Journal of Trends in the Development of Machinery
and Associated Technology
Vol. 16, No. 1, 2012, ISSN 2303-4009 (online), p.p. 103-106

SIX SIGMA MODEL TESTING IN OPTIMIZING MEDIUM-SIZED COMPANY PRODUCTION PROCESS

Hazim Bašić
University of Sarajevo, Mechanical Engineering Faculty
Vilsonovo šetalište 9, Sarajevo
Bosnia&Herzegovina

Benjamin Duraković
International University of Sarajevo, Faculty of Engineering and Natural Sciences
Hrasnička cesta 15, Ilidža, Sarajevo
Bosnia&Herzegovina

Almira Softić
University of Sarajevo, Mechanical Engineering Faculty
Vilsonovo šetalište 9, Sarajevo
Bosnia&Herzegovina

ABSTRACT
The aim of this paper is to test Six Sigma concept developed to optimize the manufacturing process for a company with about 200 employees. This test includes process monitoring, using statistical process control charts, and analyzing collected data for two different periods, before and after DMAIC methodology application. Dominant defect and its causes had been identified and it was found out that the process was not under control. Implementing improvement measures, dominant defect was eliminated but this didn't enable to put the process under control. As a conclusion, the test indicated that the model is effective but it takes more iterations to achieve the desired state.
Keywords: Six Sigma, DMAIC methodology, process, defect, control chart, process capability.

1. INTRODUCTION

Six Sigma provides a comprehensive plan, which helps companies to integrate appropriate statistical tools and other techniques in a "comprehensive" tool, for process improvement. These tools can be applied in individual phases of DMAIC (Define, Measure, Analyze, Improve, and Control) methodology in order to establish an effective processes quality improvement system [2-5]. Therefore, the aim of this research is testing and elaboration of developed model for implementation DMAIC methodology using statistical process control to monitor scrap generated in a textile cutting process, which should result in increasing processes efficiency and scrap reduction [1]. Focus of this paper is to test the model for the Six Sigma methodology implementation to optimize a textile cutting production process in a midsized company [1, 5, 6]. With the aim of showing state of the process the data collection was carried out during two periods, i.e. before and after correction measure implementation. Length of pre-test period was about 12 months and 1,085,987 pieces has been checked. Length of test period after implementation of correction measures was approximately 30 days and 642,636 pieces has been checked. In the discussion below results of the analysis for considered periods are presented for three shifts [1].

2. EXPERIMENT SCOPE

The scope of the experiment included project definition and DMAIC methodology application, where was done the following:

1. Existing data analysis over the past 12 months;
2. Dominant defect identification;

3. Identification of main defect causes;
4. Correction measure proposals and implementation;
5. Measurements of process after improvement and its analysis.

Experimental testing of the model was carried out on the main textile cutting process for three shifts. Attribute characteristics of process output were monitored using *p*-chart. For this purpose all parts were inspected, defects were recorded, and process indicators were calculated. The process consists of CNC machines and has the following stages: textile loading, vacuum clenching, textile cutting and putting aside (Figure 1).

Figure 1. Production process line.

The material is loaded in multiple layers using a vacuum clenching to the bench. The knife cuts at the same time all loaded sheets of the material per CAD generated contour. In case something goes wrong during the cutting operation, the knife will not produce only one defect but just as many as the sheets of the material is loaded.

As a Six Sigma analysis tool, software is used for readings of attribute control charts based on good-bad judgment (*p*-control chart), $\overline{X}$R chart for measured characteristics [8], Pareto analysis and correlation [7]. Fishbone diagrams, as a tool for identifying the causes of the defects, are used for brainstorming sessions.

3. RESULT DISCUSSION

Pareto analysis showed that dominant defect for pretesting is pulled fabric thread "28D" (Figure 2).

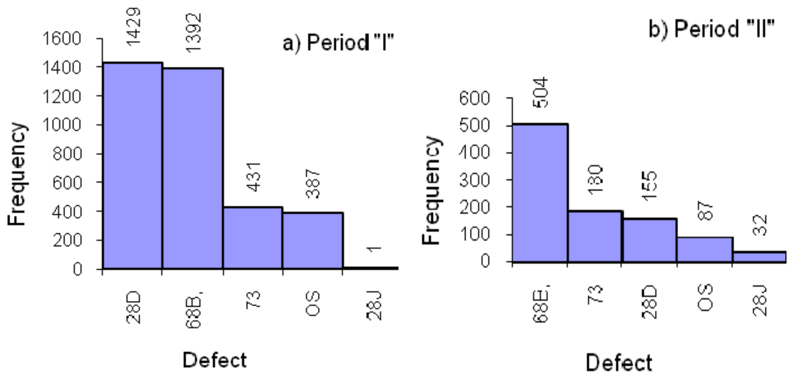

Figure 2. Two periods defect Pareto analyses.

This is systemic defect caused by machine due to irregular sharpening of material cutting knife (Figure 3). Due to bumps on the knife cutting edge, formed by sharpening grinding wheels, the knife couldn't cut the last fabric thread on the cutting contour, causing drawn thread in the next step "putting aside". Another reason for the drawing thread is the blunt knife tip, where the first knife sting into the material usually draws material thread. The cause of this bluntness is first sting knife tip hitting to knife guides or workbench in some cases.

3.1. Improvement

This issue is solved by changing method of sandpaper belt instead of grinding wheels, which is incomparably much more convenient for setting grinder and making knife cutting edge uniform.

With these changes the dominant defect "28D" (drawn thread) is significantly reduced. Defect "68B" (irregular cut)

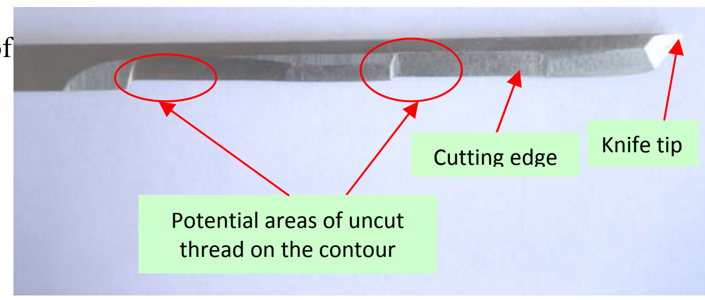

Figure 3. Example of irregular knife sharpening.

caused by human factor became a new dominant defect. The process could be under control if the defect "68B" is neglected. In that case process picture becomes quite different, and capability index becomes acceptable.

3.2. *p* – chart Discussion

Figure 4 shows the state of the process for both periods. The process is not under statistical control because it does not operate within its natural process limits i.e. Upper Control Limit (UCL). Upper Specification Limit (USL) for the process is 2%, which in this case is not satisfied also. The process is very unstable and it is necessary to stabilize process first in order to obtain realistic values of process parameters.

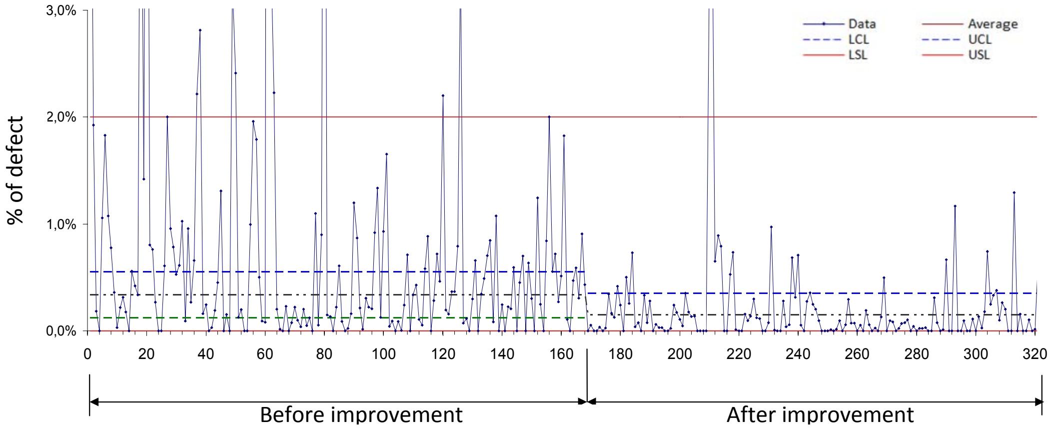

Figure 4. Process before and after changes.

3.3. Discussion of Process Capability Indices

Based on calculated index value of C_p = 4.64, it is not possible to determine process sigma level. On the other hand, if PPM *(Part per Million Opportunities)* value is observed, which is 3352, that means that the process is about 4.2 σ. This discrepancy between the PPM and C_p is explained by the fact that the process is not under control and that the values of process capability indices are meaningless. The value of standard deviation (σ = 0.00072), is much higher than in the other case for period of "II".

A similar comment applies to the period of "II", where C_p = 5.58, and value of PPM is 1491, which means that the process takes about 4.5σ level but still is not under statistical control. Thus, in both cases, none of the above process capability indices are unacceptable. This means that is necessary to stabilize the process first and then make other improvements. The standard deviation in this case is smaller than for period of "I" (σ = 0.000597), which can be visually inferred from the control chart. Therefore, the process capability index values are unrealistic because the process is not under statistical control. In both considered periods there are outliers that appear to deviate markedly from the normal process flow. These extremes are usually caused by people not by machines. The actual value of the standard deviation will be smaller if outliers are neglected. Theoretically, to make the process working in 6σ level it should produce 3.7 defects of 1,085,987 inspected pieces for period of "I", and for period of "II" should give 2.2 defects of 642,636 inspected pieces.

3.4. Correlation Testing Between Number of Defects and Batch Size

There was very small correlation between the batch size and number of defects (Figure 5), which means that little propagation of defects is evident from the increase in the number of material sheets of the batch. That means, if machine cuts 20 sheets at once, and if the operator mistakenly put an improper diameter drill, the drill will go through all 20 sheets and thus produce at least 20 defects. In that case, defect propagation is much higher than with a smaller number of sheets. Correlation was slightly higher for the period of "I" and was r = 0.38, while for the period of "II" correlation coefficient was smaller r = 0.21, which means that none of the calculated values are statistically significant and therefore they are not further discussed.

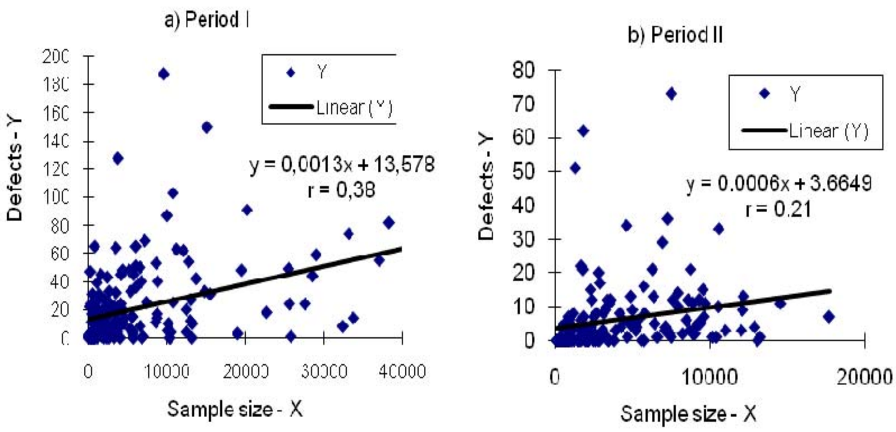

Figure 5. Defects depending on the sample size

As a next step it is necessary to maintain statistical process control per DMAIC methodology principle. Based on the previous iteration results it is necessary to take new actions in order to stabilize the process and then continue with the improvements that lead to six sigma quality level. This includes evaluation and monitoring of the each previous phase results, process verification and modification and creation of new policies, procedures, instructions to the employees. Software for defect monitoring in the production process provides a clear summary report of all process parameters creating a good history record.

4. CONCLUSION

Implementation of the DMAIC methodology during the textile cutting allows the company a systematic and systemic process monitoring. Software enables company managers to have in one place all information's about the process. Accordingly, it is possible to take appropriate corrective and preventive actions.

With reducing "28D" defect some improvements had been achieved but the process was not yet under control. "68B" defect was dominant after changes were implemented that mean that the next iteration should go to its elimination and achieve some improvements that lead the process to be controlled. Continue to repeat the iterations until it reaches the desired goal. Defect "28D" was dominant in period of "I" and was caused by machines. Defect "68B" was dominant in the period of "II" and was most likely caused by people, which will be proved in the next iteration.

5. REFERENCES

[1] Duraković B.: Aspekti implementacije šest sigma sistema kvaliteta u malim i srednjim preduzećima, Mašinski fakultet Sarajevo, 2007.

[2] Gosnik D., Vujica-Herzog N.: Success Factors for Six Sigma Implementation in Slovenian Manufacturing Companies, Advances in Production Engineering & Management; Vol. 5 Issue 4, pp. 205-216, 2010.

[3] Hoerl R. W.: Six sigma black belts: What do they need to know?, Journal of Quality Technology, Vol.33, No.4, p. 391- 406, 2001.

[4] Homrossukon S., Anurathapunt A.: Six Sigma Solutions and its Benefit-Cost Ratio for Quality Improvement, World Academy of Science, Engineering & Technology; Vol. 80, pp. 520-528, 2011.

[5] Jašarević S., Brdarević S., Petković D., Dolinšek S.: Effects of introduced quality system to organizational factors, 13th International Research/Expert Conference "Trends in the Development of Machinery and Associated Technology" TMT 2009, Hammamet, Tunisia, 16-21 October 2009.

[6] Kovach J., Stringfellow P., Turner J., Cho R. B.: The House of Competitiveness: The Marriage of Agile Manufacturing, Design for Six Sigma, and Lean Manufacturing with Quality Considerations, Journal of Industrial Technology, Vol. 21, No 3, 2005.

[7] Linderman K., Schroeder R. G., Zaheer S., Choo, A.S.: Six Sigma: a goal-theoretic perspective, Journal of Operations Management, No. 21, p.193–203, 2003.

[8] Marudhamuthu, R., Krishnaswamy, M.: Executing Lean Sigma Outline in an Indian MSME, European Journal of Scientific Research; Vol. 55, Issue 3, pp. 355-365, 2011.