Quality development with six sigma method

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Abstract - The six sigma procedure is an effective method for further development of quality management systems and it acts towards the decrease of costs and increase of effectiveness. It seems to be sure that the sigma program as a third pillar is also added to the system certification and company excellence model, and thus they will form a unit for customers, users.

I. INTRODUCTION

In mathematical statistics the sigma – in other words the dispersion – is regarded as a parameter that expresses fluctuation which determines the average difference of individual values of the data line compared to the average of the data line:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \overline{x})^2}{n}}$$

This process is better, the smaller its fluctuation, standard deviation, i.e. the value of sigma is. We could think that the smaller the multiplication coefficient before the sigma, the better the process. This is just in reverse in the six sigma technology. The sigma level shows how many times the standard deviation of the data line is fitted into the field between the average of the data line and the tolerance nearest to the average.

In case of manufacturing according to the six sigma, the width of the tolerance field compared to its centre is 6+6, that is not less than 12 standard deviations, and the shift of 1.5 standard deviation of the expectable value of the manufacture measured to the centre of the tolerance field is still allowable. In extreme cases the remaining area under the curve of Gaussian distribution that represents the manufacturing, which estimates the waste rate is 3.4 ppm (parts per million, number of defective pieces that occur at one million manufactured products).

II. THE SIX SIGMA QUALITY PROGRAM

Many components of the six sigma method follows basic principles of total quality management: such as customer-oriented business, continuous improvement and development, full participation of workers, comprehensive education, team work, leader management and setting an example. It is an essential difference, however, that the six sigma wants to express all features in numbers, both the initial position and the target. Because of numeric expressions the analysis requests demanding statistical methods and requires computer programs. Beside this, an important difference is that it extends to each business process and their optimal solution.

Its basic function: Y = f(X), where Y is the error occurrence we experience or measure. X those factors that determine the behaviour of Y.

Y – error occurrence	*$X_1 \ldots X_n$ factors*
o Dependent	independents
o Result	entries
o Effects	reasons
o Sign	problems
o Observation	control
o Reply	coefficient

Causes of standard deviation:

- Nonconforming units,
- Defective items,
- Proportion of nonconforming items.

If we represent the standard deviation of the statistic sample by s then the following figure describes the tools that can be used to decrease the growing standard deviation of the sample that was taken out from manufacturing.

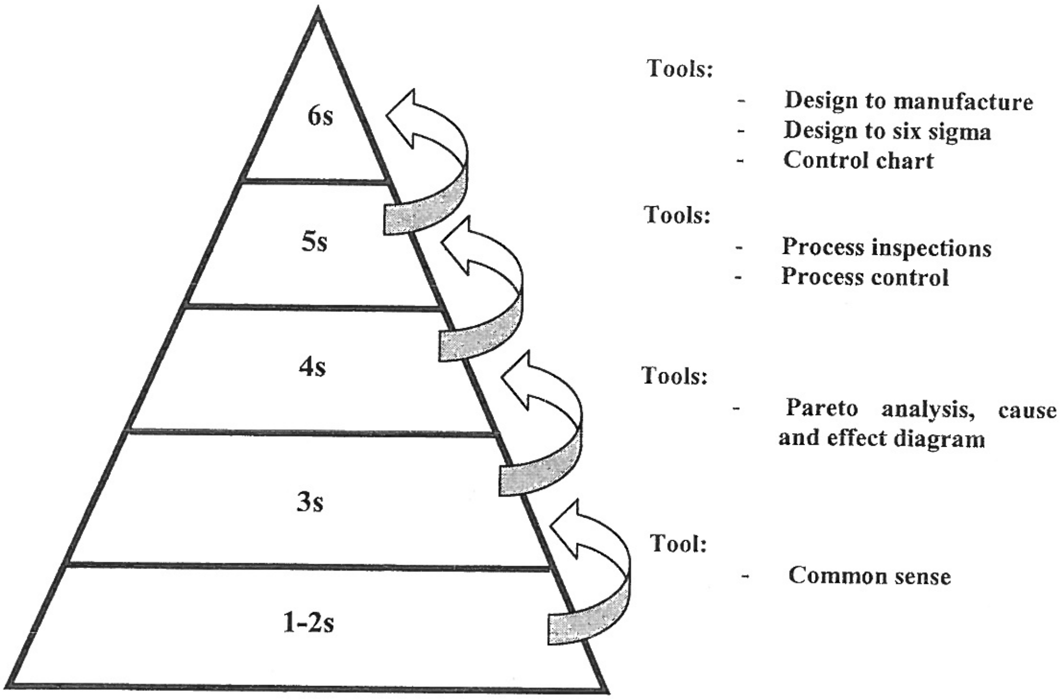


Fig. 1. Tools to decrease the standard deviation

The aim of the six sigma procedure is to increase the sigma level of the product or process according to values that are found in the table below.

SIGMA	DPPM	C_P	%
2	308527	0,67	69,15
3	66807	1,00	93,32
4	6210	1,33	99,38
5	233	1,67	99,97
6	3,4	2,00	99,99
Process capability	Number of defected products in a million	Process capability index	Probability of errorless products

Table 1.

Probability of increasing of the sigma level:

1. We decrease the standard deviation of the data line – thus the standard deviation fits several times into the field between the average and tolerance limit.
2. We increase the tolerance limits – this is an acceptable method only if specification is too strict, and we can meet the expected requirements also with wider tolerance field.
3. With process centring – the average of the data line must be placed between the limits to the centre, according to this we adjust the process.

An optimal solution always is parallel application of the 1. and 3. possibilities, i.e. by decreasing the standard deviation and by centring the process we may reach some results. We don't have to force always the 6σ process, as it may involve a high cost.

III. THE SIX SIGMA PROCESSES, ACTIVITIES AND TOOLS

The activities with existing processes (production of products or servicing) are divided into sections abbreviated by the letters of DMAIC. Sections of the existing processes:

D-Define: Definition of the existing processes, setting of business targets (projects), survey of financial effects. Assignment of characteristics that are important for quality and of the actual main process, establishment of a project team.

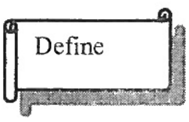
M-Measure: Determination of quantities that are typical for the process and of their measurement method. Selection of the most typical errors (Y) and learning of the process Detection of all possible reasons of errors (X), evaluation of measuring and data collection system.

A-Analyze: Analysis of collected facts and flowcharts to determine the error reasons and repair possibilities, determination of the initial process ability (for Y). The effect of the possible error reasons on the errors must be examined.

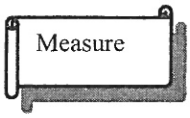
I-Improve: Filtration of possible error reasons, finding of the optimal operating parameters, justification of the solution by examinations, calculation of final process ability.

C-Control: Introduction of process monitoring, documenting of results.

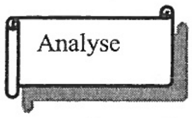
We have to find answers to the following questions:



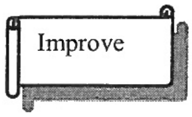
Solution of what problems gives real economy of costs or means the increase of customers' satisfaction?



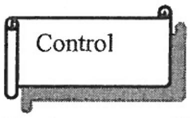
What is the frequency and type of errors?



What is the source of errors?



How can we exclude the error sources?



How to provide that errors will not occur again?

All projects must be able to answer the above questions. If answers exist then we may regard the project as solved.
The above are the main tasks to be performed. Y is the value that expresses the compliance or error in a quantitative measuring number. X is the main cause of this non-compliance. Main task for each six sigma is to find some relation between the Y and X values. This often means a concrete function relation that can be written in the form of $Y = f(X)$.

IV. EXPERIENCES OF APPLICATION OF SIX SIGMA PROCEDURE

On the product line of a factory that manufactures electronic devices a new production line was installed. After manual mounting the product undergoes a 100% inspection. One phase of inspection is a functional tester. As it is a completely new product, thus the structure of the test equipment also differed from the previous ones. Detection and elimination of errors of the testing process based on the new measuring principles can be solved using the six sigma process, so that the tester satisfies the strict quality regulations required on the product line. Since we can not eliminate the man factor, as a possible source of error, we can not allow that because of

the failure of the test equipment the rework costs will further increase. The target value for waste rate expected from the production line is 0,3%, its achievement and stable keeping is the task.
As a result of unreliability of the tester the number of pieces is not sufficient, downtimes and the rework cost are high. The output expected from the line can be achieved only when we eliminate the errors caused by the tester. For example:

- Rework cost 300 Euro/day,
- Downtime causes a loss of EUR 39 per minute because of the drop-out of the production.
- The 3 lines must produce 49500 pieces/day.

First we determine the Primary Metric Baseline that shows the initial quality rate (yield), the percentage of good products compared to total and the target to be achieved. The initial yield was about 94% at the end of 2002, at the beginning of the project. Without application of statistical methods the process in its present status provides the maximum. The target to be achieved later is 99.7%. The Secondary Metric Baseline shows the present costs and those to be achieved. The Secondary Metric Baseline numbers are derived values, the basis for which is determined by the Primary Metric Baseline. E.g.: Cost of Poor Quality

We prepare the process map that displays the following:

- the steps that do not add values, which are not necessary to satisfy customers' demands,
- the steps that can be merged,
- the errors of the process.

Using Pareto analysis we find the root reasons of the problem. Moving by levels we "dig down" to the origin of the error. On the first level the tested components that have problems are indicated. The data can be processed on the basis of the production report. It becomes visible that of the components the shielding plate causes the most errors. We broke it down further on the second level, why can the shielding cause errors? On the third level it becomes visible that the measuring pin of incorrect configuration caused the most short circuits.

The fish-bone analysis /Fig. 2./ shows the effects on the process in a structured form. Most probable root causes of problems can be identified.
After preparation and analysis of the figure we arrive at the conclusion that in the main directions there are deficiencies, non-conformities that must be eliminated.

Main error reasons for example:

- Man - incorrect setting in
- Material – bad quality, bad measurement, bad re-joint
- Machine – mechanical influence, measuring instrument attrition
- Method – bad position, calibration
- Environment – temperature, dust, voltage away

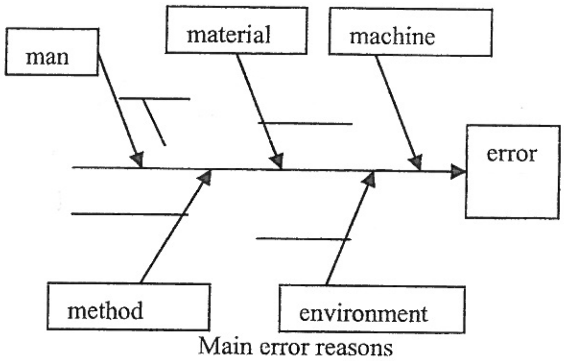


Fig. 2. Fish-bone analyse

Using the XY matrix we can flash a beam of light on the seriousness of effects of errors. X and Y must be interpreted as parameters, X→ error reason, Y → error Final result of the matrix is a weighted range sequence of possible reasons of errors.
Final result of the XY matrix, that of all possible errors, the shielding error may have the most serious consequence.
Microphone and antenna errors also require some attention.

We can further brake down the three most significant errors according to the XY matrix using FMEA (Failure Mode and Effects Analyses). By mathematical statistical calculations, based on the samples we can give some estimation concerning statistic features of the entire produced amount. We can establish the process capability.
Among the components with problems, at testing of the microphone an examination with measuring was performed. The result of the process ability with measuring is that the process on short term is five sigma, therefore it is acceptable. On long term, however, it is under three sigma, therefore the measuring system is not process-capable.

By measuring system with analysis:

- we can determine how reliable the data from the measuring system are
- we get a picture, how many % of the entire changeability of the process originates from the measuring system
- we can compare our measuring equipment
- we can raise some acceptability criteria to new measuring equipment.

The following figure presents the components of a measuring error /Fig.3./:

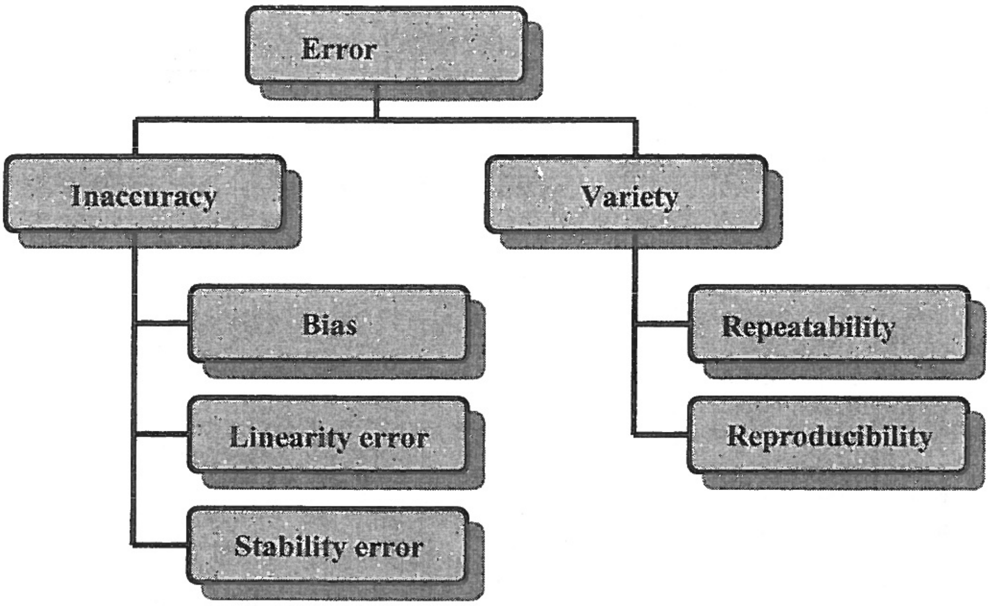


Fig. 3. Components of a measuring error

Examining conformity of the test equipment we could see that some test cycles don't meet the requirements raised by six sigma. The necessary changes were done based on a time schedule. Changes concerned only the most critical components, beside this, several measuring phases were also transformed. Process capability calculation that was performed after the changes: Cpk (changeability within a group) and Ppk (entire changeability) also exceed the six sigma requirements. Thus it was justified that the measuring equipment is process capable for short and long term.

V. REFERENCES

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