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VALUE STREAM MAPPING CONSTRUCTION WITH LEAN PRODUCTION

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Abstract: - At present, the issue of competition in the world market and a decrease in the economic sustainability of enterprises arises more and more often. Many companies are trying to reduce their costs through the introduction of modern management systems, among which the most prominent place is occupied by the Lean Production system.

Keywords: VSM, TPM, SMED, Lean Production.

1. Introduction

The functioning of the lean production system is based on the effective use of an interconnected set of special tools and methods. The most comprehensive composition of lean manufacturing tools includes such methods and approaches as Kaizen, 5S- “Ordering”, SOP-procedures, equipment maintenance system TRM, quick changeover SMED, JIT system (Just in Time), Kanban and POKA YOKA.

At the same time, preventive attempts to introduce individual or several instruments (as a rule, 5S, TPM and SMED) do not give the expected results. This is due to the fact that after their hasty, unprepared and therefore unreasonable implementation, the main production problems are not solved [1,2]:

- There are idle times due to waiting for the delivery of materials and components to workplaces;

- do not reduce the area occupied by finished products, stocks of materials and components;

- continues to be a lack of means of moving components and materials;

- There is a late production of products.

What is the reason, and how to achieve an increase in the efficiency of the entire production? In order to get an effective result from the introduction of lean manufacturing tools, you must first try to see the whole process of creating products in terms of value-creating processes and processes that do not create value (loss).

Losses - useless repetitive actions that should be immediately excluded. For example, waiting for or storing nodes [3-5].

2. The Construction of Value Stream Mapping

Identifying all losses allows the construction of a Value stream mapping - VSM. It is a graphic representation of the entire production process.

The compilation of a value flow map starts from the last production site and is carried out in the opposite direction until the start of the production cycle and may even include the process of product development and the purchase of material for production (it all depends on the number of problems in production). At each site is fixed:

-time cycle of operations that bring value;
- cycle time of operations that do not bring value (control time, equipment changeover time, waiting time of materials and components, information waiting time, product transportation time, etc.);
- the number of products in work in progress;
- quantity of stocks;
- the number of operators performing the operation.
All indicators are desirable to evaluate in monetary terms for the financial analysis of the cost of production.
Work on the mapping is carried out directly on the areas where the process is carried out. Experience shows that the most convenient way of presenting a value stream is to apply an image on a drawing paper, preferably with a pencil, so that it is possible to make corrections and clarifications [6-9].

Consider the mapping of the flow of values on a specific example. As the source data we have:

- In workshop No. 1, the part is subjected to 3-m machining processes at 3 workplaces.

- At workplace number 1, the part is cut to size.

- At workplace number 2, the part is turning.

- At workplace number 3, the part is milled.

- In workshop No. 2 at workplace No. 4, the part is assembled into an assembly unit and transferred to the finished goods warehouse.

The described procedure for moving the work piece is shown in Figure 1.

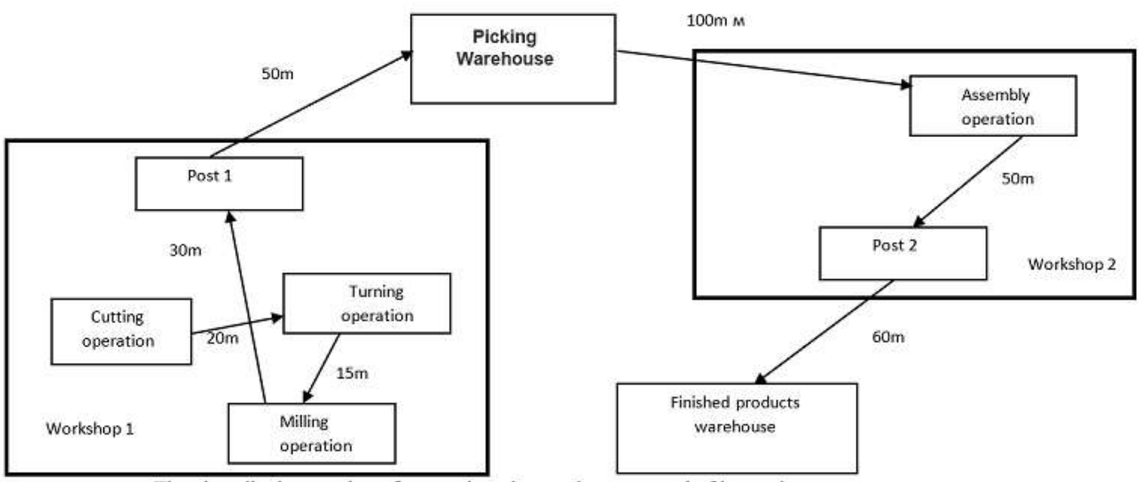

Figure1 The current state of processing parts in the workshops No.1 and No.2

3. The Analysis Process of VSM

Based on the previously defined methodology, we start the compilation of the Value stream mapping from the finished product warehouse and end it with workplace No.1. The data collected in the analysis process are recorded in the appropriate table (table 1).

As the data in Table 1 show, the total duration of the manufacturing process for processing a part is 69,700 seconds. The process consists of fifteen operations. Note that the operational time, that is, the time the value is created for the part, is 4,150 seconds. In percentage terms, this value is only 5.59%! This means that most of the process is unproductive. Production losses are so high that the process under study has a clear need for optimization in time and space.

The most significant unproductive time falls on the storage operation - it lasts 56,000 seconds. and takes 80.3% of the total process time. The share of this category of production losses in the total non-productive time is even higher - 85.4%. Thus, it is during the storage of components and finished products that an unreasonable amount of time is spent, which makes the process of processing a part irrational and of low value.

All this testifies to the fact that there is a super-inefficient organization of the production process for manufacturing the considered part. Irrational placement of jobs during the execution of technological operations does not allow to obtain a high value of the production process of processing the considered part.

On this basis, a map of the value stream is compiled with the parameters of the future state of the production process of processing the part. When constructing a map of the future state, it should be borne in mind that it is necessary to reduce as much as possible the identified losses in the form of unproductive time, material resources and space. Therefore, at this stage, the best desirable indicators of all parameters of the production process are developed, which are also reflected in the form of a similar table. In our example, the desired process value parameters are presented in table 2.

Comparing the values of similar indicators in Tables 1 and 2, we note that the total duration of the process was reduced by 59,030 seconds, that is, 6.5 times! The share of the productive time of the execution of the same fifteen operations of the production process of processing parts increased to 31.86% instead of 5.59%. Thus, the value of the flow increased 5.7 times.

Among the non-productive costs of the production process, storage time still dominates, but its share in the overall process has decreased by 33.44% and amounted to 46.86%. In the composition of non-productive costs, it will also decrease, and in the future state should be 68.78% instead of 85.4%.

Table 1
Value stream mapping of the current state of the production process of manufacturing of details

Item No.			15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	Total
Action operations			Storage	Transportation of the finished products warehouse	Quality control	Transportation to post 2	Assembly operation	Transportation to the Assembly operation	Storage	Transportation to warehouse picking	Quality control	Transportation to post 1	Milling operation	Transportation to the milling operation	Turning operation	Transport to lathe operation	Cutting operation	
Place of implementation of actions			Finished products warehouse		Post 2	Workshop 2	Workshop 2, workplace No.4	Workshop 2	Picking warehouse		Post 1	Workshop 1	Workshop 1, workplace No.3	Workshop 1	Workshop 1, workplace No.2	Workshop 1	Workshop 1, workplace No.1	
Time value creation		s					2500						850		500		300	4150
Time during which value is not created	Transportation	s		900		520		1500		840		350		380		580		4690
		m		60		50		100		50		30		15		20		325
	Control	s			600		200				600		250		125		125	1900
	Changeover	s											1380		600		600	2580
	Storage	s	28000						28000									56000
Total time of the operation		s	28000	900	600	520	2700	1500	2800	840	600	350	2380	380	1225	580	1025	69700
Stocks		P C.			15		100		500		100		100		100		50	965
work in progress		P C.	200				50											250
Number of operators		per.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15

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Table 2

Value stream mapping the future state of the production process of manufacturing of details

Item No.			15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	Total
Action operations			Storage	Transportation of the finished products warehouse	Quality control	Transportation to post 2	Assembly operation	Transportation to the Assembly operation	Storage	Transportation to warehouse picking	Quality control	Transportation to post 1	Milling operation	Transportation to the milling operation	Turning operation	Transport to lathe operation	Cutting operation	
Place of implementation of actions			Finished products warehouse		Post 2	workshop 2	workshop 2	workshop 2	picking warehouse		Post 1	workshop 1	workshop 1	workshop 1	workshop 1	workshop 1	workshop 1	
Time value creation		s					2000						850		300		250	3400
Time during which value is not created	Transportation	s		300		120												420
		m		20		10												30
	Control	s			600		200						50		50		50	950
	Changeover	s											300		300		300	900
	Storage	s	5000															5000
Total time of the operation		s	5000	300	600	120	2200						1200		650		7100	10670
Stocks		PC.					10											10
work in progress		PC.	10				10											20
Number of operators		Per.	1	1	1	1	1						1					6

An important achievement of the future state of the production process of processing parts in this example is also a significant reduction in inventory and work in progress - stocks will be only 1% of the current level, and work in progress will be reduced to 8% of what is happening at the current time. A significant change in the number of workers employed in the production process, from 15 to 6 operators, that is, 2.5 times, is another weighty argument in favor of building a Value stream mapping in order to analyze the causes and sources of production losses.

In order to summarize the obtained results, we construct a table of target indicators, in which we enter the data of the parameters of the current state and future (table 3).

Table 3

Comparative analysis of the parameters of the current and future state of the production process.

Parameters	Measurement unit	Current State	Future State
Time value creation	s.	4150	3400
Transportation	s	4690	420
	m	325	50
Control	s	1900	1850
Changeover	s	2580	1500
Storage	s	56000	10000
Total time of the operation	s	69700	17170
Stocks	PC.	965	10
work in progress	PC.	250	20
Number of operators	Per.	15	6

Economic effect

The economic effect in the table was not calculated due to the fact that the process parameters were not evaluated in monetary terms, so the financial analysis was difficult. This requires additional data and may constitute a separate line of research for the production process under consideration.

Note that there is no one right answer to such a complex question. There can be no single recipe for the success of organizations optimizing their production process based on building a Value stream mapping. As far as each organization is unique in its essence, solutions for streamlining and streamlining are just as unique.

In our example, such significant results were achieved by the fact that all the workplaces involved in the processing of the part were lined up in a U-shaped cell, which was geographically located in workshop No. 1. Figure 2 clearly shows how the spatial arrangement of workplaces changed resulting in the possibility of reducing losses during transportation and storage.

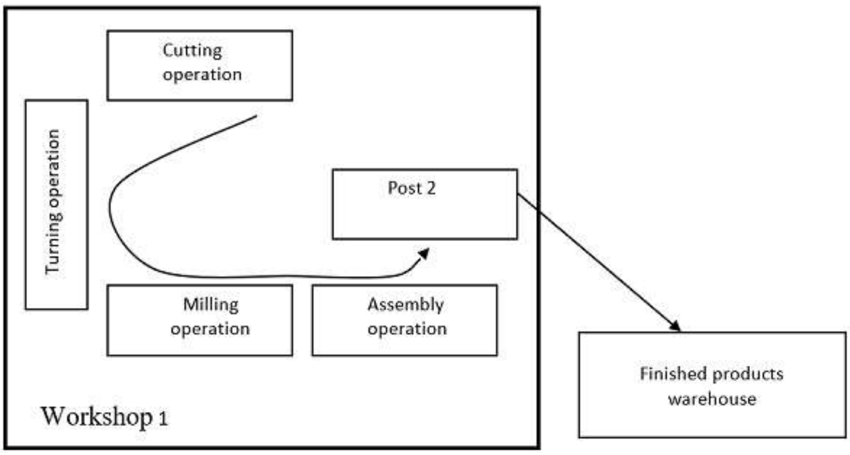

Figure 2 - The future state of machining parts in the workshop No.1

As can be seen from Figure 2, in the cell, three operations — cutting, turning, and milling — will be performed by one operator. Due to this arrangement of technological equipment and workers, it became possible to reduce the time for moving parts from one workplace to another, the time of temporary storage of parts in the component warehouse, the number of work in progress, the number of operators involved in the production process, reduce the area to further increase production.

For visual comparison and structural characteristics of the time of operations that create value and the time during which value is not created, diagrams are constructed that correspond to current and future states. The considered variant of changing the production process is presented in the form of two pairs of diagrams in Figure 3. They show that in the current state, the total duration of the process is composed almost entirely of non-value-creating time, and only a small fraction takes time, creating value. In the future state, time is unproductive only slightly longer than the time of value creation, and the overall duration of the process is significantly reduced and its temporal structure is more rational.

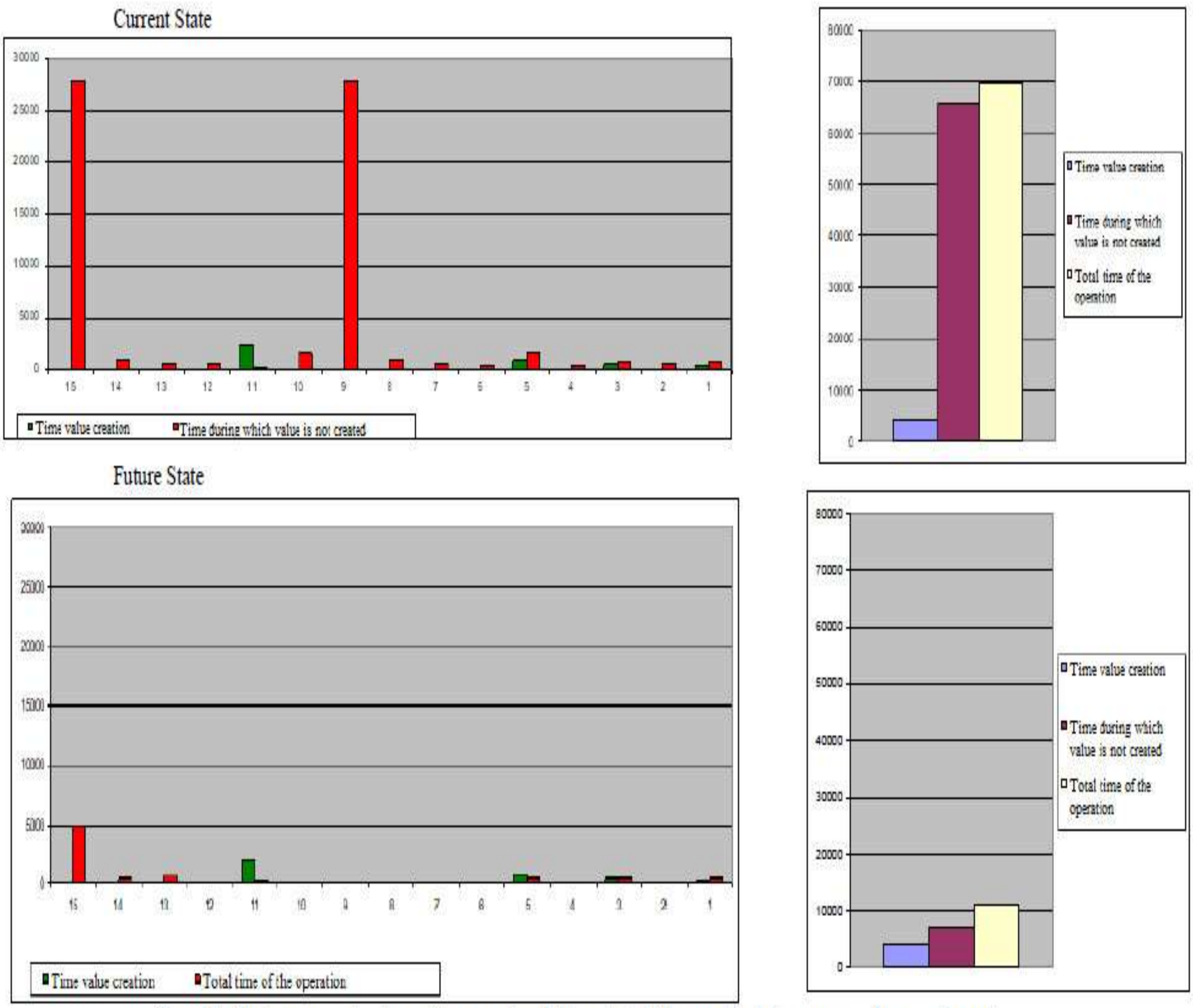

Figure 3 - The temporary structure of the current and future state of the manufacturing process of processing parts

Conclusion

The creation of a U-shaped cell alone was not enough to produce the presented results. Specialists needed to conduct a number of complementary measures and take appropriate management decisions. To achieve the targets, it was also necessary to introduce a number of lean manufacturing tools:

- in order to reduce the number of operators, it will conduct the timing of the work of operators at all workplaces, the manual work of the operator and the machine time of the equipment are highlighted. Then the "standard of the operator's work" was developed taking into account the fact that the operator must perform manual work simultaneously with the processing of the part on the equipment;
- to reduce the cycle time of operations, the system 5S - "Ordering" was introduced;
- to reduce equipment changeover time, elements of the SMED system were used;
- To reduce downtime due to equipment malfunction, a TPM system is being introduced.
- to reduce the time of quality control, the POKA YOKA approach is applied;
- to reduce unfinished production, downtime due to late delivery of materials, components used the principles of JIT.

Only such a comprehensive solution to production problems will reduce losses in the studied production process and, on this basis, increase its efficiency.

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