PhD Thesis

Evaluation of the effectiveness of a manufacturing process by applying selected aspects of quality control

Abstract

The paper presents a model of evaluation of the effectiveness of a manufacturing process consisting of a sequence of related technological operations. The efficiency measure here is the ratio of pure manufacturing costs to the sum of manufacturing costs and quality costs. The quality costs include the costs of control and the costs of non-compliance. Nine possible post-control product evaluations, resulting from the combination of three conditions: compliant products, non-compliant repairable products and non compliant non-repairable products, are included in the cost of non-compliance. This manifests the uniqueness of the model presented herein. The model includes the following descriptive variables: quality effectiveness of a manufacturing process, manufacturing costs and their distribution in the whole technological process, application or non-application of quality control, its location in the technological process, effectiveness of quality control, costs of quality control, costs of repairing repairable units, costs of liquidation of repairable units, costs of complaints. The developed model facilitates control conditions planning in a multioperational technological process.

In the introduction, the topic of the paper is presented. Moreover, the main assumptions and inspirations of the author are described. Chapter 2 delineates theoretical background directly related to the topic of the paper. The basic concepts related to production process, manufacturing process and technological process are described therein. Synthetic measures of quality effectiveness of manufacturing processes as well as the most important forms of quality control are exhibited. The issues of production process efficiency measures, quality costs, especially compliance and non-compliance costs are discussed. The problems of determining the effectiveness of control are also outlined.

The research part of the paper presents a computational model, developed by the author, of determining the efficiency index of quality control depending on selected properties of manufacturing and control processes. Input and output variables with model indicators are defined, and the relationships between them is presented. As a criterion of model verification, its compliance with the results obtained in theoretical calculations has been assumed. The last chapter contains the results of model validation, i.e. the assessment of its usefulness for practical planning of control in a manufacturing process. The methodology of determining the most important parameters of the model is put forward. The paper ends with a summary of cognitive and practical conclusions, a list of references and attachments.

Chapter 7
Summary and conclusions

The aim of the paper is to arrive at a set of assumptions and build a model for the evaluation of the effectiveness of a manufacturing process conducted as a sequence of technological operations, taking into account selected aspects of quality, primarily related to control.

The model comprises of many different aspects influencing the effectiveness of a manufacturing process, such as: process quality capability, control effectiveness, manufacturing costs, costs of quality control, costs of repairs of non-compliant units, costs of scrapping of non-compliant units, possibility of detecting non-compliant units in subsequent operations of a manufacturing process. The determinants of non-compliance costs have been determined by presenting the aspects that influence the costs of non-compliance the most.

The uniqueness of the developed model is resembled in:

- process approach to determine quality costs in subsequent technological operations (or stages understood as a group of technological operations) of a manufacturing process, taking into account the effectiveness of operations (stages) and the control of the earlier ones in the process, and the effectiveness of later operations (stage) against the whole process,
- considering costs of non-compliance depending on the classification of the product after inspection against one of nine categories, being a combination of: the condition of product once manufactured (3 conditions: compliant, non-compliant, repairable, non-compliant, non-repairable) and the correctness of recognition of this conditions during inspection (9 conditions being a combination of conditions after manufacturing operation),
- evaluation of process efficiency using PEQC, which is the ratio of manufacturing costs to the sum of manufacturing costs, control costs and non-compliance costs,
- the applicability of the model to obtain the evaluation of control cost-effectiveness in a given technological operation or to indicate the conditions under which control is effective.

The analysis, verification and validation of the developed model allows to formulate cognitive, utilitarian and directional conclusions.

7.1. Cognitive conclusions

1. The developed model allows to determine the dependence of non-compliance costs on the values describing the cost and technological aspects of the manufacturing process consisting of a sequence of technological operations or a sequence of stages involving technologically similar operations.
2. The model broadens the knowledge on the formation of non-compliance costs, the sources of their occurrence and the factors that determine them. And thus, the model has an educational value. It illustrates that in each subsequent operation, manufacturing costs (MC/KW) and control costs (CC/KK) as well as non-conformity costs (NCC/KN) are incurred. The sum of all cost components is the total costs (TCn/KC). The ratio of MCn and TCn is the value of cost effectiveness of $PEQC_n$;; Figure 7.1

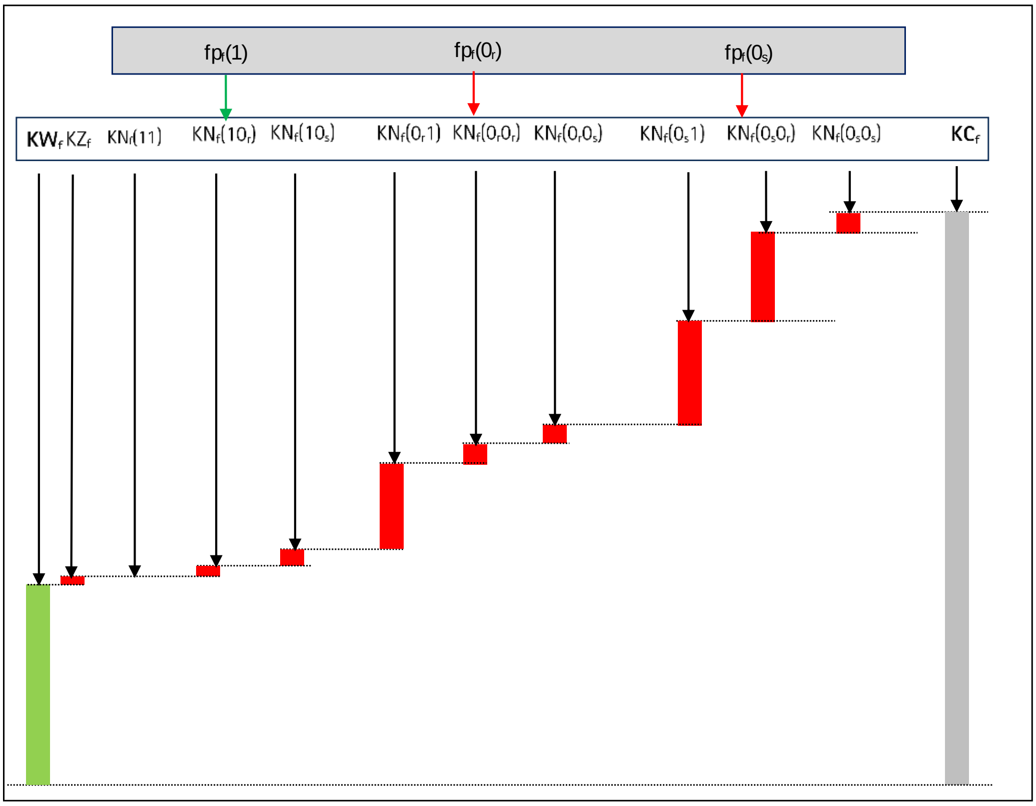

Figure 7.1. Schematic diagram of the increase in production costs for *n operations*
Source: Author's findings

3. In the case of production systems where quality control is applied, its high efficiency is a prerequisite for high efficiency in a manufacturing process, but not a sufficient prerequisite. High efficiency of a manufacturing process takes place when high quality capability goes hand in hand with high control efficiency.
4. If quality control is incorrectly located and consists in simultaneous evaluation of many independent attributes, it may be a reason for low effectiveness of a manufacturing process, because with the increase in the number of assessed attributes, the probability of making mistakes in evaluation increases. Low effectiveness of quality control may be a source of low effectiveness of a manufacturing process characterised by high quality capability.

7.2. Utilitarian conclusions

1. The model, presented in this paper, enables the assessment of the cost-effectiveness of control measures application in a manufacturing process.
2. The model can be used as a tool to support decision-making in designing new or improving existing manufacturing systems from the point of view of the location, scope and effectiveness of control. It can be used to perform a multi-criteria optimization of the control process from the perspective of the cost-effectiveness of the entire manufacturing process.
3. The model has a universal character. It can be used to describe a production system consisting of a sequence of technological and control operations, as well as a sequence of production and control stages.

7.3. Conclusions on the possibilities of expanding the developed model

1. The developed model allows to determine the size of the cost of non-compliance and the process effectiveness indicator in relation to one quality feature or a group of quality features treated as independent. In the next version of the model, this limitation should be eliminated.
2. Fractions of production and post-control units are treated as average values in the formulas for calculating the costs of non-compliance. In further developments, it is necessary to treat them as random variables, with assumed probability distribution, or as fuzzy variables.

3. The calculation model has been implemented in the EXCEL environment. It is planned to expand the model with a tool developed in the Visual Basic for Applications environment.