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APPLICATION OF STATISTICAL MANAGEMENT METHODS AND VALIDATION OF THE PRODUCTION PROCESS THROUGH MODERN MEASURING INSTRUMENTS

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Abstract

The application of statistical methods to manage and validate the manufacturing process is key to ensuring quality and efficiency. This study examines the application of statistical methods for the control and validation of the production process using modern measuring instruments. For the analysis of the production process, fifty evaluate parts (sleeves) with a diameter of 11 mm with a tolerance field and accuracy class js10, inductive probes TESA GTL22 USB with high accuracy and repeatability and statistical software TESA STAT-Express were used.

Keywords: statistical methods, validation of the production process, inductive probes.

INTRODUCTION

The application of statistical methods to manage and validate the production process is key to ensuring quality and efficiency. Some basic steps and methods can be used such as:

Data Collection: Use of advanced measuring instruments to collect data accurately and reliably from the manufacturing process.

Data Analysis: Application of statistical methods such as control charts, analysis of variance and regression analysis to identify trends and outliers.

Quality control: Using control charts to monitor processes and detect deviations in real time.

Process Validation: Conducting experiments and analyzing the results to confirm the stability and reproducibility of the process. These methods help improve manufacturing processes, reduce defects, and increase overall efficiency.

EXPOSITION

A fundamental task in many statistical analyses is to characterize the location and variability of a data set.

An additional feature of the data includes an asymmetry coefficient -(Sk) skewness and (Ku) kurtosis -an excess coefficient.

The asymmetry coefficient is a measure of symmetry, or more precisely, the lack of symmetry. (Sk) measures the asymmetry of a data distribution. It determines whether the probability function is skewed to the right (positive skewness) or to the left (negative skewness). If the skewness is zero, the distribution is symmetric. Positive skewness indicates a right tail (tail of values to the high side), while negative skewness indicates a left tail (tail of values to the low side see Sk on the Z axis). Skewness values typically range from -2 to 2.

A distribution or dataset is symmetrical if it looks the same to the left and right of the center point.

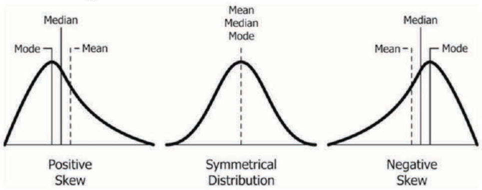

***Fig. 1**. Distribution*

The courtesy or excess coefficient in statistics is used to describe the distribution

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of a dataset and depicts the extent to which the points of the dataset for a given distribution differ from the data in a normal distribution. It is used to determine if a distribution contains extreme values.

(Ku) measures the curvature or flatness of the data distribution. High kurtosis (positive kurtosis) indicates a sharper peak (peak) in the center of the distribution, suggesting that most data points are concentrated around the mean. Conversely, low kurtosis (negative kurtosis) shows a flatter peak, meaning there are more values away from the mean. Curtrose values usually range from 0 to 10. A histogram is an effective graphical technique for showing both the distortion and the excess of a dataset.

Cp/Cpk are two statistical parameters that help us get a particularly good indicator of the stability of our production process.

In short, the main two ideas here are measuring the variation of our processes (the smaller the better) and how centered the processes are (how close the average is to the centerline between the upper and lower limits defined for each process).

Cp is a direct way to measure and analyze process capabilities. It measures how close our process is to the specified upper and lower limits compared to a reference optimal process. The higher the Cp index, the less likely it is that each unit produced in our process will be outside the specified limits.

Cpk is the same as Cp, but it has been adjusted to measure a process that is analyzed with an uncentered distribution. Cpk measures how close you are to the optimal area of our process and how consistent our process is.

The higher the Cpk index of our process, the less likely it is that each unit produced in our process will be outside the specified limits.

If our process proceeds with minimal variations, it may be far from the optimal goal towards one of the defined high or low limits. Then we will have a high index of Cp, while Cpk will be low.

On the other hand, if our process can be exactly at the optimal goal, but the level of variation is high. In this scenario, the Cpk will also be lower, but the Cp will also be high. Cpk will only be higher when our process meets the optimal purpose consistently with minimal variation and maximum quality control in production.

PRECISION MEASUREMENT

TESA is a leading designer, manufacturer, and user of inductive probes for more than 40 years. Its high-precision electronic probes are made to with-stand the stresses sustained in the production environment where they can be constantly used for series inspection. But these probes are also designed for high accuracy measurements such as those performed in gauge block calibration, for instance.

All electronic probes are mounted on ball-bearings, except for miniature axial probes. Ball-bearings are insensitive to radial forces. Probe guide system is efficiently protected against the penetration of solid and liquid contaminants by sealing rubber bellows.

In normal conditions of use, nitrile elastomer bellows are sufficient. For applications where the probes remain permanently in contact with cooling and lubricating agents, it recommends the use of Viton rubber bellows. Sealing bellows ensure full airtightness so that the measuring bolt is retracted by throwing off the air contained in the probe. This provides optimum protection of the guiding system as no mechanical device is used.

Electronic signal amplification produces excellent repeatability and low hysteresis. Resolution is as high as 0,01 μm.

For the analysis of the production process, fifty evaluate parts with diameter 11mm /js10 and TESA GTL22 USB inductive probes with high accuracy and repeatability were used (see table 1).

For calibration of the measuring tool, plane-parallel boundary measures with accuracy class 0 were used. Every five measurements, calibration is performed.

Maximum allowable error 0.4 + 0.8 • L µm (L in mm*) 0.005160000mm.

Table 1 *Data of measuring probe*

Measuring force	0.63 N
Measuring range	±2 mm
Mechanical displacement	4.3 mm
Repeatability	0.1 µm
Resolution	0.1 µm
Operating temperature range	20°C ±0.5°C.

Before product validation it is necessary to define the requirements for the manufactured devices: these requirements are quantitative, they relate to critical physical characteristics of the product (example: length, diameter, speed, etc.)

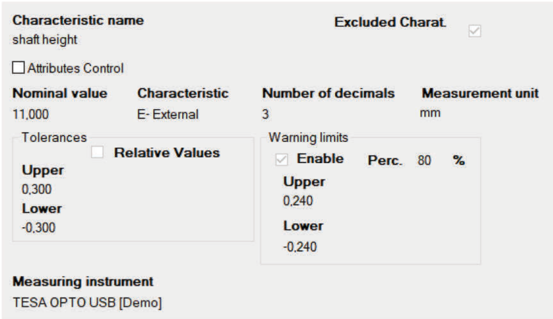

Fig. 2. *Measurement program*

The goal is to have tolerances (USL and LSL) extremely far from the mean, usually 4σ each: with a probability of compliance of 99.994% and a degree of non-compliance.

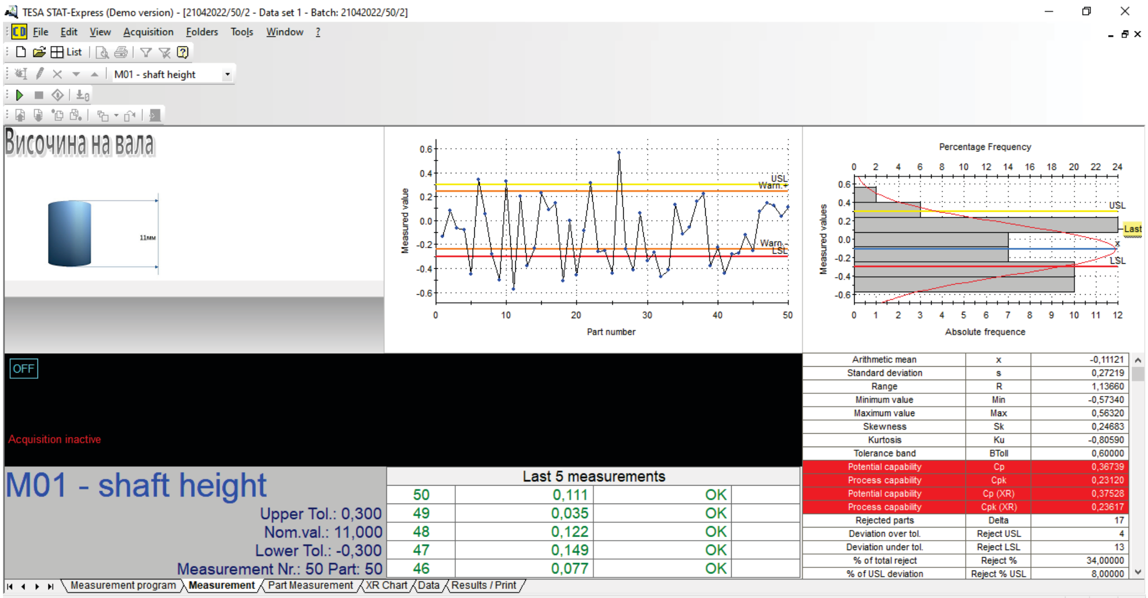

Fig. 3. *Measurement results*

The standard deviation shows how much variation there is in the values of the random variable. When the standard deviation is low, the values are close to the population mean (expected value).

When the standard deviation is high, the values are spread over a wider range.

The standard deviation is calculated as the square root of the variance of the random variable.

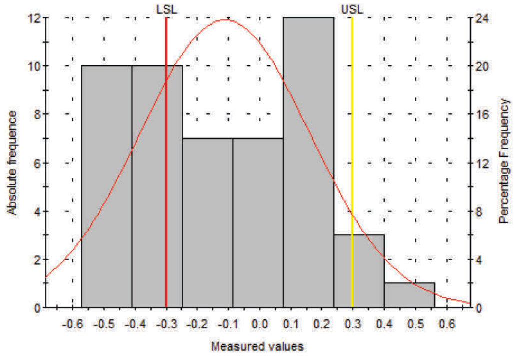

Fig. 4. *Histogram of measurement results*

The standard deviation is expressed in the same unit as the data, making it useful for comparison and analysis. So, the standard deviation helps us understand how much variation there is in the values of the random variable and how far they are from the mean.

In conclusion, the standard deviation is a useful tool for data analysis and helps to understand the distribution and mixing of values in our measurements. Knowledge of the distribution of data around the mean is essential in statistics and data analysis.

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Statistical Summary

Code	21042022/50/2 shaft heght
Customer Folder	DIAM
Batch /Order	21042022/50/2

Characteristic	Meas. N.	Mean	Range	Max	Min	Cp	Cpk
shaft height	50	-0,11121	1,13660	0,563	-0,573	0,36739	0,23120
Nom. value 11,000	Tol + 0,300 / Tol - -0,300						

Fig. 5. *Statistical summary*

Once we understand our process, we can make a good decision about how to prioritize our process improvement efforts.

CONCLUSION

This report presents a study that focuses on the repeatability and accuracy of our production.

By analyzing the influence of numerous factors such as machine settings, material quality, temperature control and regular calibration, the study highlights the complexity of the process and the importance of optimization applied in practical applications to achieve a high degree of accuracy and quality of produced details.

The results of measurements conducted using the TESA GTL22 USB inductive probes provide valuable data about the accuracy of the production. Statistical analysis, including the use of Cp and Cpk metrics, as well as skewness and kurtosis estimates, further demonstrates the ability of the process to produce quality parts within set specifications and to provide reproducibility of results under various manufacturing conditions.

This research highlights the fact that achieving high quality and accuracy requires careful control of multiple factors, including, but not limited to, the quality of materials used, machine specifications, and production conditions. As well as the ability to enter tolerances and to analyze the data, the software also provides functions for processing and archiving measured values. The users can create and save lists of measurements, measurement reports with values obtained from one or several measuring instruments, and detailed reports including statistics, which guarantees the traceability of the values.

Finally, the presented conclusions and results serve as a basis for future research, with a view to the continuous improvement of technologies and the expansion of their applications in various fields.

Effectively addressing the challenges of accuracy and repeatability will help establish process analysis as a key technology for the future of manufacturing.

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