Mgr Małgorzata Złotoś

Abstract of the doctoral dissertation entitled

"The application of methods of design of experiments in economic research"

written under the scientific guidance of prof. dr hab. Grzegorz Kończak

Intense technological advancement contributes to the search for methods and tools effectively improving the results of production processes. Modern manufacturing companies strive to obtain high-quality products while reducing production costs. One of the methods used by manufacturing enterprises to enable the improvement of technological parameters of their production processes is statistical quality control. Experimental design methods in particular make it possible to design and carry out the production process effectively. These methods are based on classical statistical methods, the use of which is conditioned by the fulfilment of assumptions regarding, among other things, the conformity of the distribution of the response variable with the normal distribution. In practice, these assumptions may not always be met or, due to a small sample size, their verification may not be reliable. This justifies the search for alternative statistical methods that allow the design of experiments to be used effectively when the outcome variable does not meet the relevant assumptions or when the number of experimental trials conducted is small.

The dissertation explores methods of design of experiments used to improve the technological and economic results of a production process. The main objective of the dissertation is to present the author's modifications of experimental design methods that use non-classical statistical methods in their design. Furthermore, the purpose of the dissertation is to present the possibility of implementing the author's alternative methods of design of experiments aimed at improving the quality of the results of the actual wood pellet production process.

The dissertation consists of four chapters. The first chapter provides an introduction to the topic of design of experiments. It includes a historical overview of the design of experiments methods and presents the procedure for design of experiments during the production process. Moreover, the theoretical foundations of the design of experiments are described and the statistical methods used in the construction of classical designs of experiments are

characterized. Topics related to the application of design of experiments methods in the activities of service enterprises and in economic research are also presented here.

The second chapter deals with the construction of selected designs of experiments. It presents the characteristics of classical designs of experiments: the single factor experiment and the two-factor experiment, the randomized complete block design, the balanced incomplete block design, the Latin square design and Graeco-Latin square design. In addition, the construction of two- and three-level factorial designs and fractional factorial designs is presented. Elements of the theory of optimal designs and methods for determining the form of optimal designs are also presented.

The third chapter presents proposals for the construction of factorial designs of experiments, which are modifications and developments of the author's selected methods from the field of design of experiments. The first part of this chapter covers alternative methods for constructing factorial designs of experiments. It presents a method for determining the levels of factors whose values have been determined imprecisely, and its application. A design of experiment that utilizes elements of the random field theory in its construction is also presented. The elements of this theory are introduced and the possibilities of its application in the construction of a factorial design of experiment are presented. In addition, the construction of a design of experiments formulated on the basis of the method of balanced half-samples and the method of grouped balanced half-samples is proposed. Thanks to the indicated solutions, it was possible to reduce the number of experimental trials carried out and to perform the experiment under relatively homogeneous conditions.

The second part of the third chapter deals with issues related to response surface function methodology. The theoretical foundation and methods for the analysis of the response surface function are introduced here. Also, a method using elements of spatial statistics is proposed; the method leads to the determination of the points of the experimental area and allows the non-linear response surface function to be analysed. Furthermore, the use of a bootstrap method is proposed for the estimation of response surface function parameters when the assumptions of classical estimation methods cannot be satisfied.

It is also in the third chapter that reference is made to permutation tests, which allow efficient inference when the assumptions of parametric tests cannot be satisfied. This chapter presents the construction of permutation tests as well as a proposal for their use in the analysis of experimental results and in the assessment of the significance of response surface parameters.

The fourth chapter presents a proposal for the implementation of design of experiments methods in the course of wood pellet production. The stages of wood pellet production are described here. Also, this chapter presents the business activity of the company where the study was carried out. The wood pellet production in the company is a complex process so the evaluation of its results required simultaneous consideration of two response variables. In order to characterize the relationship between both the quality of the produced wood pellet and the efficiency of the production line and the established factors, classical methods of design of experiments were employed. These methods did not allow conclusions or recommendations to be made for the production process under consideration. Therefore, an alternative design of experiment structure was proposed, allowing two response variables to be considered simultaneously and including factors occurring at imprecisely defined levels. The proposed design of experiment makes use of permutation tests in its construction, enabling the correct analysis of the results of carrying out a small number of experimental trials. The presented method allowed the correct conclusions and recommendations to be formulated for the production process of wood pellet in the company under consideration.

The author's modifications of the factorial designs presented in the dissertation make it possible to develop the results of the production process when the use of classical methods of design of experiments is not justified. In cases where the assumptions of statistical methods used in the design of experiments are not satisfied, it is possible to apply the proposed non-classical methods for analysing the results of experiments. In addition, the presented possibilities of the application of the authors' method for the construction of design of experiments allowed both the experiments to be carried out correctly and the obtained results to be analysed effectively. The proposed method enabled the formulation of appropriate conclusions and recommendations allowing the improvement of the wood pellet production process in the considered enterprise.