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THE OPTIMIZATION OF THE MAINTENANCE ACTIVITY THROUGH COSTS

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Abstract. In the long term management of the maintenance of the equipments an indicator called "Life Cycle Cost" is used. It has a few features depending on the application field. This paper presents a few management methods of the equipments maintenance on the basis of the optimization of some cost categories.

Keywords— cost, maintenance, optimization, repair

I. INTRODUCTION

INDUSTRIAL maintenance represents a set of measures and actions that allow the prevention, the good maintenance or the reestablishment of an equipment in a foreseen state or capable to ensure a certain service in the conditions of minimizing the maintenance costs [3].

The development of a productive economic activity in the companies, the departments, the workshops and workplaces implies inevitably the consumption of certain human, material and financial resources, necessary for the production of the goods. All these components generate expenses in various forms and sizes: the use of work force, consumption of materials, energy, water, writing-off the equipments and other fixed means, etc. These expenses localized on products are actually costs

The cost is an economic category which manifests clearly in the material production, which is directly related to value and forms of manifestations of the value law. The costs represents the total of the expenses expressed in money that the companies make representing the consumption of raw material and material, the writing-off of the fixed assets and the payment of the staff in order to manufacture some products.

Hence, the costs constitutes a generalizing synthetic indicator and represents a main criterion in the production management.

The production costs contain as a distinct component the maintenance costs due to the consumption of production factors: workmanship, spare parts, stock control etc.

II. MAINTENANCE MANAGEMENTS ACCORDING TO GLOBAL COST

Global cost (C_g) represents the sum of the expenses performed with an equipment from the moment of purchase until the elimination. The global cost is made of: the acquisition cost (diminished with the resale value), the use cost, the maintenance cost and the elimination cost .

Knowing the amount of products Q obtained during the equipments life span, *the global average cost per product unit* (C_M), is defined through the relation:

$$C_M = \frac{C_g}{Q} \left[\frac{lei}{product} \right]$$

In order to purchase an equipment, one will choose the variant with a minimum C_M which ensures a bigger benefit considering that this cost is included in the fabrication cost.

Another indicator which provides information regarding the choice of an optimal investment variant, in what regards the purchase of an equipment is the *profit of the life cycle* (R), expressed as follows:

$$R = V - C_g \text{ (lei benefit)}$$

In which V represents the sales volume. The optimal investment variant is the one that ensures a maximum R.

Figure 1 represents the evolution of the profit in time. The analysis of the graph shows the following:

- The time frame (T_r) after which the investment is recovered and the profit starts to appear, is represented by the abscise of the point M of the intersection between the curves C_g and V.
- The moment of obtaining the global maximum profit t^*, is represented by the abscise of the point N of intersection between the curve of the global cost C_g and the tangent taken from the origin.

The optimal investment variant in the purchase of an equipment will be determined on the basis of the following criteria:

1). The optimum investment corresponds to a recovery term T_r as short as possible.

2). The optimum replacement age of the equipment is represented by t^*. After the exceed of this moment the global profit decreases and as a consequence we can discuss about replacement.

3). It is mandatory to replace the equipment before a new intersection of the curve of the global cost C_g with the one of the sales volume V, in which moment the profit becomes zero; otherwise, the unit will register loss [7].

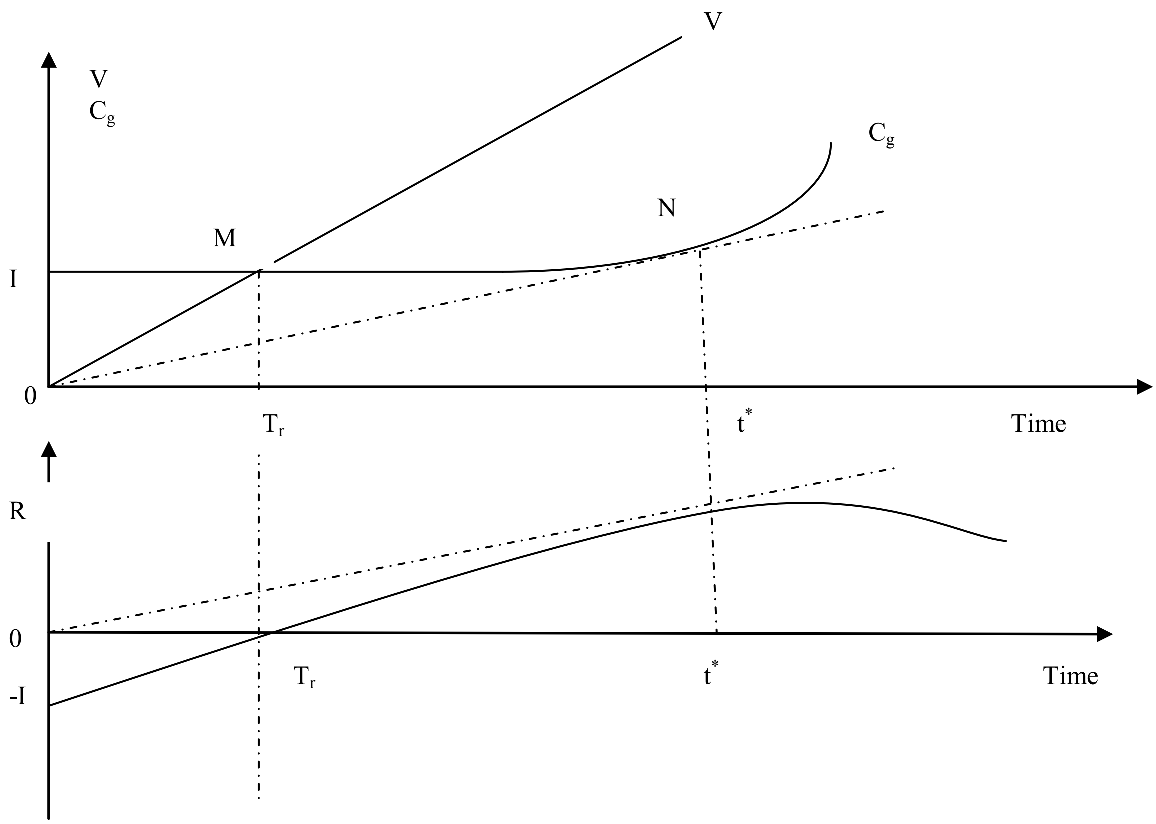

Fig. 1. The graph of the cumulated profit [7]

Another indicator used for determining the optimal investment variant is represented by the *profit cumulated on time unit* (R_t) expressed by:

$$R_t = \frac{R}{T}\left[\frac{lei.benefit}{u.t}\right]$$

Where T represents the use duration of the equipment. It is recommended to choose the investment variant for with a maximum R_t is obtained.

Also, the optimal investment variant can be established through the use of an indicator called *cumulated profit on product unit* (R_q):

$$R_q = \frac{R}{Q}\left[\frac{lei.benefit}{product}\right]$$

The optimal investment variant will be chosen in this case so that R_q is maximum

III. THE OPTIMAL AGE FOR THE REPLACEMENT OF AN EQUIPMENT

A productive equipment represents the most imortant part of the fixed assets of a factory, because it contributes directly to the development of the core prodction processes. It is subject both to physical wear and moral wear.

The physical wear represents a depreciation of the use value, which is caused both by the funcitiong of the equiment, obtainig a dynamic physical wear – which grows once with the increase of the functioning duration of the moving organisms – and by the time passing from the purchase of the equipment – a wear that acts on the component static parts, decreasing their initial quantities. For example, in a lathe, the dynamic physical wear is registered in the drive shaft, the head axis, the bearings and other moving parts. The static physical wear is shown in the chassis and other components.

The moral wear is determined by the apparition of some tolls with the same performances. It happens independently from the tool's wear level.

The optimal replacement age of an equipment ca be determined according to the global cost or taking into consideration the reduced global cost; in this last case some expenses are eliminated, such as wages, the equipments use cost, etc, which are not characteristic of the equipment.

In order to determine the optimal replacement age, we use data about the equipment referring to: the reduced global cost (C_{gr}), the maintenance cost (C_m), the marginal cost (C^*_g) represented by the cost growth as a consequence of the extended use of the equipment with a time unit, respectively from the moment t to the moment t+1, having as a mathematic model the derivate of the global cost in relation with the time. Using the option of annual average reduced global cost as well (Cgr_{med}) defined by the relationship:

$$C_{gr\ med} = \frac{C_g}{n}, \left[\frac{lei}{year}\right]$$

In which n represents the equipments life span (in years), as well as the investment value (I):

These indicators, represented graphically as in fig. 2, allow us the formulation of the following conclusions:

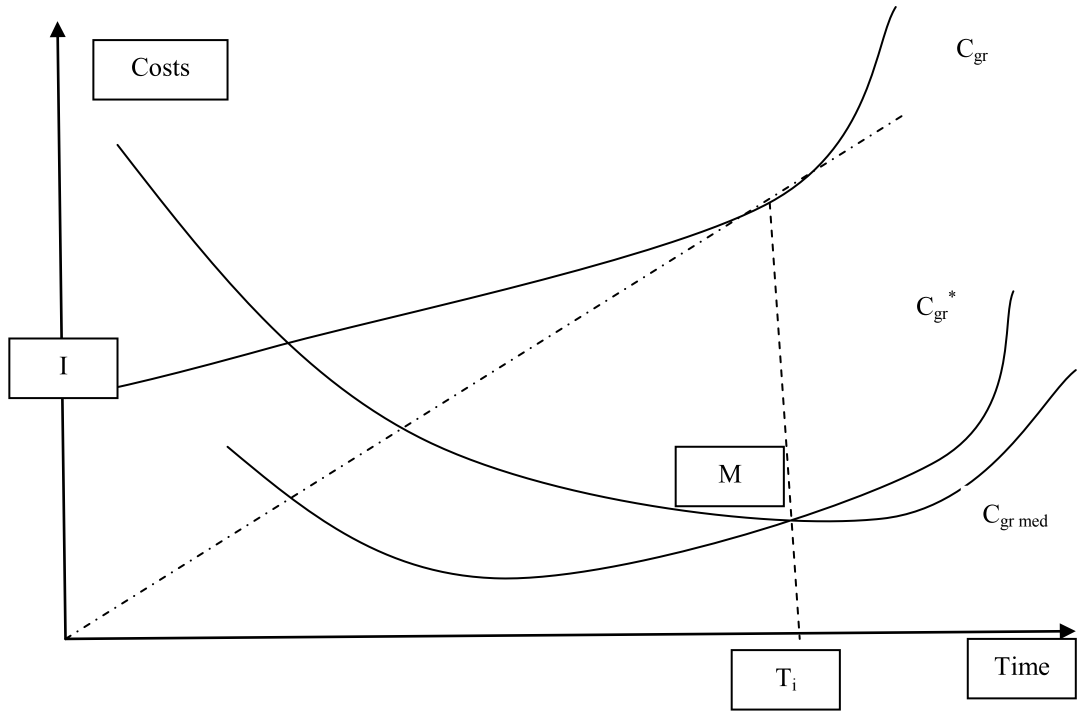

Fig.2. Evolution of the global cost, the average cost and the marginal cost [7]

1). The curve of the reduced global cost has a strictly decreasing evolution, hence the tool cannot be used for an unlimited period of time.

2) The optimal replacement age T_i is represented on the time axis by the minimum of the curve of the reduced global cost (Cgr_{med}). Up to this moment the average reduced global cost decreases, then it is followed by its increase. After a use duration equal to T_i the equipment must be replaced because by maintaining it in function it leads to a decrease of the marginal cost above the average cost.

3) The optimal replacement age coincides with the abscise in point P of the intersection between the curve of the marginal cost and the one of the average reduced cost. The equipment can be use in economic conditions only as long as the curve of the marginal cost is bellow the one of the average cost.

4) Point O also represents the intersection point of the tangent taken to the origin in the reduced global cost curve.

When establishing the correct optimal age for the replacement of an equipment some difficulties may appear in the identification and highlighting of certain costs.

IV. CASE STUDY

The object of the study consists of determining the optimal age for replacing the sewing machine used for leather surfaces on clothing.

The study was prepared for S.C. EUROCONSTIL SRL Marghita, a unit (company) equipped with sewing machines for clothing production.

The study of the machine's history, the analysis of the maintenance sheets and the evaluation of the data received from the accounting evidences of the company have led to the data presented in Table I.

TABLE I
HISTORY MAINTENANCE COST

Year	Investments and reselling	Annual maintenance costs	Reduced global costs	Average reduced global costs	Marginal cost
1	4000	-	4000	4000	4000
2		8000	4200	2100	200
3		500	4700	1560	500
4		700	5400	1350	700
5		800	6200	1240	800
6		1800	8000	1330	1800
7		2200	10200	1460	2200
8		3100	13300	1660	3100

Based on data presented in the chart, graphical representation was done in figure no. 3.

After analyzing the graphic the following aspects can be understood:

1) The reduced global cost has an increasing tendency, so the machine can not be kept for an unlimited period.

2) The marginal cost decreases at the beginning of the period, due to the investment, and then has an increasing tendency.

3) Average reduced global cost decreases in the first 5 years, after which shows an increasing tendency.

4) Starting from the sixth year of functioning, the machine will have a higher marginal cost than the medium cost.

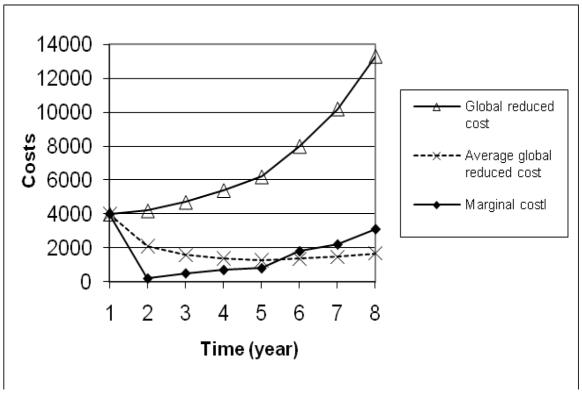

Fig.3.Graphical representation of the costs

Conclusion. Taking into consideration the fact that in the realized graphic the evolution curve of the marginal cost intersects the average reduced global cost's curve at an abscise point that has a value between 5 and 6, we deduct that the optimal age for replacing the sewing machines for leather clothing is approximately 6 years.

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