Quality Control of the Print with the Application of Statistical Methods

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Abstract. The basis for standardizing the process of offset printing is the control of print quality indicators. The solution of this problem has various approaches, among which the most important are statistical methods. Practical implementation of them for managing the quality of the printing process is very relevant and is reflected in this paper. The possibility of using the method of constructing a Control Card to identify the reasons for the deviation of the optical density for a triad of inks in offset printing is shown.

1. Introduction

The quality of products (services) is crucial in assessing the performance of each enterprise or organization. The release of effective and high-quality products allows the company to obtain more additional profits and ensures rapid production development. In order to achieve high-quality performance of printing products, it is required to combine the creative potential and practical experience of many specialists from different divisions.

An important role in solving the problem of quality improvement is played by consumers who dictate their demands and requests to producers of goods and services and evaluate the results of the organization's activities.

The task of statistical methods is to ensure the production of products that meet the requirements of consumers at the lowest cost. For this purpose, the analysis and research of operations in the enterprise are carried out. Due to the use of statistical methods of quality control of products, it is possible to achieve an improvement in the quality of both the purchased materials and the products produced and the reduction in the quantity of rejects, as well as the increase in the service life of the goods.

In addition, statistical methods of quality control help to more competently and rationally build the technological process, exercising control at its various stages.

2. Statement of the problem

Various theoretical principles and practical methods include the Total Quality Management TQM. Quality are achieved through the involvement of all personnel in the work improvement activities. The aim of quality improvement is to meet the needs of users and benefit all interested parties and society as a whole.

It is known that the statistical analysis of product quality is the study of conditions and factors that influence the quality of the analyzed object [1-5]. Manufacturing of quality products at minimum costs is the main goal of each enterprise.
The standard of printing is the determination of optimal reference tolerances and conditions for a particular technology and production conditions. They should ensure the optimal result in accordance with the recommendations.

The work on standardized methods is not limited to obtaining the results corresponding to the requirements of the standard. Strict control, designed to ensure the highest quality for print production, is not limited to a single calibration test run - the results of printing must be checked constantly. Therefore, the daily issue of quality control is more and more relevant and determines the main task of this work.

3. Methods of research
To solve this problem, statistical methods of control are used in the work: control chart of Shewhart [6-7]. Control charts are plotted on the chart time series with the indicated upper and lower boundaries, allowing understanding the ongoing process. The horizontal lines on the map represent the upper control limit (UCL), the central line (CL), and the lower control limit (LCL). Using these lines, you can trace the following dependencies:

- if too many experimental points are located above the UCL (below the BCL), the quality parameters do not correspond to the norms;
- if a number of experimental points are located between the CL and the UCL (or CL and BCL), the process requires intervention;

The main components of the printing system are the following: Speedmaster SM-102 printing machine, offset paper, ToyoInk.
Procedures were carried out to acclimatize paper (cardboard), maintain climate control and stabilize the printed image.

4. Results and discussion
The analysis of the widely used quality control for multi-color products of ISO 12647-2 standard [8] showed that the following standardized indicators are presented in it:

- reference paper types with CIELAB coordinates;
- CIELAB coordinates for basic colors (CMYK) and tolerances for reference paper types;
- secondary coordinates (RGB) for reference paper types;
- tonal values and tolerances for reference paper types;
- definition of dot gain in midtones;
- CMYK values for the gray balance scales;

Variation tolerances for base colors and dot gain when printing runs

The normalized values of optical density are presented in Table 1 [8].

| Paints | Optical density and tolerances | Coated glossy | Coated matt | Uncoated |
|--------|--------------------------------|---------------|-------------|----------|
| Blue   | 1.55± 0.1                      | 1.45± 0.1     | 1.00± 0.1   |
| Purple | 1.50 ±0.1                      | 1.40 ±0.1     | 0.95 ±0.1   |
| Yellow | 1.45± 0.1                      | 1.25± 0.1     | 0.95± 0.1   |
| Black  | 1.85 ±0.15                     | 1.75 ±0.15    | 1.25 ±0.15  |
Since in the standard ISO 12647-2 the above indicators are given only for standard paper types, the number of which is limited to five, then when working with other types of paper, the evaluation of the quality of multicolour products will be approximate. The assortment of paper in the modern market is quite large. This causes certain difficulties in choosing a reference group for them, the indicators of which are taken as standard.

The standard defines measurable results, which need to be addressed, but does not disclose the methodologies and recommendations for their achievement.

Modern methods of quality management allow us to monitor the quality of the product at all stages of its life cycle. The main function of the quality control system is the production of high-quality competitive products. During the control all possible deviations from the established norms are analyzed. At the same time, statistical methods of quality control used at all stages of the product life cycle are an important condition for the rational construction of the technological process.

Figure 1 shows the results of studies of changes in the optical density for all four CMYK ink.

![Diagram showing optical density changes over time for blue and black inks.](image-url)
For comparison, the charts also show normalized optical densities for the recommended reference paper. The value of the optical density of the printing impressions was determined with an interval of 10 minutes.

As it can be seen from the figure, in almost all cases the changes in the indices are within the permissible limits ± 0.1. The maximum deviation is observed in yellow ink. But since it is the least noticeable to the human eye, this does not greatly affect the quality of the print. The most pronounced is the contour (black) ink. In this study, deviations in black ink are minimal.

Therefore, one of the leading places in the management and control system should be the construction of control charts.

Also, in the work to predict print quality based on the structuring of the quality function, the degree of tightness of pair interactions between consumer requirements and the characteristics of the quality of multicolour products was assessed. The House of Quality has been built (Fig. 2). This allowed us to identify the following relationship: customer requirements and controlled characteristics of the printed matter; customer requirements and print quality indicators.
Figure 2. Quality House for predicting print quality parameters (symbols of the degree of tightness of communication are placed in the matrix cells: ● - strong, ○ - medium, Δ - weak).

5. Conclusion

Thus, the possibility of using the method of constructing the Shukart Control Chart for revealing the reasons for the deviation of the optical density for a triad of inks in offset printing is shown. Analysis of the graphs of the optical densities depends on all four colors on time showed that the greatest deviation from the norm is observed in yellow paint.

The analysis of the research results using quality structuring functions showed that the most important requirements of consumers are the discernibility of the image and text small details, the clarity of the print, the absence of stains and extraneous elements in the image, and its aesthetics.
The approaches considered allow us to determine the weakest place in the printing system, in particular, paper - printing ink, to assess the quality level and to give appropriate recommendations for the management of the technological process and the achievement of standardized quality indicators.

References
[1] Borisova A S and Varepo L G 2011 Izvestiya vysshikh uchebnih zavedeniy. Problemy polygrafii i izdatelskogo dela 4 p 27-35 Russian
[2] Borisova A S and Varepo L G 2011 Quality, standardization, control: theory and practice: mater 11th Intern. scientific-practical. Conf. ATM of Ukraine) p 13-15
[3] Varepo L G, Borisova A S and Golunov A V 2010 Papers of the 42-th conference: international circle of educational institutes for graphic arts technology and management (Moscow) p 145-151
[4] Goodilin D 2007 Offset printing on cardboard: problems of standardization Compuart J. 6 p 28-31 Russian
[5] Vernhes P Jean-Francis B Mercier C and Pineaux A B-B 2008 Applied Surface Science 254 (22) 7431-7437
[6] ISO 7870-1: 2014 Control charts Part 1: General guidelines
[7] ISO 7870-2: 2013 Control charts Part 2: Shewhart control charts.
[8] ISO 12647-2: 2004(E) Graphic technology Process control for the production of half-tone color separations, proof and production prints Part 2: Offset lithographic processes.