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ABOUT MANUFACTURING PROCESSES CAPABILITY ANALYSIS

I. THEORETICAL STUDY AND METHODOLOGY

BY

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Abstract. Modern control processes commonly used statistical methods to track compliance with the specifications of quality and customer satisfaction. A scientific analysis of the capability of manufacturing processes will result in any scrap percentage estimate which facilitates the adoption of measures that will improve the economic performance of the process. The purpose of this paper is to synthesize a unitary methodology process capability study.

Key words: quality management, statistical process control, process capability.

1. Introduction

Statistical Process Control (SPC) is a powerful tool to ensure and improve quality, reduce scrap and economic losses. Good management can not be done without the use of scientific methods of monitoring and forecasting the evolution process (Pyzdek, 2003). These methods can be applied in many fields,

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industrial or otherwise, that share specific series production. Compared to traditional inspections aimed at detecting defects, SPC's mission is to prevent faults by monitoring the variability of quality characteristics. In every process there is a greater or lesser variability. The general classification of variation causes account for the six major sources (material, machine, method, laborer, measurement, and environment). Each of these sources can enter the process a greater or lesser amount of variability. The theory behind SPC differentiation causes of variation. Such cases will be classified as random or common causes and special causes or systematic. Common causes are a complex set of factors influencing individual minor but whose summary results in variations in the process. Common causes influence can not be removed. Special causes are brutal intervention in the process, which strongly increase its variability. Special causes can be identified and should be eliminated from the process. In order to apply statistical methods to estimate the development process need it to be purely to random causes, or is under statistical control.

2. Processes Evolution over Time

A work only under the influence of common causes of variation will have a Gaussian distribution close to the normal law given by (1)(Oakland, 2003).

$$y = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\bar{x})^2}{2\sigma^2}} \tag{1}$$

In eq.(1) y represents the height of the curve at any point along the variable x, σ - standard deviation of the population, $\bar{x}$ - average value of the variable distribution, π - ratio of the circumference of a circle and its diameter.

If you do notation (2), then equation (1) becomes (3).

$$Z = \frac{x - \bar{x}}{\sigma} \tag{2}$$

$$y = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{z^2}{2}} \tag{3}$$

This allows the area under the curve between any two z values represents the probability that any randomly selected item will fall between the two values of z. In this way one can determine the percentage of production that is beyond a specified limit to z units of standard deviation on the media process, numerical values are tabulated in the literature.

Graphical representation of a process capable, stable as accuracy and precision is shown in Fig.1.

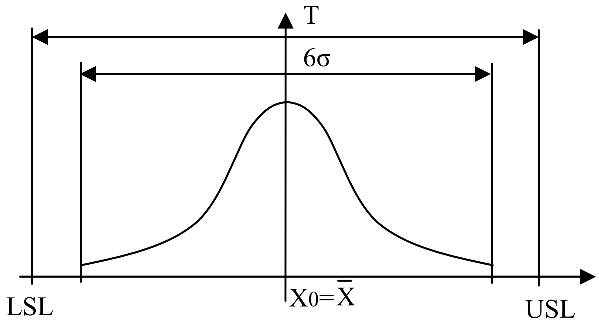

Fig. 1 – Capable, stable as accuracy and precision process.

3. Methodology for Determining the Capability and Estimate the Percentage of Improper Process Output

Operation to determine equipment performance to achieve a framing scattering field in the tolerances boundary, assuming reduction to limit for systemic influences, is known as capability study. Capability studies (Hsieh & Tong, 2006) are used in practice in the allocation of tasks to machines and so on units with fewer opportunities to achieve a small scattering field is not scheduled for processing requiring high precision class or vice versa. Of the production process is taken large enough number of copies (after some authors n = 40 ¸ 60, by others of at least 100 and maximum 300 elementary units), depending on the nature and process productivity.

Samples forming for capability study require individual incremental samples (units produced) in production order, without interruption, to achieve data volume for proposed research.

This method of making observation is known as the “large sample method”. A sample taken time to pass the quality characteristic is measured and the results are listed in sampling data sheet. If during samples collection, machines adjustment and precision remains constant, it follows one distinct group. This group has a certain statistical distribution called “instantaneous distribution”, characterized by the same grouping and the same scattering center. If during sampling something interferes in process, more groups will be formed and the distribution parameters of each experimental group determining.

3.1. Checking Observed Data Homogeneity

In the literature (Montgomery, 2001) are many tests used for this purpose (van de Waerden test, sign test, Wallis-Moore test, iterations method, Wilcoxon test, Kolmogorov Smirnov test and others). We believe that the simplest and most effective way to check the homogeneity of data is the method of iterations. It consists in grouping the values taken in smaller and greater than one distribution parameters (median). Successive values with the same property, those are either higher or lower than the median, forms an iteration. The number of values that make up iteration is iteration length. If during the data sampling operation acted only random causes (common), data are homogeneous, namely there will be a large number of iterations of small length.

Such method has two variants, based on the number and length of iterations. If, for evaluating the quality characteristic random variation in the total number of iterations to test the condition of static stability of the process is (4) where I is the total number of iterations, and I_α minimum number of iterations allowed, calculated so that the probability that I< I_α be α (for ≤ α 0.05).

$$I > I_\alpha \tag{4}$$

I_α can be calculated with equation (5), where n is the total number of data and z_α is normalized normal variable, whose value depends on Laplace function with tabulated values.

$$I_\alpha = 0,5(n + 1 - z_\alpha \sqrt{n-1}\,) \tag{5}$$

If used as a criterion for assessment of the quality characteristic random variation iteration length, condition for the process static stability is (6).

$$K < K_{min} \tag{6}$$

In equation (6) K is the maximum number of feature values found in an iteration, whether they are higher or lower than the median, and K_{min} is the minimum number of values as a feature iteration, for α given confidence level, and is calculated with (7).

$$K_{min} = \frac{lg\left[\dfrac{-0,43429n}{lg(1-\alpha)}\right]}{lg2} - 1 \tag{7}$$

3.2. Checking Normality of Quality Characteristics Frequencies Distribution

To estimate process capability and potential percentage of non-compliant products is necessary to determine whether instantaneous statistical distribution approaches to Gaussian normal distribution. To do this, the simplest and most effective method is to use Kolmogorov Smirnov test (Montgomery, 2001). This test checks compliance between a theoretical distribution F (x) (normal) and one experimental Fe (x), steps taken are:

1 - observed data are grouped into intervals (determining the number m of classes) still calculating statistical parameters of each class.

2 - grouped into time values are calculated difference.

Using Matlab to determine test h = kstest (x). If the test value h = 1, the experimental distribution can be considered a normal distribution for a significance level of 95%.

If samples are of low volume (less than 32 units), Massey test is recommended (Montgomery, 2001).

3.3. Process Capability Determining and Percentage of Improper Production Estimates.

If the process is not capable the improper output rates is determine with relations (8) and (9) (Rujnić-Sokele *et al.*, 2010).

$$Z_u = \frac{USL - \overline{X}}{\sigma} \tag{8}$$

$$Z_l = \frac{\overline{X} - LSL}{\sigma} \tag{9}$$

Effective values of rejects percentages are determined using Laplace function with tabulated values.

Graphical representation of an incapable process producing both higher improper output (Z_u) as well as lower (Z_l) is shown in Fig.2.

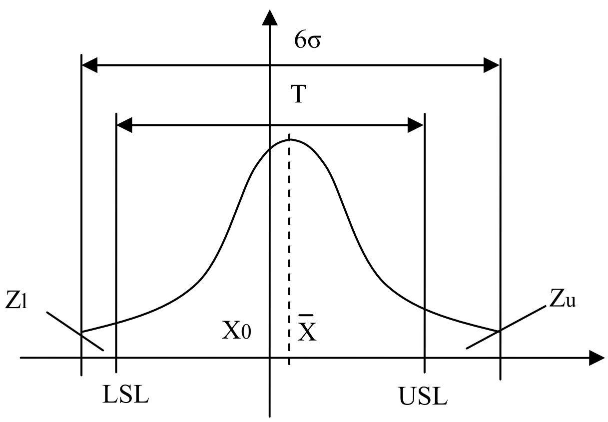

Fig. 2 − Incapable process.

4. Conclusions

The presented methodology allows observed data homogeneity checking and verifies the observed frequency distribution normality quality characteristics. If these conditions are met it is possible to determine the stability of manufacturing processes in terms of adjustment and precision. Using tabulated values of the Laplace function can estimate the percentage of products that are outside the prescribed tolerance limits. In the second part of the paper a case study will be presented.

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ASUPRA ANALIZEI CAPABILITĂŢII PROCESELOR DE FABRICAŢIE.
I. STUDIU TEORETIC ŞI METODOLOGIE

(Rezumat)

Controlul modern al proceselor utilizează frecvent metodele statisticii matematice pentru a urmări încadrarea în specificaţiile de calitate şi satisfacerea cerinţelor clientului. O analiză ştiinţifică a capabilităţii proceselor de fabricaţie va avea ca efect estimarea procentului eventualelor rebuturi ceea ce facilitează adoptarea unor acţiuni care vor ameliora performanţa economică a procesului. Scopul acestei lucrări este sintetizarea unei metodologii unitare de studiu a capabilităţii proceselor.