

# Eliminating of losses in the production process of a machine-building enterprise using lean manufacturing tools

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## ABSTRACT

The article examines the sequence of actions to eliminate losses in the production process with the help of lean production tools at the Russian engineering plant. At the same time, the tasks are solved: the stages of the process of identification, analysis and problem solving are analyzed, the algorithm of elimination of losses in the production process is shown, an algorithm is proposed to build a map of the flow of the value creation of the current state of the production process of the manufacture of the part, the tools of lean production to eliminate the main losses are presented. With the systematic and concerted development of these tools, with the active advice and support of the management of the engineering company, the management of the production process on the basis of the concept of lean production allows to reduce losses, help to grow and develop the plant.

## Keywords

lean manufacturing tools, engineering enterprise, value flow map, loss-making

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## Introduction

At the current stage of industrial development, ensuring the stable operation of enterprises to produce competitive products, is the main task. The competitiveness of products, first of all, depends on the effectiveness of all business processes taking place in the organization. (Zelentsova, L.S. et al., 2020) The problem of improving the efficiency of the organization is not new, as it is faced by all enterprises seeking to remain in the market and compete successfully with other organizations.

The topic of optimization engineering enterprises through lean production is now in high demand in Russia. The lean production system is aimed at improving the quality, operation of equipment, maintenance costs, stocks and people's work. That is, defects are reduced, equipment downtime and repair costs are reduced, inventory turnover is increasing as well as productivity. This is due to the relevance of this study. (Prosvirina, N.V. et al., 2016)

## Literature Review

Lean manufacturing is the concept of managing a production company, which is based on the constant aspiration of the company to eliminate all types of losses. Lean production involves involving each employee in the optimization process and maximizing consumer orientation. The value of the product is the properties of the product, which the consumer appreciates, and for the presence of which they are willing to pay. (Osada, T., 1991).

The actions performed with the product can be divided into 3 categories:

- Adding value to the product;
- Not adding value to the product;

- Not adding value to the product, but necessary; Losses - everything that require space, time and resources, but do not add value for the consumers. Types of losses:
- Defects, repairs etc;
- Waiting time: wasted time;
- Overproduction: production is more than necessary;
- Excessive processing: actions not demanded by the consumer;
- Movements: lots of movements that don't add value;
- Supplies: storing too much raw materials;
- Transportation: too many movements of raw materials and products;
- Not using the experience and skills of the staff. (Matsui, Y., 2007).

## Methodology and research.

Let's consider the transformation of the production process of the Russian engineering company on the example of the assembly plant using the tools of lean production. The assembly plant is one of the units of the Russian engineering company and is an assembly shop where turbochargers are assembled, repaired and shipped. About 3-4 ready-made turbochargers come off production every day. (Prosvirina, N.V., 2017).

The first tasks facing the employee of the enterprise include checking the quality of ready-made turbochargers and diagnosing them.

The turbocharger technology includes control of the most important quality of the turbine. Stable and high-quality production in accordance with the job plan allows modern principles of production.

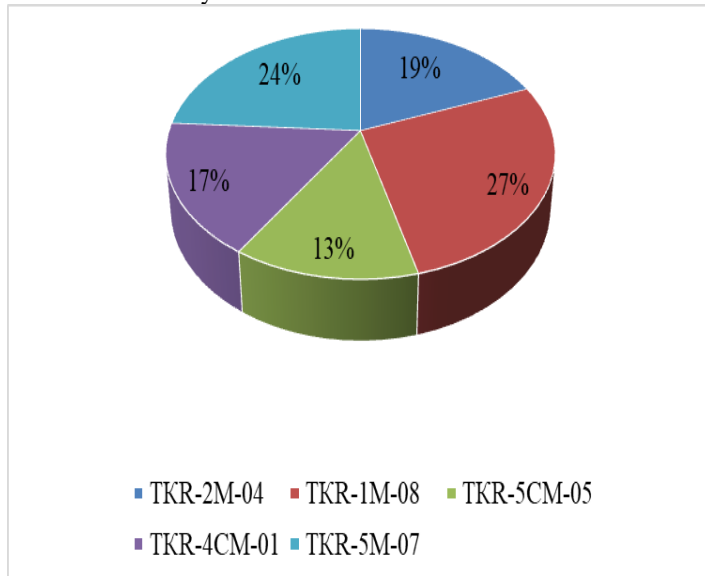
Let's consider the main processes of assembly production of the machine-building plant. Table 1 shows the distribution

of responsibility for the processes that exist in assembly production.

**Table 1.** The matrix of responsibility for assembly manufacturing processes

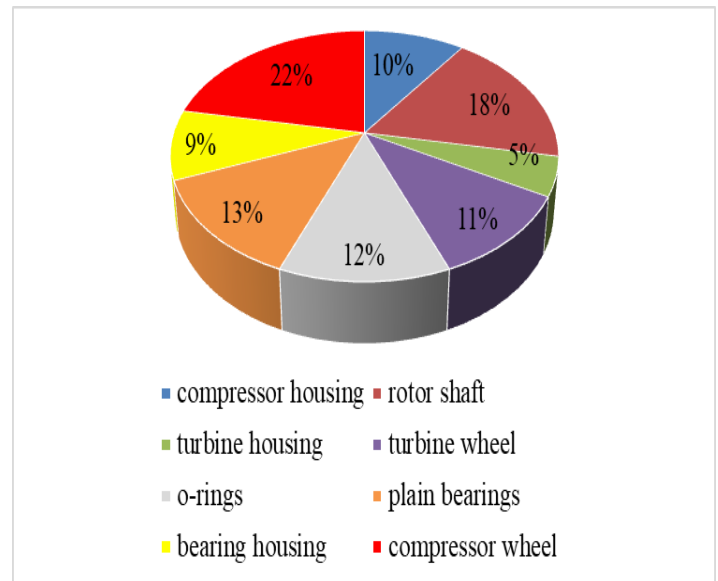
№	Name of the process	Process leaders
1	Conduct an analysis of assembly production process by management	Director
2	Take corrective and preventive actions	Chief engineer
3	Produce turbines. Collect turbochargers. Carry out control, test and refine ready-made turbochargers	Deputy chief engineer
4	Maintenance and repair of assembly equipment	Deputy chief engineer
5	Provide a snap and tools	Chief engineer

Distribution of non-conforming products by models is presented in Figure 1, which clearly shows that the main share of defects lays on the model TKR-1M-08.



**Figure.1.** Model distribution chart

Let's consider the problems of assembly production products on the example of one model, namely the TKR-1M-08 turbocharger. According to defect statistics, we will build a diagram by distributing the main defects by nodes (Figure 2)



**Figure.2.** Node distribution chart

This diagram shows that the main share of assembly defects is accounted for by the compressor wheel - 22%. The next stage of work will consider the process of making a compressor wheel in a machine-building plant.

In shop No.1, the part is subjected to 3 processing treatment at 3 workplaces.

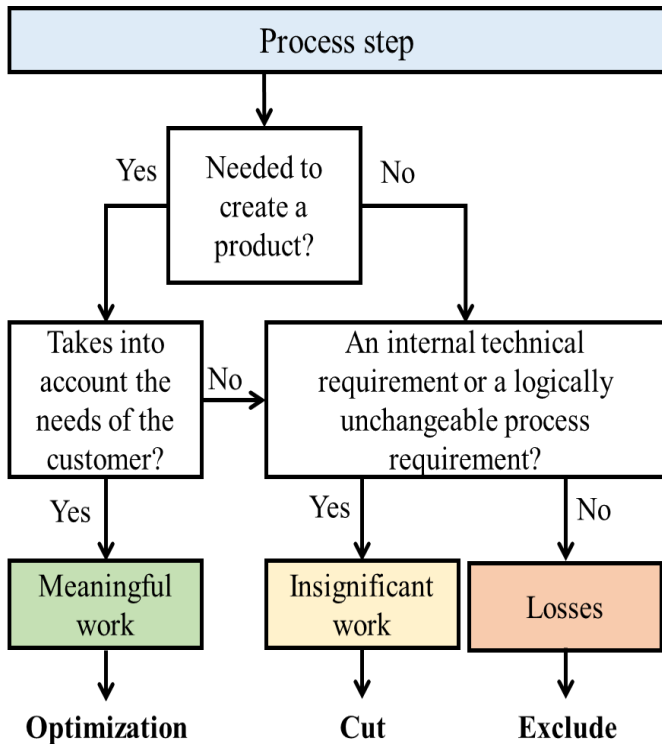
- In workplace number 1, the part is cut into size.
- At workplace number 2, the part is turning.
- At workplace number 3, the part is milled.

In the shop number 2 at workplace number 4, the part is assembled into the assembly unit and transferred to the warehouse of finished products. The total length of the part processing process is 69,700 seconds. ((1161.67 mins ( 19.36 hours)

The process consists of fifteen operations:

1. Cutting operation (1025 sec.);
2. Transportation to the turning operation (580 sec.);
3. Operation turner (1225 sec.)
4. Transportation to milling operation (380 sec.);
5. Operation milling (2480 sec.);
6. Transportation to the checkpoint 1 (350 sec.);
7. TCD control (600 sec.);
8. Transportation to the warehouse (840 sec.);
9. Storage (28,000 sec.);
10. Transportation to the assembly operation (1500 sec.);
11. Operation assembly (2700 sec.);
12. Transportation to the checkpoint 2 (520 sec.);
13. TCD control (600 sec.);
14. Transportation to the warehouse of finished products (900 sec.);
15. Storage (28,000 sec.);

The operating time, that is, the time of creation of the value of the part is 4 150 seconds. As a percentage, this value is only 5.59%. This means that most of the process is not productive. The production losses are so big that the process under study has a clear need to optimize in time and space. In order to eliminate all losses and minimize all minor work, you need to stick to the algorithm depicted in the Figure. 3.



**Figure 3.** Algorithm to eliminate losses in the production process

The most significant non-productive time in the manufacture of the part in question falls on the storage operation - it lasts 56,000 seconds. and takes up 80.3% of the total process time. The share of this category of production losses in the total non-production time is even higher - 85.4%. In this way, it is in the storage of components and finished products spent unreasonably a lot of time, which makes the process of processing the part irrational and having low value.

All this shows that there is a super-inefficient organization of the production process of the manufacture of the part in question. The irrational placement of jobs during technological operations does not allow for high value of the production process of processing the part in question. Stocks and unfinished production are also accumulating in warehouses. That is, in this process there are such losses as: waiting, unnecessary transportation, unnecessary movements, excessive reserves. The total duration of the production process of processing the part in question (compressor wheel) is 69,700 seconds, of which only 6% is operational time. the time of creation of the value of the part, and 94% - it is production losses. (Kumar, C. & Panneerselvam, R., 2007).

To visualize the results, you need to organize the information in the form of Table 2 and Table 3.

**Table 2.** Time loss detected during compressor wheel processing

№	Operation	Duration of operations, sec.	Time to create value	Waste of time	Type of losses
1	Cutting operation	1025	300	Control – 125 Changeover – 600	Excessive processing; Extra movements; Resource management

2	Transportation to the turning operation	580	-	580	Moving materials; Extra movements
3	Operation turner	1225	500	Control – 125 Changeover – 600	Excessive processing; Extra movements; Resource management
4	Transportation to milling operation	380	-	380	Moving materials; Extra movements
5	Operation milling	2480	850	Control – 250 Changeover – 1380	Excessive processing; Movement; Resource management
6	Transportation to the checkpoint 1	350	-	350	Moving materials; Extra movements
7	TCD control	600	-	600	Defects
8	Transportation to the warehouse	840	-	840	Moving materials; Extra movements;
9	Storage	28000	-	28000	Waiting; Stocks Overproduction
10	Transportation to the assembly operation	1500	-	1500	Moving materials; Extra movements
11	Operation assembly	2700	2500	Control – 200	Excessive processing;
12	Transportation to the checkpoint 2	520	-	520	Moving materials; Extra movements
13	TCD control	600	-	600	Defects
14	Transportation to the warehouse of finished products	900	-	900	Moving materials; Extra movements
15	Storage	28000	-	28000	Waiting; Stocks Overproduction
	Total	69700	4150	65550	

As you can see from the table, the total time loss is 65,550 seconds, which is 94.0% of the total time of the operation. The most significant non-productive time in the manufacture of the part in question falls on the storage operation - it lasts 56,000 seconds. and takes up 80.3% of the total process time. The share of this category of production losses in the total non-production time is even higher - 85.4%. The transport time is 5070 seconds. and takes 7.3% of the total time of the operation. 2,580 seconds, which is 3.7%. Control takes 1,900 seconds. (2,7%) from the entire time of the operation.

**Table 3.** Loss of part handling associated with transportation

№	Operation	Distance, m.	Type of losses
1	Transportation to the turning operation	20	Transportation: Too much movements; Extra movement
2	Transportation to milling operation	15	
3	Transportation to the checkpoint 1	30	
4	Transportation to the picking warehouse	50	
5	Transportation to the assembly operation	100	
6	Transportation to the checkpoint 2	50	
7	Transportation to the warehouse of finished products	60	
	Total	325	

The order of moving the workpiece is shown in Figure 4.

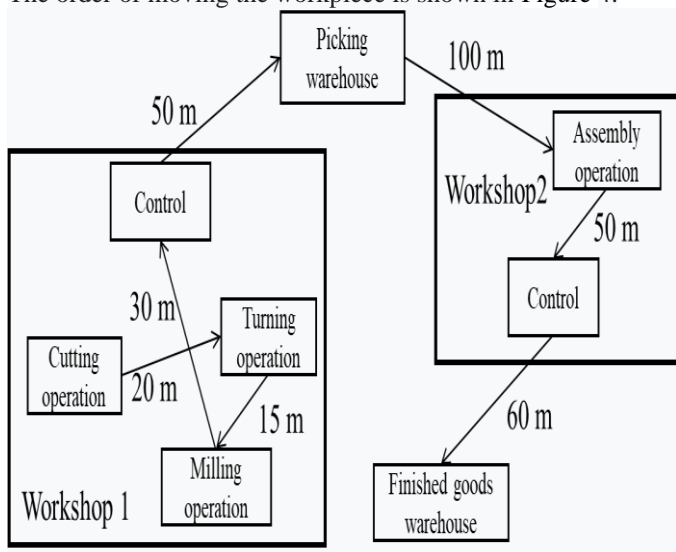


Figure 4. The order of part movements during processing

The total duration of transportation is 325 meters. Also during the production process of the part accumulates reserves in the volume of 965 pieces and unfinished production in the amount of 250 pieces. In this way, in the processing the parts were revealed various losses in a large number of operations. Basically, it is losses from waiting, over-processing, overproduction, unnecessary movement and movements, irrational use of labor. Lean manufacturing tools should be used to organize the value flow and then improve it. Before determining which lean production tools will help to get rid of the identified losses, it is advisable to build a map of the current state of the flow. The map is being mapped directly at the sites where the process is being carried out. Making a map of the flow of value creation begin with the warehouse of finished products and finish with the workplace number 1. The data collected during the analysis are entered into the relevant table. Based on the recommendations of Russian and foreign scientists and the above results, a map of the current state is built (Figure.5).

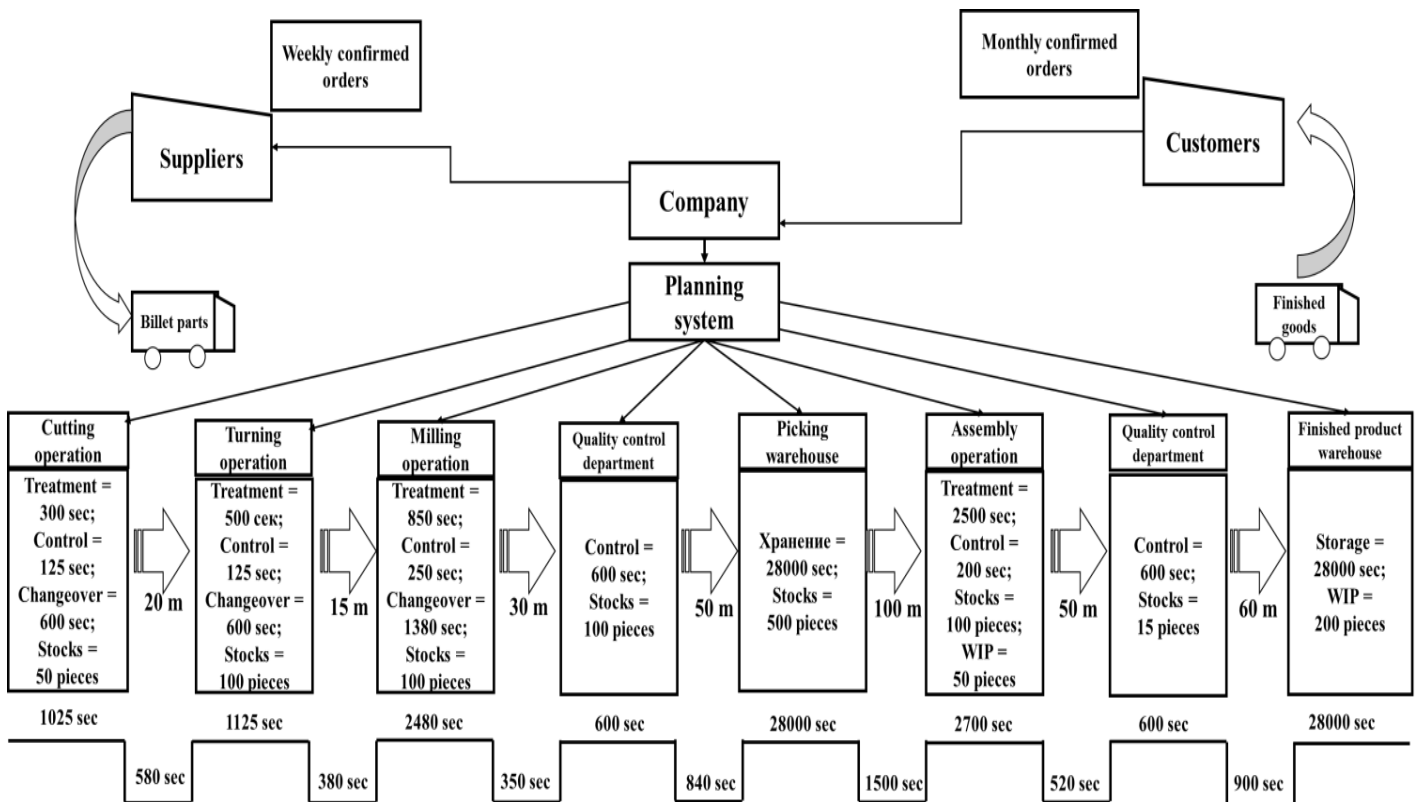


Figure 5. Map of the current state of the production process of the compressor wheel

May be noticed that most of the problems identified require changes. The next step is to consider the existing lean production tools that are used to eliminate various types of losses, select a specific toolkit that will eliminate the major identified losses in the part processing process under consideration (Table 4) and develop an action plan using them. (Jasti, N. & Kodali, R., 2015).

Table 4. Lean production tools to eliminate major losses

Type of losses	Lean manufacturing tools to get rid of losses
Waiting	5S
	VSM

Extra movements	SMED
	TPM
	Visualization
	Standardized work
Defects	Redevelopment of the workspace
	5S
	8D
	Visual controls
Extra movements	Error prevention tools
	5S
	VSM
	Redevelopment of the workspace



Irrational using of manpower	Accounting for workflows
Excess stocks	5S
	Standardized work
	Just in Time
Overproduction	Exploring the need in operation
	Standardized work
Excessive processing	Data collection method

To address the identified losses, we need to look more closely at these tools, as well as offer specific measures that will optimize the part processing process under consideration by minimizing or eliminating losses.

### Conclusions

The solution to the problem of increasing the competitiveness of a machine-building enterprise is largely due to the quality of strategic management, correct goal-setting, the use of implementation mechanisms adequate to strategic goals, the introduction of the philosophy and ideology of lean production, the organization of teamwork and the implementation of rational proposals, the organization of work to reduce losses and effective resource management. (Holweg, M., 2007). It is in this connection that the issues of development and organization of lean production acquire an important role.

In the course of this study, the current level of defect in the mechanical assembly industry was analyzed, losses in the production process of the part were identified, a map of the current state of the process was built, and lean production tools were proposed to reduce the level of losses in the production process.

Planned effect from the implementation of measures based on lean production: increase in labor productivity by more than 25%; reduction of the cycle duration by 6.5 times; reduction of losses of working time by 9 times; cost reduction by 25%; reducing the time for machine tool changeover by 2 times; and storage time - 11 times; reduction of stocks by 99%; reduction of the volume of work in progress by 12.5 times.

With the systematic and concerted development of these tools, with active advice and support from management, the transition to an improvement in production allows to reduce losses, grow and develop the plant.

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