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EXPERIMENTAL METHODS OF TESTING AND ANALYSIS CAPABILITIES OF PROCESS AS PART OF QUALITY MANAGEMENT ACTIVITIES

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ABSTRACT
Concerning the fact that constant quality improvement enables the possibilities for faster investment refund (greater refund), the organizations wishing to improve their market position should use the quality as an advantage concerning the prices as well as high marketing expenses. This paper presents the essence of the research, analysis and evaluation of the process capability with special emphasis on capability indicators: an index of potentials and process capability. Processing of measurement results as well as the analysis of the results which show the process capabilities using the software package Minitab was done as an example of production.Ø4,3$^{-0,075}$ mm diametrical body of the striking needle in terms of mass production.
Keywords: Process capability, Capacity indicators, the Index of Potential and Capability Index

1. INTRODUCTION
Starting from the initial idea to the results implementation, the experimental testing includes a group of complex activities which require considerable consumption of disposable resources (materials, equipment, energy, time, etc.). Therefore, what is necessary is: High-quality pre-design of experiments, High-quality design of experiments, High-quality realization of experiments and High-quality processing and analysis of the results of experimental testing.
A good quality management enables strong relations and determines the significance of connecting managing process and the process which defines quality, as well as the controlling process and the process where quality is made. The capability of a process which creates quality is often tested (measured and controlled), analyzed and assessed through the usage of capability indicators such as: potential index or preciseness of a process Cp (measure for process dissipation) and capability preciseness index Cpk (measure for process adjustment). The capability of a process represents a measure for standardization of a final step of a process. It is a measure for a long-term period of parameters process effects since the process itself consists of effects of the workers, machines, raw materials, methods and working conditions. The smallest requirement for dissipation of production process is $\overline{X} \pm 3\sigma$(for variable characteristics) which also has to be within the limits of a specification, i.e.,99.73% of a product is placed within the limits of tolerance.

2. INDEXES OF PROCESS CAPABILITY
The capability of a process is most often tested, analyzed and assessed by the index of capability such as : the index of potential of process precisenss Cp (measure of dissipation process); the index of capability –preciseness Cpk (measure of process adjustment).

- The indicators of process capability and equipment Cp, CPU, CPL, k and Cpk compound a definite group of capability indicators-quality process:

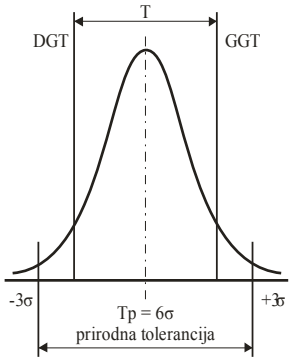
$$Cp = \frac{GGT - DGT}{6 \cdot \sigma} = \frac{T}{Tp} \quad (1); \qquad CPU = \frac{GGT - \overline{X}}{3 \cdot \sigma} \quad (2)$$

$$CPL = \frac{\overline{X} - DGT}{3 \cdot \sigma} \quad (3); \qquad k = \frac{2 \cdot \left| m - \overline{X} \right|}{GGT + DGT} \quad (4)$$

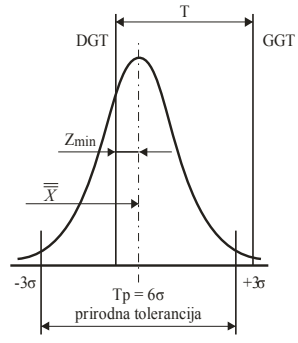
$$Cpk = (1 - k) \cdot Cp \quad (5)$$

The capability of a process, system, equipment condition, etc. are mostly assessed by usage of the index of:potential Cp for the process and Cm for equipment and capability Cpk for the process and Cmk for equipment.

The index of the potential of a process (Picture 1.) is a relation between the prescribed (T) and normal tolerance or dissipation process (TP).It points to the preciseness and dissipation of a process and it is often called **the index of preciseness**.



Picture 1. The Index of Potential of a Process



Picture 2. The Position of a Process Depending on the Specification Limits

Depending on the value of the index Cp, the process is defined as :

1. not precise Cp $Cp < 1$,
2. critically precise $1 < Cp < 1,33$ i
3. precise $Cp \geq 1,33$.

The index of preciseness shows the adjustment of a process (position of the process in relation with the limits of the specification, Picture 2.). It is defined with the expression:

$$Cpk = \frac{Z_{min}}{3 \cdot \sigma} \quad (6) \quad \text{with} \quad Z_{min} = min\left(GGT - \overline{\overline{X}}, \overline{\overline{X}} - DGT\right) \quad (7)$$

The index of Cpk shows the preciseness (adjustment) of a process and equipment and is often called **the index of preciseness**. Depending on the Cpk value, the process is defined as:

1) inaccurate (not adjusted) $Cpk < 1$,
2) critically accurate $1 < Cpk < 1,33$ and
3) accurate (adjusted) $Cpk \geq 1,33$.

The process is capable if it is precise and accurate,i.e. when the index of

- preciseness is $Cp \geq 1,33$ (descriptive assessment**:precise**) and
- accuracy $Cpk \geq 1,33$ (descriptive assessment:**accurate-adjusted**).

The indexes of capability are suitable non-dimensional system of capability process parametres. therefore, the filed of application of cpability parametres are very important, such as follows:

- prevention of waste,
- continuous improvement and perfection,
- determining the priorities of improvement and perfection,
- the analysis and assessment of dissipation and adjustment of process and equipment,
- checking of production sustem capability, etc.

3. MEASUREMENT AND ANALYSIS OF PROCESS CAPABILITY

The analysis of process capability should be conducted in normal circumstances of production with constant factors affecting the process.

During the period of collection the data necessary for the analysis, the raw materials have to be from the same delivery and the workers controlling the process should be the same. Repairs or adjustments should be avoided during the analysis. Calibration of measuring equipment should not be conducted unless it is supposed to happen according to the determined plan.

The analysis of capability of a process has to be based on as numerous number of measurements as possible in order to obtain so called representative sample. Fifty measurements is the minimal number considered to be optimal for most operations(the minimal posssible sample is greater than 30). It is important to keep the exact order during the measurement, so that if there is the slightest suspicion concerning preciseness of measuring, it can be checked over again. At the same time, special attention should be paid to the changes that could have happened in the meantime, such as changes of the dimensions due to the increase or decrease of the temperature, reduced percentage of moisture, etc.

The analysis of capability process enables prediction of the variability limits which a machine or process might reach. Thus, the capability of a machine or process can be measured and compared to the tolerances that are required.

Each machine or process has a certain level of variability. If the variability is less than the set tolerance, the machine is capable of determining parts within the tolerance limits, and if the variability is greater than the tolerance, it is necessary to replace the machine or the process mentioned. The machines chosen for the production of certain part considerably affect the dissipation and quality during the production process.

If the necessary equipment for production is accurate enough, it can reach the desired quality prescribed by the tolerances, realistic expenses of production and acceptable level of quality can be expected. If the production equipment does not fulfill the determined tolerances, the consequences are the following: high expenses, wastes and repairs(finsh).

Measuring and testing of a process capability represent basic tool for process evaluation and finding the possibilities for constant improvement in agreement with the vision and strategic goals of a company.

Monitoring and measuring of the process of production capability highlight the necessity for an organization to establish survey of a process including all productional levels (monitoring of smaller machine parts, machine parts and products so that the process capability can be verified and the additional input information necessary for the process of control can be ensured.

Testing of capability process has been conducted by the application of statistical methods of control, measurementof quality characteristics (diameter of the body of the striking needle) $Ø4{,}3^{-0{,}075}$ mm on the sample of 50 units (products). Measuring of the diameter has been done with the micrometer for external measurement whose preciseness is 0.001mm with digital reading and the results are as follows in the Table 1.

Table 1. Measurement Results

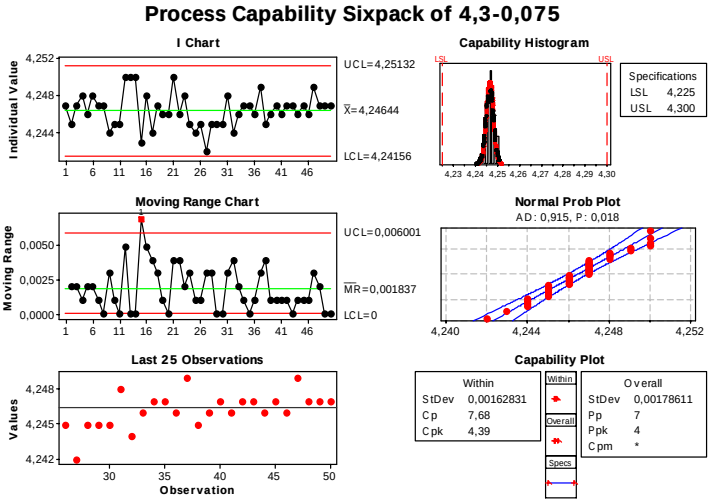
Quality characteristic: diameter $Ø4{,}3^{-0{,}075}$ mm			
number	Measured Value	Number.	Measured value
1	4.247	26	4.245
2	4.245	27	4.242
3	4.247	28	4.245
...	...	...	....
24	4.245	49	4.247
25	4.244	50	4.247

4. COMPUTER PROCESSING OF THE RESULTS OF MEASURING AND ASSESSMENT OF CAPABILITY PROCESS USING THE METHOD OF CAPABILITY INDEXS

Computer processing of the results of measuring has been done with the application of the applicable Software Minitab which shows the overall scheme (of final results, Picture 3.) for the controlled characteristics of quality and it contains:

- $\bar{X} - R$ -control card, R-card and X-card (for the last 25 samples), which show the stability of process with points within the control limits,

- histogram of Statistical Division of Process Sample and Curve of Normal Division Process with Values of the Medium (Target) , Lower(LSL) and upper (USL) level of Tolerance.,
- regression straight line and limiting straight line of normality with the points of the measured values,
- regression straight line and limiting straight line of normality with the points of measured values which are concentrated around the regression straight line with critical values of possibility (P).
- values of the sample process (Within), standard deviations; preciseness index (Cp) and accuracy index (Cpk) of a process which show possible imprecision or inaccuracy of a process.
- overall process value (Overall) and medium of a process (Cpm),
- scheme of the width of a sample process (Within), Overall process (Overall) and tolerance (Spec.).



Picture 3. Overall Scheme of the Results of Measuring the Quality Characteristic Ø4,3$^{-0,075}$ mm

Concerning the overall Minitab scheme (processing of measurement results) it can be pointed out that the potential index (*Cp > 1,33*) and capability index (*Cpk > 1,33*) fulfill all the criteria concerning preciseness and accuracy of the processes. Therefore, it is possible to claim that the process is capable of processing the diameter Ø4,3$^{-0,075}$ mm of the body of the striking needle.

5. CONCLUSION

Production process as a very complex system with great number of effective factors requires continuous monitoring and analysis. Testing, analysis and assessment of a process capability answers the following questions:

1. Are the process, workers, tools and equipment capable of enabling necessary level of quality?
2. Does the process have low instability?
3. Does the process fulfill the limits of the specifiction?

The most important advantage of the index-parametre of capability is not only its orientation towards prevention of unadjustment(waste), but also the monitoring of a process and continuous improvement and perfection in a wide range.

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