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## Modern methods of the quality improvement and their application in managing of changes in a company

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### Abstract

This article deals about the application of the Six Sigma methodology by using modern methods in various stages of the DMAIC improvement model. The change management of business processes in terms of quality is determined by the correct choice of methods and tools for reducing discrepancies and non-productive costs. The evaluation of selected processes of furniture production through defects per million opportunities, efficiency, capability and sigma level before the change and after the change in the quality process provides relevant information for ensuring continuous quality improvement. Implementation of assessing changes in the process is a source of information for continuous improvement of process performance.

Keywords: Processes, quality improvement, Six Sigma, DMAIC, changes in processes.

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## 1. Introduction

Success of a company depends on the efficient use of resources, its innovative strength, productivity, reducing delivery times and respecting delivery dates, on good quality products and services. Currently, companies must act on the incentive of satisfying increasingly demanding needs and requirements of customers. Globalization, rapid developments in technology and increasingly strengthening competition force businesses to use new, modern management approaches besides the traditional ones. Such approach also includes process management that helps to improve the efficiency of production processes by using modern methods of quality improvement. Furniture businesses, as well as companies in general, can be considered as the sum of processes consisting of various actions and activities. However, they differ by their specific focus. To maintain the ability of furniture-making companies to compete, it is important to adapt the process management of a company in order to secure direct and daily management, measurement, quality control and thus secure improvement of processes at all levels. Terms such as quality or quality management have become an integral part of business management in all areas of economic life (Drabek & Merkova, 2010).

This article aimed to illustrate the use of the Six Sigma methodology with the application of the DMAIC model through selected methods and tools in order to improve the quality and efficiency of furniture production.

The results of theoretical studies in the areas of quality improvement and process performance increase, and their subsequent application in the specific conditions of furniture production using modern methods of quality improvement has led the authors to create a procedure for application of these methods within the Six Sigma methodology.

## 2. Materials and methods

Owen and Maidment (1996) define quality as a sum of features and characteristics of the product (production line), or a service related to its ability to meet the desired need. Customers are changing their expectations and requirements due to the availability of information. The assurance and improvement of the processes can be achieved by various methods and techniques such as ISO standards total quality management, the European Foundation for Quality Management (EFQM) excellence model, statistical methods of SPC, Plan-Do-Check-Act (PDCA) cycle, DMAIC and Six Sigma conception.

### 2.1. *The process, quality improvement and changes in processes*

According to Veber et al. (2006), the concept of quality is characterised as a degree of compliance with the requirements by the set of inherent characteristics. While the requirement is defined as the need or expectation that is determined, they are generally assumed or binding, inherent is interpreted as existing in something, especially as a mark and the term character (characteristics) as a distinguishing feature.

Owen and Maidment (1996) define quality as a sum of features and characteristics of the product (production line), or a service related to its ability to meet the desired needs.

Process represents integrated activities that generally require participation of several activities. Processes must be purposeful and efficient, and they should serve customers, not the company (Kassay, 2013).

Hammer and Champy (2000) define process as a set of activities that require one or several types of inputs and create outputs that have a certain value for the customer.

Smida (2007) defines the process as an organized group of interrelated activities, passing through one or more departments within or outside the company, in which inputs are consumed and outputs produced that have value for the customer. Change is a manifestation of the development process and, currently, there is a great pressure on the need for change.

Ludek (2005) says that process is a sequence of partial operations with clearly defined output at the end as a characteristic variable of process management.

Process is a term that is used in various meanings. In the real world, there are several types of processes, such as chemical process, manufacturing process, biological process, technological process, or process as a run of application (Coulson, 1994).

Process management is focused on the causes of arising discrepancies, not on the final outputs. This type of management control is based on the idea that the cause of company's bad results is inefficient running of company processes where it is necessary to make them rationale and more effective, which will result in higher added value for the customer (Marcinekova & Sujova, 2015).

The process approach focuses on the objectives and outputs of the process regardless of which departments of the company the process passes through. Company departments are in the relationship of a supplier and a customer; the owners of the processes provide services to each other within the enterprise. Process approach allows the identification of critical points in the creation of value for the customer faster than in the case of functional management.

The basis of the change, according to Vodacek and Vodackova (2001), is in the conversion from the state at the start to the state at the finish for the purpose of the improvement of the company position at the market. There must be constant care about the development of the company and its processes.

Palan (2002) argues that the management of changes is a core set of knowledge and skills that are essential to ensure the required quality solutions to the problems of organizational changes. Change means a qualitative transformation of certain characteristic parameters that describe the state of the object or event.

Based on the study of opinions of various authors on the Six Sigma methodology, we can see a consensus that the methodology Six Sigma is an approach or system that, combining the use of statistical methods, understanding customer requirements and reducing process variability, moves towards improving the processes and increases their level of perfection, expressed by a maximum number of errors per million opportunities and this value should be around 3.4 errors.

## **2.2. The Six Sigma methodology and DMAIC**

Grasseova, Dubec and Horak (2008), Mateides et al. (2006), Pande, Cavanagh and Neuman (2002), Topfer (2008), Cierna and Sujova (2016) and others are in agreement that among the most well-known and used methods and tools that are used in the process approach are PDCA (Deming cycle), DMAIC, SIX SIGMA, systems of quality control, balance scorecard, models EFQM, Common Assessment Framework, norms ISO order 9000 and others.

The idea of quality assessment that is not based on ready-made products, but rather on the manufacturing process was nothing original or innovative at the time, but the introduction of the Six Sigma measuring tool and preparing the entire methodology based primarily on the structure of the DMAIC model were taken over by other companies such as Kodak, Allied Signal and General Electric.

Topfer (2008) perceives the importance of Six Sigma as a business strategy that dramatically improves quality by planning and observing everyday activities. It directly ensures greater satisfaction of customers through quality improvement. Subsequently, it is connected with the associated increase in profits, jobs and increased competitiveness of a company.

The Six Sigma concept has become widespread and recognised approach leading to improved performance of organisations (Stamatis, 2004).

Six Sigma is focused on the reduction of variability in production processes. It attempts to minimise and prevent possible variations of production raising unnecessary costs. It requires high accuracy of individual processes and solves the dislocation of costs. The aim is to minimise the costs, respectively, to stabilize them. This method leads a company towards the basic idea to produce maximum value at minimal costs. Flexibility and precision are fundamental attributes of this method. It analyses errors that arose, improves the process and finally, by regular checks it prevents errors (Rastogi, 2010).

The aim of introducing Six Sigma is, according to Pyzdeka and Kellera (2010), a performance without errors. The performance is measured by a Greek letter sigma  $\sigma$  that is used for mathematical measurement of variability. Standard Six Sigma is 3.4 errors per million opportunities. The measure is defects per million opportunities (DPMO).

### 2.3. DPMO and indexes capability

**DPMO** represents *the number of defects* that occurs per million opportunities in product manufacturing. As one of the main criteria of Six Sigma, it was calculated according to the following formula (Nenadal & Plura, 2008):

$$DPMO = \frac{\text{number of defect products}}{\text{total number of products} * \text{number of opportunities}} * 10^6 \quad (1)$$

Capability index  $C_p$  as an indicator of potential process capability, characterizing process variation was calculated as

$$C_p = \frac{USL - LSL}{6\sigma} \quad (2)$$

where USL – upper tolerance limit; LSL – lower tolerance limit;  $\sigma$  – standard deviation;  $6\sigma - 3\sigma$  on the left and  $3\sigma$  on the right on the target value  $T$

We compared the result of calculating  $C_p$  and evaluated by the following values of  $C_p$ :

If:  $C_p < 1$  – production process is not capable,  $C_p = 1$  – production process is close to capable,  $C_p > 1$ , 33 to 1, 67 – manufacturing process is capable to fulfil the tasks for which is was designated.

The value of critical capability index  $C_{pk}$  represents the actual, real process capability. To calculate critical index, capability we used:

$$C_{pk\ USL} = \frac{USL - \bar{X}}{3\sigma} \quad C_{pk\ LSL} = \frac{\bar{X} - LSL}{3\sigma} \quad (3)$$

where USL – upper tolerance limit; LSL – lower tolerance limit;  $\bar{X}$  – average mean value in subgroups, overall selective mean;

$\sigma$  – standard deviation.

Capability index always considers the lower value:

$$C_{pk} = \min (C_{pkUSL}, C_{pkLSL}) \quad (4)$$

### 3. Results and discussion

The number of defects associated with individual processes of furniture parts production was an essential source of information for setting the critical process according to the values of **DPMO, efficiency and Sigma**. Effectivity calculations were carried out by defining the formula  $= 1 - \text{DPMO} / 1000000$  \* 100 and for the level of sigma =  $\text{VNormal}(1 - \text{DPMO} / 1000000; 1,5;1)$ . Calculations were carried out using program Excel and STATISTICA CZ.

**Table 1. Tracking defects on furniture parts**

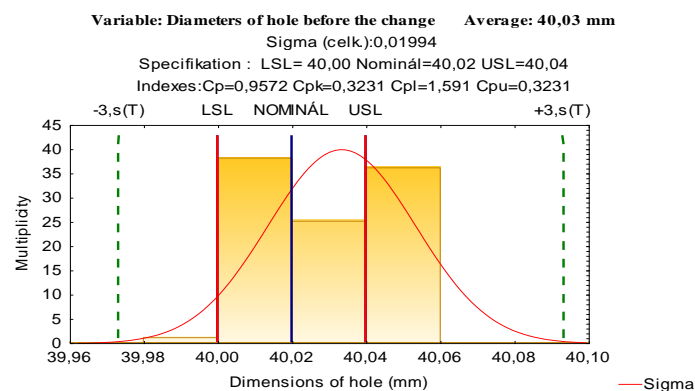
Defects	Number of detected defects (pcs)	Defect frequency (%)	Cumulative Percentage (%)
Wrong holes for fitting	1,739.00	39.69%	39.69%
Pressing	1,204.00	27.48%	67.16%
Sanding	489.00	11.16%	78.32%
Defective edges	333.00	7.60%	85.92%
Surface treatment	284.00	6.48%	92.40%
Veneer faults	96.00	2.19%	94.59%
Chipboard faults	84.00	1.92%	96.51%
Mechanical damage	64.00	1.46%	97.97%
Dimension faults	52.00	1.19%	99.16%
Dirt	37.00	0.84%	100.00%
Defects total	4,382.00	100,00%	
Production in pcs	68,665.00		

Source: internal company documents and personal processing

Based on the results of DPMO, efficiency and the level of Sigma, drilling holes for fittings on furniture parts was defined as a critical process. According to Table 2, the process of drilling holes reached the highest value of DPMO, which represents 151,955.14 DPMO. The above-mentioned process presented the lowest effectivity value 84.80 and the lowest value of Sigma 2.53.

Phase Define was completed by the Six Sigma application project charter defining work positions, responsibilities, tasks, time tables of individual phases and economic evaluation.

Phase Measure was focused on measurement, analysis and evaluation of the critical process measurement results – drilling holes. Qualitative mark was the diameter of the hole for fittings on a furniture part. Results of holes diameter measurement were evaluated using the program STATISTICA CZ – Industrial statistics. The results of which were Sigma values and capability coefficients.



**Figure 1. Measurement of hole diameters before the change.**

Source: personal processing

It is apparent from Figure 1 that holes diameter values vary in an unnatural way. Variability values of the observed mark show signs of process incapability, where the variance of values is very large and the process is not even centred because it is outside the tolerance limits.

In the phase Analyse, methods such as Ishikawa diagram and Affinity diagram were recommended to find out the reasons for defects that caused the analysed state during the drilling holes operation (Figure 2).

Within the phase Improve, a response plan was proposed precisely describing activities and corrective measures to improve the critical state of the process.

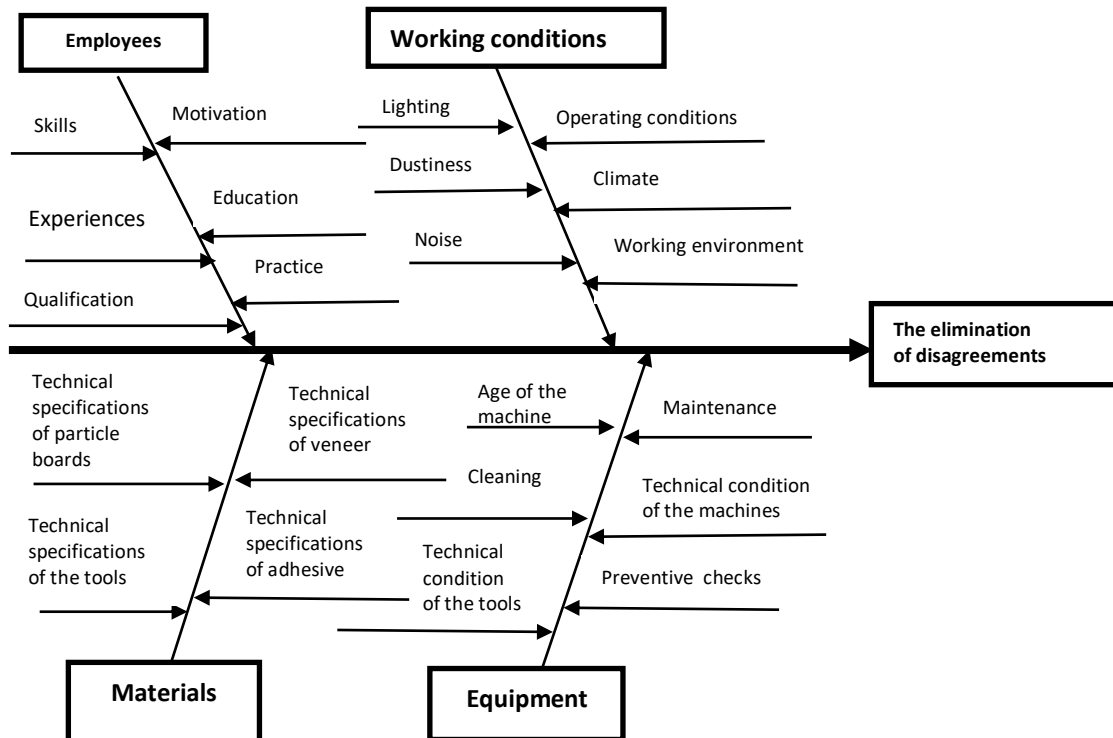
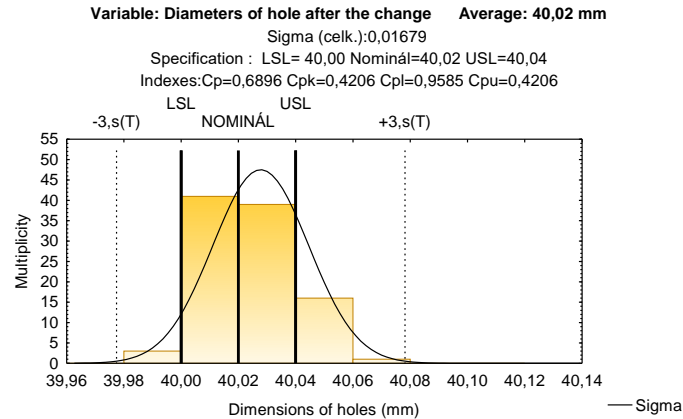


Figure 2. Ishikawa diagram – The elimination of disagreements.

Source: personal processing

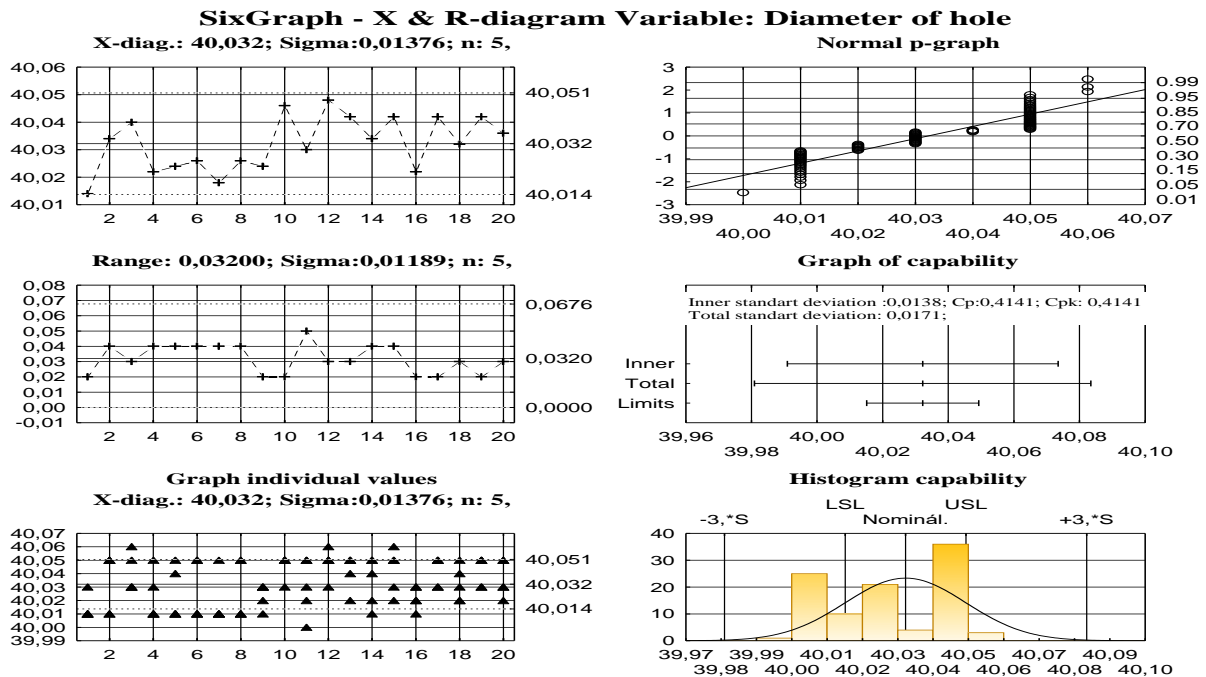
The results of subsequent measurement of the qualitative mark – diameter of the hole for fittings – were repeatedly used for calculation of Sigma levels and capability coefficients (Figure 3). On this basis, it was possible to make a comparison with the original state of the process, analysis of improvements and effectivity of corrective measures.



**Figure 3. Measurement of hole diameters after the change.**  
 Source: personal processing

From the chart in Figure 3, we can see a radical reduction of the number of diameter values in the range 40.06–40.08 mm, a reduction of variability and variance values of the observed quality mark. Histogram is bell-shaped and there was also an improvement in centring the process.

In the phase Manage, summary charts of qualitative characteristics for follow-up checks and critical process management were used. Program STATISTICA CZ – Industrial statistics was used also in this phase, which produces processed results of measured values that offer early information about critical process.



**Figure 4. Summary charts of holes diameter measurements after change**  
 Source: personal processing

#### 4. Conclusion

Based on a specific example of application of selected modern methods of quality improvement within the Six Sigma methodology, we can say that the number of defects in the furniture parts manufacturing process was reduced by 28.23%, which represents monthly saving costs of 3,564.66 € for the output of 68,665 furniture parts. As we can see in Table 3, DPMO value was reduced by 42,903.94, which is a value reducing the number of DPMO, effectivity grew by 4.29% and Sigma value by 0.2.

**Table 2. Defects, DPMO, effectivity and Sigma of furniture parts production process**

Process	Number of defects	Performance	DPMO	Effectivity	Sigma
Drilling holes before change	1, 739, 0068, 665, 00	151, 955, 14	84, 80	2, 53	
Drilling holes after change	1, 248, 00	68, 665, 00	109, 051, 20	89, 09	2, 73

Source: internal company data and personal processing

Observation of processes capability is a dynamic tool that allows making operational changes in the production process. Fluctuation of the quality mark values is a natural part of the process, and it is impossible to achieve its absolute uniformity. At the same time, it is necessary to monitor this value because if there are systematic causes in the production process they will result in the process with the variability values so diversified that its performance is very low, with defects in output, increasing overall costs and unproductive losses, as it was in the process observed in this case.

Using modern methods in the critical process of drilling holes, applying them and comparing the state before and after the change, we have reached the following conclusions:

- they offer relevant information for the management of processes
- they simplify the management of processes
- they improve the quality of processes
- they increase the performance of processes
- they reduce variability values and process capability, thus reducing the occurrence of defective products,
- through the management of processes, we can presume the output quality in time,
- by reducing unproductive costs we can improve the economic results of the organization.

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