An algorithm of a costing system for electroplating

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Abstract

Businesses are increasingly competitive and rigorous and it is essential the existence of a strong, effective and realistic costing system. Decisions taken on the basis of the costing are very important, they can make the difference between success and failure of the organization. This paper explains the construction of an initial algorithm that aims to calculate the costs associated with electroplating of metal articles, in a specific company. This work can act as a possible guide for the construction of the costing system algorithms in this type of industry.

Keywords

Costing system, algorithm's variables, electroplating, finishing of metal articles.

1. Introduction

This paper presents a case study of the construction of an initial algorithm in order to calculate the costs associated with the process of electroplating in metal articles. In section 2 it is explained the electroplating process and in section 3 is briefly presented the current costing system. Starting with this outdated costing system, the case study is presented in section 4, namely the main problems to solve, the construction of the costing algorithm and the validation and main results obtained. Finally, the main conclusions of this work are presented in section 5.

2. Electroplating Process

Given the high number of processes in the factory that produces metallic accessories, it would be very complex to find an algorithm for all of them. In order to centralize the efforts to obtain better results the algorithm will be elaborated for one of the most sensitive areas and of greater value addition of the company, the electroplating process.

This process is an electrolytic process that consists of coating the surface of metal parts with other nobler metals, to give it chemical, corrosion and wear protection, as well as improving the aesthetic and decorative finish. It consists of a series of sequential activities that result in a finishing that is distinguished mainly by their aesthetic aspect rather than their mechanical and chemical characteristics.

Most of the activities in the electroplating process are shared by various finishes, this means that a small representative set of finishes can hold the genesis for all others.

In figure 1 and figure 2 we can see the electroplating workstation where the process is executed and samples of finished parts.

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Figure 1. Electroplating workstation

Figure 2. Finished parts

3. Costing System

An algorithm is a finite sequence of well-defined and unambiguous instructions, each of which must be performed mechanically or electronically in a finite period of time and with a finite amount of effort. (Horngren, C. T. et al, 1996)

There are several types of algorithms more complex. For example, the evolutionary algorithms that have great robustness and have been used to solve numerous problems of great complexity (Zhang and Ishikawa, 2004). Others like genetic algorithms that allowed a practical application in problems of mathematical functions (Goldbarg and Luna, 2000).

In our case, the clustering of costs per activity allows the setting of costs based on a detailed activity, and these are conducted through cost drivers. Time-Driven Activity-Based Costing, is a variant of the model that, instead of allocating costs by activity, results in a cost per activity per unit time. (Kaplan and Anderson, 2004).

An analysis was made of the current costing system and its associated software, to identify gaps and limitations in order to develop a new algorithm. This was made in order to surpass in a sustained and efficient way the identified problems and make proposals for improvement that can be validated. These should translate into an increase in the rigor and coherence of the algorithm created.

The choice of finishes to be analysed tries to cover as many activities as possible, within the total number that exist in the electroplating station, so that the work after to update the entire costing system is less time consuming.

The best-selling finish, being also the most produced finish, is a good starting point for updating our costing formula (see figure 3). The most expensive finishing per unit of surface as the second choice (see figure 4), and finally, the second best-selling and expensive finish. So, the types of finishes selected were:

- NI, Nickel - The most sold finish, the final look is much sought after due to its brightness, colour and reduced cost;
- BRBO, Gold White Bronze - The nickel free alternative of finish, gives the piece an exquisite look with a colour and lustre that makes it look like it is gold plated. Although expensive, the gold-plated finishes have a lot of demand being this finish the second best-selling finish;
- OV, Old Gold - This finish gives the piece a shabby look in bronze tones. The choice of this finish is due not only because it is the second most sold finish and the second more expensive but also because of its operating range contain activities different from the other two, such as oxidation and abrasion wear.

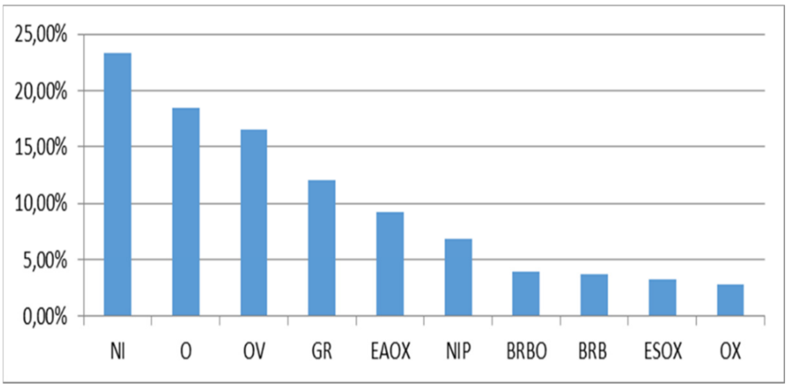

Figure 3. Percentage of sales of types of finishes

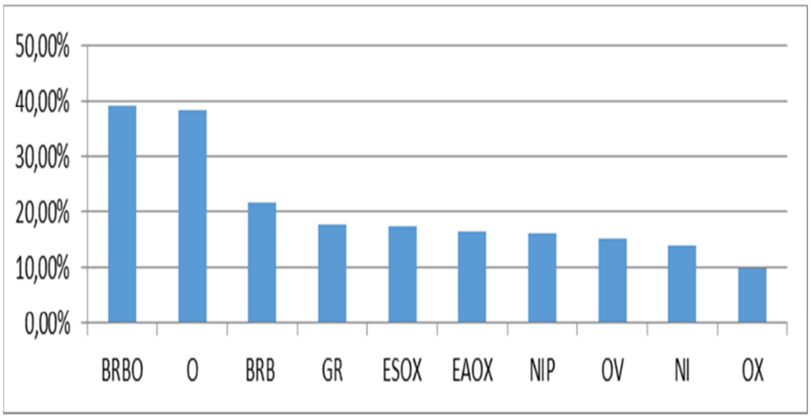

Figure 4. Percentage value of the finish in the total in the part

4. Case Study

In this section, the authors will present the case study, starting to identify the main problems of the current costing system in order to construct an initial new algorithm that can be validated and allows to increase the accuracy and adjustment to reality of the electroplating costing system.

4.1. Problems to Solve

The main problem is not the current software and its operation, but the outdated variables and activities that are no longer in accordance with the processes currently in place. The equipment, the techniques, the employees, the raw materials used, the variation of electric costs and materials are examples of factors that may no longer be in agreement. The fact that there is an immensity of activities and variables makes rectification of these values very difficult. Each process in production consists of one or more activities, which in turn are mathematically represented by variables. The list of the main problems identified appears below in table 1.

Table 1. Main problems

Problem 1	Formulation Incomplete
Problem 2	Outdated formulation
Problem 3	Incorrect fixed variables
Problem 4	Outdated fixed variables
Problem 5	Non-differentiation between folding and non-folding and base material (brass and zamac)
Problem 6	Accuracy of variables
Problem 7	Proximity of cost to reality

Problem 1 is easily observed by the functions currently used, there are activities that are not considered. Problem 2 is observed when cost functions are out of date with current practices. Problem 3 is due to incorrect measurement of costs or properties in fixed variables. Problem 4 is when for reasons of updating the process the variables are not in agreement with observed. Problem 5 is that the cost functions used did not consider the difference in procedure between foldable and non-foldable parts and between parts with different base material, in the new algorithm this difference is supposed to be considered. Problem 6 is the accuracy of the variables, this can come from the rounding done in the calculation of the variables or their measurement. For example, the process of measuring the surface area tends to be inaccurate the more complex the measured surface since the object of measurement is a pachymetry. Problem 7 is the resultant of all problems represents the distance from the actual cost to that calculated by the algorithm. This difference would ideally be zero, but due to the characteristics of this process this becomes impossible. This difference should be as little as possible.

Below are represented, some examples of the activities necessary for the accomplishment of the three finishes selected.

Table 2. Some examples of the activities necessary for the accomplishment of the three finishes selected.

CODIFICATION	ACTIVITIES
FGM001	Acid Water Activation
FGM003	Activation of Acid Salts
FGA001	White Bronze Suspension
FGM005	White Bronze Drum

FGA005	Copper Alkaline Suspension
FGM009	Copper Alkaline Drum
FGM010	Chemical Degreasing
FGM012	Abrasion Wear on Vibrator
FGA007	Brass Suspension
FGM015	Brass Drum
FGA009	Nickel Suspension
FGM017	Nickel Drum
FGA011	Gold Suspension

4.2. Costing Algorithm

In order to calculate the cost of an activity that affects the part, it is necessary to insert into the function the variables that will distinguish the same part from any other. The variables are called user variables such as mass, surface area, time that the activity takes, or any other indicator. There are activities that in a production cycle conclude numerous pieces, the cost associated with a cycle of this activity will have to be diluted by its capacity. This ability depends, in most activities, on the dimension of the piece, the larger the piece, the more space it takes, so fewer pieces can be executed at one time. The dimension of the part can be represented by its mass, so it is an easily measured property.

Through experiments carried out based on the activity data sheets, the average mass of a part load is calculated and the average cycle time of each one, we used a spreadsheet to calculate, through these data, the capacity of each activity.

Table 3. Costs Matrix of the Activity Acid Water Activation

MATERIALS	**Cost**
Sulfuric Acid 98% (3L)	0,90€/week
Water (30L)	0,16€/week
LABOR	**Cost**
40h	258,86€/week
PRODUCTION	**Cost**
Amortization of equipment	negligible
M.O. Weekly renewal (30min)	3,24€/week
Total	263,16€/week
Capacity	2448kg/week
Cost/Capacity	0,00010750€/g

All the necessary variables were defined for the construction of the algorithm, so there are conditions to build the costing algorithm for the three target finishes. Through the flow charts the order of activities is indicated, and the frequency with which they are performed, since an activity can be performed more than once during the process. Tables have been defined for the activities that are included in each finishing variant, for the use of the logical variables that will select the different variants. Now that all conditions are met, for each finish, the variables are assembled and simplified, resulting in the costing algorithm for each target finish.

Example of costing algorithm for finishing NICKEL – NI
C_(UA,UM)=FGM010*UM+FGM003*UM+LG004*(FGM013*UM+LG002*(FGM008*UM+FGA005*UA+LG001*(FGM001*UM+FGM006*UM+FGA003*UA+FGM001*UM+FGM016*UM+FGA009*UA)+LG003*(FGM001*UM+FGM006*UM+FGA003*UA+FGM001*UM+FGM016*UM+FGA009*UA))+LG006*(FG008*UM+FGA005*UA+FGM001*UM+FGM006*UM+FGA003*UA+FGM001*UM+FGM016*UM+FGA009*UA)+FGM011*UM)+LG005*(LG002*(FGM001*UM+LG001*(FGM017*UM+FGA10*UA)+LG003*(FGM017*UM+FGA010*UA))+LG006*(FGM009*UM+FGA006*UA+FGM001*UM+FGM017*UM+FGA010*UA))+FGM021*UM

4.3. Validation and Main Results

It is assumed that the most valid algorithm is the one whose result is closer to reality. Instead of just validating the algorithm by concluding that it has been the target of a study, for which it is more up to date, we aim to prove in numerical values that the new costing algorithm is also more accurate than its predecessor.

By consulting the records of the previous budgeting program, whose database has more than 3000 costing calculations, we find the properties of the average part. According to production records for the year 2015, 6 270 439 pieces were executed, all these pieces have some associated finish. It is known how many pieces of each finish were performed. Finding the properties of the average piece, we can then know, through the costing algorithm, how much the various finishes cost. By the accounting consultation associated with the cost center we know the associated expenses that total the value of 195 701.17€. We can now apply the costing algorithms, new and old, for the quantity of parts executed in their finish and compare with the accounting values.

Table 4. Validation

	TOTAL	NI – Nickel	OV – Old Gold	BRBO – Gold White Bronze
Percentage of parts executed	100%	23,36%	16,57%	3,88%
Cost associated with executed parts (by accounting)	195 701,17€	45 720,13 €	32 424,67 €	7 597,41 €
Number of parts executed	6 270 439	1 464 914	1 038 915	243 428
Cost associated with executed parts (by new algorithm)	-	47 385,09 €	27 084,02 €	11 108,95 €
Cost associated with executed parts (by the previous algorithm)	-	28 987,71 €	25 613,13 €	26 345,12 €

We can conclude that the algorithm created has a greater degree of accuracy and adjustment to reality than its predecessor, resulting not only in an organizational improvement of the current costing system but also a greater rigor and effectiveness that will surely translate into a better approach to budgeting with inherent potential capital gains.

Following the problems described, we now make a parallel with the new algorithm. This was built according to the flowcharts of the production process of the quality manual, being rigorous with current method of work. This argument allows the functions to be complete and updated thus correcting problem 1 and 2. The activities were studied individually, for which a cost allocation was made to current production methods and equipment, random multiplication factors were eliminated, and new coding acronyms were created to simplify the process of algorithm construction. The result eliminates the incorrect and outdated variables, thus correcting problem 3 and 4. Through the creation of logical variables it is possible, in the same function, to result in a cost for different types of finishes. With this change, problem 5 is solved. Regarding problem 6, it is understood that with the study of the activities the accuracy of its value has increased in relation to the previous ones, always existing the deviation caused by the rounding's and measurements. Problem 7 summarizes all the others and the purpose of this work, to approximate the cost calculated through the algorithm to reality. Using the cost center of the electroplating cost center, the new algorithm was more closely approximated at the standard cost compared to its predecessor.

5. Conclusions

The algorithm was constructed with the variables of cost per capacity of each activity, having as unknowns the logical variables, that selected different activities depending on the needs, and the properties of the target piece. It can be concluded that the algorithm created has a higher degree of accuracy and adjustment to reality than its predecessor. This work led to an organizational improvement of the current costing system, providing greater rigor and optimization in this fundamental area.

The main consequence is the improvement of the costing system of the company, allowing a greater approximation of costs to the reality that results in a better support to the decision making and in the capacity to budget projects in a more competitive and capable way, responding to the demands of the current market.

Applying these current concepts, techniques and methods to the productive reality of the industry, it is intended that this work serves as a possible guide to support the creation of costing algorithms that result in a practical, simple and effective costing system.

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