the traveling time is a little more than 8 hours one way) and the fact that the drivers transporting the components do not work 8 hours a day but more. Thus, it can be assumed that the drivers can cover the entire distance (in both ways) in one day (full day, not working day), while having the time for a break. Therefore, the assumption that out of the remaining five days, one day is spent on the transport seems to be safe. In connection with the above, there remain 4 working days, during which anti-corrosion coating is applied on the components. Assuming that the external company operates in a similar manner (1 shift, 8 working hours each, including 1 hour for a break and additional activities), 4 working days account 28 hours (100,800 seconds). The company sends, as it has been calculated earlier, 990 components on average, so the estimated processing time of one component is slightly less than 101 seconds. It should also be taken into account that in the area, in which

adequate conditions for drying should be ensured, the monitoring of every single piece would not be economically justified. It has been assumed in this project that all the ordered products (990 pcs) can be dried at the same time. These assumptions and the results of estimations are given in Table 3.

Table 3. The process of covering the housings with anti-corrosion coating in the external company

Time	Days	Hours	Seconds
Transport from/to the company	1.00	24.00	86400.00
Covering a component with anti-corrosion coating (1 piece)	N/A	0.03	100.80
Drying of the anti-corrosion coating (batch of 18 pieces)	5.00	35.00	126000.00
Drying of the anti-corrosion coating (1 piece)	0.28	1.94	7000.00
Processing time (Value Added, one piece of component)	0.28	1.97	7100.80
Lead time	10.00	70.00	252000.00
Production batch		18.00	pieces

It should be emphasized that both the process of covering the components with anti-corrosion coating and the process of drying are value-adding activities, as they affect the resistance of the components to corrosion, which is a feature important for the customer.

3. VALUE STREAM MAPPING IN THE COMPANY EXAMINED

The value stream mapping method allows analyzing all the processes occurring within the company during the manufacture of the product and helps identify the areas that can be improved. It happens very often that VSM indicates a disparity between the number of value-added activities and the number of the activities that do not add value in companies. The key objective that can be achieved by using the value stream mapping is to cause that the analyzed process “consists in the largest part of value-added activities” (Czerska, 2009, p. 22). Of course, this objective should be achieved not by extending the time of these activities, but by reducing the time spent on the performance of non-value-added activities. The processes examined during the value stream mapping have been grouped according to Table 1. This division results from the fact that there occurs a one-piece flow between individual operations within the whole group, which allows merging these operations.

3.1. Map of the current state

"Value Stream Mapping is a graphical representation of all the processes necessary to deliver the final product or service to the customer (external or internal)" (Adamczak, Domański, Cyplik & Pruska, 2013, p. 258).

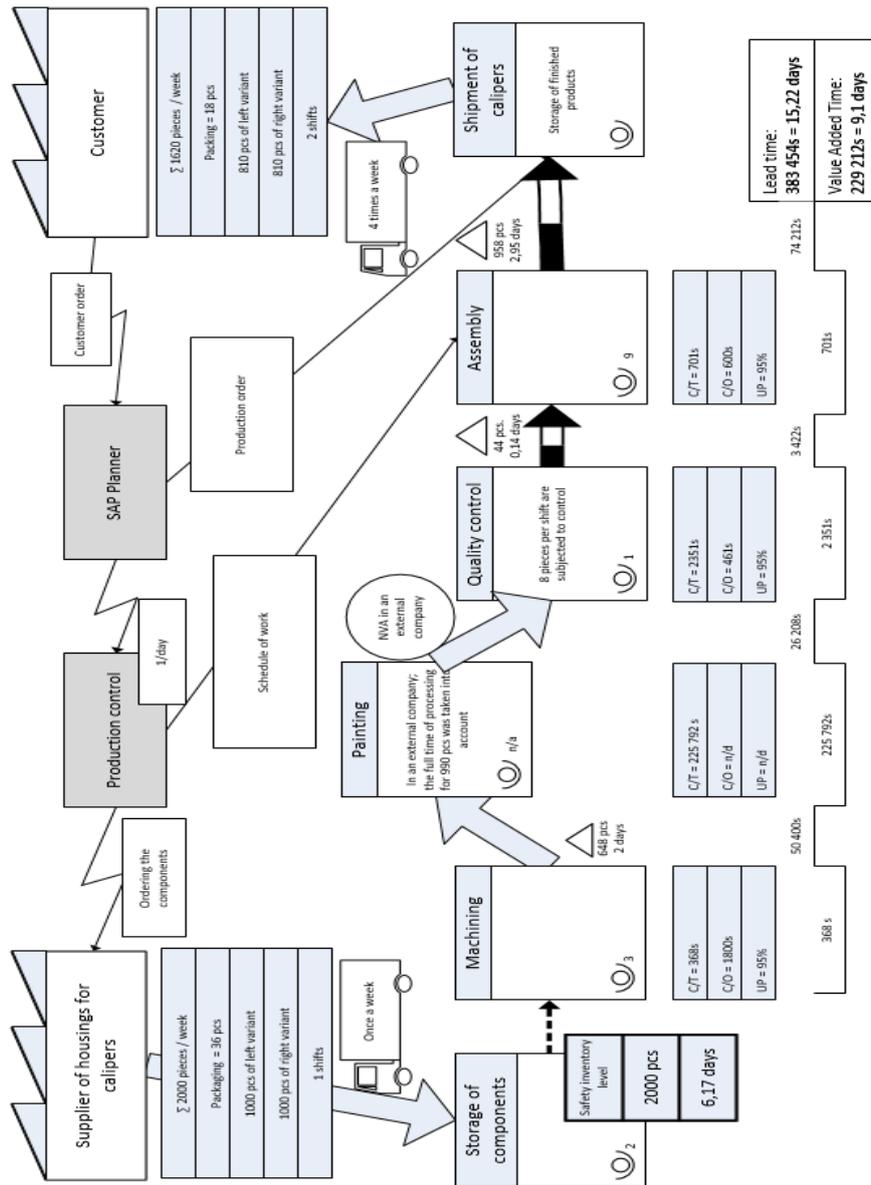


Fig. 1. Map of the current state

Therefore, in accordance with the information given earlier in the paper and the methodology of performing the value stream mapping, the map of the current state has been designed, which is shown in Figure 1. In accordance with the measurements and calculations performed, taking into account the shipment and the painting of the components in the external company, the whole process takes 383,454 seconds, i.e. over 15 working days. Out of this, 229,212 seconds, that is 9.1 days, is the time spent on processing. In order to present the data in a more clear way, they were converted into percentage values and summarized in a form of a graph in Figure 2.

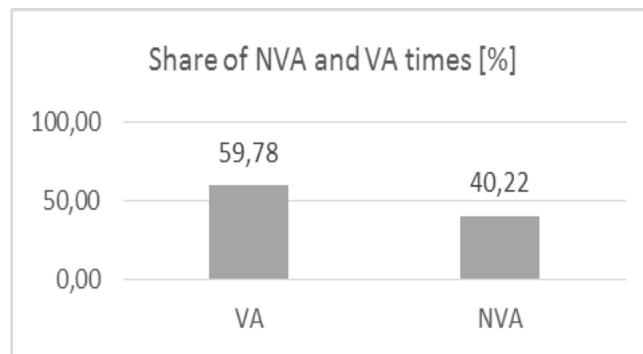


Fig. 2. Share of the VA and NVA times in the entire production process

According to the information given in Figure 2, almost 60% of the time is spent on the value-added operations, while approx 40% – on non-value-added operations. This is still a very large part of the process, which is a phenomenon unfavorable for the company, because "one of the most important goals of the logistics is to add value" (Klepacki & Gidziński, 2015, p. 65). In the company in question, this results from the accumulation of vast amounts of inventories in connection with the shipment of the components to an external company. Despite the fact that the company attaches importance to the flow of a single piece within the processes, this is still a big problem due to inventories of hundreds of pieces accumulating between processes. This problem not only extends the overall time of production, but also generates the need of storing inventories which occupy the space available in the factory. These are sources of waste in this company.

3.2. Areas of improvement, proposal of improvement

Considering the fact that the WIP inventories have been identified as one of the main sources of waste, a proposal of reorganizing the shipments of components prepared. The only element that could generate additional costs in this solution is

the increase in the frequency of shipment of housings for painting – from two to four times a week.

Thus, the project of improvements assumes limiting the inventory level in the company by reducing the batches of housings sent for painting from 990 pcs to 405 pcs. This number was determined based on the following calculations: the customer orders 1620 pieces of calipers a week, including 810 pieces of the left variant and the 810 pieces of the right variant. Hence the reduction of the shipment volume to 405 pcs was adopted, which represents a quarter of the weekly customer's demand. This is also caused by the fact that the shipment to the customer takes place four times a week, so 1620 pieces divided into four travels is just 405 pieces. Making the number of pieces sent for painting equal to the number of pieces sent to the customer should lead to streamlining and reducing the inventory level.

Table 4. The data before and after the change in the dispatch of components for painting

	Before the change		After the change	
Size of shipment	990	pieces	405	pieces
Frequency of the dispatch of components for painting	2	times/week	4	times/week
Frequency of the dispatch of finished products to the customer	4	times/week	4	times/week
The time of collecting the inventory for one shipment for painting	4.5	shifts	2	shifts
Inventory level: machining	648	pieces	405	pieces
Inventory level: quality control	44	pieces	18	pieces
Inventory level: assembly	958	pieces	387	pieces

Furthermore, one shift of machining produces approximately 220 calipers. Therefore, in order to send 990 pcs of housings for painting, 4.5 shifts are needed, i.e. over two working days. During that time, more and more inventories are accumulated in the company. A reduction in the shipment volume to 405 pcs will cause that the production of one batch of components will take less than two shifts, i.e. one working day. This means that the inventories which have been generated since the morning will disappear from the company by the end of the second shift on the same day at the latest. This will also result in a reduction in the inventory of components blocked at the quality control and before the control process itself. 8 pieces per shift are subjected to measurements. This means that 36 pcs are needed to perform adequate control for the shipment volume of approx. 990 pcs. In the case of a reduction in the shipment volume to 405 pcs, it is sufficient to control 18 pcs of the product. This means a reduction of the maximum possible level of inventories associated with quality control and thus a reduction in the number

of blocked pieces from 954 to 387. The data collected before and after the proposed change are presented in Table 4.

The estimated inventory levels after the introduction of the proposed change were calculated as the maximum values that may occur in accordance with the precautionary principle. As a result, it can be stated that the company should achieve a level of savings at least the same as estimated in the project. It should be emphasized that the aforementioned proposal of improvements requires from the company only a reorganization of the shipment logistics without incurring any expenses other than those associated with covering the components with anti-corrosion coating outside the company.

3.3. Map of the future state

Knowing the changes in volumes, the map of the future state can be developed. This map is presented in Figure 3.

As it can be observed, the processing stage is not changed in any way in the proposed improvement and therefore it takes the same time, i.e. 9.1 days. The situation is different in the case of the lead time, which is shortened as a result of the reduction in inventories to 12.64 days.

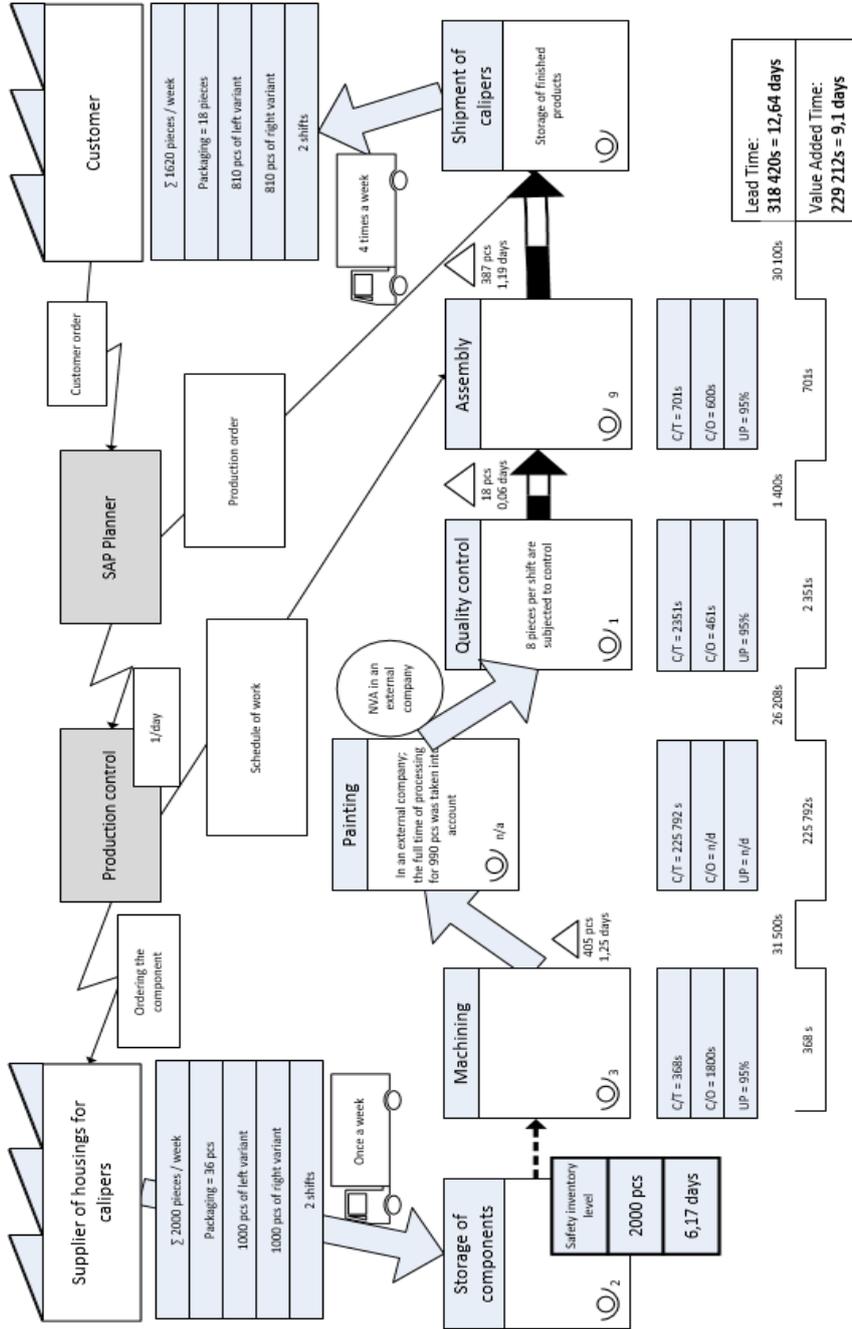


Fig. 3. Map of the future state

4. CONCLUSION

Table 5 summarizes the calculated total sum of all the times observed in the current state and in the planned future state of the company.

Table 5. Summary of potential benefits

SUMMARY		Current state		Future state	
NVA&VA times	Total sum of all times (NVA&VA)	383454	seconds	318420	seconds
		106,52	hours	88,45	hours
		15,22	working days	12,64	working days
	Decreasing the total sum of all times in relation to the current state	N/A		18,07	decrease (hours)
N/A		16,96	decrease (%)		
VA times	Sum of processing times	229212	seconds	229212	seconds
		63,67	hours	63,67	hours
	The share of processing times in the total sum of all times	59,78	%	71,98	%
NVA times	Sum of NVA times	154242	seconds	89208	seconds
		42,85	hours	24,78	hours
	Shortening the transition times in relation to the current state	N/A		18	decrease (hours)
		N/A		42,16	decrease (%)
The share of transition times in the total sum of all times	40,22	%	28,02	%	
Inventories	Inventory level	1650	pieces	810	pieces
	Reduction in the inventory level	n/d		840	less pieces
		n/d		50,91	% less

It is worth noting that despite the lack of interference in the processing operations, their share in the total processing time has changed, i.e. it increased from the level of less than 60% to almost 72%. This increase is caused by a reduction in the lead time, which is a desirable effect as it means that a greater portion of the total time spent on the production generates a value for the customer. Reduction in the lead time from over 15 working days to slightly more than 12.5 working days may

not be a spectacular achievement, but the scale of the proposed changes should be emphasized – it is very small and should generate only slight, barely noticeable costs. However, due to a lack of data, the financial part of the improvement is not analyzed in detail in this study. Much more noticeable improvement can be observed in the area of inventory accumulation – the inventory level should decrease from 1650 pcs to no more than 810 pcs. This means a reduction in the inventory level by more than half, which entails benefits not only in the form of shortening the production time, but also, and perhaps primarily – in the form of saving a lot of space in the production hall.

The aim of the study was to identify the sources of waste and propose a manner of streamlining the processes occurring in the company. This aim was achieved by using value stream mapping, with particular emphasis put on the reduction of inventories, which turned out to be the biggest problem for the company resulting from outsourcing a part of the process to an external company. The method of value stream mapping used in this paper allowed identifying the sources of waste. It was used to design the solutions that improve the processes, with a special emphasis put on the analysis of the value stream. The aim of the studies has been achieved. According to the calculations performed, the implementation of the proposed improvements should bring measurable benefits for the company in the form of reducing the inventory levels accumulated in the course of production by more than half. In connection with this reduction, the time of production of brake calipers should be decreased by nearly 2.6 working days. As a result, the share of processing operations in the total processing time should be increased to almost 72%, i.e. by over 12 percentage points, which is a very desirable effect in the economic practice.

All the calculations and estimations of profits for the company described in this paper should be discussed and analyzed in close consultation between the company management and the logistics department involved in the shipment of components in order to optimally adjust the changes to the needs and plans of the company.

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BIOGRAPHICAL NOTES

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