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Chosen aspects of evaluation of productive processes on the example of productive chains of gear

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ABSTRACT

Purpose: The purpose of the study was to present an original approach to evaluation of the real productive chains, including its utilization as a benchmarking method.
Design/methodology/approach: In the paper an analysis of value in the productive chains with account of activities based costs was used. The evaluation of the effectivity was made by econometric coefficients.
Findings: The paper presents obtained particular results of the analysis of value in the productive chains indicating effectivity of their solutions' realization.
Research limitations/implications: Limitations of the study are associated with particularity of defining of costs of particular operations.
Practical implications: Presented method of evaluation of the productive chains gives possibility to assess effectivity of the realized activities.
Originality/value: This method is based on the methodology by L.D.Miles and M.E.Porter.
Keywords: Production and operations management; Productive chain; Value analysis; Cost; Time

1. Introduction

In the existing organizational systems process of transformation of raw materials (materials at the entry) into the products of definite structure is called production and it accompanies the mankind from ancient times. It determines one of the main pillars of free market formation, where this economic subject wins which is able to produce goods expected by the Customer, assuming the lowest costs (not lowering the quality of the product in relation to products of the competitive subjects). With reference to processes realized in the firms it should be established how each process influences the ability to realization of defined requirements [4,11]. This is why the management of processes should be based on management of the processes' results and of recourses influencing the process effectivity ; so important is analysis of costs and quality of the process [6]. Costs determine one of the tools of indirect qualification of competitiveness of the given good. Indirect, because it results from observations and investigations that not only costs determine the coefficient deciding in evaluation of competitiveness. In the literature one could find three such coefficient which influence the success of the firm:

- quality,
- cost,
- time.

The high cost of the production need not testify to high quality of the product. On the other hand, the low cost can be the reason of not holding the basic standards [6]. So costs determine the platform of reference, it can be even the benchmarking coefficient used to comparison of productive processes realized in different organizational and productive systems. The source of information which is given in the costs is not easy to define, particularly when the cost analysis concerns selected and separated

processes, operations or activities [4,7,10]. The approach which allows to define the costs of activities is based on calculation presented in the method: Activity – Based Costing (ABC) [1,10]. This method allows to reduce to a minimum one of the difficulty in undertaking value analysis, i.e. incomplete information about costs of production [2].

Each organization must found its activity on defined strategy concerning working of the system, and in particular choose the most proper technology of production, tightly connected to the existing productive chain (comprising supplies and distribution) and informative and control system what will be the guarantee of proper working of applied technologies. The investigations and analyses of the productive chains made by the author conduct to establish a proposition, that one of the strategies allowing to reach competitive efficiency there is a strategy of savings first of all based on analysis of values of the products and elimination of the unprofitable operations in the productive processes [4,6,10,11].

Acceptance the strategy of minimal costs by the firms permits to form a position of predominant producer [10].

Nowadays the projecting of the processes should be based on material, real, objective and scrupulous confrontation of the customer's needs with:

- productive possibilities of the firm;
- carried costs in the limits of organizational and productive system;
- offered quality of the product basing on modernity of applied technologies.

This is why usage of high technology is the distinguishing factor creating standards of the products [10-12].

Careless or not objective calculation of costs of productive processes allows to conclude that evaluation of the whole process does not realize requirements of the value analysis, and also does not permit to evaluate correctly the economy of the process.

The economy of the processes (understood through prism of costs and profits) is the inseparable element of evaluation of the productive cycle which influences the productiveness of the system. From here the integral condition improving productiveness is the proper organization of the productive cycle (reducing the store, limitation of transportation operations and control etc.) [5,7,9].

In the organizational aspect of realized processes, reducing the own costs can be based on two methods [10,11]:

- change of technology
- change of organization of production.

All above leads to conclusion, that penetration of technologies and organizational systems of the production permits on seeking optimal processes, i.e. those which allow to obtain a desirable effect in the partial analysis concerning costs, quality, influencing the environment etc. or in multi-criterion analysis of a number of selected criteria [9,10].

So one is still seeking for methods of evaluation and measurement of obtained results by the firms. The question about results of undertaken activities accompanies the mankind from the ancient times, when Platon in his work "Nation" described a theory of organization of the work in different professions and where he wrote that one should "produce more, better and cheaper", or when Aristotle presented its rule of "the gold means" in taking decisions in the work "Nicomachean Ethics".

One of the methods of evaluation and projecting of the processes is Value Analysis (Value Engineering). Approach of L.D. Miles to the value analysis determined such technics, which aims were qualification of the function of the product, establishment of values of these function, and in the end realization of the values of these functions at the minimal entire costs of production. This is why so important is concentration on functions realized by the given product and evaluation of its value [2].

This functional approach to the evaluation can we describe as it was shown in Figure 1.

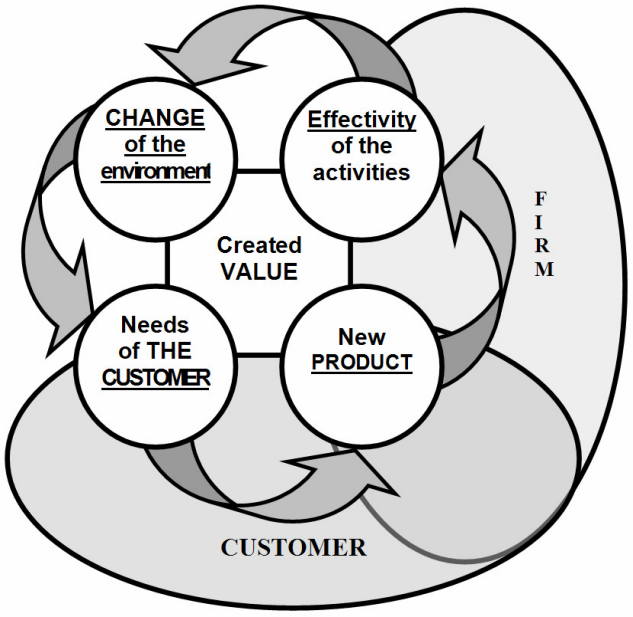

Fig. 1. Links of the process of creation of value added (according to own elaboration)

Creating the value is generated by changeable environment which influences the form of new consumptive needs of the customer. Approaching compliance with these requirements, the firms produce goods in the shape of products with possibly optimal features fulfilling defined needs. Efficiency of activities undertaken by firms in creation of values is seen in effectivity of productive chains. The evaluation of realized activities – also values supplied to the customer – is a determinant of changes in the environment.

The evaluation of the value created in the processes - in the other formulation - was suggested by M.E.Porter. The conception of value chain described by M.E.Porter was associated with presented approach, that all the undertakings are certain sequences of the activities [8].

The value chain should define "values adding" in the process through all the successively defined operations so productive as organizational. M.E.Porter distinguished two types of activities creating value: basic and auxiliary activities. The analysis should comprise all the operations: adding and not adding value, because they all participate in the costs. The analysis should also include analysis of time of particular operations. For the whole point of view at the value of the product it could be made analysis of the

reached quality of the product and the processes with reference to the costs using e.g. analysis of lacks in the process based on statistical control of the quality, and wanting to indicate directions of liquidation of lacks – analysis FMEA. Foundations of value analysis by L.D.Miles correspond with quality analysis of the product.

So made analysis should allow to describe value created in the productive chains [4,10,11].

Above described ideas of two approaches to value analysis differ in many aspects between themselves. So they can be supplementary methods. The method of value analysis by L.D. Miles mainly refers to description of the functions of the product and their values (and through it to reducing the costs to the minimum). On the other hand, the "value chain" method by M.E. Porter induces to analysing of the productive chains and looking for the most cheaper solution at a minimal time. One should consider that this method has its roots in logistics. The connection of these two methods determines more effective manner of measurement and analysis of the productive chains with reference to the studied products.

The author of this study accepted the coefficient V to the evaluation of created value in the productive processes. Coefficient V describes quotient of increase in the costs of the activities adding value to the value of the product, for which one accepted the price of the product. From the point of view of the customer this value should be maximal, what can make, that at the purchase the customer will cover the costs mostly associated with the production of the given good, but not the indirect costs or the costs not influencing the form of the product. From the point of view of the firm this value should tend to minimum, what will testify about more profitable technological and organizational solution of the process (e.g. lower costs of the applied technology). In the aim of complex estimation one should make calculation of effectivity according to costs and time. The processes should be economically analysed, with particular description of the costs, most profitable using method ABC (Activity – Based Costing) [10].

2. Experimental procedure

The aim of the study was a detailed analysis of the productive process of the gear in the real technological and organizational conditions with application of the analysis of value added and the detailed investigation of the quality of the used technology. The investigative problem concerned possibilities of reorganization of the examined productive process in the aim to increase effectivity of its realization regarding costs, time and quality.

The investigations of the productive process of the gear were done in one of the Silesian firms of mechanical industry. The firm possesses Quality Management System.

The characteristics of the examined product**:** In the study process of cylindrical gear (Fig. 2) was analysed. The gears are produced in the series of 20 pieces, and in the scale of the year in the serial production.

Characteristics of the parameters of the examined gear:

- Teeth – normal,
- Mesh – zero,
- Class of accuracy - 8 - according to PN,
- Number of teeth – 31,
- Module M – 5,
- Nominal angle of tooth contact α - 20˚,
- Coefficient of tooth's height – 1,
- Margin between teeth L0 - 0.14 + 0.42.

The teeth should be carburized on depth 1.0 ± 0.2 mm and temper to hardness 62 ± 2 HRC.

Top and frontal edges of teeth should be bended by phase 1x45˚, sharp edges – blunted.

Mass of the gear: 3.5 kg.

Material used in the process is a forged rod ø185 made of steel type 20H2N4A delivered by qualified sub-supplier of metallurgic and welding products "A" – in the amount of 1.3 m and 275 kg (for the series of 20 pieces).

Steel type 20H2N4A is a constructional alloy steel for carburizing, used for production of particularly loaded equipment – according to norm PN-72/H-84035, e.g. equipment for aeroplanes, parts in internal-combustion engine. Semi-manufactured articles of this steel there are rods rolled on hot or forged. This is a steel of limited weldability; it doesn't show increased resistance to any corrosive environment (including atmospherical) [3].

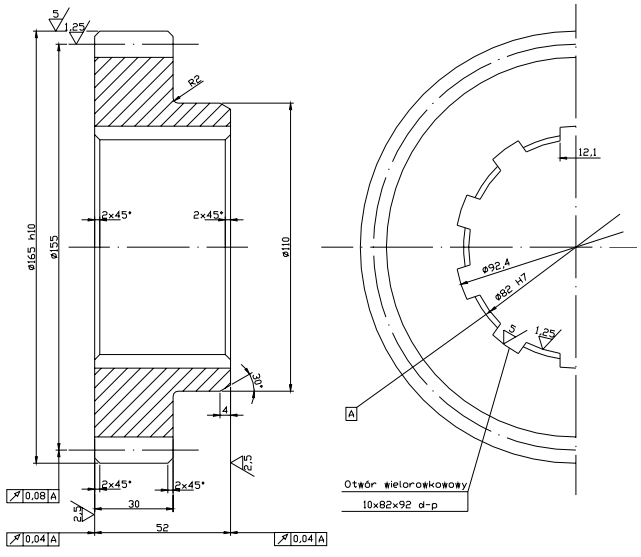

Fig. 2. Draught of gear

Results of the analyses and examination of the process:

The conducted particular examination of costs and time for the investigated process permitted to make an analysis of effectivity.

In the table 1 there are presented costs and time not bringing value added in the analysed process of production of gear. The obtainment of considerable values of time and costs of operation not bringing value added to the final product unfavourably influences the results of the effectivity of the examined process.

The structure of operation not bringing value for the examined process is as follows: the greatest participation in the total costs of production determine the operations of control (17.97%), operations of transportation (14.8%) and storing (4.2%). Based on

data presented in Table 1 the calculations of time effectivity and cost effectivity for the analysed process were done. The results are presented in Table 2

Table 1
Analysis of time and costs not bringing value added in the process of production of gear

Operations which do not bring value to the final product	Cost (% of total cost of production)	Time (% of total time of production)
Storing	4.25	4.26
Transportation	14.80	14.85
Preparing to control and Control	17.97	18.02
Together	37.02	37.13

Table 2
Time effectivity (Eh) and cost effectvity (Ek) for technological process of gear

Type of effectivity	Process before reorganization
Cost effectvity Ek [%]	62.98
Time effectivity Eh [%]	62.87

Following, analysis of value added for the investigated process was done, by means of computer application. The results are shown in Fig. 3. The process working in this way gained the value V at the level 0.73%, i.e. that the level of defined costs of operations adding value in relation to price of the product is 73%. This process is characterized by low effectivity in time and costs.

The reorganization was suggested for so working process. It included reduction of selected operations, e.g. operations of interoperating control, resignation and modifications of transportation (because untill now the process was realized on 5 separate productive halls), liquidation of operations of storing at the entry to the process and resignation from executing investigations of chemical composition of the entrance material by increasing the rigour of conditions of ordering materials at the qualified suppliers.

In the technological sphere one transferred operations of rolling to the centre-chuck lathe type TAE – 25 N with the system of numeral steering (Fig. 4). Performed detailed investigations of time and costs for the studied process after reorganization permit of secondary analysis of effectivity after the process.

In the table 3 there are presented costs and time of operations not bringing value added in the analysed process of gear production after reorganization. The structure of operations not bringing value added for the investigated process is following: operations of control constitute 12.56% of total costs of production, next operations of transportation (9.7%) and storing (1.04%). Based on data presented in table 3 one make calculations of cost effectivity and time effectivity for the analysed process. The results are presented in table 4.

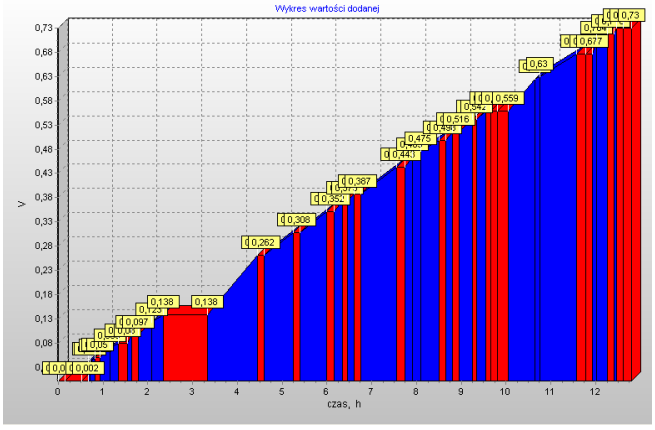

Fig. 3. Chain of creation of value added for the process of gear production (module 5) – before reorganization (number of operations-55)

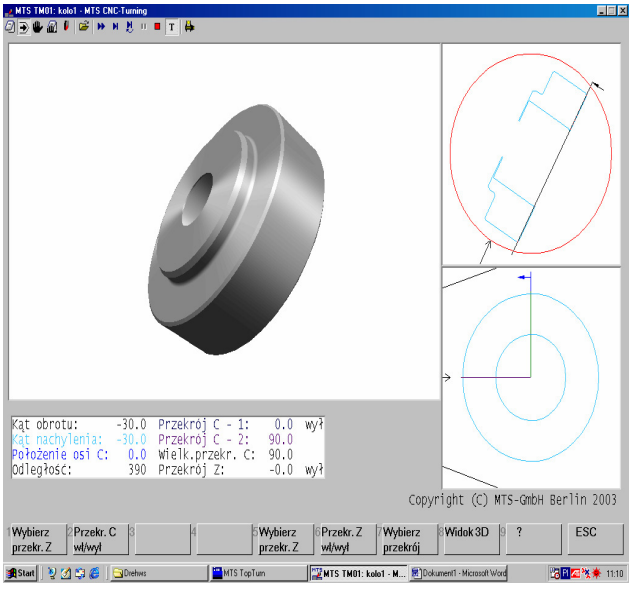

Fig. 4. Semi-manufactured product after tooling on centre-chuck lathe type TAE – 25 N with the system of numeral steering

Table 3
Analysis of time and cost not bringing value added in the process of gear production after reorganization

Operations which do not bring value to the final product	Cost (% of total cost of production)	Time (% of total time of production)
Storing	1.04	1.04
Transportation	9.70	9.76
Preparing to control and Control	12.56	12.62
Together	23.30	23.42

Table 4
Time effectivity (Eh) and cost effectvity (Ek) for technological process of gear after reorganization

Type of effectivity	Process after reorganization
Cost effectvity Ek [%]	76.70
Time effectivity Eh [%]	76.57

Following, analysis of value added for the investigated process was done, by means of computer application. The results are shown in Fig. 5. The process working in this way gained the value V at the level 0.497%, i.e. that the level of defined costs of operations adding value in relation to price of the product is 49.7%. This process is characterized by relative higher effectivity in time and costs in comparison to the process before reorganization.

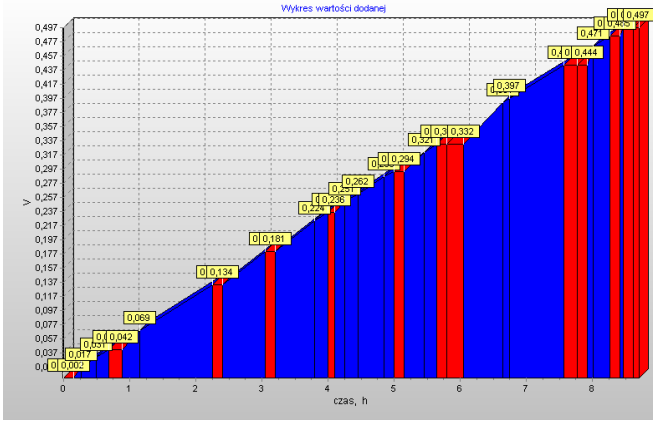

Fig. 5. Chain of creation of value added for the process of gear production (module 5) – after reorganization (number of operations-34)

3. Discussion of investigation results

Suggested in the study reorganization of the productive process for the investigated product assures better cost, time and quality effectivity. Usage of lathe with the system of numeral steering warranted high repeatability of the quality of manufactured products, what allows to eliminate the lacks, associated with human factor. From the point of effectivity of investigated process it is essential that participation of removed material during tooling is up to 74.43%. This is the level which should be diminished. Selection of the entrance material with smaller diameter, according to the catalogue of metallurgic products, permits on effective improvement – when the diameter of the rod is diminished from Ø185 to Ø175, loss of the mass decreases to 71.15%. Such activity could diminish amount of waste material having negative influence on the environment, and also allow to reduce to the minimum costs of the electric energy associated with conducted mechanical tooling. Suggested reorganization of the process allow to decrease costs, and also time of production, what caused in improvement in cost effectivity and time effectivity. Detailed comparative data concerning investigated process are presented in table 5 (referring obtained results to price of the article as 100%).

In the table 5 there is presented comparison of performed analyses of value for technological process of gear before and after reorganization

Ineffective cost determines 37.02 % of the total cost of the process before reorganization, however, after reorganization – 23.3 %. Ineffective time determines 37.13 % of the total time of the process before reorganization, on the other hand, after reorganization – 23.4 %. Suggested reorganization caused in increase of cost effectivity by 13.72 % in comparison to the total cost and increase in time effectivity by 13.73 % in relation to the total time.

In the table 6 there is presented comparison of number of operations in the analysed process before and after reorganization.

Table 5
Data from technological process of the gear before and after the reorganization T

Data from technological process	Process before reorganization	Process after reorganization
The total cost	75%	51.16%
Ineffective cost	27.76%	11.92%
The total time [h]	12.802	8.723
Ineffective time [h]	4.753	2.041
Cost effectivity [%]	62.98	76.70
Time effectivity [%]	62.87	76.60

Table 6
Comparison of number of operations before and after reorganization in the investigated process

Type of operation	Process before reorganization	Process after reorganization
Production	29	22
Control	10	7
Transportation	13	5
Storing	2	1
Together	54	35

Analysing obtained data, one have ascertained, that operations of production bringing value for the investigated productive process of gear before reorganization carried out 53.70 % of all the operations in the process, instead after reorganization – 62.86 %.

In chance of operations not bringing value for the investigated process (control, transportation, storing) this participation is as follows: 46.30 % before reorganization and 37.14 % after reorganization. Particularly, operations of control determine 18.52 % of the total number of operations in the process before reorganization, operations of transportation – 24.07 %, operations of storing – 3.70 %. After reorganization control determines 20 %, transportation – 14.29 % and storing – 2.86 %.

Thanks to suggested reorganization participation of operations of control in the total number of operations in the process increased by 1.48 %, on the other hand participation of operations of transportation and storing decreased by 9.78 % and 0.84 %, properly.

Successively, an evaluation of productive chains of gear was made using a coefficient of productiveness according to value added – P_{AV} (1) [5], which was defined as the relation of value added to the time of production t_w:

$$P_{AV} = \frac{C - K}{t_w} \quad (1)$$

C – price,
K – costs of production.

Obtained for analysed process value of productiveness after reorganization is significantly greater, it confirms the rightness of undertaken activities. At suggested manner of reorganization of the process in such modification of technology, the process of production allows to gain greater effectivity of organization of production, what means generating greater profits for the firm (Fig. 6).

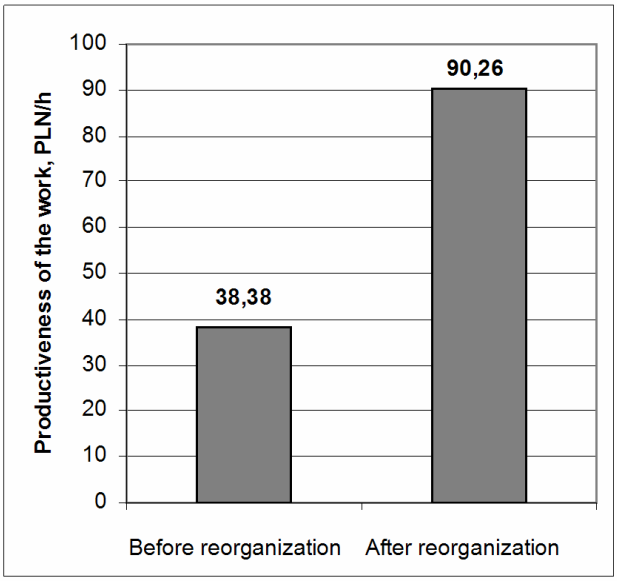

Fig. 6. Value of productiveness

Suggested solution of reorganization of the process is only one of many solutions being situated in the sphere of searches for real improvements in the realized technological and organizational systems. The ideal solution – according to the method of evaluation of processes by G.Nedler for the investigated process – could give much better results of productiveness, but ideal status, at zero-costs of production - from foundation - is unreachable, it determines the direction of undertaken activities and analyses looking for optimal solutions.

4. Summary

Presented in the study approach to analysis of productive chains through prism of criterion of value created in them, and in particular obtained results, confirm the thesis, that strategy of economy based on analysis of value described above, is an efficient instrument allowing to reach competitive position by economic subjects.

Analysis of value and its application to the evaluation and optimization of processes and productive chains brings a lot of strategic information for the firms. A modern approach to costs concerning production (based on the formula: profit from the product determines the difference between price established by free market and costs of production of the given good) describes the direction of activities: making the profit maximal – reducing the price to the minimum. As in the example described above one can see that not only elimination of operations not bringing value (creating the costs), but also suitable selection of operations bringing value, has its influence on formation of economic results of the firms. It should be emphasized that one of the difficulties of so suggested approach there is initiating the calculation of costs of the activities in the firms as a tool of management in economics of production.

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