

USE OF STATISTICAL MODELS IN CONTROLLING THE STABILITY OF TECHNOLOGICAL PROCESSES

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Abstract. The stability issue, which is one of the key elements in regulating the quality of product manufacturing in technological process operations, is the focus of this thesis. The study examines the function of stability in the statistical quality assurance system as well as the theoretical and practical underpinnings of its implementation. Specifically, the essence of the Walter Andrews control chart approach is disclosed and some useful techniques for evaluating the stability of the technological process are explained. Additionally, new control charts based on one-dimensional and two-dimensional normal distributions have been created to assess the stability of technological processes.

Keywords: process stability, controls, statistical techniques, loss function, distribution parameters

Аннотация. В центре внимания данной диссертации — вопрос стабильности, являющийся одним из ключевых элементов регулирования качества производства продукции в технологических процессах. Исследование рассматривает функцию стабильности в статистической системе обеспечения качества, а также теоретические и практические основы её применения. В частности, раскрывается сущность подхода контрольных карт Уолтера Эндрюса и объясняются некоторые полезные методы оценки стабильности технологического процесса. Кроме того, для оценки стабильности технологических процессов созданы новые контрольные карты, основанные на одномерном и двумерном нормальном распределении.

Ключевые слова: стабильность процесса, контроль, статистические методы, функция потерь, параметры распределения.

One of the key structural directions of the statistical quality assurance system is the problem of regulating the stability of technological processes based on statistical approaches. Statistical quality assurance is defined narrowly as evaluating whether the manufactured product complies with project or standard requirements. This idea broadly refers to applying statistical techniques to control every step of the product development process [1]. This covers control tasks related to the procurement of components and raw materials, their acceptance, the manufacturing of products, and the use of completed goods. These controls are all implemented using statistical methods. In this sense, one of the crucial practical phases of the statistical quality assurance system is guaranteeing and managing the stability of the technical process[2].

Process stability is understood as the property of a process that determines the reproducibility of the probability distribution of its parameters over a certain period of time without external intervention. By process stability we mean the property of ensuring the accuracy of product quality parameters over time, and stability is a general indicator of stability.

The stability of TJ affects the quality of items generated in technological operations. A number of software programs, such as CAQ (computer-aided quality assurance) and PPS (production planning and control software package), have been developed recently to measure SST and, in particular, its stability using the powers of science and technology. However, the manufacturing of subpar goods still results in losses in actual output. The reason is that some businesses have not fully adopted scientific advancements, such as statistical techniques.

The quality attributes of products manufactured through technological processes vary. As a result, variance (dispersion) exists. Two principles have been used historically to lessen this variation. The first is the engineering concept, which divides goods into high-quality and low-quality categories according to a standard (tolerance). From Eli Whitney's 1793 concept of interchangeable parts to the American engineer Walter Andrew Shewhart's 1924 development of the concept of statistical approaches in SST, this idea persisted. In the past, expenses were high, low-quality items did not decline, and the first principle did not support itself. He developed control charts (CCs), a statistical tool that decreased expenses and variation[3].

For a long time, Walter Shewhart's control charts were not widely acknowledged in scientific and technological circles. The practical potential of this statistical tool was not completely recognized for around fifty years. But his adherents saw the method's enormous theoretical and practical promise. Specifically, E. Deming was able to show the Japanese scientific and engineering community how beneficial this method is. As a result, one of the key instruments in the process of reviving and expanding Japanese industry and economy was the control chart approach. It eventually established itself as one of the seven primary statistical tools used in statistical quality assurance in Japan. Following that, sophisticated industrial businesses in America and Europe started to use this technique extensively. This approach has been in use in Russia since the 1990s of the 20th century, and it was implemented in our country concurrently with the growth of joint ventures.

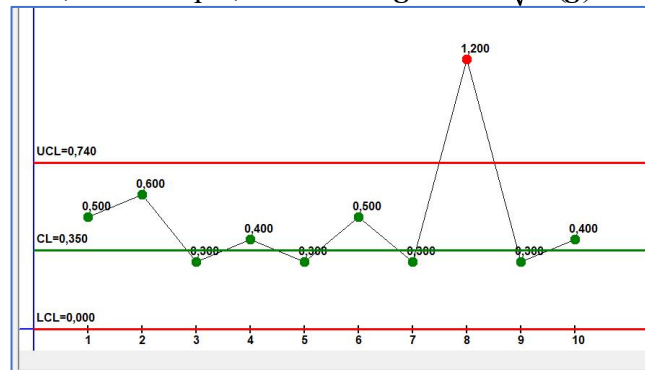
The Taguti loss function is currently one of the useful statistical techniques based on control charts that helps to attain a high degree of quality. This method enables the present control of the technical process, the evaluation of quality-related financial losses, and their mitigation through the use of control charts. At the same time, it is crucial to continuously monitor the technical process's stability. This requirement has led to the development of numerous statistical models to evaluate the technological process's stability [4]. If Taguchi's loss function serves in quality control to assess the economic consequences of deviations in process parameters, then, in the theory of optimal quadrature formulas, a comparable role is played by the error functional. In this context, the principal objective is to minimize, as far as possible, the error arising in the approximate evaluation of an integral. Therefore, the construction of optimal quadrature formulas may, in a certain sense, be interpreted as a manifestation in mathematical analysis of the idea of minimizing loss. On this basis, various mathematical models have been developed for determining the optimal coefficients, nodes, and remainder terms of quadrature formulas [5,6,7].

a) Schuhart's control chart model.

Let's say X the operating characteristic of a specific product is its nominal value and τ tolerance (tolerance) determined by the engineer. $[\tau-\Delta\tau; \tau+\Delta\tau]$ In production, there are almost no two identical products, that is, $X \neq \tau$ The relationship is appropriate. When it is according to engineering principles $X \in [\tau-\Delta\tau; \tau+\Delta\tau]$, the product is usable, otherwise it is unusable or needs repair.

Walter Andrews is a process by nature X The unknown distribution of the number sign is based on the idea that almost all values of the quality-determining parameters lie in an interval of length "Six Sigma" $(a-3\sigma, a+3\sigma)$, where $a=M(X)$ - X The mathematical expectation of , $\sigma=\sqrt{D(X)}$ the X standard deviation of . For this, in practice, based on statistical methods,

$t=1,2,\dots,m$ in unit times Instantaneous samples are taken and $(X_1, X_2, \dots, X_n)$ the values of the statistics $(a-3\sigma, a+3\sigma)$, $a=M(g)$ correlated with the quality $g=g(X_1, X_2, \dots, X_n)$ are checked to fall into the interval ; . In this case, for example, Shewhart's g -NC $\sigma=\sqrt{D(g)}$ is constructed as follows:



g-NK diagram.

Unknown distribution parameters are considered as statistics, as we described in gWalter Andrews's NKs: mean; median; standard deviation; variation coefficient; number or percentage of defective items. As we have explained, maintaining the stability of the TJ requires controlling the correctness of these parameters over time. The location of the points on the NK diagram in relation to the center line and in intervals based on sigma scales have been used to develop methods for determining stability. By guaranteeing its stability, stability is attained based on them.

NCs statistically evaluate the state of the process and, in particular, sequentially test the following statistical hypotheses:

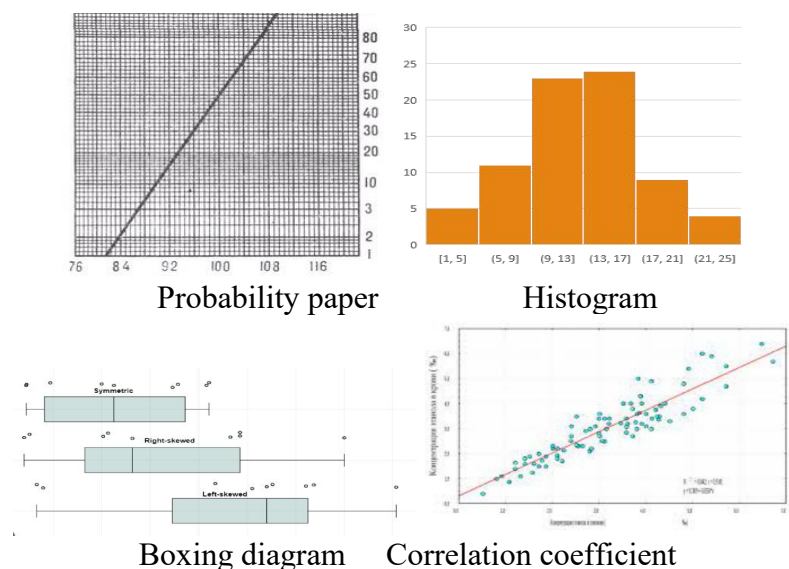
H_0 : The process is under statistical control;

H_1 : The process is not in statistical control .

If the hypothesis $g \in (LCL_g; UCL_g)$ is H_0 true, H_1 the hypothesis is false. In Figure 1.2, $t=1-7,9,10$ in the samples in H_0 , $t=8$ and H_1 The hypothesis is becoming plausible.

b) Diagrammatic method for checking the stability of TJ modeled with a normal distribution.

In this case, the reproducibility of the distribution density function is checked and its stability is assessed using diagrams such as "Histogram", "Box diagram", "Probability plot" and "Correlation coefficient ". For example, the diagrams are stable if the following conditions are observed:



Let's now concentrate on alternative approaches. A number of stability coefficients are used to evaluate stability, and their values are also used to evaluate the stability of the TJ. By lowering the TJ's average expenses, G. Taguti's loss function can be used to guarantee the TJ's stability. The stability of the TJ has also been enhanced by the use of seven distinct statistical tools targeted at the SST of Japan (Graph; Ishikawa diagram; Pareto diagram; Scatter diagram; Histogram; Control card and Control sheet). Furthermore, comparison-based approaches exist.

In many situations, the researcher's in-depth understanding of the topic pertinent to the issue under study will determine which statistical techniques and tools will be most successful.

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