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TEXTILE CUTTING PROCESS OPTIMIZATION MODEL BASED ON SIX SIGMA METHODOLOGY IN A MEDIUM-SIZED COMPANY

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ABSTRACT
In today's dynamic market, constantly improving quality is a key response to the problems of business in which Six Sigma system has a substantial role. In order to use the advantages offered by this system, this paper analyzes the manufacturing process and considers the possibilities of using DMAIC methodology to the textile cutting process. The points of discussion in this paper are the possibilities of selecting and implementing Six Sigma projects as well as algorithms of continuous improvement after implementation of the projects. Taking into account all characteristics of the production process, a systematic continuous improvement process solution is designed as a first step in implementing Six Sigma quality system. From the standpoint of feasibility and cost-effectiveness, the selected model is applicable for small and medium-sized organizations, and is considered as a solution that will provide positive results.
Key words: Six Sigma, DMAIC, process capability, defect, control chart

1. INTRODUCTION

Six Sigma as more advanced quality system is recently become attractive to many companies especially for those that aspire to business excellence. After many successful stories of implementing Six Sigma in large global companies such as General Electric, Caterpillar and others, today Six Sigma is more likely becoming successful story in some smaller companies over the globe. Six Sigma is a more advanced level of quality, which will certainly implement those organizations that tend to business excellence after QMS certification per ISO 9000 series. Six Sigma is an opportunity for organizations to increase the product/process quality and profits, and to reduce costs [1,2].
In statistical terms, sigma (σ) is a measure of scattering processes. By definition, Six Sigma is less than 3.4 Defect Per Million Opportunities (DPMO) or parts per million (PPM). In other words 99.99966% accuracy, which is the ultimate goal to improve and reduce the costs of poor quality at 1÷2 %. Six Sigma is defined as a set of techniques based on Statistical Process Control (SPC) which can help companies to achieve significant improvement in product quality and therefore increase competitiveness [4,5].

2. PROBLEM DEFINITION AND PROCESS IDENTIFICATION

Implementing Six Sigma in small and medium-sized enterprises is not sufficiently investigated and there is no enough data about successful implementation. The traditional approach to the implementation specific for large companies is expensive and requires a lot of resources. Therefore, implementation of Six Sigma in small and medium-sized enterprises represents an additional barrier to the success of such projects [3,5,6].

Six Sigma concept discussed in this paper is developed for the export-oriented medium-sized company that employs about 200 workers, taking into account all the specifics of business processes and problem faced. The approach in the implementation typical for large companies was modified in a manner that will enable the implementation of projects using less resources, what makes it applicable to medium-sized companies [6,7,8]. In order to maintain its competitive advantage, the company is dedicated to the programs of implementing advanced quality systems such as Six Sigma, immediately after the implementation of the ISO standards.

The primary goal of the optimization is to reduce the number of defects that occur in the textile cutting process. The ultimate goal is to reduce the number of defective units to a level that will meet the Six Sigma level, i.e. producing 3.4 defected part per million. Due to defects in the production process, outages had been observed that lead to delay delivery in some cases. Therefore, additional time, material and transportation are necessary in order to deliver parts to the customer site per Just in Time principle. In the worst case, this leads to reducing regular production time, working under stress, making extra costs, new defect accumulation which reflects to the regular production process schedule.

2.1. Research Methodology

As a first step in developing model proposal was approach to the production process mapping and categorizing on the major and subordinate. The second step was identification processes that have a determinate process of work, which is one of the main requirements for the application of DMAIC (Define, Measure, Analyze, Improve, and Control) methodology.

The main production process of textile cutting is carried out in four phases and consists of nine CNC machines. Features of this process are high flexibility, high production, a large number of defective units, and longer production time per unit. On that basis, the main process operation had been identified in the following stages (Figure 1).

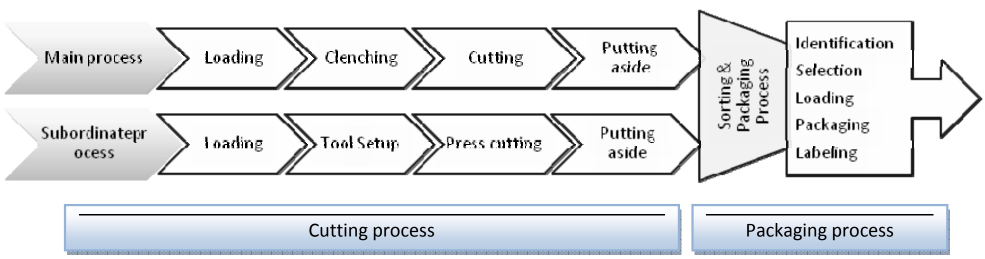

Figure 1. Textile cutting process.

A side process of the textile cutting is cutting through that takes place in four phases and consists of three presses. Features of the process are high speed per unit of the product, a low number of defective pieces, modular parts (inflexibility) and low productivity.

Another side process of sorting and part preparation for the next process of sewing had been identified as well. This process consists of selection and packaging of the parts per sewing plan. Features of this process are: small available space, slow identification and large variety of parts. On the basis of the sewing plan, workers pack required quantities of assemblies and sub-assemblies. Dominant defects from this process are wrong quantities and wrong parts, what is caused by workers. The previous three processes represent manufacturing process of textile cutting in which defects occur.

3. PROJECT SELECTION AND DMAIC METHODOLOGY APPLICATION

Statistically speaking, it was shown that the main process contributes most to the production of defective units and therefore this process is proposed as project no. 1 for the optimization. The process of nomination and selection of projects is carrying out per the following algorithm (Figure 2).

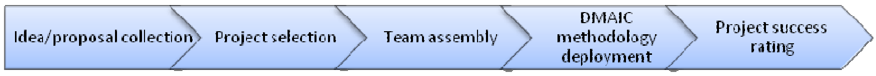

Figure 2. Process of project selection and implementation.

Due to the size of the company, it is anticipated that the project teams work "part time" on the project, and to be supervised by a Black Belt, who will manage projects and train team members [9,10].

3.1. Process Continuous Improvement Model

Once Six Sigma project is implemented in a process, the performance of the process is necessary to improve continuously per DMAIC methodology with the aim of business excellence aspiration. This approach allows the effective use of data in order to eliminate the causes of defective products. In accordance with this requirement designed is the flowchart of DMAIC methodology application for manufacturing process (Figure 3).

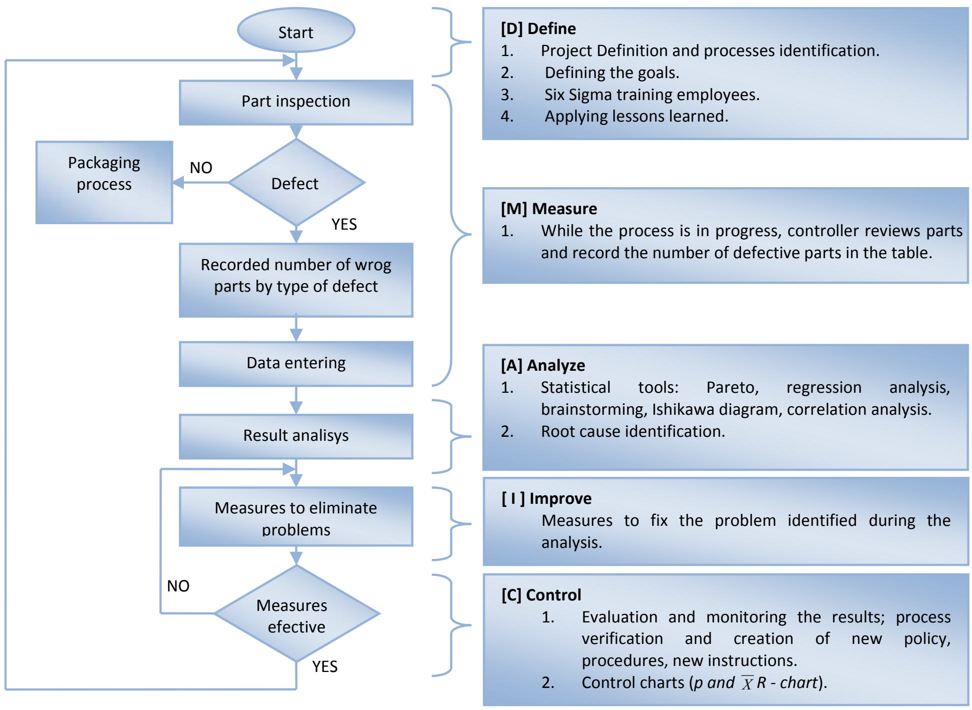

Figure 3. Continuous improvement flowchart for implemented project.

Process monitoring control charts are used to collect and analyze data and based on that it is possible to act proactively in problem solving. Using *p*–control chart it is possible to track "good/bad" part characteristics. Using $\overline{X}\,R$-control charts it is possible to track measured values of the part features. Fishbone diagrams are used for brainstorming sessions that take into account the main affecting elements of the process quality (man, machine, material, method, environment, and measurement). If any of these elements have significantly changed, the system of the processes will be changed as well, and there will be corresponding changes in product quality.

Software is used to analyze collected data that automatically show the state of process in the control charts and calculating process capability indices C_p and C_{pk}. If C_p<1, then the process does not meet specifications; if C_p> 1 then

$$C_p = \frac{USL - LSL}{6\sigma}$$

USL – Upper Specification Limit
LSL – Lower Specification Limit
σ – Standard deviation

process meets specifications. If the process is "under control" computing capability index does not make sense [8,9]. Some companies now require that the minimum value of C_p index is 1.33. Some other companies raise this requirement up to 1.67 or $Cp \geq 2$, what corresponds to the Six Sigma level.

3.2. Expected Results

Using this model, the company has a framework for optimizing the textiles cutting process, where it is necessary to take corrective action first in order to stabilize the process and then undertake improvement steps.

Positive assessment of the project success is reflected in the process monitoring after project implementation, and should give results about the process in accordance with Figure 4. The figure shows a clear difference in behavior of the process before and after project implementation per DMAIC methodology where improvement is obvious.

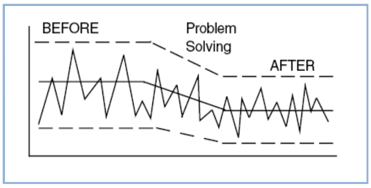

Figure 4. Process improvement expected results

4. CONCLUSION

The main result of applying the described model is the selection of suitable solutions applicable to small and medium-sized organizations. Application of the model guarantees success in improving the process because it provides a scientific basis in decision-making process to eliminate defects. Systemic and systematic approach that is applicable to the entire production process, allows that in any moment the process parameters can be easily calculated (natural process limits, standard deviation ...), and process capability indices C_p, C_{pk}. On that basis can be determined sigma level of the process. The next step is to do experimental work to test this concept in order to assess the model efficiency and influence of certain factors on the process stability.

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