USING 6 SIGMA IN SYSTEM CAPABILITY DIAGNOSIS TO INCREASE PRODUCTIVITY

Ioana Catalina ENACHE[1], Ionel SIMION[2], Ana-Maria AVRAMESCU[3], Florina CHISCOP[4], Marius Adrian CHISCOP[5]

In current global market, competition manufactures are forced to use different strategies to increase productivity and gain a competitive advantage. An efficient method in the manufacturing process is to use the proper quantitative analysis of data. This article is based on a case study of the injection process. Using a measurement system analysis that is based on a collection of statistical methods, we measure the system capability. Our purpose is to verify if the studied system is capable to satisfy the client necessities.

Key words: Six SIGMA, DMAIC, statistical method, process optimization.

1. Introduction

In order to improve the studied process we used the Six SIGMA method, were SIGMA is a statistical measure of the process variation. The basic approach is to measure the performance of a process, comparison with the ideal statistically values and identifying methods to eliminate variation. At first, a detailed analysis is made to measure the critical factors influencing client's demands and to find ways to remove the obstacles that stand in the way of that success.

The core model of the Six SIGMA implementation is DMAIC (Define, Measure, Analyze, Improve and Control). In figure 1 we presented the specific steps of a Six Sigma analyse [1].

The expectations after each step are:

- DEFINE - Everybody understands the goals and boundaries of the project, the effect of the project on customers is expressed well;

[1] Assistant, Department of Engineering Graphics and Industrial Design, University POLITEHNICA of Bucharest, Romania, e-mail: dobre.catalina@yahoo.fr
[2]Professor, Department of Engineering Graphics and Industrial Design, University POLITEHNICA of Bucharest, Romania, e-mail: ionel_simion@yahoo.com
[3]Assistant, Department of Engineering Graphics and Industrial Design, University POLITEHNICA of Bucharest, Romania, e-mail: avr_ana@yahoo.com
[4]Assistant, Department of Machines and Manufacturing Systems, University POLITEHNICA of Bucharest, Romania, e-mail: florinachiscop@gmail.com
[5]Student, Department of Machines and Manufacturing Systems, University POLITEHNICA of Bucharest, Romania, e-mail: marius_chiscop@yahoo.com

- MEASURE - Making sure that the output(s) and the potential inputs of the project are measured correctly. Models are created using graphical analysis.
- ANALYZE - Determining the important inputs causing variation in the process, analyzing their levels, and identifying the time traps.
- IMPROVE - Identifying and testing the levels of the important inputs causing variation in the process.
- CONTROL - Preparing control plans and controlling the process to make sure that continuous improvement has been achieved.

Fig. 1. Six SIGMA stages

2. Case study

A Six SIGMA project contains five distinctive stages: problem definition, data measurement, data analyses, process improvement and control.

First three phases are based on already known information while the last two represent the optimization process of the studied architecture (see figure 2).

The paper focuses on the algorithm that a Six SIGMA project must follow by using a manufacturing architecture as a case study.

Fig. 2. Analyses and optimization in Six SIGMA stages

In order to implement the Six SIGMA project we will use principals, techniques and instruments available in this aria specialty literature. Never the less all gathered information must be adapted to the characteristics and necessities of the studied enterprise.

Each stage in a Six SIGMA project is divided into steps. In figure 3 we detailed the required first two steps for improving the injection.

1. DEFINE	*PROCESS CHARTER*
	VOICE OF CUSTEMER - CRITICAL FOR QUALITY VOC - CTQ
	PROCESS MAPPING
	FLOW CHART
	SIPOC (SUPLAIER, IMPUTS, PROCESS, OUTPUTS, CUSTOMER)
2. MEASURE	*DATA COLLECTION PLAN*
	GAGE R&R
	CONTROL CHARTS
	CAPABILITY ANALYSIS

Fig. 3. Steps of the injecting process

2.1. Problem definition

In this stage, the first step is to define the problem as to allow the team to come up with a plan for organising the project ongoing. The site is equipped with:

- 1 granule Preexpandor
- 9 Injection moulding machines
- 1 mill waste ground

PEX injection moulding machines can manufacture two different parts that we named “component 1” and “component 2”. These parts can be manufactured both simultaneously and individually.

On a regular day the productivity of this machine can be 1676 “Component 1” parts and 838 sets of “component 2”. For both components, the manufacturing cycle time is 80 seconds.

The two components are used in the assembling of different refrigerators models produced on the site, as seen in Figure 4 [2].

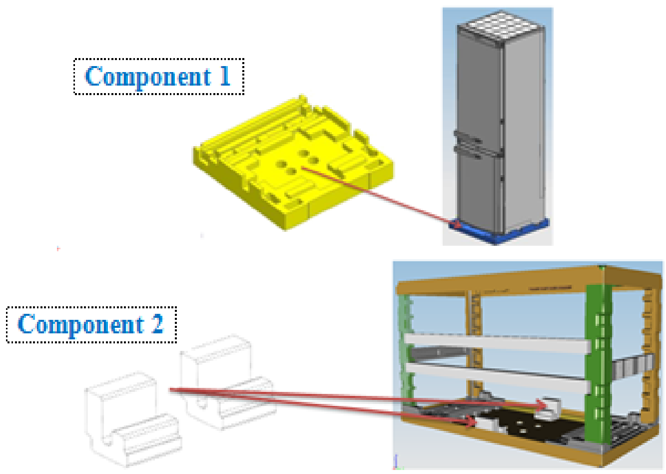


Fig. 4. Components 1 and 2 places in the assembled product

The number of refrigerators models produced on the site on a daily base requires a certain amount of the two components that is currently not available. The necessary parts are 2000 pieces of component 1 and 1400 sets of component 2. Due to the insufficient number of components, the whole productivity rate is held back. In order to solve the problem and finish assembling the required number of refrigerators we must increase the number of manufactured components 1 and 2, as to meet the requirements [3].

2.2. Reasons for choosing this project

1. Customers demand for a greater number of components (in this case the client is represented by the refrigerators assembly department).
2. Company’s goal to increase productivity and reduce the number of products with defects.

For a better understanding of the problem and in order to define the focus points used for information gathering as a part in the problem solving process a flow chart was drawn (Figure 5) [4].

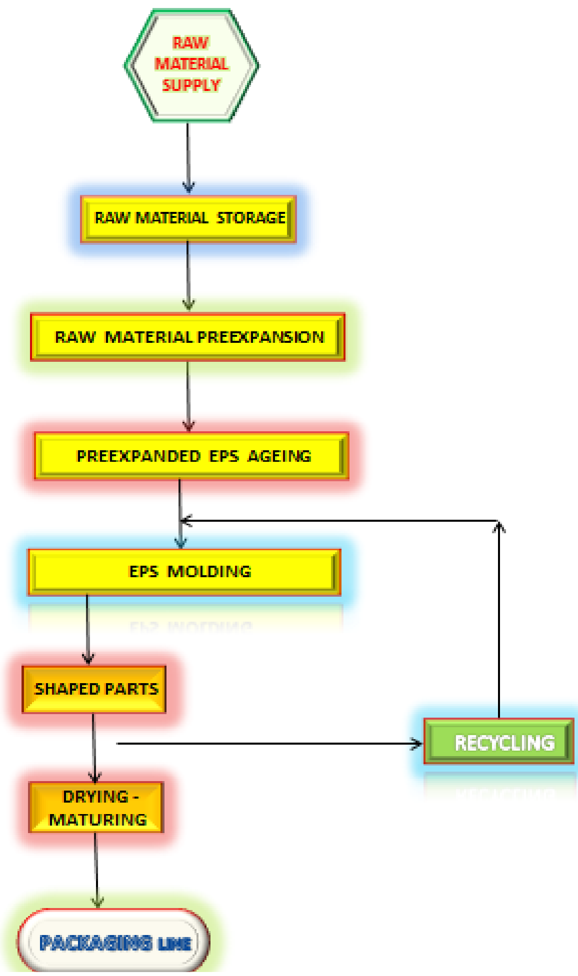


Fig. 5. Material flow chart

A major importance step during the Define phase of the project is to transform VOC – costumer's voice into CTQ – costumer's demands. In this manner, we could identify which were the most important costumer's demands and corresponding arias in the manufacturing process influencing these demands.

A cause – effect matrix was made and each CTQ was given a corresponding input in the process.

The process definition and graphic representation indicates the process itself, the suppliers, the process input and output for each step and customer. An example of this diagram type that connects suppliers / inputs / process / outputs / customer – SIPOC is given in Figure 6.

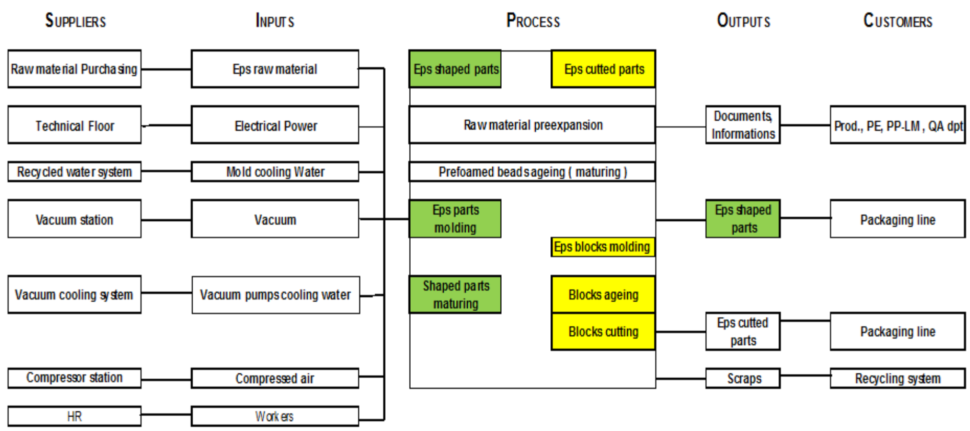


Fig. 6. SIPOC

2.3. Measurement phase

In the manufacturing process concerning the two components, the workers use special matrix with the same geometry and functionality as the components.

Both matrixes are designed as to obtain two individual parts for each injection cycle, regardless of the component type. The matrix dimensions are also the same:

- Length – 1450 mm
- Width – 435 mm

These dimensions are not random as the matrixes are specially conceived to be used for both components, individual or combined depending on the work schedule. For example, in the injection process the workers can use only matrix for component 1 or can also add the component 2 corresponding matrix (Figure 7).

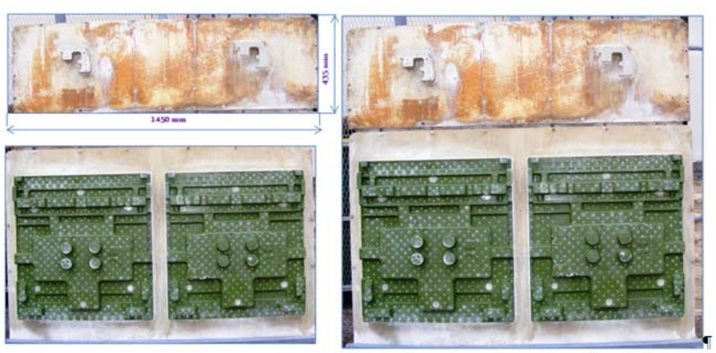


Fig. 7. Matrix used for injecting component 1 and 2

For this project, the most important criteria regarding measurement phase was the manufacturing cycle time duration for component 1 and 2. Three different operators repeated the measurements for a period of three weeks, in the same manner and moment of time, during different time frames of work shifts. The instruments used were three identical digital chronometers with a precision of 0.01 s.

The information collected will be used as input for a statistic analyse performed in Minitab software [5]. The injection process contains six phases:

Next, we studied the injection process manufacturing times diagram for component 1 and 2.

For each phase of the process, we identified the cause which leads to increased manufacturing time as follows:

- Phase 2 – injecting material in matrix – the material distribution in the matrix;
- Phase 3 – stemming operation – the large surface that needs to be covered;
- Phase 4 – cooling operation – the large surface that needs to be covered;
- Phase 5 – vacuum operation –the big amount of water that needs to be drained;
- Phase 6 – extraction of component – its big dimensions.

There cycle time in the first phase doesn't influence the injection process.

The operating principal of injection machine and its auxiliary equipment is needed for a better understanding of the six phases for the injection process.

The machine-operating principal is standard as thought the work parameters does not influence the indicators measured.

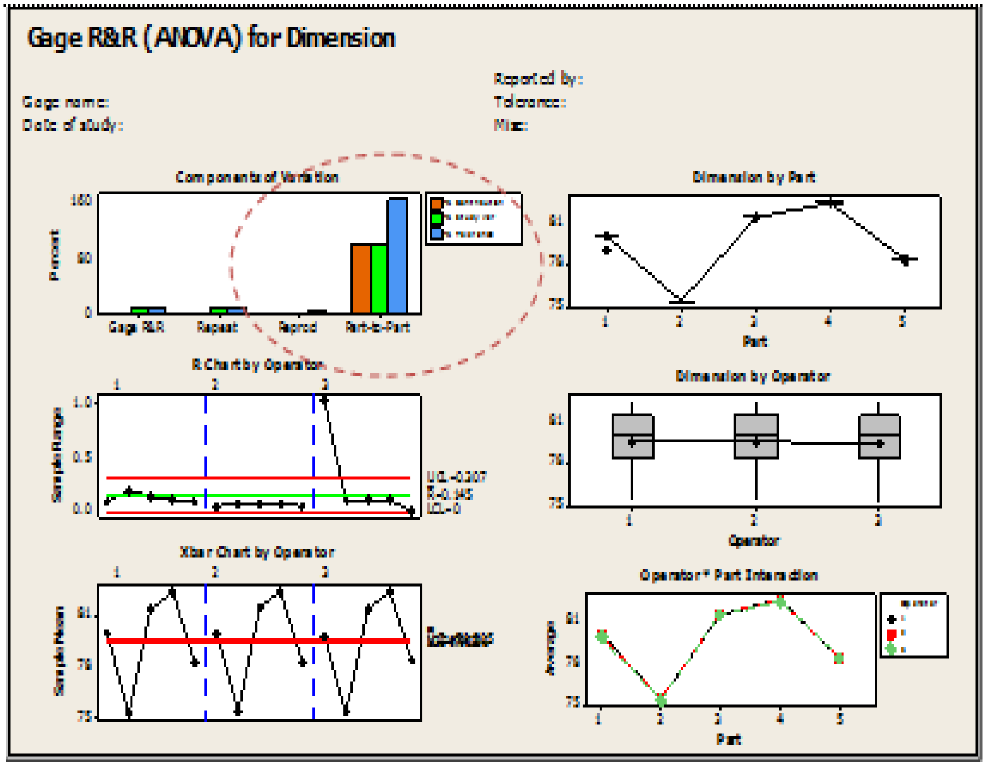
2.4. Measure procedure

1. Measurement in made by three operators in the same time;
2. The auxiliary time is observed and compared;
3. The chronometer is stopped at each cycle end;
4. The value displayed on the chronometer is read;
5. Each operator writes down the value.

Next we performed a Gage R & R repeat and reproduce analyse. For this matter five measurement sets were carried out during different time intervals and work shifts. Three operators achieved each individual set simultaneously. The gathered data was then thoroughly analysed.

The repeat aspect of this analyse refers to the same person recording measurement in the same conditions and obtain the same results.

This analyse is considered to reproduce when other persons obtain the same measurement results, while running tests in identical conditions.



Source	StudyVar StdDev(SD)	%StudyVar (6 * SD)	%Tolerance (%SV)	(SV/Toler)
Total Gage R&R	0.12689	0.7613	4.65	7.61
Repeatability	0.12141	0.7285	4.45	7.28
Reproducibility	0.03688	0.2213	1.35	2.21
Operator	0.03688	0.2213	1.35	2.21
Part-To-Part	2.72670	16.3602	99.89	163.60
Total Variation	2.72965	16.3779	100.00	163.78

Number of Distinct Categories = 30

Fig. 8. Gage R&R analyses

The analysed system is acceptable 4.65% < 30%. On Gage R&R scale we obtained 4.65% < 10%, which means the analysed system is ideal. In the measurement system we have more than four categories (30). In addition we could notice that all three operators strictly respect the same measurement method, thus they don’t influence the measurement procedure or results.

The biggest variations are due to the components geometry.

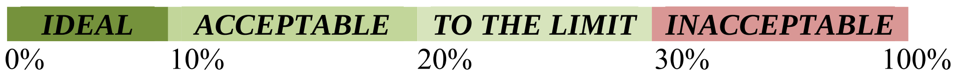


Fig. 9. Gage R&R analyze test interpretation

3. Conclusions

Based on the data gathered from the measure analyses we could also determine the existing process capability. We considered the limitations induced by clients, in our case the manufacturing cycle time must be situated between 57 and 63 seconds. In the graphic below, interrupted vertical lines (Fig. 10) mark these limits.

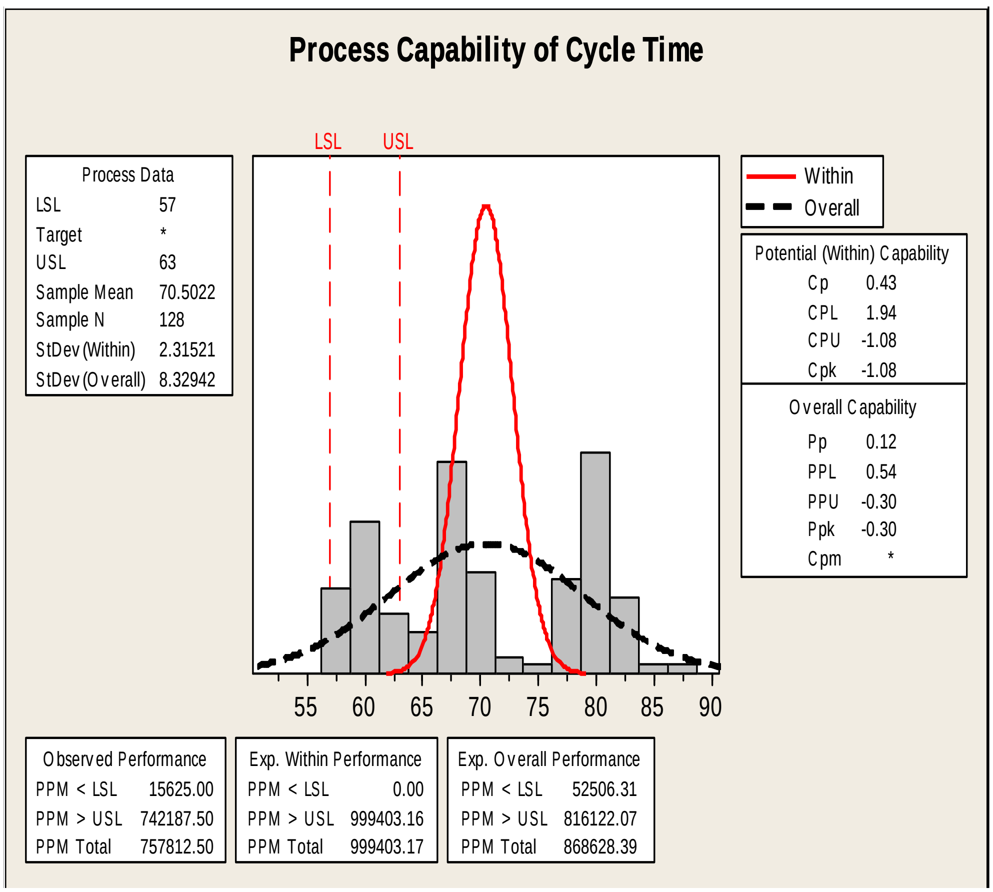


Fig. 10. Process capability

Another value that reflects the studied systems behaviour is the average value. This value is directly influenced by the systems extreme values:

$$\overline{x} = 1/n \sum_{i=1}^{n} x_i = 70.5$$

$\overline{x}$ – average value;
n – number of measured values;
x_i – measured values.

Instant capability value for this process *Cp* is 0.43. According to theory this value shows the studied process exceeds specifications because a big data number is outside the limits set.

A process capability indicator *Cpk* determines the system's performance. This indicator value is -1.08 which means that the average process result is outside the specification limits.

In Figure 10, it can be seen that the average process is outside the upper limit and that 100% of outcomes are outside the specification limits. Level SIGMA "σ" will indicate the presence of defects occurring approximately one million opportunities.

$$Level\ \sigma = 3 \cdot Cpk + 1.5 = -1.74$$

This value reveals a large number of defects per million opportunities.

REFERENCES

[1] *P. Thomas*. The Six SIGMA Handbook – A Complete Guide for Green Belts, Black Belts, and Managers at All Levels, New York, Chicago, San Francisco, Lisbon, London, Madrid, Mexico City, Milan, New Delhi, San Juan, Toronto, Mc Graw Hill, 2003, ISBN 0-07-141596 -3&0-07-141015-5

[2] www.arctic.ro

[3] *I. C. Dobre, I. Simion & F. Chiscop (2012)*. Determination and elimination the material flux concentrator for an assembly line - case study, Academic Journal of Manufacturing Engineering, Vol. 10, No. 4/2012, pg. 24-29, ISSN 1583-7904, CNCSIS "Clasa B", 3rd International Conference on Computing and Solutions in Manufacturing Engineering, CoSME 12, Transilvania University of Brasov, 25-26 Octomber2012

[4] I. *C. Enache, F. Chiscop, I. Simion, S. P. Funar* (2012). Manufacturing architecture diagnosis using discrete material flow management, Annals of DAAAM for 2012 & Proceedings of the 23nd DAAAM Symposium "Intelligent Manufacturing & Automation", Editor B.[ranko] Katalinic, ISSN 1726-9679, ISBN 978-3-901509-83-4, 24-27th October 2012, Zadar, Croatia, Published by DAAAM International, Vienna, 2012

[5] http://www.minitab.com