Algorithms Of Using Statistical Methods in The New Software Module

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Abstract. The article is devoted to the developed software module for statistical control of production quality allowing to use the following quality tools: Pareto chart, Shewhart control charts (map of mean values and range chart), scatter chart, control charts of the proportions P and the number of nonconforming units nP, control charts of the number of nonconformities C and the number of discrepancies per unit U, Ishikawa diagram. The article can be useful for specialists involved in statistical quality control and looking for an alternative to other software that can be introduced into the production process.

1. Introduction
It is well known that in the modern world, according to the quality management system, which is regulated by the ICO 9001 standard, one of the main principles is customer orientation. This means only one thing - it is the buyer of the finished product that regulates the behavior and demand for the product. [1] Consumer demand for a specific product or service depends on many factors, but the main one is its quality components, which give the main competitive advantage over competitors. Therefore at present almost any company that produces goods or services is doing its best to standardize its production and improve the quality of production. [2]

The program for calculating statistical indicators for assessing the quality of goods and services "Expert" was developed in January 2020 by the team of employees and students of the Don State Technical University: Golubeva Olesya Anatolyevna, Shemerey Georgy Ivanovich, Nikolaeva Nadezhda Aleksandrovna, Fomichenko Yulia Aleksandrovna.

The goal of the program development is the improvement of manufactured products quality, more flexible adjustment of the production process through timely tracking of defects in manufactured products at each stage of production and use of modern technologies in production planning. [3]

At the initial stage of working with the program it is possible to select the quality required to the tool use directly with an automatic or manual input method giving flexibility in using this software tool. [4]

2. Developed Software Module Description
The developed software is based on the function of automatic analysis and processing of input data from operators' stationary computers at each stage of the production process. There can be both identification and elimination of problem areas of production, and the use of new production methods of quality management with flexible adjustment of the product manufacturing process and its timely adjustment.

Its has become possible due to the introduction of statistical quality control methods: Shewhart X...
and R control charts, Pareto charts, control charts of the number and proportion of nonconformities, control charts of the number of nonconformities, scatter diagrams into the developed software. The production planning process has also become more flexible by expanding the functionality of the created software with the ability to build Ishikawa diagrams. [5]

Also, one of the advantages of the developed software tool is the ability to integrate it into a larger information system under which the enterprise operates.

At the stage of preparation for writing the source code of the software tool, some types of production were analyzed, namely footwear at specialized enterprises. On the basis of these data, methods of statistical management of the production process were selected for implementation in the developed information system. [6]

The work of the developed software module is based on statistical processing of input production information using statistical quality control methods. [7]

In this article we will look at the algorithmic workplan for such quality tools as the Pareto chart, scatter chart and Ishikawa chart. [8]

3. Pareto chart
Algorithmic working plan of the statistical quality tool for the Pareto diagram in the developed software module consists of several steps:

- initial data are collected for their further processing;
- a check is carried out for the correctness of the input information and its belonging to the process under study;
- the input data is confirmed and divided into several categories, depending on their type;
- the names of the horizontal and vertical axes are given;
- the width of the horizontal bands for plotting the chart is selected and the categories are named in descending order;
- on the vertical axis, numbers are plotted, the size of which slightly exceeds the rating of the highest category, plotted horizontally;
- the width of each column - category is calculated, depending on the number of categories and the width of the working window of the application;
- panels of categories are created, plotted along the vertical axis, relative to the horizontal;
- aggregation lines and calculations are added.

The Pareto chart is one of the most visual quality tools [9], allowing you to assess the deviations of the workflow. Its disadvantage is that, unlike control charts, its use is not possible in real time. [10]

A general view of the operation screen of this quality tool in the developed software tool is shown in the figure 1.
Figure 1. Overview of the quality tool "Pareto Chart" in the developed software.

| Pareto Chart | Scatter chart | Shewhart X and R control charts | Control charts of the number of discrepancies | Control charts of the number and share of discrepancies | Ishikawa chart | Number of factors | Build a chart | Factor name | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Amount |
|--------------|---------------|---------------------------------|-----------------------------------------------|-----------------------------------------------------|----------------|------------------|-------------|------------|--------|---------|-----------|---------|--------|---------|--------|
|              |               |                                 |                                               |                                                     |                |                  |             | Factor 3   | factor 5 | factor 4 | factor 6  | factor 2 | factor 5 | factor 6 | factor 2 |

4. Scatter diagram
Scatterplot is one of the powerful quality tools that allows you to determine the degree of dependence between different correlated inputs in a visual way - using graphs. [11]
In the developed software module for automatic monitoring of the quality of production processes, the scatter diagram functions according to the following algorithm:

- the initial state is initialized and the monitoring process is configured;
- the observation period is planned;
- a sample is prepared for control;
- data are collected in pairs (that is, for x and y), between which you want to check the correlation relationship;
- the received data is sorted in ascending order;
- approximately equal length scales of the axes are selected for applying the obtained values to them;
- a graph is built: points are plotted, all the necessary designations for scales, points, etc.
- the correlation coefficient is calculated:

\[
 r = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2 \sum_{i=1}^{n}(y_i - \bar{y})^2}}
\]  

(1)

where \( y_i, x_i \) – input statistical data, \( \bar{x}, \bar{y} \) – mean values x, y, n – collected pairs of input data, \( r \) – correlation coefficient;
- the probability of the correlation coefficient is calculated, that is, its average error:

\[
 m_r = \pm \frac{1-r^2}{\sqrt{n}}
\]  

(2)

where \( r \) – correlation coefficient, n – collected pairs of input data,

Significance of the correlation coefficient:

- meaning - if that is \( \frac{r}{m_r} > 3 \), the connection is proven,
- insignificant - if that is \( \frac{r}{m_r} < 3 \), the connection is not proven;
- the evaluation of indicators is checked;
- indicators are evaluated;
- statistical reachability is checked;
- verification is carried out for violations of the assessment;
- the measurement technique is suspended;
- the current calculation process ends.

The value of the correlation coefficient is used in the case of a linear relationship of different quantities only. Typically the value for the correlation coefficient is between -1 and +1. There are several types of correlation:

- communication is impossible when \( r \) equals 1;
- weak - when the absolute value of \( r \) is less than 0.5;
- average - the absolute value of \( r \) is in the range from 0.5 to 0.7;
- strong - the absolute value of \( r \) is in the range from 0.7 to 1.

Due to the capabilities of the scatter diagram, one of which is the identification of regular manufacturing defects, the inclusion of this quality tool into the developed software module is determined.

5. Ishikawa diagram

Ishikawa diagram is the way of visualizing problems and factors influencing their origin, connected by
cause and effect relationships. At present this diagram has found application not only in terms of production processes and tracking their quality but also in other problem areas of science and knowledge. [13]

The advantages of this quality tool are:

- group assistance in highlighting the main problems of the process under study;
- allowing to highlight the most significant causes and rejects incidentally arising false signs, providing an opportunity to focus on the analysis and solution;
- with a general discussion of the selected problems, it creates the effect of a collective mind.

In the developed software module for constructing the Ishikawa diagram, the following algorithm of actions takes place:

- the initial state is initialized and the monitoring process is configured;
- the problem is determined and its consequences are discussed;
- the received data is entered into the program;
- each reason is subjected to a more detailed analysis and, if clarifications and additions arise, they are immediately entered into the program;
- checking is carried out for the completeness of the analyzed input information and its belonging to the process under study;
- statements about the problem and its causes are chosen that are closest to reality;
- is established a set of the most influential reasons for the emergence of the analyzed problem;
- the plausibility of the most probable reasons is checked;
- indicators are evaluated;
- verification is carried out for violations of the assessment;
- the current analysis process ends. [14]

The overview of this tool in the developed software is shown in the figure 2.

![Figure 2. Overview of “Ishikawa Chart” quality tool in the developed software.](image-url)
6. Conclusions

Due to its flexible and rich functionality the developed software can be implemented in almost any enterprise engaged in the production of finished products. The target audience of consumers for this information system is planned to select mainly the light industry, in particular, enterprises engaged in the manufacture of footwear.

The developed software module for statistical control of production quality was subject to patent protection and received a certificate of state registration. [15]

The number of the certificate of state registration for the developed software module RU 2020612932, application number 2020610998, registration date 02/04/2020.

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