

ESTIMATIONS ON MAIN MANUFACTURING ELEMENTS OF COST SPECIFIC TO EDM OPERATIONS

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ABSTRACT: Cost estimation can be considered as the determination of the relationship between activity and related involved costs and also as an important source of information, in taking decisions, for an enterprise management. This paper describes the required issues regarding main component elements of cost estimation, related to electro discharge manufacturing. We have considered specific aspects for a Small and Medium Enterprise located in Romania. Estimated elements on manufacturing cost should be treated as internal references, should be estimated using considered organization particularities and periodically updated.

KEY WORDS: manufacturing cost, costs elements, production cost, EDM costs, management accounting

1 INTRODUCTION

Technology can be defined “as a combination of relevant knowledge, skills, technical equipment and machinery necessary for people to transform raw materials into useful products and services”[1].

Technology must be considered within the overall business operations. A possible approach regarding technology is to consider it’s main application areas. So we can consider product technology, process technology and information technology. In order to understand and act properly, management must take into account all of this areas.

A product is a customer demand, but from another point of view it represents the output of a manufacturing system and it is determined by quantity, quality, time and cost. The manufacturing process is done on bases of manufacturing process planes, considering the existence and interaction of factors and elements, for a specific production entity framework. The most important specific elements considered are:

- used technologies, materials;
- production equipment;
- personnel (qualification and expertise);
- energy (type, amount, transfer, price);
- organization (space structure).

The above classification of elements that influence the drafting of the manufacturing process is greatly simplified. Even so considerable complexity result from it, at the decision level, about the real components involved in real case. Based on the impact on these factors and the entity possibilities the suitable technology for part production involves

successive complex and precise decisions.

Today’s business structure is more complex and dynamic than ever, considering that market requires rapid changes manufacturing area, which directly affects the work of manufacturing organizations. We must also take into account information technology (including digitization and virtualization) which provides new ways regarding manufacturing processes. These two concepts generated the transition trend to digital factory and digital manufacturing. These facts allow the improvement of engineering products and change the manufacturing process considerations, where sustainability is one of the most important factors to be taken into account for business management [2, 3].

Based on these considerations, this paper take into account a small or medium type (SME) enterprise, whose activity is based on electro discharge (EDM) manufacturing processes. In order to simplify the problem we assumed that all possible support activities are third party services. This assumption allows us to identify more clearly all costs related to this specific technology. Estimating manufacturing costs, considering also all technical possibilities of the considered entity can be a key factor in management decisions besides a customer product demand. Not at least, estimating, recording, analyzing and comparing costs or costs elements, organization management have the right financial information tools in order to properly act. Costs analyze goal is to reveal where the deficiencies lie and which components of the system delivers the most impact (by accounting means).

2 CONSIDERATIONS ON MANAGEMENT ACCOUNTING

The development of the production activity must be closely followed by the development of the accounting system which needs to be integrated into a suitable informational system at organizational level. The accounting information and especially the management accounting information is the key feature of management decisions. The accuracy, speed and flexibility can make the difference between competitors in current economic conditions characterized by uncertainty and risk. The technological and organizational particularities of the considered production entity, as well as the economic, social, business and legal regulations of the geographic location (country, region) should be taken into account in any adopted management accounting system.

By literature survey we identified several cost and management accounting techniques. The main activities involved by each of techniques are: identifying, measuring, analyzing, interpretation, preparing and communicating information. In our opinion, as a result of detailed particularities, advantages and limitations of all known methods, the Activity Based Costing method (ABC) and the Standard Cost (SC) method are the most suitable to use in considered case. Traditional management accounting techniques, such as full costing, direct costing and standard costing are more accurate, but more suitable for strategic management decisions. Our target is to gain rapid, flexible and precise information about the costs related to a customer demand. So we can conclude that ABC method focuses on measuring of the operation costs, based on: analysis of costs elements, determination of performances based on activities, estimation/measurement of production and functional costs, determination and usage of required resources.

The method can provide reporting and control of activities related to relevant costs, from identification level of a considered entity point of view, is also useful in measuring of overhead of the activities, identification of value added activities from non value added activities, measure the needed resource consumption for each component process of activity etc.

By dedicated literature survey [4] we identified some specific aspects and issues concerning ABC method implementation:

a) accounting information is affected by business environment at a certain time (including financial regulations, regional location etc.);

- b) accounting information systems must consider the culture and shared values appropriate to the particular organization;
- c) implemented system must be designed to be able to produce appropriate control information at appropriate times (by control we mean the process by which the system adapts to its environment);
- d) to achieve self regulation clear objectives and definitions are required;
- e) also the feedback system (comparison between expected outputs and real ones) must be considered. Planning is a form feed-forward control;

We can conclude that the ideal conditions for best results in applying ABC management accounting method (or any other modern method) are:

- a stable operating environment;
- a clear-cut, flexible organizational hierarchy;
- clear definitions, tasks, procedures etc.;
- little interdependence between parts (sectors) of the organization.

3 EDM MACHINE CIBERNETIC MODEL

For implementation of every machining process the appropriate machine is required, because the process performance depends on the chosen EDM machine. So the manufacturing process design must begin with the machine selection, from a database of available suitable machines. This is one of the most important criteria in order to obtain the lowest costs.

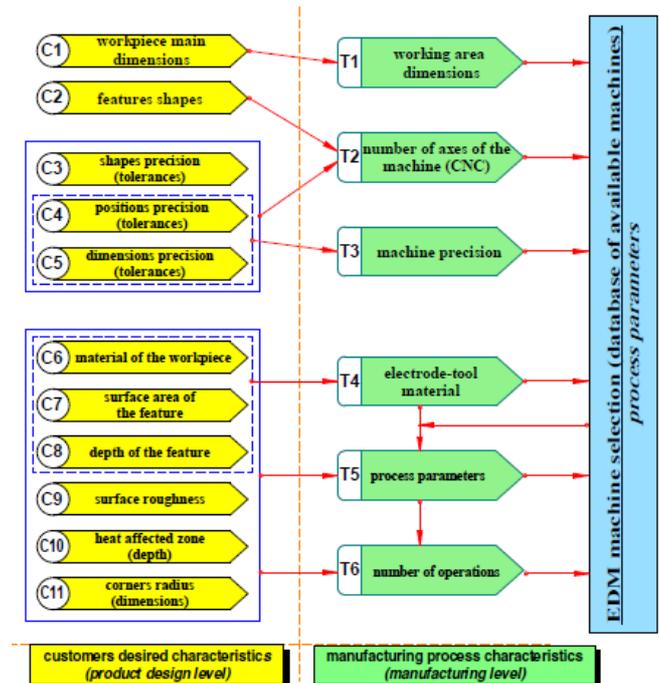


Figure 1. Design-Manufacturing levels connections

On figure 1 connections between product characteristics and the demanding manufacturing

parameters are shown. Manufacturing process structure and machining parameters are in close connection with EDM machine capabilities.

ABC method requires detailed modeling of analyzed processes of the organization. Because we refer to a general SME, which gathers only EDM machines, we find useful to detail the main activities, costs generating on a single machine, all other support activities are considered the same as for a production plant. So the processes needed for a single machine will be described with accuracy, mentioning all the resources needed and the costs related. This approach is transversal in to enterprise and do not concern about structural aspects of it.

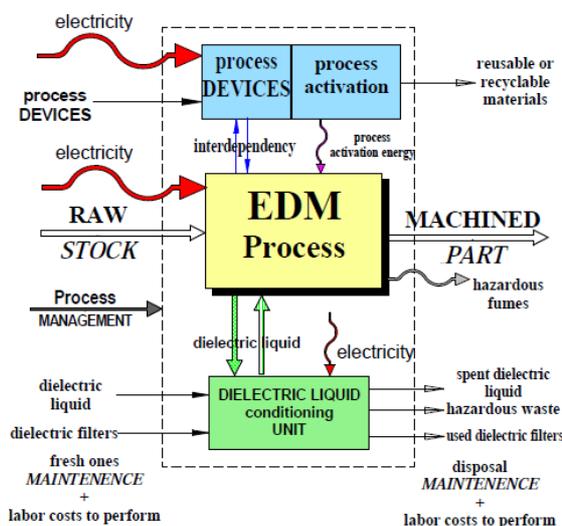


Figure 2. Inputs/Outputs EDM machine model

Based on the information gathered by model presented in figure 2. we identified the following costs categories (presented in table 1.)

Table 1. Considered costs categories

Costs category	Considered component elements
Costs related to EDM machine	<ul style="list-style-type: none"> - initial cost (cost of investment); - energy costs (functioning time); - maintenance, repairs costs; - costs related to consumables (dielectric liquid, filters, hydraulic oil etc.).
Tolling and other devices costs	<ul style="list-style-type: none"> - electrode-tool costs; - process activation costs (ultrasonic assistance, magnetic activation etc.); - operation special devices (both for electrode-tool and workpiece, if any); - special measuring/positioning devices; - devices maintenance (both universal and special);
Costs related to labor and health protection, fire prevention	<ul style="list-style-type: none"> - costs related to evacuate and neutralize of hazardous fumes; - costs related to assure of law, specific regulations and requirements..
Costs related to labor	<ul style="list-style-type: none"> - direct labor costs; - costs related on automation, robots, mechanized transportation etc.;

About these costs the following consideration must be provided. A first category of costs named Fixed Machine Costs (FMC) are associated with having the machine eroding parts. This class of costs includes: electrode-tools, electricity, consumables, devices costs, maintenance costs etc. These type of costs may vary depending on considered geographic location, machine ,manufacturer, age of the machine. For example electricity costs can not be reduced unless relocating the facility. All of these costs affects unit production cost. Maintenance costs will be greater for older equipment as it is supposed to require more time and sparing parts to keep these machines in working order. Some authors consider [5] consider FMC will average between 18...32\$/h, depending on manufactured shape and complexity.

A second category of costs are related to the operator of the equipment (Operator Costs – OC). This category is also dependent on geographic location, but depends also on the level of expertise run the equipment. OC costs may vary widely by geographic location (depending on the level of benefits provided for employees), and can be estimated at an average cost between 20...40\$/h [5]. They also consider that OC is one of the most important factor to be considered on lowering production cost. A lower cost for equipment operating does not necessarily relate directly to the cost of the produced parts. A less experienced operator have obviously a lower hourly wage but may also cost more in increased operation setup time or even scrapped parts.

4 COSTS ESTIMATION ON RAM EDM PRODUCTION

Our estimations refer to a SME enterprise, located in Romania, relative to 2013 legal regulations, which's activity is based only on RAM EDM production.

4.1 Costs related to EDM machines

In order to acquire a EDM machine (available also for all types of machines and equipment) we identified two possibilities: the first refers to financed machines, which are financed over a 4...5 years period with a fixed monthly payment and a second possibility related to purchasing outright, and uses a monthly depreciation rate, regarding ownership cost. Sometimes, if permitted an aggressive depreciation is used in order to minimize taxes. For Romania, a 8...12 years lifetime should be considered. In order to properly estimate the average cost involved in acquiring a new EDM machine, we've considered three categories of machines, assuming that a EDM manufacturer needs large, medium and small ones, as presented in table 2.

Table 2. Main characteristics on RAM EDM machines

Technical characteristic	Working conditions		
	Roughing	Intermediate	Finishing
Power [kVA]	30...3	3...1	<1
t_{on} time [μ s]	10.000...100	100...25	<25
Frequency [kHz]	0,05...3	1...10	>20
MRR [μ m ³ /min]	30.000...100	200...30	<30
Roughness [μ m]	100...12,5	12,5...3,2	3,2...0,2

Based on characteristics presented in table 2. and on different manufacturers price lists we can estimate that an average price for acquiring a RAM EDM machine is about 70.000 €/unit, considering an uniform need distribution upon considered types of machines. Considering 10 years of usage, 254 working days a year, 8 hours a day and a 80% average grade of usage we obtained $C_{md} = 4,3$ €/h.

4.2 Electricity costs on EDM machines

In theory electricity costs are considered as variable costs. In this study we will consider energy as a fixed cost per hour of manufacturing. Considering the average consumption (according to figures on table 2.) of 20 kVA at a price estimated of 35 €/kVA, we estimated a hourly estimated energy cost of $C_{ec} = 0,7$ €/h.

4.3 Maintenance, repairs on EDM machines

This category of costs includes also consumables, which, in our case include dielectric renewal, installing new filters, hydraulic oil etc. This kind of costs can be estimate properly using history records regarding such operations. By literature survey [6] we can assume that an average quantum of these costs is about 15% of acquisition cost of the machine (considering 2600 hours of usage /year). Because in our study we have considered 1656 hours of usage/year we can estimate the average hourly maintenance at 10%, which results in $C_{mnt} = 2,4$ €/h.

4.4 Electrode-tools and devices costs on EDM

Considering the huge diversity of shapes and dimensions regarding electrode-tools used in RAM EDM operations, estimating hourly costs for this category of costs is a very difficult task. So we used some statistical data mentioned in considered field literature [6]. So we find out that an average cost regarding tooling and special devices on EDM operations can reach 50...60% of production costs. In our case (considering medium complexity of the manufactured parts) we will take into account an average of 40% of production costs.

4.5 Costs related to labor and health protection, fire prevention on EDM

In Romania labor and health protection are regulated by Law 319/2006, Law 307/2006 and specific norms

NSSM 14 (on non-conventional manufacturing processes). Because in this activity there are no specific demands regarding green costs, we will consider all costs related to labor and health protection, as well as fire prevention costs included in overhead costs. Because the considered SME produces small quantities of hazardous trash and at this moment no specific measures are specified, the disposal cost are also included in overhead costs.

4.6 Direct labor costs

In this study we've considered that the only significant variable cost is with labor. For RAM EDM costs regarding tooling has been considered as a separate cost. Labor cost is closely related with process (operations duration). On RAM EDM labor costs is one of the most important factor in calculating the overall manufacturing cost. Time estimation, with accuracy, on RAM EDM is a very complex problem due to EDM stochastic nature. Often estimation errors of 100%, even 200% [7] can occur. Considering a 3,1 €/h average salary and a rate of 44,6% total labor taxes and contributions, we can assume an average hourly labor cost $C_{lc} = 4,8$ €/h.

4.7 Quality costs

Quality costs, as an integral part of overall costs, are a significant item in manufacturing costs and have a tendency of continued growth due to increasing market requirements. From the manufacturer's point of view, quality should be analyzed in connection to costs in order to achieve a satisfactory quality level. Manufacturer should consider at least 10% of manufacturing costs, as mentioned in dedicated literature.

Figure 3. reveals the hierarchy of costs aggregation in order to obtain intermediate categories of cost.

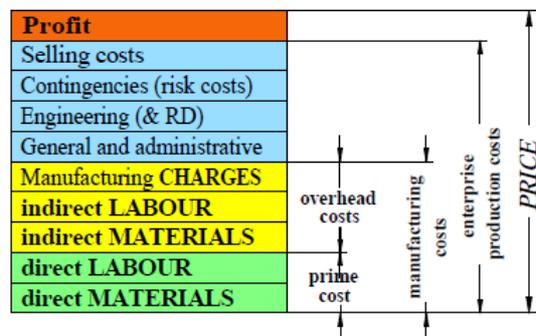


Figure 3. Aggregation of costs

Considering overhead is an indirect expense incurred at various levels of activity of an organization. Total of all costs of manufacturing except direct materials and direct labor represents manufacturing overhead. In our study we have considered a 175% overhead rate. Using estimated

costs the average hourly manufacturing cost for EDM operations is $C_{amc} = 27,8$ €/h. In the considered case labor costs are for full attention on the considered operation. Labor cost can be lowered considering multiserving operator assistance. Of course in this case manufacturing cost level is lower.

Based on estimated total manufacturing cost, as well as on determined elements of cost, management can take appropriate decisions regarding acceptance of new customer demands, monitoring the production flow solution on improving processes etc. Elements of cost should be treated as an internal reference cost, should be estimated using considered organization particularities and periodically updated.

5 CONCLUSIONS

Efforts should be carried out both regarding product unit activities (which are the most visible) and on product sustaining activities level (where exist significant opportunities). ABC method using also some features of the Standard Cost method are extremely useful to improve the organizational performance by delivering the right information at the right time in order that management should take the right decisions.

The considered way of obtaining and using management accounting information, gathered with a proper organizational management can conduct organization a competitiveness advantage. Competitive advantage can lead in:

- time advantage – considered when organizational processes are faster than the others in achieving the same results. Time advantage is created through careful analyses of all activities (including supporting activities) and elimination (reduction) of those that don't add any value to the process.
- cost advantage – is created when superior (innovative), cheaper manufacturing process is used. Cost advantage can also be created through elimination (reducing) of waste from thru process, and also by optimizing the process within the process constrains. These improvements are necessary to sustain the advantage over time. Cost advantage allows the company to become more profitable and expand its market share (customers portfolio).
- efficiency advantage – is created when a process provide higher throughput. Throughput quantifies the output of a process per unit time. Sometime by efficiency we consider assets utilization in a manufacturing context. Assets in a manufacturing environment can be people, machinery, technology or anything that involves costing in order to maintain and provides a useful function in the

business process. Efficiency advantage normally results in more favorable cost structure and supports a cost-based business strategy.

- quality advantage – is created when considered manufacturing process creates fewer defects than another. Quality advantage is generally the result of standardizing, automating or simplifying a process.

In the considered manufacturing context, we agree that a statistical process control allows the manufacturer to monitor the health of the process, resulting in reduction of recorded defects.

Sustainable competitive advantage allows the maintain and improvement of the organization's competitive position in the market place.

So we consider that a good framework, built on a crystal-clear understanding of major processes parameters is the critical key in order to gain sustainable competitive advantage on marketplace.

Further researches should be carried out on usable methods in order to lower manufacturing costs. Not at least quality and green costs should be studied.

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7 REFERENCES

1. Jones G., *Organizational Theory, Design and Change*, New York, Addison Wesley, (2004).
2. Westkämper E., *Manufacture and Sustainable Manufacturing*, Proceedings of CIRP Conference on Manufacturing Systems, pp.20-28, (2008).
3. Mattucci M., *Factories of the Future*, COMAU, EFRA, Milano, (2010).
4. Coombs H., Hobbs D., Jenkins E., *Management accounting. Principles and applications – SE*, Sage Publications, London, (2011).
5. http://www.cam-1.com/edm_profitability.htm [23/03/2013].
6. Sommer C., Sommer S., M.E., *Complete EDM Handbook*, Chap.13/Reducing EDM costs, online – www.ReliableEDM.com, U.S., 2010.
7. Vanderauwera W., Lauwers B., *Time estimation for Sinking EDM Operations*, 16th International Symposium on Electromachining (ISEM XVI), China, 2010