STRESZCZENIE PRACY W JĘZYKU ANGIELSKIM

This doctoral dissertation presents an approach focused on the paralel application of the Statistical Process Control (SPC) model and Design of Experiments (DoE) combined with the Pareto principle. The absence of in-depth analyses integrating these concepts to optimize processes by minimizing natural variability constituted the foundation of the identified research gap within the methodological domain.

As a result, the primary objective of the analysis conducted in this doctoral dissertation was to assess the effectiveness of applying the Pareto principle in conjunction with an integrated model of SPC and DoE in quality management of production processes. The case study was based on empirical research conducted in the production process of single-component paint.

The quantitative research conducted included statistical analysis of process data and experimental modeling of variables influencing product quality. SPC enabled the monitoring of process variability and the identification of areas requiring optimization, while DoE facilitated the systematic examination of key factors affecting product quality. The Pareto principle was used to prioritize the most significant factors, streamlining the decision-making process and enhancing the effectiveness of improvement initiatives.

The findings confirmed Hypothesis 1: *The implementation of the Pareto principle, which describes a universal pattern indicating the concentration of key factors with the greatest impact on outcomes, in combination with an integrated model of Statistical Process Control and Design of Experiments, contributes to the optimization of quality management in production processes by identifying and effectively controlling the main sources of variability*. The integrated SPC and DoE model, along with the Pareto principle, enables a comprehensive understanding of the cause-and-effect relationships within the process, encompassing a logical sequence of actions: from identifying nonconformities, through defining dominant areas contributing to natural variability, to pinpointing individual factors or interactions that shape quality.

At the same time, Hypothesis 2 was also confirmed: *Measurement system resolution, precision, and operator interchangeability lead to improved decision-making*

accuracy. It was demonstrated that proper measurement system resolution, its precision, and the ability to substitute operators are crucial for the reliability of obtained results, directly influencing the accuracy of quality-related decisions.

The proposed model has certain limitations, including the requirement for a normal distribution of the analyzed data and the limited sensitivity of Shewhart control charts in detecting small or gradual changes in the process.

Future research should focus on developing a universal mathematical approach for control charts, enabling their effective application regardless of the distribution of analyzed data and enhancing their sensitivity to small changes in the process.

The dissertation is divided into four chapters, preceded by an introduction. Each chapter concludes with a summary of key findings, while the entire work is complemented by a final section presenting conclusions drawn from the conducted research. The first chapter provides a theoretical introduction to quality management, outlining the evolution of concepts from classical models to modern strategies. The second chapter focuses on the theoretical analysis of SPC tools, describing types of variability in production processes, emphasizing the importance of measurement system analysis, and characterizing various approaches to experimental design. The third chapter presents an analysis of the integration of SPC, DoE, and the Pareto principle as a synergistic approach to quality management in dynamic production environments. It also explores the application of modern Industry 4.0 technologies in process optimization and variability reduction through the implementation of the integrated model with the Pareto principle. The fourth chapter assesses the impact of the integrated model and the Pareto principle based on empirical research conducted in the production of singlecomponent paint. It describes the methodological framework and presents the research findings.

Keywords: Pareto principle, Statistical Process Control (SPC), Design of Experiments (DoE), quality management, measurement system analysis (MSA), Industry 4.0, Six Sigma, Lean, Total Quality Management (TQM)