**Dorota WIĘCEK**

# COSTS DETERMINATION AT THE STAGE OF PRODUCTION PROCESSES DESIGN

## 1. Introduction

Nowadays it is impossible to begin the process of design and transformation of a new product in manufacturing enterprises without an accurate estimation of total costs of its production. A significant influence on the cost consumption of the production process is exaggerated by designers on the stage of product development, in which the concept and functional structure of a product is prepared, and also materials, technology, structure and production process parameters are chosen [1, 2].

The more information about the designed elements is available, the smaller share in product cost belongs to undetermined product costs, which can be seen in figure 1. The more advanced the manufacturing process, the smaller chances to decrease prime costs due to large expenses for process modification [3].

On the stage of product design arises a problem related to cost estimation in the moment when elements are not yet definitely designed. Depending on the amount of the available information, more or less precise cost estimation methods are applied, i.e.: intuitive methods, analogical (variant) methods, analytical methods, statistical and parametric methods. These are called cost estimation methods, as they operate on an incomplete information set needed to determine final production costs of the designed product [4].

## 2. Assumptions of the method of proceeding

Analogical (variant) methods allow to determine the costs of designed products on the basis of similarity with already manufactured products in a given production system with the use of classification systems.

The proposed method of cost estimation is based on a formalized description of information about features of construction, manufacturing and organization related to the designed element, automation methods of technological processes design (variant design) using methods of group technology and a model of production costs of machine elements based on Activity Based Costing [5].

The method uses the rules of elements identification, thanks to which previously designed manufacturing processes of similar elements can be found. For this aim, it is necessary to build a system describing features of the designed element. The description proposed within the research assumes a division into constructional (KCOPE), organizational (OCOPE) and manufacturing (WCOPE) features, which is shown in figure 2.

KCOPE are the most common features and therefore they are additionally divided into geometric features (GCOPE) and features related to input material for production (MCOPE). A significant element of the proposed method of describing the designed element are the constructional elementary objects (KOBE). KOBE are the objects which directly create constructional shape of the designed element and each of them is connected to one of the KCOPE.

Manufacturing process search takes place on the basis of similarity of constructional, manufacturing and organizational features of a new element and the already produced ones, i.e. on the basis of a parametric description of the designed element, necessary when scanning through the existing base of manufacturing processes, the itinerary process for a previously designed element, which is the closest to the new element is found [6]. The approach which consists of using a database to find the manufacturing process for a similar element is called the variant method. With the manufacturing process of a similar element and the data about the value of costogenic factors, together with a cost calculation system, it is possible to determine manufacturing costs of a designed element.

The parametric description will later be used when correcting the so called costogenic factors on the basis of differences between parameters of the designed element and its closest counterpart.

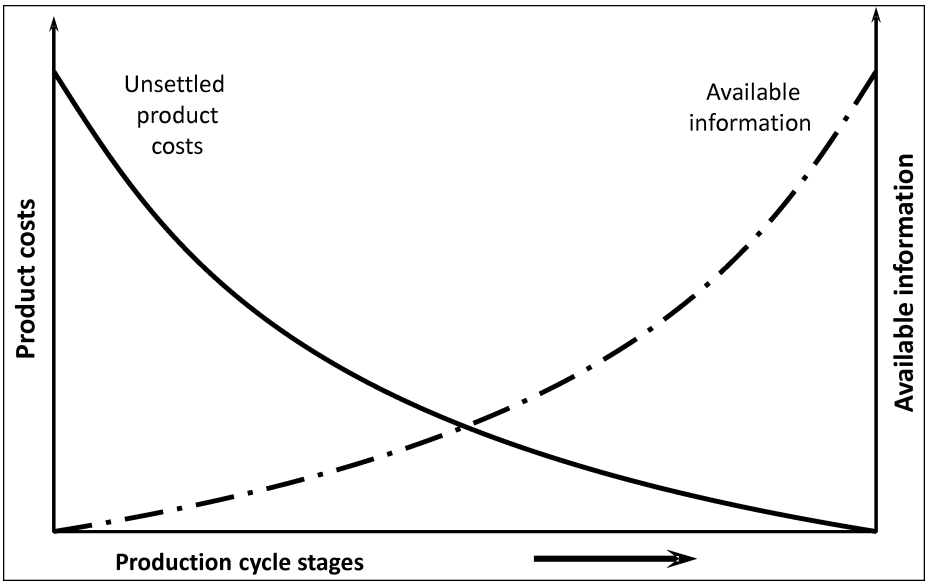


Fig. 1. The Paradox of cost estimation. Source: [3]

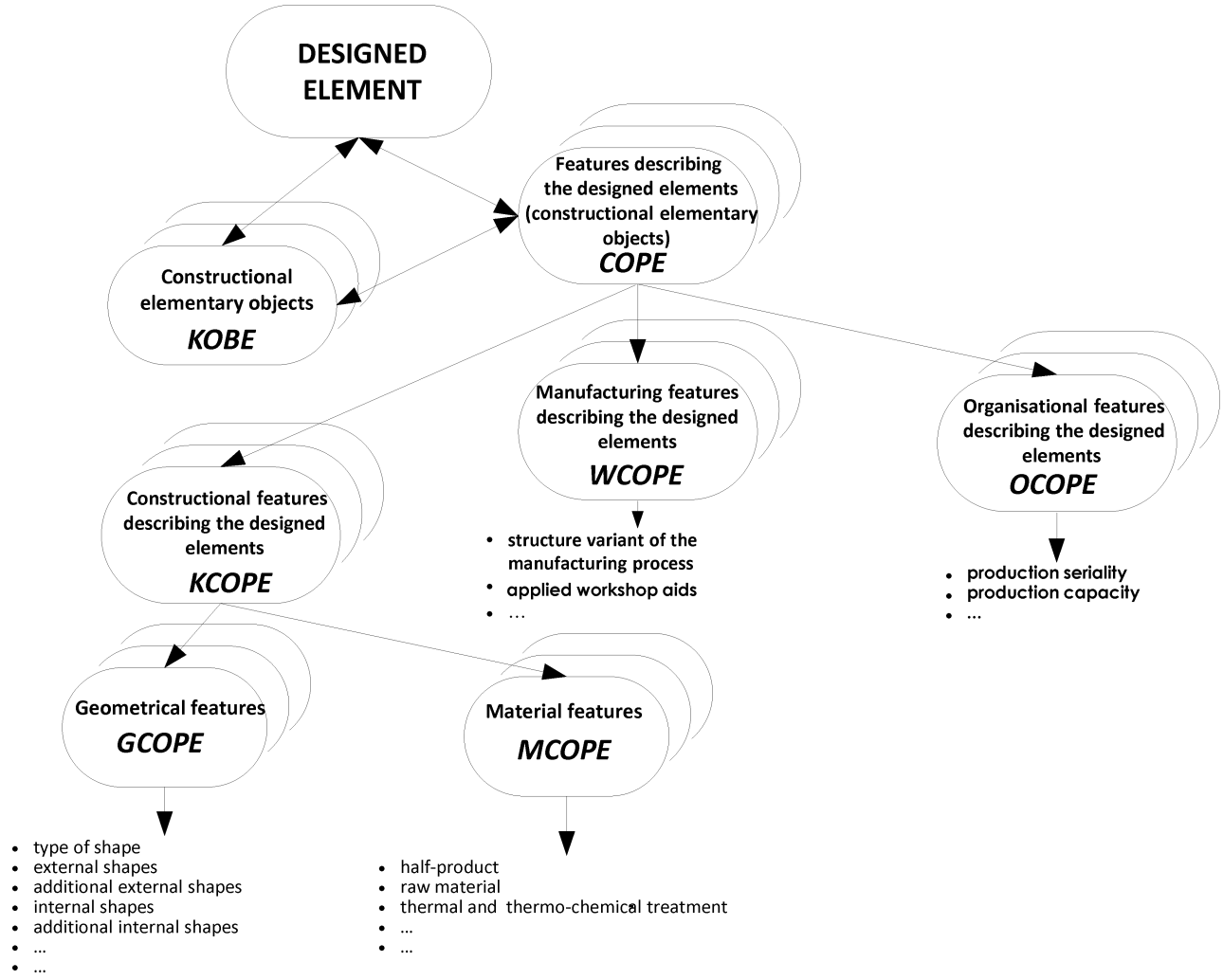


Fig. 2. Designation and division of features describing machine element

## 3. Determining the volume of direct actions

The first stage of production costs estimation for designed elements is to determine the value of cost components which create production cost structure. The presented example assumes the methodology of cost determination based on Activity Based Costing. The basic components of production costs in this methodology are costs of direct actions, which are cost drivers assigned to the produced elements. Costs of direct action are needed to determine costs of cost objects, e.g. COPE, elements, sets, products, etc.
On the basis of the information available in financial-accounting systems about costs encumbered in previous periods, information on the presence of separate activities in the sample production system, costs of direct actions have been determined, as shown in table 1.
By means of the determined unit values of measure rates of direct action units the way of generating approximate costs for the designed element will be presented.

## 4. Variant cost estimation

The proposed methodology departs from the traditional principle of coding information about features of manufactured elements and storing the information in form of a classification code, but uses a complete set of information about the features of manufactured element generated in a previous phase and features of model elements. The data is stored in a database of features describing manufactured elements (COPE) and the COPE database for model elements, which is completed in the course of system functioning. Data about manufacturing processes assigned to model elements is taken from databases of the CAPP system. Methodology is based on a three-level identification structure, which uses picture identification basing on class models, represented by the elements recorded in the COPE database, by means of the minimum distance method, for which the Canberra metric is probability measure for the compared elements. The first level of identification arbitrarily determines the kind of production object that the designed element belongs to. Next, on the basis of a set of features describing the elements from a given kind of production object, and a set of characteristics describing the designed element an attributive code of features is created in form of a zero-one vector [7].
The mentioned vector is then compared with analogical vectors of model elements and a technological type is determined, whose model is the most similar to the designed element. This step is connected to separating a sub-set of model elements, which are the closest to the designed element

| No | Action | Action costs by type in PLN | Costs of indirect action in PLN | Total action cost in PLN |
|---|---|---|---|---|
| … | … | … | … | … |
| 14 | Sales orders | 536.93 | 151.49 | 688.42 |
| 15 | Transport of finished products | 701.75 | 101.82 | 803.57 |
| 16 | Reception of sales materials | 1 968.61 | 442.37 | 2 410.98 |
| 17 | Storing sales materials | 7 255.55 | 1 548.10 | 8 803.64 |
| 18 | Releasing sales materials | 3 908.57 | 814.79 | 4 723.36 |
| 19 | Action performer on cutting-off machines | 5 922.90 | 4 894.95 | 10 817.85 |
| 20 | Action performed on universal milling machines | 2 269.07 | 2 366.56 | 4 635.63 |
| 21 | Action performed on gear hobbers | 5 699.12 | 4 740.10 | 10 439.22 |
| 22 | Action performed on multiradial drilling machines | 3 898.12 | 3 493.83 | 7 391.95 |
| 23 | Action performed on cylindrical grinders | 6 966.49 | 5 617.10 | 12 583.58 |
| 24 | Action performed on centre lathes | 26 061.56 | 18 830.59 | 44 892.15 |
| 25 | Action performed on automatic lathes | 1 954.77 | 2 149.07 | 4 103.84 |
| 26 | Action performed on generating grinders | 5 661.05 | 4 713.75 | 10 374.80 |
| 27 | Action performed on furnaces | 26 097.17 | 8 249.46 | 34 346.63 |
| 28 | Action performed on assembly stations | 19 059.65 | 14 166.69 | 33 226.34 |
| 29 | Action performed on slotting machines | 2 521.80 | 2 565.43 | 5 087.23 |
| 30 | Action performed on quenching tanks | 8 568.80 | 5 818.82 | 14 387.62 |
| 31 | Co-operation | 1 346.65 | 365.63 | 1 712.27 |
| 32 | Storing elements | 1 451.11 | 309.62 | 1 760.73 |
| 33 | Control of elements | 30 041.32 | 6 216.49 | 36 257.81 |
| … | … | … | … | … |
| TOTAL COST | | | | 516 146.44 |

Table. 1. Costs of direct action – a fragment

from the point of view of COPE common features with the designed element – i.e. a weighted sum of common features of the designed element and model elements.

The next step is to choose the element, for which the Canberra metric value, determined on the basis of values of parameters describing COPE of this element and the designed element, is the lowest. During the last stage a set of parameter values of the manufacturing process is chosen, and then, on the basis of a set of cost drivers of the variant model of cost determination, a variant set of cost drivers values is determined – figure 3.

Departing from information comparison in form of classification codes for the sake of comparing complete sets of information about features of manufactured elements on the one hand improved the quality of searching for similar elements, but on the other, it significantly increased the amount of processed information. Higher number of the compared parameters, and, consequently, increased equipment requirements caused the need to divide the identification process in the proposed methodology into several steps.

## 5. Conclusions

Values of prime costs of machine elements depend on values of parameters of constructional, manufacturing and organizational features determined on the stage of production processes design.

Accuracy of methods basing on variant approach on creating a set of cost drivers values is dependent on proximity of the designed element and the so called variant element, which is significantly influenced by the number of variant elements, for which data is stored in databases of the CAPP system.

The proposed methods require full implementation of activity based costing in an enterprise, operation of the CAPP system with an up-to-date base of technological possibilities of the production system and analysis of constructional documentation to create a base of features describing the designed elements. The proposed solutions were adapted to production systems operating in conditions of unit and small series production.

**References:**


[1] Farineau T., Rabenasolo B., Castelain J.M., Meyer Y., Duverlie P.: *Use of Parametric Models in an Economic Evaluation Step During the Design Phase*. Advanced Manufacturing Technology, London 2001.

[2] Brinke E.: *Costing support and cost control in manufacturing*. PhD. Thesis, University of Twente, Enschede 2002.

[3] Bode J.: *Neural networks for cost estimation*. "Cost Engineering", 40/1, 1998.

[4] Roy R., Kerr C.: *Cost engineering: Why, what and how?* Decision Engineering. Report Series, Cranfield University, Cranfield 2003.

[5] Plinta D., Więcek D.: *Szacowanie kosztów wytwarzania elementów maszyn z wykorzystaniem narzędzi wspomagających projektowanie procesów produkcyjnych*. „Pomiary, Automatyka, Robotyka" 2011/2.

[6] Więcek D.: *Sformalizowany opis elementów maszyn*, [w:] *Metody i techniki zarządzania w inżynierii produkcji*, red. J. Matuszek. Wydawnictwo ATH, Bielsko-Biała 2009.

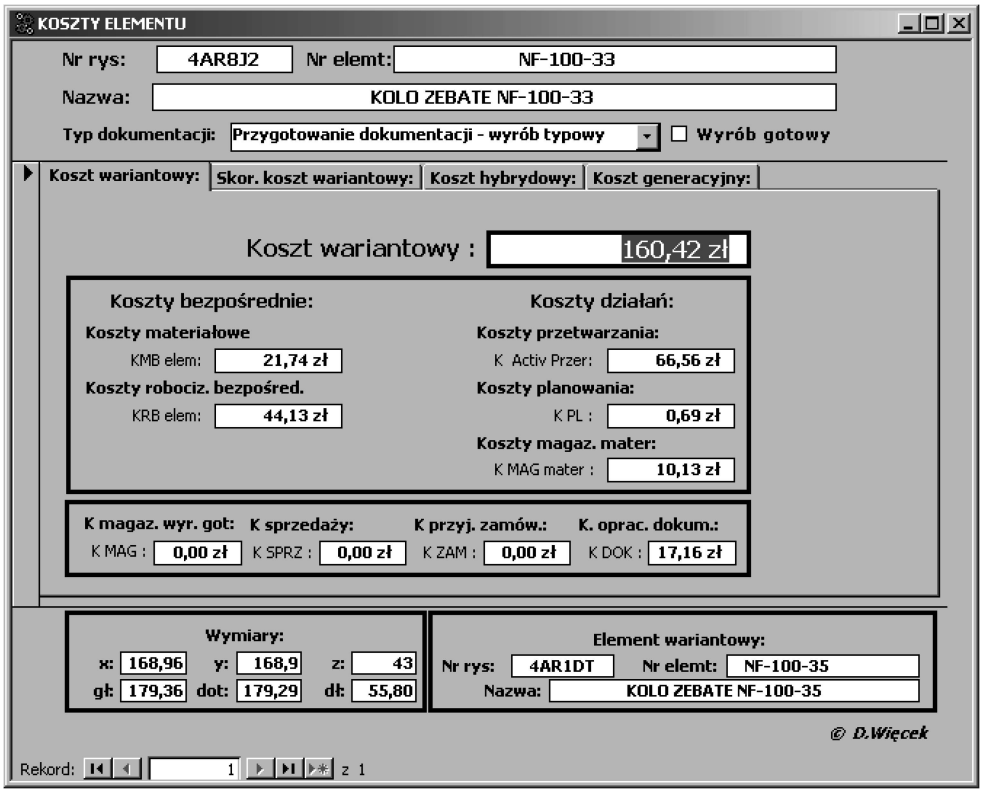


Fig. 3. Estimated variant cost of the designed element

[7] Więcek D.: *Implementation of artificial intelligence in estimating prime costs of producing machine elements*. "Advances in Manufacturing Science and Technology" 2013, Vol. 37, No. 1.

**Key words:**
estimation of production costs, activity based costing.

**Abstract:**
Nowadays it is impossible for a manufacturer to start the process of designing and manufacturing a new product without careful estimation of its total production costs. In order to prevent too high expenses for launching the production of future products, their costs must be estimated as promptly and precisely as possible. To this end, a method was proposed of describing constructional, technological and organizational features of elements during the process of their design and, in connection to assigning costs to activities, mathematical models were constructed for identifying cost drivers, which are key to evaluating the costs of elements designed.

## OKREŚLANIE KOSZTÓW NA ETAPIE PROJEKTOWANIA PROCESÓW PRODUKCYJNYCH

**Słowa kluczowe:**
szacowanie kosztów produkcji, rachunek kosztów działań.

**Streszczenie:**
Obecnie w przedsiębiorstwach produkcyjnych rozpoczęcie procesu projektowania i przetwarzania dla nowego produktu jest niemożliwe bez dokładnego oszacowania jego całkowitych kosztów produkcji. W celu uniknięcia zbyt dużych nakładów środków pieniężnych na uruchomienie produkcji przyszłych produktów, konieczne jest szybkie i w miarę dokładne oszacowanie kosztów tych produktów, jak tylko to jest możliwe. Opis cech konstrukcyjnych, wytwarzania i organizacyjnych projektowanych elementów dokonywany w trakcie zapisu konstrukcji wraz z metodą kalkulacji kosztów opartą o rachunek kosztów działań pozwalają na określenie zbiorów wartości nośników kosztów, które są podstawą szacowania kosztów projektowanych elementów.

**Dr inż. Dorota WIĘCEK**
Katedra Inżynierii Produkcji
Wydział Budowy Maszyn i Informatyki
Akademia Techniczno-Humanistyczna
w Bielsku-Białej
dwiecek@ath.bielsko.pl