Comparative study between different methods for the efficiency of the production activity in the wood industry

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Abstract. Generally speaking,the quality and cost of goods and in particular of the wood products is a decisive condition in their sales on the market, attracting buyers to satisfy their wishes and requirements. Starting from the general idea, by which it is considered that the manufacturing activity is effective if production is obtained at maximum quality with a low (minimum) cost, or when the revenue from the sale of products exceeds the market expenditure which is necessary to achieve it, this research article aims to study ways to make production more efficient by methods which could also be applied in the wood industry, by presenting a comparative study on production optimization methods in this industry.

1 Introduction

Starting from the general idea that a manufacturing activity is effective if production is obtained at maximum quality with low (minimum) cost, or when the proceeds from the sale of products exceed the market expenditures that were necessary to achieve them, any optimization of machining processes must consider primarily an optimization on economic criteria.

These criteria once applied to the studied process will inevitably lead to finding technical solutions to meet the requirements of the market. Optimizing a process can be done by applying various methods of assessing the performance of the studied process, such as the Target Costing method, the Taguchi Method, the Six Sigma method and so on.

By applying them, all listed methods bring more or less important improvements, but the starting questions are: which of the applied assessment methods are most effective? and which of them would lead to those improvements that converge towards a real optimization? These questions, once clarified facilitate the process management, positively influencing both the decrease of losses (in material or energy) and especially the growth of the company profit.

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As a result of the unfolded researches, the authors of this paper have found the answer to the two questions, an answer that will be detailed and fundamented in the presentation below.

2 Means and methods of work

The goal of any company and therefore of those in the wood processing industry is to obtain maximum profit. For this, special attention needs to be granted to the management that must find the right method for optimizing the production flow, increasing the quality and the degree of polishing for the finished products and be the easiest to implement and also give the fastest results and the most significant results in terms of quantity and quality [1].

Of the many techniques and methods of economic analysis that are used to optimize production costs, following a meeting of the company management of SC Famos SA, active in the wood processing industry, with the engineers directly involved in the production, there were selected and surveyed three methods for economic efficientization:

The Target Costing method: is part of a strategic management approach according to which each cost carrier is analyzed throughout their life cycle. The target or objective cost is a cost management concept used and developed in Japanese companies, especially in the automotive industry since the 70s. Underlying this target cost concept there was the need to produce smaller series of products that can better adapt to the market needs, the introduction of the new production organization methods (Just In Time operating system) and the introduction of automation-based technologies (CIM - Computer Integrated Manufacturing - systems).

The Taguchi method imposed itself as being more effective than other methods of experiment planning. It derives from the method of factorial experiments and proposes an alternative method for calculating the average effects of factors and interactions, thus making mathematical modeling much easier. Its efficiency is due to reducing the number of tests given by the split plan method, which allows modeling with much less experiments than the full plan method. The Taguchi method is one of these split plan methods and has also the advantage that it is easy to apply in practice. When determining the number of experiments involving the study of a phenomenon by this method, stricter conditions must be applied.

The Six Sigma Method represents the standard deviation in statistics and it is a management methodology aimed at increasing product quality by determining and removing the continuous causes of defects and process variability (potential or detected) in order to ensure customer satisfaction, based on the methods FMEA (Failure Mode and effect and Analysis) and QFD (Quality Function Deployment) and modern management methods applied to the joint teams made up of manufacturer, supplier, client, professional, research centers etc [2].

Each of the three methods aims to achieve the economic efficiency of the company by taking into account certain parameters that significantly or less significantly influence the process optimization. Among the projected (common and / or different) parameters for each method, there were studied only the parameters that the three methods have in common, so that a managerial decision can be taken on the method to be applied within the company.

The optimal decisions for the company management, since there are several alternatives (methods), can be obtained by applying a multi-criteria analysis method (AMC). The goal of this method is to conduct a comparative evaluation of the proposed options (methods). For the AMC, all common parameters of the selected methods were taken into account simultaneously in a complex situation. The method is designed to assist decision makers by integrating different options, reflecting the views of the actors involved in a prospective or retrospective framework. The analyzed parameters reflect how objectives are achieved. The best option will be the one that will be closest to achieving most objectives and that will obtain the highest scoring.

The comparison was made between the efficiency models that could be selected taking into account the specific characteristics of the wood processing industry.

The analysis consists of the calculation of value hierarchizing coefficients, for the performance of the objects under comparison.

The result of the multi-criteria analysis, properly applied, provides scientific and effective results for optimal solutions in the technological process which will be reflected in the economic cost/price of the final product.

3 Research methodology

The multi-criteria analysis (MCA) describes any structured approach to be used in determining the general preferences of several alternative options, options that lead to achieving a number of objectives. In the current case, our main goal is to optimize production by reducing costs at SC Famos SA. The steps that were followed are:

3.1 Establishing methods and evaluation criteria in the decision-making context

For identifying the optimization method with the greatest applicability in the wood processing industry, the research was based on the use of brainstorming techniques and multi-criteria analysis.

Within this step there were identified the alternative criteria to be taken into account. In our case the options considered are: alternative 1 the Target Costing method; alternative 2 the Taguchi method. Alternative 3 the 6 Sigma method.

Through the multi-criteria analysis (MCA) there race, eliminating the subjectivity, since the order of the criteria is determined by comparing each criterion relative to other selected criteria.

The brainstorming consisted in organizing a work meeting with a group consisting of the company management and 10 engineers from SC Famos SA Odorheiul Secuiesc. During the brainstorming session, held in the company's meeting hall, there were presented several ways to optimize production from which there were chosen the 3 mentioned methods and the participants generated a number of ideas regarding the applicability of these methods in the technological process.

After continuing the brainstorming session, there were generated following evaluation criteria that must be followed in the process of multi-criteria analysis:

1. Cost of implementing the methods (C);
2. The simplicity of using the method (S);
3. The effect of applying the method reflected in a reduction of the energy consumption (E);
4. Acceleration of the technological process - eliminating some steps in the process => reducing the time and costs that are reflected in the price (A);
5. Ease of implementing the methods (U);
6. The quality of the product (O);
7. Number of failures / waste (N).

3.2 Determining the share of criteria common for the three methods selected for relative quantifying

At this stage, after identifying the 7 common criteria which are relevant for solving the problem in selecting the decisional problem for the efficientisation method, they have been ranked. This ranking took into account the major categories of costs and benefits resulting from the options considered. The scoring was done according to the principle – a criterion is more important than the other (= 1), as important (= 1/2), less important (= 0) Table 1 presents the calculation of points, the level and the weighting coefficient Y_i [3].

Table 1. Point calculation, the level and the weighting coefficient Yi.

Criteria	C(1)	S(2)	E(3)	A(4)	U(5)	O(6)	N(7)	points	level	Yi
C(1)	0.5	0	0.5	0	0	0.5	0	1.5	7	0.27
S(2)	1	0.5	0.5	0.5	1	1	0	4.5	2	2.89
E(3)	0.5	0.5	0.5	0	0.5	1	0	3	5	1.17
A(4)	1	0.5	1	0.5	1	0	0	4	3	2.2
U(5)	1	0	0.5	0	0.5	0	0.5	2.5	6	0.77
O(6)	0.5	0	0	1	1	0.5	0.5	3.5	4	1.64
N(7)	1	1	1	1	0.5	0.5	0.5	5.5	1	4.57

3.3 Hierarchizing the options

As a result of the inter-criteria comparison process, there resulted a matrix whose sum by lines (sum of each criterion in part) (column 9) resulted in a hierarchy (column 10) of the criteria's significance as seen in table 1.

The next step in the MCA procedure was calculation of the weighting coefficient (Y_i) column11, which is calculated using the FRISCO formula (1)

$$\gamma_i = \frac{p + \Delta p + m + 0.5}{-\Delta p' + \frac{N_{crt}}{2}} \tag{1}$$

Where:
p – is the sum of points obtained on the line by the considered item;
Δp – the difference between the score of the considered item and the score of the item at the last level.
m – represents the number of surpassed criteria, i.e. the number of criteria with scores below the item;
Ncrt – number of criteria taken into account;
Δp` - the difference between the score of the considered element and the score of the element in the first rank (a negative result).

3.4 The standardization of score

The standardization of score for each criterion was made in a common scale ranging from 1 to 10 and taking into account the effect that it will have on the company's activity. The result of the analysis is presented in Table 2.

Table 2. Criteria and their value range.

Criteria	Indicator	Value ranges	Effect
C1(C)	Cost of implementing the methods (C);	1-10	-
C2(S)	The simplicity of using the method (S);	1-10	+
C3(E)	Effect of applying the method reflected in a reduction of the energy consumption (E);	1-10	+
C4(A);	Acceleration of the technological process (A);	1-10	+
C5(U)	Ease of implementing the methods (U);	1-10	+
C6(O);	The quality of the product (A);	1-10	+
C7(N).	Number of failures / waste (N).	1-10	-

3.5 The creation of the performance matrix

The creation of the performance matrix describes the expected performances of each option according to the chosen criteria. The information on the dimension of each criterion can be expressed in units. Table 3 presents the performance matrix and the assigned values were determined by the personnel of SC Famos SA within the organized brainstorming session.

Table 3. Performance matrix.

	TC Method	T Method	6S Method
C(1)	8	9	10
S(2)	9	8	10
E(3)	9	10	9
A(4)	10	8	9
U(5)	10	9	10
O(6)	10	10	10
N(7)	9	10	9

3.6 Examining of results

Considering the performance matrix and the weighting coefficient there was calculated the product between the Yi coefficient and the performance degree Ni, then the products were added by criterion to achieve the final result. The data obtained are presented in Table 4 and can be compared.

Table 4. Calculation of the products between the grades N and the weighting coefficients

		Method TC		**Method T**		**Method 6S**	
Criteria	**Yi**	Ni	Ni*Yi	Ni	Ni*Yi	Ni	Ni*Yi
C(1)	0.27	8	2.16	9	2.43	10	2.7
S(2)	2.89	9	26.01	8	23.12	10	28.9
E(3)	1.17	9	10.53	10	11.7	9	10.53
A(4)	2.2	10	22	8	17.6	9	19.8
U(5)	0.77	9	6.93	9	6.93	10	7.7
O(6)	1.64	10	16.4	10	16.4	10	16.4
N(7)	4.57	9	41.13	10	45.7	9	41.13
Final Score			**125.16**		**123.88**		**127.16**

The final analysis was done taking into account the sums of all criteria that influence each method. It can be noticed that 6S is the most effective method, totaling the highest value. In MCA procedure, there is also a sensitivity analysis stage that was not required to be unfolded here, given that the sensitivity of the criteria in relation to changing the method is very close.

4 Conclusions

Following the multi-criteria analysis applied at the wood processing company SC Famos SA in order to choose the assessment method for optimizing the technological process, there resulted that the most efficient method that the company management should choose in order to apply it in production is the 6Sigma method that earned the highest score - 127.16, compared to the Target Costing method that obtained 125.16 and the Taguchi method that scored only 123.88.

These results confirmed the discussions and opinions of the engineers from SC Famos SA expressed during the brainstorming session that the Taguchi method is obsolete, due to the managerial principles it takes into account, while the Target Costing method is limited in its application to certain industrial branches, being incomplete compared to the multitude of managerial aspects and decisions that the management must make in the wood processing industry.

After applying the 6Sigma method for optimizing the milling process that is found in the manufacturing technology at SC Famos SA and that significantly affects production, one of the criteria analyzed was energy consumption. The most telling parameter of energy consumption in wood milling is the specific strength (K), that characterizes the timber processed and that can be calculated for milling function of the absorbed chipping power, using the relation [4]:

$$K = \frac{P \cdot 6 \cdot 10^3}{b \cdot h \cdot u} \text{ [N/mm}^2\text{]} \quad (2)$$

Where:
P = cutting power measured in kW;
b = cutting width, measured in mm;
h = cutting depth, measured in mm;
u = feed ratthat ie, measured in m / min

It was found that a significant difference in energy consumption was recorded in processing on the transversal direction of the wood, compared to that on the longitudinal direction, the power consumption being much higher in the first case. Also, during the transversal processing, apart from the higher energy consumption, it also requires an additional stage in processing, in order to finish the products at the same quality as the products obtained through processing on the longitudinal direction [5]. These steps are generating additional costs and are also responsible for extending the production time. Also, during the finishing in the additional phases there is generated more waste and also the risk of generating more failures can increase (requiring, for more complicated models the applying of manual finishing) [6].

Despite the slightly higher costs to put in practice the management decision using 6 S noticed during the implementation, these will be eventually annihilated and will produce the effect of optimizing costs by minimizing the amounts of failures and waste produced.

There was a unanimous opinion on the ease with which this method can be applied at all stages of production, especially since it implies the operating personnel's involvement in the continuous measurement, assessment and improvement of parameters.

The quality and cost of wood products and of other finished products prove decisive in their offering on the market, in attracting buyers and satisfying their wishes and requirements. The sellable product quality and value depends heavily on the equipment performance, on the level of the technical endowment, on the organization of the manufacturing and processing processes [7].

A higher quality level can be achieved by eliminating as much as possible of the elements that negatively affect yields, consumption of raw materials, energy, some of them leading to the need to retool production lines and in the end the product quality from a technical point of view.

All the listed items as well as others that have resulted from the analysis have as effect the increase of production costs, reflected in the cost of the finished product and therefore in reducing the production yield by decreasing the company's profitability [8].

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