Network model of project "Lean Production"

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Abstract. Economical production implies primarily new approaches to culture of management and organization of production and offers a set of tools and techniques that allows reducing losses significantly and making the process cheaper and faster. Economical production tools are simple solutions that allow one to see opportunities for improvement of all aspects of the business, to reduce losses significantly, to constantly improve the whole spectrum of business processes, to increase significantly the transparency and manageability of the organization, to take advantage of the potential of each employee of the company, to increase competitiveness, and to obtain significant economic benefits without making large financial expenditures. Each of economical production tools solves a specific part of the problems, and only application of their combination will allow one to solve the problem or minimize it to acceptable values. The research of the governance process project "Lean Production" permitted studying the methods and tools of lean production and developing measures for their improvement.

1. Introduction

The purpose of the study was the development of activities for project governance improvement of the project "Lean Production" in industry undertakings. The study focuses on the project governance process "Lean Production".

The theoretical and methodological framework of the research was based on the work of D. Woomak, D. Jones, D. Kraftik, D. Laiker, T. Ono, S. Shingo, D. Hobbs, M. George in the field of lean production. The approach of lean production seeks to reduce all types of losses, improving product quality and increasing labor productivity. As a result, T. Ono, one of the founders of Toyota's production system, has dedicated seven types of losses that needed to be eliminated and minimized [1].

Achieving measurable results is the main objective of any project. The technique of implementing lean production is established to obtain them through concentration it is in precisely on improving the efficiency of production. An approach that involves achieving real results defines the specific stages and steps necessary to achieve the goal.

Studying the theoretical foundations of the Lean production project management, the authors discovered the basic principles, methods and tools of lean manufacturing, as well as the stages of project implementation [4].

The move from existing production methods to lean manufacturing methods may require considerable efforts. At the initial stage of the development of the project "Lean Production", the managed
scope of the project for implementation of the principles of lean production might be determined, which were identified by M. George [2].

Each of economical production tools solves a determined part of the problems, and only application of their combination will allow solving the problem, or minimizing it to acceptable values [3].

The implementation of lean production is a steady and time-consuming process that requires significant transformation. One of the algorithms for implementing lean production was suggested by James Wumek and Dennis Hobbs [5]. The venture chooses one algorithm among the many implementation algorithms that meets its objectives.

By learning the practical experience of managing projects "Lean Production" we presented the foreign and Russian experience in the development and implementation of the project "Lean Production" and noted the features of the application of lean production methods and tools at Russian enterprises.

The authors discovered that a large number of Russian enterprises are aimed at a quick result from the use of lean tools. They are willing to invest significant resources in technology and equipment, rather than in continuous improvement. In their opinion, gradual and continuous improvement is a longer process with an unclear economic effect. Many enterprises, using tools of lean production, underestimate the importance of the "philosophy" of lean production.

2. Methods
The "Lean Production" project is a planned change in the organizational system in order to obtain the required results, limited by time and resources. The project is divided into stages, the duration and labor intensity of each stage are estimated, interrelations between operations are determined, the criteria of transition from one phase of the project to another is determined and the basic resources of the project (labor and material) are substantiated.

The hierarchical structure of work on the project with the interrelations between operations is presented in Figure 1

![The hierarchical structure of the project](image)

Figure 1. The hierarchical structure of the project

The authors used methods of network modeling during managing the project "Lean Production". Network modeling is based on the application of a network model of a set of interrelated works aimed at achieving a specific goal.

The authors have built a project path network for early terms, before applying the model (Figure 2). With the proper duration of work, the critical path length is 39 days. On the critical path there are works 1.1, 2.1, 2.2, 3.1, 3.4, 4.1, 5.1, 5.3, 6.1, 6.2, 6.3. To determine the costs of project implementation for the proper duration of work, it is sufficient to sum up the costs of the work that lies on the critical path. As a result, there is a cost of 326640 rubles.
Figure 2. The network project schedule for the early deadlines prior to the application of the model, lasting 39 days

Reduction in time of project implementation is associated with the use of additional resources, such as an increase in the number of workers, organization of work in overtime. Consequently, with the reduction of the project implementation period, the costs for its implementation increase. As a result, it is required to seek a compromise between shortening the time of performance of a particular job and saving additional costs for the project.

3. Results
Supposing that it is necessary to shorten the project implementation time from 39 to 34 days.

To calculate the minimum costs required to reduce the project implementation time to 34 days, a linear programming model can be used.

The initial data for constructing the model are presented in Table 1.

Using notation $x_i$ - the time of occurrence of the event $i$, $y_{ij}$ - the reduction in the working time ($i, j$), let us obtain the following linear programming model for determining the minimum costs required to shorten the duration of the project from 39 to 34 days.
Table 1. The initial data of the task of minimizing costs

| Job | Execution time, date | Expenses for execution time, rubles | Unit costs (per day), roubles |
|-----|----------------------|-------------------------------------|-----------------------------|
|     | proper $\tau_{ij}$ | minimal $\tau_{ij}$ | proper $C_{ij}$ | minimal $C_{ij}$ |
| 1.1 | 3                    | 2                              | 1440                     | 960                 | 480           |
| 1.2 | 1                    | 0.5                            | 480                      | 240                 | 480           |
| 1.3 | 1                    | 0.5                            | 480                      | 240                 | 480           |
| 1.4 | 1                    | 0.5                            | 432                      | 216                 | 432           |
| 2.1 | 3                    | 2                              | 2448                     | 1632                | 816           |
| 2.2 | 3                    | 2                              | 2448                     | 1632                | 816           |
| 2.3 | 1                    | 0.5                            | 360                      | 180                 | 360           |
| 2.4 | 2                    | 1                              | 720                      | 360                 | 360           |
| 2.5 | 1                    | 0.5                            | 360                      | 180                 | 360           |
| 3.1 | 2                    | 1                              | 1632                     | 816                 | 816           |
| 3.2 | 1                    | 0.5                            | 432                      | 216                 | 432           |
| 3.3 | 2                    | 2                              | 1632                     | 408                 | 816           |
| 3.4 | 5                    | 2                              | 2160                     | 864                 | 432           |
| 4.1 | 4                    | 3                              | 1920                     | 1440                | 480           |
| 4.2 | 4                    | 2                              | 1728                     | 864                 | 432           |
| 4.3 | 3                    | 2                              | 1440                     | 960                 | 480           |
| 5.1 | 2                    | 1                              | 768                      | 384                 | 384           |
| 5.2 | 5                    | 3                              | 1800                     | 1080                | 360           |
| 5.3 | 7                    | 4                              | 3024                     | 1728                | 432           |
| 5.4 | 3                    | 1                              | 1440                     | 480                 | 480           |
| 6.1 | 3                    | 1                              | 1440                     | 480                 | 480           |
| 6.2 | 1                    | 0.5                            | 480                      | 240                 | 480           |
| 6.3 | 3                    | 1                              | 1440                     | 480                 | 480           |

The aim function is determined by formula 1:

\[ 480y_{1,3.1} + 480y_{1,2.2} + 480y_{2,3} + 432y_{1,3.2} + 816y_{3,4} + 816y_{4,5.1} + 360y_{4,5.2} + 360y_{4,5.3} + 360y_{4,5.4} + 816y_{5,6.1} + 432y_{5,6.2} + 816y_{5,6.3} + 432y_{6,7} + 432y_{7,8.1} + 480y_{7,8.2} + 432y_{7,8.3} + 480y_{8,8} + 384y_{8,9} + 360y_{9,10.1} + 432y_{9,10.2} + 480y_{9,10.3} + 480y_{10,11} + 480y_{11,12} + 480y_{12,13} \]

Limitations are determined by formula 2:

\[
\begin{align*}
& x_2 = x_1 + 2 - y_{12}, \quad x_3 = x_1 + 6 - y_{11}, \quad x_4 = x_1 + 2 - y_{12}, \quad x_5 = x_1 + 6 - y_{12}, \\
& x_6 = x_1 + y_{45}, \quad x_7 = x_1 + 2 - y_{45}, \quad x_8 = x_1 + 4 - y_{45}, \quad x_9 = x_1 + 2 - y_{45}, \quad x_10 = x_1 + 4 - y_{56}, \\
& x_{10} = x_1 + y_{56}, \quad x_{11} = x_1 + 6 - y_{10.1}, \quad x_{11} = x_1 + 2 - y_{11.1}, \quad x_{12} = x_1 + 6 - y_{12}, \\
& y_{11} = 1, \quad y_{12} = 1, \quad y_{13} = 1, \quad y_{14} = 1, \quad y_{15} = 1, \quad y_{16} = 1, \quad y_{17} = 1, \quad y_{18} = 1, \quad y_{19} = 1, \quad y_{20} = 1, \\
& y_{31} = 3, \quad y_{32} = 6, \quad y_{33} = 6, \quad y_{34} = 6, \quad y_{35} = 6, \quad y_{36} = 6, \quad y_{37} = 6, \quad y_{38} = 6, \\
& x_1 = 68, \quad x_2 = 0, \quad y_1 = 0, \quad (i,j) \in P
\end{align*}
\]
Thus, the minimum costs necessary to shorten the duration of the project from 39 to 34 days (for 5 days) are 12480 rubles.

Figure 3. The network path of the project in the early term after the application of the model, the duration - 34 days

4. Conclusions
The authors have suggested a network model of the project "Lean Production", based on a set of interrelated works aimed at achieving a specific goal. For the purpose of minimizing the project costs, the generated model allows one to optimize the project in terms of time and costs.

With the proper duration of work, the critical path length is 39 days. The authors supposed that the expected time for the project is not satisfactory and it is necessary to reduce it from 39 to 34 days. To determine the minimum additional costs required to reduce the duration of the project to 34 days, the authors built a linear programming model and graphically presented the sequence of work based on the previous work data.

As a result, the minimum costs necessary to reduce the duration of the project by 5 days are 12480 rubles.

For planning, analysis and control of the project, the authors used the information system OpenProj. Opportunities OpenProj-Ganttgram, histograms and tables showing the resources involved in the project, free resources, network graphs, diagrams of mastered the amount of work and resources used, predecessor tasks and tasks-followers, as well as actual costs. A number of reports on the project, resources, tasks and performers are available.

The authors researched the theoretical and practical foundations of project management "Lean Production". It was found out that when implementing the provisions of lean production, organizations experience the following problems:
- lack of a thorough understanding of methodology;
- lack of adaptation of the methodology to the specifics of a particular organization;
- the lack of a systematic approach to the organization's transformation, namely the use of the lean manufacturing system as a set of operational-level tools;
- the introduction of a formal project with formal objectives and formal results;
- lack of special knowledge and skills for the implementation of the lean manufacturing project;
- the complexity of understanding the entire architecture of the lean manufacturing system;
- resistance to changes on the part of employees.

The authors have proposed the following activities for the management of the project "Lean Production":
- in the process of improvement, it is necessary to involve all employees of the organization;
- for the introduction of lean production, it is necessary to educate leaders and train specialists in the implementation of lean manufacturing principles;
- it is necessary to start from pilot projects to show the staff of the organization the effectiveness of lean tools and to use the "go and see" principle;
- the key element of "lean production" is standardization, consolidation of the achieved, without which there will be no development, and a return to the initial position will become inevitable.

The use of the suggested activities and recommendations will allow more efficient management of resources in the process of implementing the Lean Production project.

References

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