

Lean Production Technologies: Application in Modern Industrial Practice

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Abstract — Russian industrial enterprises are interested in resource-efficient business. That is why the need of applying of production experience gained in other countries increases. The result of this experience was a set of methods aimed at eliminating traditional industrial production losses. This set of methods now is called Lean Production. The concept of Lean Production fits well into the management system of the enterprise based on quality, known as the Quality Management System. Both systems provide improvements in the production process and increase its efficiency, which contributes to the achievement of the organization sustainable and successful activity in the conditions of growing competition. In the presented work, the analysis of experience of application of tools of Lean Production is carried out. The efficiency of their application for resource saving is shown. The directions of further development of the use of integrated systems of lean production and quality management are revealed.

Keywords — *modern industrial practice, Lean Production, Quality Management System, production efficiency, production process management*

I. INTRODUCTION

The main trend of business development directs towards low-cost and resource-efficient business models [1]. Lean Production (LEAN) often forms the basis of this model. LEAN orientation becomes more and more popular in various industrial enterprises in Russia at the present stage of industrialization [2]. The goal of that orientation is the elimination of traditional losses that are typical for industrial production, such as overproduction, excess inventory, excess processing, delays, and losses during the move [3]. The concept of Lean Production fits well into production process management system in the case the last is formed on the base of quality. That means production process management operates as quality management system (QMS). Both management systems involve improving the production process and increasing its efficiency, which contributes to the organization's sustainable and successful activities in an increasingly competitive environment.

II. MODERN PROGRAMS OF PRODUCTION CAPACITY DEVELOPMENT

Quality Management System (QMS) at the present stage of industrialization is a prevalent technology of enterprise management. It combines all constituents of production, which are necessary for successful business: human resources, infrastructure, information resources, raw materials, etc., in accordance with international standards.

The modern aspect of the ratio of the Quality Management System with the overall management system of the organization is that the QMS should organically fit into the overall management system of the company, which should be based on the same principles. First, it should be based on customer orientation. Consumers are the main source of profit of the company. The main guideline of quality management is to meet the requirements of the consumers and strive to exceed their expectations. Each aspect of interaction with the consumers provides an opportunity to create increasing value for them, which will result in increasing business efficiency. Sustainable success can be achieved when the organization engages and retains the trust of consumers and other stakeholders on which it depends. Companies that want to be successful sustainably manage their stakeholder relationships as they have a significant impact on the functioning of the enterprise. Sustainable success is more likely to be achieved when the organization manages its stakeholder relationships in a way that optimizes their impact on its production process. The management of an organization's relationships with its suppliers and partners is often of particular importance.

The next important aspect of the QMS is the leadership in the organization [4]. Leaders at all levels establish unity of purpose and direction and create an environment in which employees are involved in achieving specific organizational quality objectives. Creating unity of purpose, direction and involvement enables an organization to align its production processes and resources to achieve specific business goals. Modern organization is a system of interacting teams. People need to be motivated to quality work and thus be involved in

the processes of continuous improvement of the organization. Competent, empowered and engaged staff increase the organization's ability to create value.

The essential necessity of development of enterprise production capacity leads to implementation of the requirements of international standards ISO 9000. In this case, it is very important to assess the capabilities of the company and its internal reserves, as any organization strives to achieve a low-cost and resource-efficient business model. Solutions based on production cost analysis and an accurate assessment of the data are more likely to yield the intended results. Subsequent decision-making can be a complex process and it always involves some uncertainty. It is important to understand cause-and-effect relationships and the possible implications for the productive capacity of the enterprise. Currently, many tools to improve efficiency have been developed and tested in industrial practice.

Increased efficiency through the analysis and activation of internal reserves has been developed in the form of a variety of concepts. For example, Six Sigma, Business Process Management, Business Process Re-engineering, Total Quality Management, Dynamic Case Management and others. Six Sigma is one of the methods of process management based on statistical evaluation of the facts and maintaining the necessary level of error-free production process to increase customer satisfaction. Business Process Management is the concept of process management of the organization considering business processes as the special resources of the enterprise, which allow the organization to adapt to constant changes. Business Process Re-engineering is fundamental redesigning of business processes to achieve the maximum effect of production, financial and economic activities. The main idea of TQM is that the company must constantly work on the parallel improvement of three components: product quality, quality of organization processes, the level of qualification of personnel. Dynamic Case Management systems allow solving the problems of collective interaction of employees, issue tasks and assignments and controlling the timing of their execution. Thus the organization can form a real library of "best practices" at each stage of the work. As firms require the formation of low-cost and resource-efficient business models, Lean Production remains one of the most popular concept.

The essence of this concept is to identify the maximum value for the consumer and to eliminate the production losses. The loss is any activity that consumes the resources of an enterprise but does not create a value. Within the framework of the Lean Production concept, a number of "traditional" losses are singled out. Excess inventory, unnecessary transportation, unused human potential, unplanned interruptions and sub-optimal time of transition to new products – there are all symptoms of loss. The exclusion of these factors makes it possible to improve the profitability and efficiency of the enterprise. In most cases, non-production losses management technology is implemented by using a value stream-mapping tool. Mapping the value streams

involves the classification of production operations into three categories:

- actions that create value for the consumer;
- actions that do not create value but that cannot be removed from the manufacturing process;
- actions that, from the consumer's point of view, do not create value and therefore should be excluded from the flow [5].

The following LEAN tools are the most widely used in the production practice of Russian enterprises: Standardization of Works, 5S Workspace Organization, Value stream mapping, Visualization, Single Minute Exchange of Dies (SMED), Poke-yoke (Zero-defect), Kanban, Total Productive Maintenance (TPM).

Standardized work is a set of definite procedures that establish best practices and a sequence of operations for each process and each worker. This approach allows revealing the optimum level of loading of workers and the equipment that is most corresponding to consumer demand. Standardized operations allow to optimize the use of material resources, personnel and equipment, and allow to synchronize the production rhythm with consumer demand.

5S workspace organization is a method of organizing the working space both in the industrial plant and in the office, the purpose of which is to create optimal conditions for operations, maintaining order, cleanliness, accuracy, saving time and energy.

Value Stream Mapping (VSM) is the most common method of identifying losses in the production flow. It is a visual description of the flow of business process value creation (both material and informational). Value stream map allows you immediately to see the weak points of the flow and to identify all non-productive costs and processes. The purpose of this Lean method is to develop an improvement plan based on the elimination of unproductive losses.

Visualization is the method of presenting information in the form of an optical image (figures, diagrams, color maps, tables, etc.), that is the easiest and most effective way to transmit information. The use of this method bases on the phenomenon that the transmission of information in a visual way is faster than in a form of text (for example, in a form of written instructions).

Single Minute Exchange of Dies (SMED) is a set of theoretical and practical methods that reduce setup and reconfiguration time. The main purpose of this tool is to minimize the size of production lot between changeovers of equipment.

Poka-yoke (Zero defects) is an error prevention. This is a way of production organizing, according to which the work can be done only in one correct way. The defect simply cannot appear.

Kanban is a system of organization of production and supply, which allows you to implement the principle of "Just in Time" within the enterprise.

Total Productive Maintenance (TPM) is a concept of production equipment management, the purpose of which is to improve the efficiency of maintenance. The concept of TPM is

based on stabilization and continuous improvement of maintenance processes, system of scheduled preventive maintenance, works on the principle of "zero defects" and systematic elimination of all sources of losses [6].

III. INDUSTRIAL PRACTICE OF LEAN TOOLS APPLICATION

The principle of "Standardization of Works" is so widely used in the works of enterprises that has been recognized at the legislative level in the form of standards of the organization, which are used in the work of the enterprise in the form of technical conditions for products or services, job descriptions, as well as an organizational tool [7].

One of the largest mechanical plants of Perm region adopted a program of development of the production system based on the philosophy of Lean Production. The structure of the program includes many tools and approaches: TPM, SMED, Kanban pulling system, value stream mapping [8]. More than 2,400 standards have been developed: equipment maintenance standards, standards for storage of billets, standards for performance of operations, standard control cards, etc. The most widely used LEAN tool becomes 5S workplace organization system. The application of this system at that mechanical plant was carried out in two stages. The first was a theoretical study of 5S principles. The second was the presentation of workplaces that was organized in accordance with this system. At Figure 1 a view of the workplace of actuator locksmith is shown.



Fig. 1. An example of the workplace of actuator locksmith after 5S applying

The optimization of the workplace arrangement has resulted in a reduction of the actuator assembly time from 32 to 12 hours.

The use of LEAN approaches allowed this mechanical enterprise to increase productivity by an average of 18% and the economic effect is prognosticated to exceed 700 million rubles.

Losses of the production process in the pipeline production shop of a large industrial enterprise of Perm region were analyzed with the help of LEAN Value Stream Mapping tool. The purpose of this tool was to determine the distance and time of movement of parts and workers in the manufacturing

process. The spaghetti chart was used to build the VSM (fig. 2).

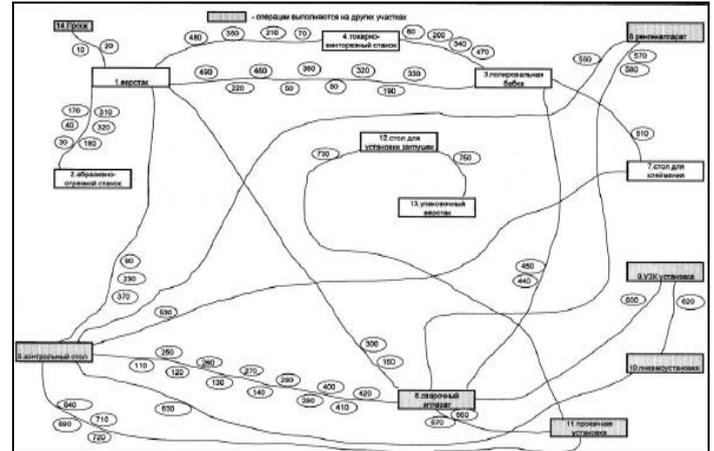


Fig. 2. Spaghetti chart as an example of VSM applying in analysis of losses in the pipeline production [9]

The results of measurements and evaluation of operations location showed that it is inconvenient to move through the stages of the pipeline manufacturing cycle for the workers. For example, it is difficult to transport large pipelines from one floor to another. The duration of transitions has a negative impact on the production process. The production cycle time is increased, productivity is reduced, employees' efforts are wasted. Due to the implementation of manipulations that do not increase the volume of work there was an increase in dissatisfaction of workers who work on piece-rate wage conditions. Time on the transitions between the locations of the jobs were still 31,58 minutes. The total distance traveled by the operator was 1124 m. In addition to the large distances between the location of jobs, workers are constantly experiencing inconvenience in the transportation of blanks: 16 times they had to climb and descend stairs, 6 times to pass on a slippery surface and 4 times to pass through unused equipment of other sites. The time of this production process is 511.75 minutes. The total loss of time according to the results of the survey was 177.04 minutes, which is the third part (34.6 %) of the time for the operation.

The organization of the production process at the enterprise is the arrangement of equipment, planning the sequence of technological operations and movements of the worker. Two different types of time are distinguished in the structure of the technological operation: time for manual procedures and time of automatic operation of production equipment. After performing manual procedures related to the installation of an unfinished detail, equipment setup, etc., the worker starts the production equipment for automatic operation and can move to the next workplace to perform other manual actions on the next technological operation. Due to this method of interaction of the equipment and workers, the procedure for manual actions of operators in the workplace may not coincide with the sequence of technological operations on the detail. One of the most common and effective methods of eliminating this discrepancy is the

application of method of U-shaped productive cells with the combination of related manual procedures by workers. which minimizes the loss of time, unnecessary movement and production space. The procedure for performing manual procedures by operators in the workplace may not coincide with the sequence of technological operations due to this method of interaction of workers with the equipment. One of the most common and effective methods of eliminating of this discrepancy is the use of U-shaped cells with the combination of workers related manual procedure. This way of workplace organization allows you to minimize the loss of time, unnecessary movement and production space.

The next aspect of Lean manufacturing technology is the preventive maintenance and repair management system, called Total Productive Maintenance, TPM. The basis of TRM is the scheduling of preventive maintenance and repair of equipment. It must be emphasized that under this system of service operators acquire new competences and authority, which can significantly extend the service life of equipment and prevent defects of the products. This is ensured by the rapid detection and elimination of the problem of production equipment. The heads of the enterprise departments involved in TPM determine the required number of preventive equipment stops, planned maintenance and financing of these works at the required time.

During the application of various LEAN tools, the following areas of improvement of the production process were planned:

- improvement of equipment location,
- implementation of 5S system,
- organization of the minimum amount of work in progress in remote workplaces,
- implementation of TRM technique and reduction of time for equipment changeover.

The "Visualization" tool has found its worthy application in production practice in various forms. It can be used in a variety of forms depending on the production needs. These can be, for example, colorful diagrams of the sequence of production operations, placed in prominent places in the space of the production site. It can be the technological instructions issued on the principle of LEAN "Visualization". This can be the layout of the production room (fig. 3).

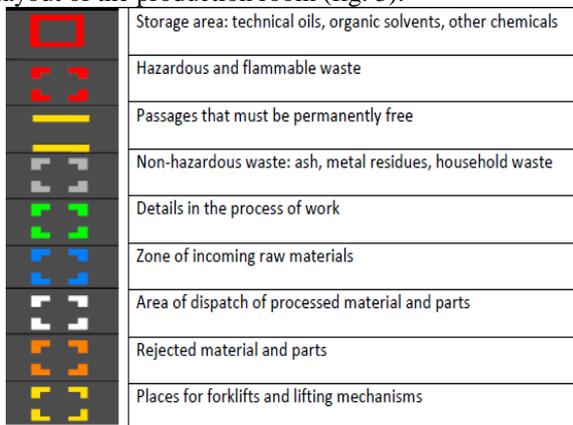


Fig. 3. An example of "Visualization" tool applying as floor marking of the production shop [10]

LEAN optimization of various stages of the production cycle has led to a reduction in lead time and has accelerated the release of the final product to the market. Thus, the solution to the common problem was achieved through detailing with the use of LEAN tools and solving problems that are more specific.

It is obvious that the processes of Single Minute Exchange of Dies and protection against unintended errors Poka-yoke will be deeply individual not only for different types of production, but also at each enterprise. Nevertheless, the use of SMED invariably allows to increase productivity and reduce the cost of manipulation of production equipment as it was possible to get at the Homa Holding. Thanks to the use of this LEAN tool in one of the workshops, the cost of equipment cleaning was reduced twice and productivity increased by 13%. The use of Poka-yoke approaches allowed to avoid mistakes in the production process, which previously cost the company hundreds of thousands of rubles [11].

V. DISCUSSION AND CONCLUSION

Manufacturers pay great attention to the concept of Lean Production in the world of modern production practice. Enterprises of the Russian Federation also are involved in this process and had acquired sufficient positive experience in this area. The use of production systems that apply LEAN principles and tools provide the basis for improving production efficiency and building low-cost and resource-efficient business models. Until recently, the management of Russian companies was forced to study the concept of Lean Production, based on popular scientific literature describing the use of individual projects in this area [12]. In 2014, the Russian government initiated the creation of a system of national standards for Lean Production. This system has created a platform for system application of LEAN tools. A number of major corporations, such as PSC "KAMAZ", SK "Rosatom", the Group "GAZ", PSC "SIBUR holding", JSC "RZD", PSC "UAC", JSC "AVTOVAZ", etc. they actively use LEAN standards in their work and get both a reduction in non-productive costs, including through increased productivity, and an overall increase in production efficiency.

Currently, there are two modern aspects of Lean Production integration with Quality Management System. One is the creation of conditions and atmosphere of common involvement of the company's management and staff in solving the problems of improving business efficiency. As shown in the practice of companies, groupware is always more effective for the development of production systems. The staff should be motivated to quality work and, thus, involve in the processes of continuous improvement of the enterprise activity. Recognition, empowerment and improvement of skills and knowledge facilitate the involvement of people in achieving of certain goals of the company. The use of LEAN tools contribute to this. In addition, the second modern aspect is working with consumers, customers, suppliers and other stakeholders. These trends make possible the integrative application of Lean Production concept and Quality Management System, which allows to transform the ways of

performing the basic functions of the management of the organization and to improve the efficiency of the business as a whole.

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