Managing the suitability of cost calculation for manufacturing technology in the mechanical processing industry

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Abstract. Maximizing returns and increasing efficiency in manufacturing can also be achieved by organizing, managing and controlling production costs. Moving from the independent approach of costing to a systemic approach, by considering dependence and conditioning correlations with manufacturing technologies means reconsidering the concept of cost management. Both subsystems involve specific and common instruments and procedures, which allows a conceptual summation leading to a new system of approaching the goal of higher resource utilization in economic processes. The adaptation of calculation methods to manufacturing technologies is circumscribed to managerial measures undertaken to increase efficiency and internal yields as fundamental objectives. Reorganizing the enterprise through segmentation into Responsibility Centres can provide viable solutions for achieving management goals. Segmenting the enterprise and implementing integrated procedures requires significant costs that can’t be borne by all businesses, especially small and medium-sized enterprises that are still in the early stages of development. The proposed solution responds to the need of directing the activity through costs in SMEs in early developmental stages, which hold modest resources that do not allow the acquisition of integrated software. The application provides information with a high degree of utility, both in the pre-calculation and post-calculating phase, and has a high capacity to adapt to changes in technology. The results obtained from the analysis of the deviations require corrective or improvement operational measures, shortening the time gap between the moment of consumption and the corrections.

1. Introduction
Industry is the most dynamic sector in modern economies that contributes most to added value (45.5%) and to Gross Domestic Product (23.6%). Within the industry, enterprises carrying out mechanical processing (machining) activities are SMEs that are in early stages of financial accumulation. Machining means several specific operations, such as milling, turning, splicing, grinding, sanding, etc. which require significant consumption of material, human and informational resources. The limited financial resources from these activities make it impossible to apply technology management principles, methods and tools as an interdisciplinary field: "engineering, science and management disciplines for the purpose of planning, developing and implementing technological capabilities to form and achieve the strategic and operational objectives of an organization."

Considering the need to increase return and efficiency in the management of mechanical processing enterprises, this paper proposes an application for adapting cost-calculation methods to manufacturing
technologies. Implementation of this application has as a fundamental requirement the process of segmentation of activity by Responsibility Centres: "...a component of the enterprise management system ..."

2. Technical and economic information, linking the system of suitability of cost calculation for the manufacturing technologies

Management in the mechanical processing industry is subordinated to the concepts of: planning, designing, drawing up technical documentation, organizing technological flows and executing specific operations. These directions of action aim to increase efficiency and internal returns, indicators that support the fierce competition in specific markets. Measurement of efficiency indicators is also done through the cost of production, which reflects internal efficiency and returns. The production cost economic indicator represents "the numerical expression of the quantitative side of economic phenomena and processes..." and is obtained from an organized and scientifically applied calculation. The size of this indicator shows the quality, efficiency and yields recorded in the production process. Cost calculation is the duty of management.

The cost of production, as "the monetary expression of the consumption of production factors", is determined in a distinct process called cost calculation. This phrase refers to all the mathematical operations that are carried out under the authority of technical and economic thinking in order to determine specific indicators that reflect the returns and the efficiency of resource consumption. The significance of the cost has two valences: economic, found in internal returns and financial, measuring the degree of recovery of advanced resources.

The syntax manufacturing technology is the summation factor of the methods, processes, operations performed or applied to resources such as labour force, raw materials and materials and information to produce an industrial or commercial product for the market. The concept of system means several interconnected elements or components that influence and coordinate each other, aiming at reaching certain technical - economic parameters or performing certain functions.

Cost calculation is indissolubly linked to the specifics of the manufacturing technologies. The manufacturing technology validates its efficiency through the size of the cost. The combination of the two technologies with the cost calculation results in an independent system with specific functions, methods and tools.

The tools, procedures and working methods used by the costing process are associated with the economic sciences, and the methods and operations defining the manufacturing technologies belong to the engineering field. Both the technologies and the cost calculation underpin the same objective: increasing economic and financial efficiency in the resource management process. Both have the capacity to measure returns: technologies can measure economic return while calculations can measure financial return.

It can be argued that the two subsystems are mutually conditional and measure the objectives of the economic activities, i.e. to generate added value and positive financial results. The combination of the two concepts is done through technical and economic information. Information combines the two subsystems as a new concept, which we can define as a mechanism for the suitability of costing methods for manufacturing technologies.

Technical and economic information, as a "process research tool" shows cause-effect objective links between system components. At the same time, information is the decisional support of the act of conducting and controlling economic activities. The connection between technology and calculation is made by managerial accounting, understood "as a set of procedures for the identification, quantification, collection, analysis and reporting of information". This data processing and analysis laboratory is not a regulated one. The organization of managerial accounting is related to the company's abilities, requirements, guidelines and needs. From this perspective, the technical and economic information will be built, processed and provided on the management-driven flows to serve them in substantiating decisions.
Cost calculation adapts to manufacturing technologies, not vice versa. The choice of calculation methods is based on the managerial decision in accordance with the applied technology. The result is a comprehensive perception of the higher use of available resources in relation to the proposed goals.

3. Directions for action for the suitability of costing for manufacturing technologies

The suitability of costing methods, respectively, "the way or method to carry out research and interpret phenomena", for manufacturing technology has as its starting point the segmentation of the enterprise on responsibility centres. These centres are relatively independent structures designed to collect costs by a particular method, a numerical quantification model of production costs, variable and fixed, as determinable economic dimensions. At the same time, the responsibility centre also means "a hierarchical sequence of enterprise management" capable of self-government on the basis of correlative relationships with other centres, generating new functional relationships. By applying the principle of self-management, the centres can independently measure returns and efficiency based on cost.

Enterprise segmentation can be performed on the basis of functional or spatial criteria and their choice depends on: the field of activity, the technology used, the way of organizing the production process, the diversity and complexity of the manufactured production, the level of equipment, social or psychological factors. The segmentation criteria may be: production activity (execution of a product or service); technological process (machining, assembly, finishing, etc.); field of activity (design, supply, sale, etc.) or related and auxiliary activities (repairs, energy production, maintenance, SDVs etc.)

The enterprise segmentation decision will be substantiated by the quality and content of the answers to a set of questions, such as:

1. How to translate expenditures into cost elements?
2. What are the possibilities for variable cost planning?
3. How can indirect expenditures be allocated to the responsibility centre and the product?
4. How do we determine actual costs?
5. Are there preconditions for determining deviations between planned and actual costs?

Obtaining answers to the above questions means just as many stages of work to be done so that, finally, it is possible to connect the most suitable calculation method to the manufacturing technology.

4. Steps to suit the calculation of production costs for manufacturing technologies

Once the enterprise segmentation stage has been completed on responsibility centres, which can also be referred to as production centres, the next stage is the organization of the "laboratory" for collecting, processing and supplying the technical-economic information, called cost management.

Through the five steps below, management in the mechanical processing industry can organize a personalized cost management system, capable of providing the required high-quality technical and economic information. For any corrections it is possible to intervene in real-time.

4.1. Limiting expenditures and translating them into cost elements

Responsibility Centres (CR) are represented as Production Centres. In this category, it is recommended to include the machines used for the mechanical processing operations, i.e. for production.

From this perspective, the construction of the production cost takes into account the presentation structure. It will be determined by the following calculation formula:

\[ C_p = C_{md} + C_{sd} + C_{ind} \]

where:
- \( C_p \) - the cost of production, which will be obtained as a sum total of:
- \( C_{md} \) - direct material cost which means all specific inputs of identifiable raw materials and materials for each product,
- \( C_{sd} \) - the direct wage cost is calculated according to the consumption norm (Ncs) and the norm of the machine's operating time (Nut). The consumption norm means the time it takes
an employee to perform an operation in the technological flow. The machine norm is the
time it takes to operate the machine within the normal work norm. For a correct
determination, several times are taken into account: preparation, operation, maintenance or
accidental stops,

\[ C_{\text{ind}} = \sum_{r=1}^{n} (C_{\text{hc}} + C_{\text{hg}} + C_{\text{ha}}) \] (2)

r = the category to which the indirect expenditure belongs,
C_{\text{hc}} - the indirect common costs of responsibility centres, such as those incurred for repairing
work equipment and adjacent areas, the cost of electricity consumed in the responsibility
centre which cannot be allocated directly to the product, spare parts, maintenance materials
other than direct ones etc.,
C_{\text{hg}} - the general indirect costs, which consist of: the salary costs of engineers, designers,
supply and sales staff, foremen and other staff involved indirectly in the production centre’s
work. In the category of general indirect costs it is also possible to include those for lighting
and heating of production sites, cleaning, maintenance of buildings related to the production
area etc.,
C_{\text{ha}} - the indirect management costs related to the TESA department, including the
maintenance and repair of the buildings in which they operate.

4.2. Planning variable cost elements by Responsibility Centers

In the mechanical processing industry, variable cost is determinant. The variable cost elements are
directly proportional to the volume of production. This is the reason why they are pursued with
priority and the fixed costs are left in the secondary plan. From the value point of view, the variable
cost has the majority share in the total cost of production.

The choice of cost collection processes is made by adapting to manufacturing technologies to best
meet the cost control requirements. In practice, there are a number of cost-accounting procedures for
cost carriers, among which: weighing quantities with prices or purchase rates, applying proportionate
percentages to absolute amounts, pro rata temporis, applying flat rates etc.

When calculating the material expenses (raw materials, auxiliary materials, semi-finished products,
fuel, spare parts, electricity, water, steam, other utilities, inventory items, protective equipment etc.)
that can be expressed quantitatively, the mathematics of weighing quantities with prices or tariffs is
widely used.

Transforming a material expense into a cost element is done by applying the generic formula:

\[ C_{\text{md}} = \sum_{i}^{j} (q \cdot P) \] (3)

where:  
C_{\text{md}} - the monetary expression of material consumption,
j - the product in relation to which the expense is identified and for which it will become a
cost element,
i - raw materials, materials etc.,
q - the amount consumed according to the consumption norm,
P - the unit price of the element of material cost.

For the assessment of actual consumption of materials and utilities, in the post-calculation phase
we will use the evaluation based on the actual cost of acquisition of the cost element, by applying one
of the stock evaluation methods: FIFO, LIFO or Weighted Average Cost.

The following expenditure components are considered in the calculation of costs for direct salaries
to the bearer, before they become calculation elements.
The salary rate that takes into account the categories of personnel, working time and the forms of pay used, respectively, the agreement: individual or global or the time-based pay system. The form of pay in the agreement is common for directly productive workers who are directly involved in the production process.

The established formula for determining wage costs is the following:

\[
C_{nd} = \sum_{i}^{n} (N_{i} \cdot T_{i})_{j}
\]

where:
- \(N_{i}\) - is the time norm obtained as a result of normalization of work,
- \(T_{i}\) - pay rate,
- \(j\) - product, cost bearer.

Once the theoretical model of variable expenses planning has been defined, the manufacturing technology can be outlined to the smallest details, respectively, the operations flow from the technological flow, in their logical sequence, starting from the reality which states that “manufacturing flexibility is aimed at increasing productivity”. Once these terms have been obtained, the specific consumption of raw materials and materials for each product is calculated, as well as the wage costs according to the rates applied to the personnel involved in the production activity. At this stage, both the raw material costs and those resulting from the remuneration of staff for the next production cycle are predicted, depending on the volume of production. Thus, we are able to know the working times of the machines involved in the technological flow.

The running time of the machine will become a basis for calculating the amount of indirect costs for a product.

4.3. Distribution of indirect costs for the Responsibility Center and Product

Indirect costs (\(C_{ind}\)) are collected at enterprise level, in each period, according to the requirements of the organizational and managerial system. In most cases, in the mechanical processing industry, indirect costs are collected monthly. Where control and tracking of production costs is done online, indirect costs are collected at shorter intervals, sometimes daily.

In the case of the mechanical processing industry, the number of hours of operation of the machines for the next month is planned from the design phase. In the production cost pre-calculation phase we can determine the amount of indirect costs with a high degree of accuracy for one hour of operation of a particular machine. For the purposes of calculating indirect cost elements we need to choose the basis of allocation, which typically is a relatively stable cost element, such as the “direct payroll expense”. The choice of the allocation criterion is based on the stability and complexity of the operations performed on a machine, and the direct payroll cost directly meets these requirements.

Once the allocation base has been defined, it is possible to determine the indirect costs of a product out of their total. The indirect cost allocation operation is made by using the following calculation algorithm:

\[
K_{ind} = \frac{C_{ind}}{\sum C_{fix}}
\]
Knowing the normal running times of all machines \((N_{fu})\) in the responsibility centres to which the indirect costs will be allocated, it is necessary to determine the share of indirect costs for each machine using the calculation formula:

\[
THM_n = \frac{k \cdot C_{hsc}}{N_{fu}}
\]

(6)

where:
- \(k \cdot C_{hsc}\) - is the sum of the indirect costs of a machine (CR),
- \(THM_n\) - is the indirect cost of one hour of operation of the machine (CR) to which the indirect costs have been allocated,
- \(N_{fu}\) - the number of hours of operation of the machine,
- \(n\) - represents the machine (CR).

The dispersion of indirect costs of the Responsibility Center on each product obtained with the respective machine is determined by the sum of the working times counted per machine (Σ\(T_{fun}\)) using the calculation formula:

\[
C_{ind,i} = \frac{THM_n}{\sum T_{fu}}
\]

(7)

where: \(i\) is the product.

The planned production cost is obtained from the sum of the above-determined cost structure elements, respectively:

\[
C_{p0} = C_{md0} + C_{sd0} + C_{ind0}
\]

(8)

4.4. Calculation of the actual production cost

The same steps will be taken in the post-calculation phase. The difference between pre-calculation and post-calculation is the nature of the expenditures. For the pre-calculation stage we use the planned expenditures, which are determined based on measurements or norms, while the post-calculation takes into account the actual expenditures incurred, provided by the management accounting.

\[
C_{pi} = C_{mdi} + C_{sdi} + C_{indi}
\]

(9)

In most cases there are differences between the planned production cost \((C_{p0})\) and the actual one \((C_{pi})\), differences which are called deviations.

4.5. Determining the deviations between actual and planned costs

One of the significant cost functions relates to ensuring the conditions for measuring the efficiency of resource utilization, the return recorded in the manufacturing process. Comparing actual and planned consumption results in positive differences when actual costs are below those planned or negative in the reverse situation. The analysis of deviations is of great importance for management, from both perspectives:

a) in the case of positive deviations, they may result from streamlining the technological flow, the intensive use of working time or from a poor planning mechanism;

b) the causes for negative deviations can be given by: deviations from the technological flow, communication and relationship deficiencies between the Responsibility Centres, exceeding consumption norms or the manufacturing times (negligence or misuse of the time base), increases in actual purchase prices, mistakes in planning activity etc.

Deviations are calculated at the level of each structural component of the production cost, for the entire responsibility centre and for each product, and the results are subject to independent analysis.

Once the causes are identified, management may order the appropriate measures for each situation that derives from the economic activity carried out.
5. Conclusions
The application that can be used to efficiently suit production costs calculation for manufacturing technologies can find its usefulness in the managing process of SMEs that do not have sufficient resources to acquire integrated accounting and computing systems. The process of directing activity through costs allows management to have at least the following directions of action:

• building a planning and budgeting platform on sub-units up to the machine level that allows the activity to be broken down to unit cost per product;
• the possibility of keeping track of the internal returns, caused by the internal consumption of material, human and informational resources;
• measuring individual efficiency at the level of each segment (equipment) on economic and financial coordinates, but also from the perspective of valorisation of the human potential;
• deviation analysis is an efficient and pragmatic internal control tool that allows for the operative implementation of corrections but also the undertaking of measures to increase returns and efficiency;
• the application is flexible and can be easily adapted to any changes in the manufacturing technology.

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