

QUALITY IMPROVEMENT IN PRODUCTION ENTERPRISE. CASE STUDY

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Abstract. The main objective of this paper is to determine the meaning of quality in present enterprise as well as its influence for the continuous development. There is shown comparison of chosen quality management conceptions as well as description of one of them, Six Sigma which is an innovative approach to quality. Presented case study was developed in a printing company specialized in production of books in hard covers. This study presents the proposition of improvement to increase the effectiveness of the production process.

Keywords: quality management, process improvement.

1. Introduction

In recent years, it may be noticed a huge pressure on enterprises to maintain and develop high quality level in organization, and at the same time to decrease ineffectiveness and reduce the number of errors. In order to gain and keep customers, organizations have to compete with each other. Sometimes it may be difficult, because present enterprises show very good adaptation to upcoming changes. It is essential to understand that the most important in quality management is to satisfy customers' needs, because the customers are the factor which drive the market economy nowadays. There are many different conceptions, methods and tools that may be used to maintain the good quality level and help in continuous development in the company. One example of well-known conception is Six Sigma which is an innovative method introduced in Motorola by Bob Galvin and Bill Smith in the middle of the eighties.

The article focuses on presenting the term of quality and emphasize its role in continuous development in production enterprise. It also shows differences between conceptions of quality management and describe one of them in details. Knowing all main conceptions, methods and tools the company can freely decide which is adequate to its brand and activities and which to use in specific situations. Presented case study shows the bottleneck which appears during production process in one of the printing company. There is shown the whole

analysis of the problem as well as proposition of improvement which may be introduced in order to increase the effectiveness of the whole process.

2. Quality improvement

There are many different definitions of quality which can be found in literature (Słowiński, 1996). Generally, quality is defined as the sum of characteristics of a product or service which gives the opportunity to meet the customer's needs (Rogoziński, 2000). This definition can be completed by the definition of quality management, as a continuous improvement of everything which is performed in the organization in aspects of quality using well-known methods and with the participation of all employees. According to ISO norm 9000, quality is "degree to which a set of inherent characteristics fulfils requirement" (PN-EN ISO 9000:2006 – polish version).

The evolution of the term quality may be presented as follows:

- Quality is efficiency in use – J.M. Juran, 1970,
- Quality meets customers' needs – T. Ishikawa, 1980,
- Quality is something when missing means loss for everybody – G. Taguchi, 1980,
- Quality means zero defects – P.B. Crosby, 1985 (Rączka, 1993).

Nowadays, it may be seen that quality is one of the basic factors which decides about company's competitiveness. Quickly changes environment requires from enterprises easily reacting for them. The company is forced to search for new conceptions and methods of development. Contemporary environment is characterized by process globalization, shortening the life-cycle of products and technology. Scientific and technological development, increased level of education, easy migration of all resources, high distribution of technology and information, are the chances for organization to achieve better position in the market and being more competitive (Łukasiński, 2013).

High-quality products and services give the company competitive advantage in domestic and international market. Good quality increases productivity, while reducing costs, but what is the most important, it creates satisfied customers who are more willing to buy the products again and will also recommend the company to other buyers. When mass production has started, there was a need to introduce quality control to the process and create separate quality departments. During 1950' W. Edwards Deming and Joseph Juran were invited to Japan to help the companies in quality management. They strongly believed in importance of quality and using statistical tools in order to improve quality. Nowadays, everyone may learn from the Japanese that it is impossible not to pay attention to quality and that taking care of quality issues is the responsibility of every employee in organization (Evans, 1992).

Quality improvement should be connected with a widely understood customer satisfaction. However, sometimes it is really difficult to define the term of quality which may be understood in several ways, because it is an individual and subjective evaluation of every client (Bielawa, 2011). If the quality is assumed as a totality of meeting expectations relative to acquired product or service it may happen that the same purchase will have different evaluation from a different customer. Despite these variances it is worth to take care of quality aspects. The issue is particularly important for everything which goes directly to the customer. Therefore, it is observed at this time that in management practice many companies tend to implement variety of instruments related to quality improvement (Lenik, 2011).

Starting from popularization of technical control in production enterprises, from XX century intensive development of organization form, methods and range of quality management has started. Especially, the last decades brought new conceptions in this field. It is difficult to date particular phases of quality management, because they develop differently in other countries or branch of economy.

Quality management can be divided into stages:

- technical control – it takes place in production enterprise, the objective of the control is final product and its technical aspects,
- quality control – this stage claims that quality cannot be extorted from technical controls, but it has to be created in enterprise, the responsibility for quality should be taken from management and employees,
- quality development – this stage contains more functions of management, controls and corrections, planning and control stimulating (Woźniak, 2008).

Main conception and standards of quality management are presented in the table below. Data which may be compared are timeliness, range and dominant feature.

Table 1.
Comparison of chosen quality management conceptions

Conception/Standard	Timeliness	Range	Dominant feature
Quality management system ISO 9000	Used since the 80' XX century until today	Used in every organization. There is no geographic, political and cultural boundaries	Formal and bureaucratic, but allowing freedom in the interpretation and application
Standard compliance-requirements of industry standards	Used since the 70' XX century until today	Range limited to industry	Formal and bureaucratic, not flexible
TQM	Known since the 80' XX century until today	Known and introduced to organizations all over the world	Appeal for common commitment and improvement
Kaizen	Known since the 80' XX century until today	Used in organizations in which Japanese culture of work is accepted	Similar to TQM
Six Sigma	Known since the 80' XX century, but widely disseminated only from last 10 years	For now limited, used mostly in big organizations	Based on planning of venture which goal is to measure the effectiveness of activity

cont. table 1

SPC (Statistical Process Control)	Beginnings from the 30' XX century (Shewhart), but widely known during 70' and 80'	Used in organizations with mass production, now a fixed component in automotive industry standards	Based on statistical tools and methods
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Source: Hamrol, 2007.

To achieve the goals and realize the tasks of every organization it is needed to have some funds that enable to form the quality of the products at every stage of the product life cycle. In literature different techniques and methods supporting quality management may be found. They may be divided into:

- Conceptions and principles of quality management – by using the principles of quality management in practice the organization can strengthen its position on the market, increase the revenue and achieve other benefits. They help in establishing the strategy and goals of the company. The examples can be TQM, Six Sigma or Kaizen.
- Tools of quality management – in quality management the strategic and operational decisions at every stage of production process should be made based on facts. To gain actual data, tools of quality management are essential. They are usually divided into traditional and new tools. The examples are a block diagram, Ishikawa diagram, Pareto diagram, histogram, correlation graphs, control card.
- Methods of quality management – the methods are more complex than tools. Using methods of quality management requires knowledge from statistics, data processing and consequence. In every method the set of tools are used. The examples can be: Quality Function Deployment, value analysis, FMEA, Statistical Process Control (Hamrol, 2017).

Although the term of quality is difficult to clearly define and measure, it is essential to take care of it in an organization. The main determinant of quality nowadays is a customer and his needs and expectations which should be met in order to achieve his satisfaction. The companies need to focus on development and improvement of all the processes and in general its functioning. Different types of quality management system may be found in different organizations. It is important to choose the best practice adequate to the branch and activity of the company.

3. The concept of Six Sigma

Six Sigma is an implementation of proven quality in organization. Sigma is a Greek letter used in statistics to measure the variability in the process. The performance of the company is measured by the sigma level in their process. Most of the companies agree on three or four

sigma performance levels as a norm, but it may be seen that in these cases the processes create between 6210 and 66807 defects per million opportunities. In order to meet all the customers' needs and expectations that are still increasing, the Six Sigma program may be introduced and implemented in organization. At the Six Sigma level there are 3.4 defects for million opportunities. Six Sigma is based on reliable and valuable methods that are commonly known. It refuses the whole complexity which characterizes Total Quality Management (TQM). It was counted that there were around 400 different methods and tools connected with TQM which may be overwhelming and difficult to implement and use. Six Sigma based on smaller amount of methods and tools and trains leaders who are known as Master Black Belts and have theoretical and practical knowledge about proven methods (Pyzdek, 2013).

Six Sigma may be characterized by six principles:

- concentration on customer,
- based on facts,
- process approach for improvements and management,
- proactive management,
- cooperation without boundaries,
- toleration of defects, but set for perfection (www.projekty.4innovations.pl/2009/08/charakterystyka-metody-six-sigma).

Sigma Performance Scale is presented below in the form of table. It shows the defects per million opportunities, percentage of good products and estimated cost or poor quality according to Sigma level which may occur in organization.

Table 2.
Sigma Performance Scale

Sigma level	Defects for million opportunities (DPMO)	Percentage of good products	Estimated Cost or Poor Quality (% Revenue)
1 sigma	690 000	31%	>40%
2 sigma	308 537 (uncompetitive enterprises)	69.14%	30-40%
3 sigma	66 807	93.32%	20-30%
4 sigma	6 210 (average enterprises)	99.38%	15-20%
5 sigma	233	99.97%	10-15%
6 sigma	3.4 (world's leaders)	99.99%	<10%

Source: Watson, 2005.

The goals of Six Sigma are connected with eliminating the number of defects, taking care of the customers' satisfaction, elimination of time in production cycle, reduction of costs connected with mistakes and reparation and improvement of the image of the company in the market. Taking into consideration the functioning of all aspects of enterprises the main tasks of Six Sigma program are: a measure of customer satisfaction which has to be defined at an every stage of the project, determination of the quality index as well as the estimated number

of products with defects. After each cycle of DMAIC phases, gained results should be analyzed and actions to reduce the time in one cycle should be taken (Aruleswaran, 2009).

Although Six Sigma is usually perceived as a method which may bring many profits to an organization there are some myths connected with the perception of its functioning which may result in resistance of workers before its implementation. The first myth claims that it may work only in manufacturing organizations. Although, before Six Sigma was much more popular in the production companies, in the recent time there are a lot of publications about implementation and using Six Sigma in other processes such as administration. Another example of the myth is that Six Sigma ignores the needs of the customers and focuses only on the benefits for the organization. It is rather a wrong interpretation, because every customer brings profit to enterprise. Many people also think that Six Sigma is just another quality program using complicated statistical methods and tools, but actually it is a way of managing the whole organization and maintaining the best quality level. When implementing Six Sigma with full awareness it may bring different profits even in short period of time (Breyfogle, Cupello, Meadows, 2001).

One of the methods which supports Six Sigma is DMAIC cycle which based on process improvement. DMAIC is an acronym comes from Define, Measure, Analyze, Improve, Control. All these five phases are connected which each other and help to order the whole improvement process. The goal of the first phase Define is to identify the problem which will be an issue to solve in the next stages. It is also about defining all needed resources, processes in organization and support from management. It is important to divide the processes into external and internal, and firstly focus on elimination of the external ones. The next step which is Measure, is about collecting data and information which will be needed in the next stages to compare the results and to show the achieved progress. The most important in this phase is to check if there is enough data to measure. In Analyze stage different analysis are performed using various tools and methods of quality management. It is needed to perform process capability. The main goal of Improve phase is to create an action plan which should be implemented in order to achieve planned goals, while the last stage, Control is about continuous verification if implemented changes bring expected profitability (Shankar, 2009).

4. Case study

The research study was done in 2018 in the printing company which is specialized in production of books, especially in hard covers. The enterprise was found in 1989 and nowadays it is one of the leaders in printing industry not only in Poland, but also abroad. It offers wide range of products which means that the production process is diversified and advanced. The main customers of the company are the biggest publishing houses from Poland

and other European countries. The company owns three production halls and offices. It employs more than 300 workers which perform their activities on different production machines.

The enterprise develops quickly, invests in new machinery and production halls. In 2014 it received ISO 9001 and 14001 certificates. It also got Forest Stewardship Council certificate that confirms the responsible attitude for environmental issues and practical care about forests. The company has already implemented different tools of quality management to support the production and eliminate unnecessary activities. However, there are still some downtime in production process which should be improved. The implementation of lean management was supposed to bring different profits to organization, but what is more to deliver the product to the customers in shortest possible lead time and according to their needs and requirements.

Due to the fact that competitiveness on the market is high, the enterprise wants to increase its efficiency and provide products with higher quality. At the same it tries to maintain the same amount of resources and machinery. In order to monitor implemented lean management tools and methods continuous control is used in daily activities. The companies nowadays have to attract their customers by demonstrating the ability to meet their expectations and offering highest possible quality of products and services.

The first phase of research study started with the meeting in the company where the processes and its bottlenecks were discussed. Also the management board took part in this discussion. After deep analysis of the whole process it was seen that there are some downtime of the production on specific printing machines. It was observed that two machines has lower efficiency than others and also that the efficiency level is not stable, but it varies depends on different seasons. The main problem was clearly defined in the form to be understood by everybody involved in the quality improvement process. Based on the discussion with management board, the needed resources were also defined. The idea is to offer the customer the product with highest possible quality and deliver it on time. That is why it is important to analyze and implement some solutions in order to increase the effectiveness of the process and eliminate bottlenecks which appears on production line.

Measured data, which are the process capacity, are presented in the form of graphs below. It concerns the amount of printed products on two specific equipment Roland IV and Roland V which are four-colors printing machines used in the technique called offset printing. The data are taken from years 2014-2017 and presented month by month for comparison of particular period in different years. From the first graph it may be seen that production process is not stable and varies a lot. There are some fluctuations which appeared on machine Roland IV. The bigger amount of products were produced in the second half of the year.

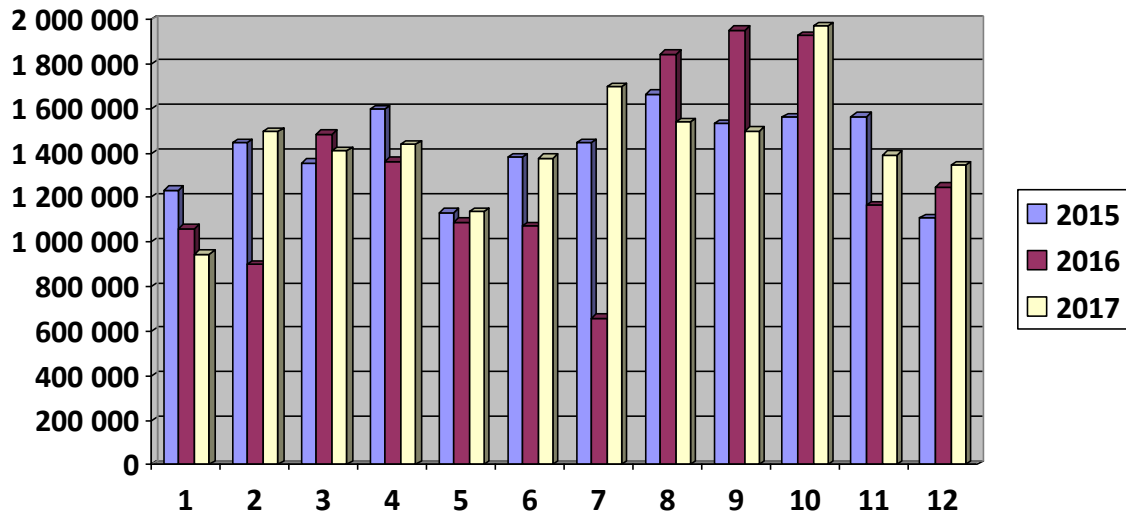


Figure 1. The amount of production on machine Roland IV, month by month in years 2015-2017

Second graph presents the amount of produced goods on machine Roland V. It may be seen that there are a lot of instability of the production process, similar to previously presented machine. The highest production was in July 2017 which may be surprising, while the lowest was in July 2016. It is well visible that there is no rule which determine the level of production and process efficiency.

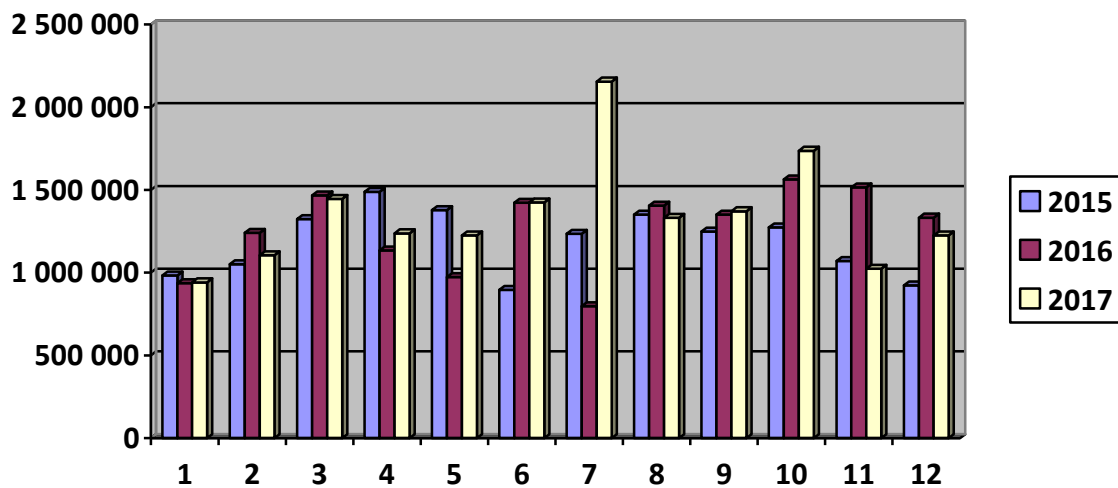


Figure 2. The amount of production on machine Roland V, month by month in years 2015-2017.

From the graph below it may be noticed that the quantity of printed products was always bigger on machine Roland IV. In general, the lowest production was in 2015 on machine Roland V while the biggest production was in 2014 on machine Roland IV.

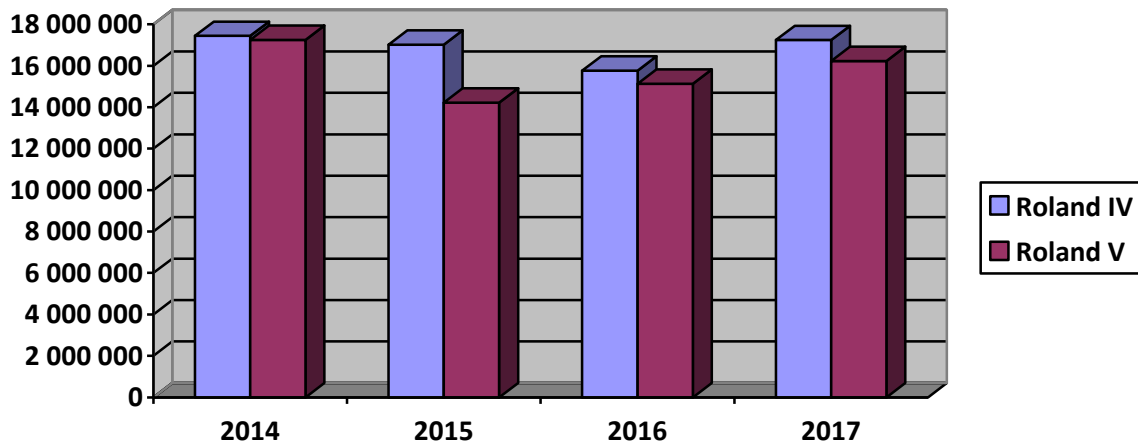


Figure 3. The comparison of production on machines Roland IV and V, month by month in years 2015-2017.

Analyze phase started with discussion about measured information and data. After collecting all ideas about the reasons of downtimes in the production processes, gained issues were divided into few categories of causes, such as man, method and machine. From the data it was seen that there are a lot of fluctuations in the printing process which may be due to the fact that there is a significant rotation of the employees working on production line. Usually, during holiday season when the human resources are limited there is a help from students internships. Continuous rotation results in additional time spent on trainings. Another cause of variability of the process is connected with lack of clear work instructions concerning process of production and setups. It is not defined for workers which activities should be perform in order or which processes may be eliminated. Also technical state and condition of the machine have influence on the process performance. The machinery used in printing company is old, so its maintenance requires costs and time which has a big impact on production effectiveness.

Improvement proposition concerns all three aspects which are the main reasons for downtimes on machines Roland IV and V. First proposition is connected with performing SMED on printing machines to eliminate unnecessary activities and reduce the time spent on setups. Single minute means that the time needed for a setup is with a single digit. In the printing company it was observed that there was no procedure how to do changeover in the way to be the most effective. After preparing correct work instructions SMED may be implemented in production process. Another proposition how to increase the effectiveness of production performed on the printing machines is to decrease rotation of workers. The key to long-term employee retention is the recruitment process. It is very important to look for a specific potential in candidates during interviews. After hiring qualified employees, the company have to face much more difficult issue - how to keep an employee and motivate to develop and work effectively. One idea is to introduce the bonus system for workers to thank

them for their engagement. The last proposition of improvement is to prepare good work instructions which will help to identify internal and external activities, eliminate unnecessary operations and organize work to be most effective.

Very important in improvement process is control which is the last phase of DMAIC cycle. Control should be continuous in order to be effective and to check future process performance. It may be done by creating a control plan which help in measuring the results and checking if the estimated progress and set goals were achieved. Control is the process which is essential in measuring if the implemented changes bring profits to the organization. It may be done by comparing the performance from analyze phase and after implementation of improvements.

5. Conclusions

Taking all into consideration it is essential to take care of quality aspects in enterprise. Nowadays, the environment is changing at the rapid rate and that is why the ability to quickly react to upcoming changes is very important. However, the term quality is difficult to define, it is essential to satisfy the customers' needs, because they are the factors which drive the economy. The history of quality and different conceptions and tools may contribute to better understanding the development and evolution of quality management. In different organizations there may be found different ways of quality development and improvement. The enterprise has to decide by itself which method is adequate for it and which one brings the best profits. One of the presented methods is Six Sigma which based on DMAIC cycle. Using this methodology in the printing company helps in defining and measuring the main problem which occurs on production line. Analyze of the issue is essential to create the improvement proposition which was presented in order to increase the effectiveness of the process. It may be achieved if there is continuous control.

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