Technical project management for meeting high quality requirements of machined parts

Z Monica¹ and A Czupryński ²
¹ Silesian University of Technology, Faculty of Mechanical Engineering, Department of Engineering Processes Automation and Integrated Manufacturing Systems
Konarskiego 18A, 44-100 Gliwice, Poland
² Silesian University of Technology, Faculty of Mechanical Engineering, Department of Welding, Konarskiego 18A, 44-100 Gliwice, Poland
E-mail: zbigniew.monica@polsl.pl

Abstract. A project is a sequence of unique, complex and related tasks that have a common goal, and which are intended to be completed within a specified period of time without exceeding the set budget, in accordance with the previously assumed requirements. In the case of typical technical projects two situations are possible. If the parameters of the manufactured element turn out to be correct (they meet the technological requirements), then the angle of the main surface is corrected, i.e. the change in the plane's geometry, which is supposed to improve the parameter of the element. If its parameters are not correct, it means that an error occurred during machining and its surface should be improved. This sequence is conducted to fulfill the quality requirements. In the paper is presented the results of investigation the process of improving the technological process.

1. Introduction
Today, the environment of enterprises is changing rapidly. The success that an economic entity can achieve largely depends on their skills of self-improvement, in other words the way to prepare and introduce changes that are carried out under the pressure of limited time and budget. The implementation of tasks that are determined by time and financial resources is the domain of projects referred to as projects. These types of initiatives combine resources, skills, technologies as well as ideas, with the goal of obtaining specific benefits. In the implementation of projects, efficient management is an extremely important aspect, which helps to achieve the achievement of the objectives set out at the beginning of the budget, within a strictly defined time and in accordance with the quality standards adopted by the organization. Thanks to project management, you can also clearly identify people as well as teams responsible for the implementation of individual stages of the project. It helps to increase the productivity of project participants, develops teamwork, and encourages continuous learning and mutual support of people who are part of the project team. The project manager is responsible for project management.

In each technological process, we are focused on continuous observation, monitoring of each production stage to be able to quickly respond to any anomalies, discrepancies and errors arising during the process [1-4]. We are able to detect emerging errors or errors that may occur during production through many methods through qualitative improvement, and we know and are aware that quality improvement is a continuous and never-ending process. Each rational decision requires many
actions, observations, cause and effect analysis, brainstorming and exchange of experience. Currently, the most popular management system is the system based on the EN ISO 9001 standard. This well-implemented system becomes a tool for creating the image of the company and becomes a confirmation of partner responsibility in conducted business [5,6].

By acquiring the appropriate knowledge and skills related to continuous training, we are able to constantly improve the production process so that our product is not only good, but also very good or the best and allows us to maintain the leading position on a very demanding and competitive automotive market.

2. Quality management of technical projects

Nowadays, TQM is a management method - management philosophy, i.e. subordinating the idea of comprehensive, total quality to all levels operating in the organization and thus improving its competitiveness, efficiency and flexibility. The entire enterprise must therefore be involved, each department, each production line and each individual person placed in the company structure. The effectiveness of the organization is that all its parts must function absolutely together, given that each person is assigned a specific activity that has a specific impact on quality. We can achieve the expected result of the TQM philosophy provided that it becomes a way of life for an organization. TQM is a company management philosophy that aims to meet the high expectations and needs of customers provided that all members of the company are involved in improving the process and quality of manufactured products, this approach is strictly quality-oriented.

One of the important problems is to determine the role of TQM in technical project management (figure 1). The project is a new venture that has no standard and has not been implemented before. Refers to a new situation and requires a non-routine approach.

For a project, you cannot rely on historical practices to deal with a particular problem. The project can be said to be an undertaking consisting of a set of characteristic activities, because they have a start date, specific goals are set in them, they are subject to certain limits, they define the responsibility

![Figure 1. Phases of the project management process [7].](image-url)
(scope of duties) of the implementers, a budget is prepared, and a schedule of activities is formulated, and also indicates the date of completion of project activities. The features indicated determine what was previously stated that the project is a new project that does not have a pattern implemented in the past. According to the definition developed by the Project Management Institute (PMI), a project is called an action that is taken to create a unique product or service. In some approaches project can be defined as a sequence of unique, complex and interrelated tasks that have a common goal, are designed to be completed within a specified time limit, without exceeding the set budget, as well as in accordance with the requirements that were formulated at the beginning of the project.

3. Methods of technical project management

At present, organizations operate in a changing environment, have problems with a significant reduction of resources, and also have to deal with shortening the production time of new products or services. This means that they decide to use proven and orderly methods and solutions that fall within the scope of project management. Traditional approaches used in project management that are most popular include methodologies such as: PRINCE2, PMI and IPMA. In turn, agile (or otherwise soft) methodologies include, for example, SCRUM. The following methodologies are described below.

The PRINCE2 (Projects In Controlled Environments) method is a publicly available and legally independent project management method that is used worldwide and is one of the most widely accepted approaches. This is mainly due to its generality, because it can be used to carry out projects in organizations operating in any industry and having different sizes. It is also used regardless of the scale and type of project. The basic assumptions of PRINCE2 were taken from the PROMPT (Project Resource Organization Management and Planning Techniques) methodology. The characterized methodology has gained great popularity and recognition in over 150 countries and is a standard recommended by the European Union. All NATO structures are also implementing it. Although it is owned by the British Government, you do not need to have a license to use it. Ongoing updates and customization of the methodology are implemented by the British government agency - Office of Government Commerce (OGC). The PRINCE2 methodology is successfully used by international corporations and small service enterprises. In Poland, it is still a relatively new approach, which is popularized by the Center for Managerial Solutions S.A. by developing own version of SPOCLE Ltd. training materials accredited by APM Group. The most recognized applications of this methodology in our country include the implementation of the design of the electronic Platform of Public Administration Services, which was implemented in the Computerization Department of the Ministry of the Interior and Administration. The methodology characterized exhaustively defines the roles necessary for project management. It indicates the responsibilities and decision-making and executive responsibility. The methodology can be adapted to the complexity of a particular project, as well as to the organization's capabilities.

Another methodology was developed by the American association PMI, mentioned above, whose volunteers in 1983 decided to separate and formulate the best standards for project implementation in 1983. This is how the PMBoK (Project Management Body of Knowledge) methodology was created, which is a guide, a canon of knowledge or a collection of the best and widely recognized project management solutions, which were collected and published by PMI members. PMBoK is a methodology strongly focused on a systematic set of specific and proven management techniques and tools, where the work is described as the result of individual processes. Due to the fact that in her case there is greater freedom of implementation than with the previously discussed methodology, it is more often used by large, private corporations. It provides information about the environment that lies outside the project area, and also covers the topics of communication, interpersonal or supply issues.

4. Quality management approach in an industrial waste reduction project

In response to the need to reduce production costs while increasing the efficiency of its operations, analyzed company decided to implement the Kaizen method in production management. It contributes to achieving the possibility of improving the efficiency of own business without the necessity of
incuring very high financial costs resulting from investments in development and improvement. Although the origin of the method should be traced to Japanese management philosophy, it is used by economic entities from around the world, including, among others, analyzed company examined. The implementation of the Kaizen philosophy by the company comes down to, among other things, the proper organization of jobs, which requires two-step proceedings. First of all, it is very important to develop and test rules that apply to the appearance of the workplace, as well as its functioning. Secondly, self-discipline should be maintained, because it allows rules that have been formulated earlier to become procedures.

The project that was carried out in the examined company was related to the modernization of the production line. It was created by merging two special production lines into one production system. The production lines undergoing reconstruction produced switches and disconnectors for low voltage apparatus. The first assembly line (Line 1 – L1) was created by two stations, where the chamber mechanism was assembled. Next, the whole was placed in a universal housing for single-pole cameras, as well as bi-chamber housing for two-pole cameras. In the next production phase, the products were controlled by the Quality Controller. After passing the control, they were transported to the second assembly line (Line 2 – L2), what is seen in the figure 2.

![Figure 2. Layout of the technical system before improvement.](image)

The area that was occupied before the implementation of the modernization project of the production line, the two existing lines – L1 and L2, occupied 76m². In addition, the space occupied by the production lines was not fully utilized. At positions on both lines, a lot of space was occupied by semi-finished products from the production taking place on each of these lines. In addition, many elements related to L1, i.e. production in progress, were created. The cart on the L2 line stored compacts, which created a large amount of inventory, which was one of the elements of waste. In turn, on the L2 line, there was a shelf where the components of the components used for production on the L2 line were stored. Therefore, the operator had to move parts between two production lines. This was another element of waste that was associated with excessive transport of components used in production.
The implementation of the project for the reconstruction of production lines in the analyzed company was necessary due to the fact that on the two pre-existing lines (L1 and L2) many operations were carried out that did not create added value for the entity. It was primarily the collection of parts needed for production, the creation of stocks in progress and unnecessary transport activities. In addition, the production process was carried out in a way that resulted in duplication of operations. As an example, the assembly of the cover on the second station of the L1 line could be indicated, which had to be removed on the first station of the line L2 to carry out the assembly of the housing subassembly element, and then reassembled. Due to such a flow of products between production lines, there were difficulties in effective process management. Employees had to make many moves between individual workstations that were not needed, resulted in a waste of time, and as a result reduced work efficiency.

During the implementation of the modernization of the production line in the analyzed enterprise, it was necessary to modify some existing manual workstations, as well as to implement a new production line layout. Modification of the two lines on which the production took place consisted in reducing the area occupied by them from the existing 76m² to 46m². In addition, the number of work stations on the production lines before modernization was 8. On the modernized line, they were limited to 5 work places. The project began with the dismantling of two existing production lines. Next, in accordance with the previously developed project, new workstations forming a modernized production line were installed. The diagram of the new production line along with the dimensions of its individual elements is shown in figure 3.

As a result of the modernization of the production line, the physical workflow has changed. On the new production line, it takes place from right to left. The organization of the flow of manufactured products has also changed. In addition, the actual value of work in progress was determined for each position. The modernization of the production line allowed for the elimination of one control of semi-finished products, which was performed by a quality controller before the apparatus was moved from the last position of the L1 line to the first position L2. The liquidated jobs were moved to other, modernized places. In order to facilitate the organization of work, all components used for production were located at the front of the production line on new shelves equipped with rollers, which allowed them to be moved. The workstations located on the modernized production line were designed to be...
modular, i.e. easily connected to each other, so that it was possible to quickly detect various signals, and production could be stopped after detecting the first irregularity in the manufactured product.

Special construction materials were used to construct the work stations. They have been combined with the use of properly selected assembly units. The roller track equipment includes a set of wheels terminated with profile mounting brackets. The whole structure was based on metal legs, thanks to which there was a possibility of stable foundation of positions. On the modernized production line, empty boxes are removed by sliding from roller rails equipped with a set of wheels. The conventions were located under the counter at individual work stations. The ends of the glass profiles are secured with end caps to improve the safety of working conditions, as well as aesthetics. At the end of the work, lighting and gutters for the flow of Kanban cards were installed at the stations, which allow maintaining relatively small production reserves in progress, preventing wastage but at the same time protecting against the possible need to stop production in the absence of components. Kanban cards allow the use of short processing times for small stocks, as well as contribute to timely production. Thanks to them, the production was adjusted to the number of orders and quality control was carried out by assembly line employees at all stages of production. The components used in production are delivered to the hall by external transport based on the demand indicated in the Kanban card. Cards play the role of production orders and documents describing the contents of cartons delivered to the production line. During the production process, a person who works at a specific position by retrieving the last component from the carton puts the Kanban card in a designated place, from where it is taken by a supply employee responsible for supplying raw materials to the production line.

5. Conclusions
When analyzing the obtained operation data, it can be seen that due to the modernization of the production line, production efficiency has increased significantly. In the case of one person participating in the production process, the increase in the number of manufactured products was over 5 pieces in one work shift. In the case of two-person work, the increase in production capacity was almost 11 units during the work shift. In contrast, with three people, production capacity increased by 16 units, and with four by almost 20 units. With the work of four employees, the theoretical production capacity increased by up to 21 items during a work shift.

After modifying the production line, the company also achieved other benefits. Before the implementation of the project in the production process implemented on two lines – L1 and L2, losses occurred, manifesting itself by making unnecessary movements, performing excessive transport of components between production lines, as well as creating inventory of production in progress. The modification of the production line allowed eliminating the double operation of putting on the lid, removing it, packing the product into a carton, labeling the carton and transporting components between two production lines. In the case of stocks maintenance, significant changes also took place. Reducing the number of inventories to the necessary minimum has contributed to reducing their maintenance costs. The modification of the production line also resulted in material savings.

Taking into account the solutions presented in the paper it is possible to introduce the described approach in different project related to improving the technical systems [8-10].

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