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STATE OF RESEARCH ON THE OPTIMIZATION OF THE PRODUCTION MANAGEMENT PROCESS THROUGH TOTAL QUALITY MANAGEMENT METHODS IN WOOD INDUSTRY

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Abstract:

Generally speaking, the quality and cost of goods and in particular of wood products are–decisive conditions in their sales on the market and at the same time must satisfy the clients' demands.

This article aims to present how can be increased the quality of the final product (including its finishing) through the optimization of the production process by using the total quality management (TCM) methods. This study is destined for using ways and methods to make production more efficient it in the wood industry.

The authors, based on the research carried out and brainstorming meetings focused on the choice of a scientific method or criteria for measuring interdependencies in order to optimize the solid wood processing. Poor literature was found in the applicability of Six Sigma method in wood and finished wood products industry.

The studies conducted by the authors over the course of two years showed that Six Sigma method is an extremely efficient method for optimizing technological flows in industry.

From preliminary research, it was estimated that all the items found contribute to a significant decrease in production costs that are reflected in the cost of the finished/final product and consequently increase of production yield and at the same time maximize the company profit.

***Key words**: Total Quality Management; efficiency; production; wood industry.*

INTRODUCTION

From the multitude of Total Quality Management Control Techniques (TQM) and economic analysis methods (The Target Costing method, The Taguchi method, Pokayoke method, Kaizen method etc.) that are used to optimize the production costs, following a meeting with the company's management, along with engineers directly involved in production, several methods have been selected and studied (The Six Sigma Method was chosen for the economic efficiency evaluation after applying the Multi-criteria Analysis at SC Famos SA Company which is a company with specificity in wood industry. Modern Six Sigma methodology was initiated by Motorola in the early 1980s in response to the challenge of corporate leadership to reduce ten-fold defects within five years. Six Sigma methodology was taken over by GE Aircraft Engines, Texas Instruments, Allied Signal, Eastman Kodak, BorgWarner Automotive, GenCorp, Navistar International etc.

Six Sigma is a management technique that aims to improve business processes to create and deliver almost perfect products and services. This measures how many defects exist in a process and then determines in a systematic way how to improve this business activity. At the same time, this method uses the standard deviation in statistics and has the purpose of increasing product quality by continuously determining and removing the causes of defects and process variability (potential or detected) so as to ensure customer satisfaction. It is based on FMEA methods (Failure Mode and Effect Analysis) and QFD (Quality Function Deployment) as well as on modern management methods which are applied to the mixed teams of the producer, supplier, customer, specialist, research centers etc.

The method quantifies the value of a variable (or more) that shows the distribution of an output characteristic in a process. A higher value for the Sigma index indicates a more stable process (less risk for scrap, lower costs). The symbol for this indicator is σ, the Greek letter used in statistics to represent the standard deviation (Fig.1., 2).

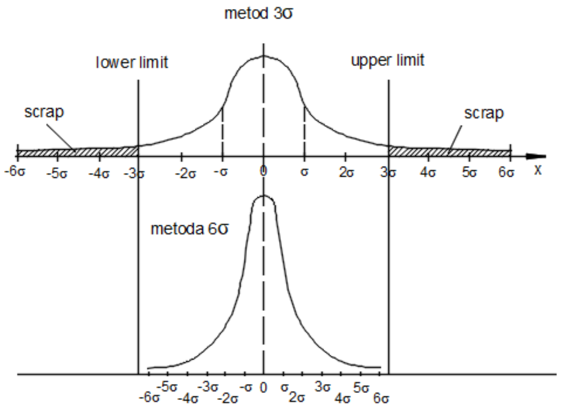

Fig.1.
Representation of 6σ (Source: Lean six sigma community).

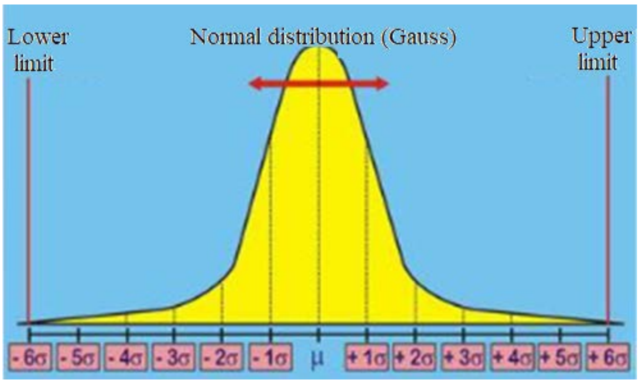

Fig. 2.
Distribution representation for a generic process (Source: Lean six sigma community).

Improvement is achieved by focusing on the customer and, thanks to this, it increase the consumer satisfaction.

Table 1

Correlation Six Sigma and ISO 9001:2008 (Rohan 2014)

. SIGMA SIGMA - ISO 9001: 2008 CORRELATION	
THE PRINCIPLE OF QUALITY MANAGEMENT	CORRELATION
FOCUSING ON THE CONSUMER	SIX SIGMA IS INDICATING THE MODULE OF ALINING THE OBJECTIVES OF THE ORGANIZATION REGARDING THE CONSUMER REQUIREMENTS BY MEASURING THE OBTAINED PERFORMANCE AFTER FOCUSING THE ATTENTION ON THE CONSUMER
LEADERSHIP	TOP MANAGEMENT IS ACTIVLY INVOLVED IN SIX SIGMA PROJECT BY PROVIDING FINANCIAL SUPPORT AND THE NEEDED TRAINING
IMPLICATION OF ALL FACTORS REQUIRED	THE SIX SIX PROJECTS ARE DESIGN TO ENSURE THE IMPLEMENTATION OF ALL INTERESTED FACTORS; THE POGRAM OFFERS THE NEEDED TRAINING FOR THE USE OF THE WORKING TECHNIQUES AND FOR THE DEVELOPMENT OF TEAM WORK
PROCESSING APPROACH	ANY SIX SIGMA PROJECT IDENTIFY, ANALISE AND EVALUATE THE ORGANIZATION PROCESSES FOR IMPROVEING
SISTEMICAL APPROACH	SIX SIGMA PROJECTS ARE BASED ON INTERACTION BETWEEN PEOPLE AND PROCESSES CONNECTED WITH AN INTERDEPENDENT SYSTEM; THIS SYSTEM PROVIDES IMPORTANT PERFORMANCES BY STUDIENG RELATED MEASURED OBJECTIVES
CONTINUING IMPROVEMENT	ORGANIZATIONS THAT IMPLEMENT THE SIX SIGMA METHOD UNDERSTAND THAT THE QUALITY OF THEIR PROCESSES MUST BE CONTINUESLY IMPROVED, SO THAT THIS WILL REMAIN THE MAIN FACTOR FOR SUCCESS IN A COMPETITIVENESS CONDITIONS
MANAGEMENT BASED ON THE DECISION	SIX SIGMA TEAMS ARE FOCUSES THEIR ATTENTION ON DATA COLLECTION AND ANALYSIS ON WHICH BASIS THEY ARE FORMULATING THERE VIEWS AND SUSTAIN THERE ARGUMENTS, SO THAT THEY GUARANTEE A UNITARY UNDERSTANDING

By reducing losses, improving the quality and lifecycle of products and customer satisfaction, the profit grows and leads to an increase in employee satisfaction. The easier it is to maximize profits, the lower the operating costs and the significant recovery of investments, which is the result of changing in the operating mode: "working smarter not harder".

By implementing the Six Sigma method, the organization also implements requirements from quality standards; (e.g. ISO 9000) standard which is based on the use of fundamental principles of quality management. Integrating the Six Sigma strategy with the ISO 9001: 2008 quality management system, helps the organization to increase its benefits, as is outlined in Table 1.

OBJECTIVE

Any technological process based on machines, equipment and industrial installations can be characterized by inputs and outputs of materials, energy and information.

In the process that will be subjected to analyze it will be considered only the inputs and outputs of materials and energy consumption. On this process it will be applied the TQM method in the form of six sigma in order to evaluate the amount of defects/losses and the places in the technological streamline where they appear and find different ethical solutions to minimize them.

Since the production process in wood industry as a component of the entire cycle of manufacturing system includes activities that employ solid wood and other raw materials, in order to obtain a finished product, furniture or an intermediate product as a reconstituted wood panels. These can bear a series of losses that are sum both quantitatively and in value.

That is why the manufacturing system can be represented as a set of elements between which there are connections and interdependences and on which it can act from the outside and which, in turn, act on the external environment, but all of them have a common denominator, meaning the monetary expression, because everything is ultimately quantified in money.

The vision over the technological process as a system in which the inputs are transformed into outputs in order to achieve the objectives set in the fabrication, leads to the representation showed in Fig. 2, where **xi1, xi2… xin** represent the inputs in the system and **xe1, xe2 ... xen** represent outputs of the system.

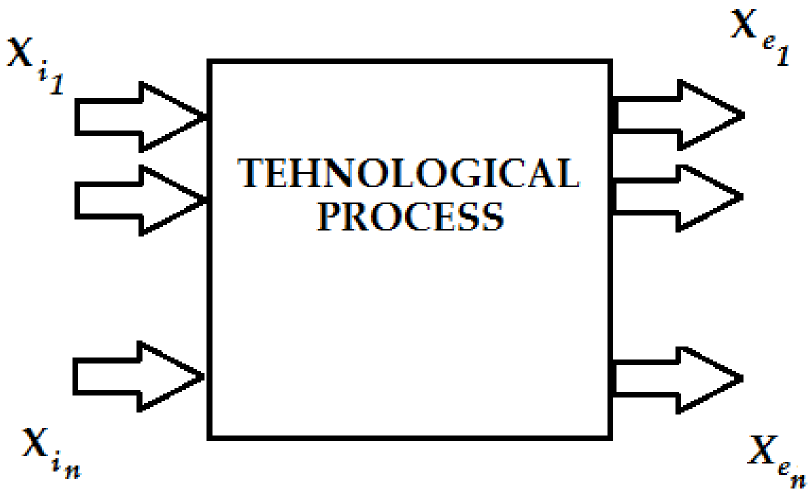

Fig. 2.
Schematic representation of the manufacturing process.

In this manufacturing system, wood raw material undergoes physical and chemical transformation processes (drying, machining, finishing etc), as well as disruptive actions that are offset by order quantities. Output variables are dependent on inputs, disturbance and command factors. This dependence can be expressed mathematically by the relation:

$$x_e = f(x_i, x_p, i, e) \qquad (1)$$

where:

x_e – *the size of the output variables (intermediate product (reconstituted wood panel) or finished product (furniture));*

xi - the size of input variables (raw material (solid wood), energy, auxiliary materials (varnishes, paints, abrasive material etc.);

x_p - disturbing factors (variation of the raw material composition (wood quality), change in the environmental factors (wood drying degree etc.);

i, e – command (control) variables.

Input sizes and output sizes are called characteristic variables and can be grouped as in Fig. 3.

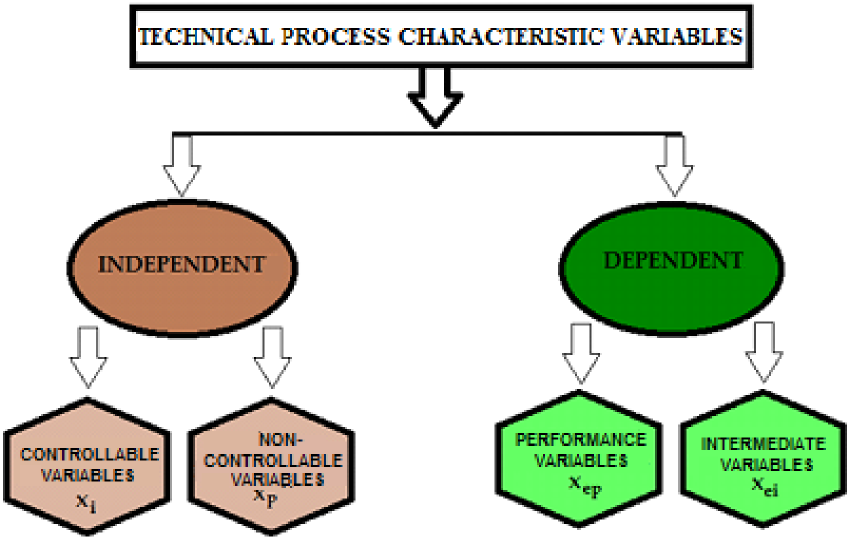

Fig. 3.
Classification of characteristic variables.

METHOD, MATERIAL, EQUIPMENT IN TECHNOLOGICAL PROCESS

The TQM through the Six Sigma method 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.

The overall function of a manufacturing system is to convert a flow of raw materials, materials, and a flow of information by means of an energy flow so as to increase the value of the products obtained at the system exit achieved by their superior quality or longer life cycle.

The manufacturing process is conditioned both by the correct operation of each subsystem and each component of interaction and by many interlinked that are established between these subsystems: resource sharing, synchronization of operations, competition.

Therefore, the technological process is characterized by variables that intervene at the input and output of the process, or during the process. These variables can be:

- **Controllable independent variables** are those sizes and characteristics that can be modified by the operator/ manufacturer within the technological process at the desired value and sense so that the performance required by the manufacturing system to be obtained (quality, quantity, profit etc.).
- **Non-controllable independent variables**, also called disturbances, are those sizes and characteristics (in our case the quality of wood raw material) that cannot be modified by the operator in the desired sense, they are random variables;
- **Performance dependent variables** are those sizes and characteristics that lead to the assessment of the economic and technical performance of the technological process. These variables are: cost of production, productivity, yield, and profit, quantity of main products, quantity of by-products, quality of resulting products, protection of workers and the environment.
- **Intermediate variables** can be important indicators in monitoring of industrial process with advanced retrofitting, with the aim of modifying the command (control) variables (in particular the technological parameters of machines), so that at the end of production process the desired results are obtained.

Resource sharing is the complex process of rational design for raw materials, energy (fuel) and information materials, as well as human resources needed to conduct a particular production activity.

In a modern manufacturing system, flows of materials and raw materials, energy and information are directly interrelated which leads to increased performance of company in terms of productivity, profitability, environment and competitive products.

The resources involved in the manufacturing process are divided into human resources, technical-material resources and energy resources:

- ► **Human resources** represent all the employees involved in the manufacturing process. Human involvement is present through its activities in all systems, even in subsystems.
- ► **Technical and material resources** include raw materials, materials, energy, all equipment, and machinery components of the manufacturing system. Run the manufacturing process in optimal conditions is conditioned, besides other factors, on the nature, quality, accessibility of the raw materials and materials used.

In this study the technical-material resources and energy resources are considered.

The material balance is a document with all raw materials and materials subjected to transformations during manufacturing process. Its content depends on the type and peculiarities of the technological process. The quantitative representation of materials (inputs and outputs) is made in RON in order to have a common comparative value (for the price), even these are characterized by different units of measure (UM). An example as is presented in Table 2.

Table 2

Balance sheet material

Nr.	INPUT MATERIALS	QUANTITY			TOTAL PRICE (RON)
		UM	Quantity	Ron/UM	
1.	Raw materials (solid oak wood)	m^3	6	30	180
2.	Auxiliary materials (hinges)	pieces	2	12	24
3.	Recovered and reused materials (sawdust)	kg	3	3	9
4.	Energy	kwh	5	22	110
	TOTAL:				323

Nr.	OUTPUT MATERIALS	QUANTITY			TOTAL PRICE (RON)	EFFECT
		UM	Quantity	Ron/UM		
1.	Finished product (furniture set)	pieces	15	800	12000	+
2.	Semi-manufactured (reconstituted panel)	m	5	32	160	+
3.	By-product (firewood)	kg	100	15	1500	+
4.	Waste	kg	3	5	15	-
5.	Reject material	pieces	1	500	500	-
6.	Recoverable materials (sawdust)	kg	3	3	9	+
7.	Technological losses (powder/ dust/)	g	0,5	32	16	-
	TOTAL:				13138	

Input materials include:

- Raw materials: the initial materials subjected to transformations during the technological process. They are found in the highest proportion in the finished product. New manufacturing technologies are focused towards reducing the raw material consumption and the usage of all its components;

- Auxiliary materials: auxiliary materials (dyes, varnishes, additives etc.) involved in the raw material processing, without which the finished product cannot be achieved; they are consumed in small quantities compared to raw materials.

- Materials recovered from other manufacturing processes used to reduce the consumption of raw materials and implicitly the manufacturing costs;

- **Energy** calculated in the material balance (only if it reacts with the raw material and materials). It is expressed in KWh or Mwah and refers to electricity, natural gas and thermal energy.

Output materials:

- Finished products (also called main products) which have to meet the quality requirements specified in the technological documentation.

- **Semi-manufactured product**s **-** products of a certain degree of processing, intended to be further processed in order to obtain the finished product;

- **By-products** - products resulting from the technological process along with the main product, but in much smaller quantities;

- **Waste materials, parts** of the raw material, which may be reused in the same or another process, for the purpose of recovering the raw material and reducing the specific consumption and material costs (eg chips resulting from planning);

- **Scraps -** finished products that do not meet the quality requirements set out in the technical documentation of the product. Scraps can be:

• recoverable if defects can be remedied by additional operations or can be capitalized with manufacturing wastes in order to expand the raw material base, which is reflected in a positive financial results at the level of the economic operator;

• irrecoverable if they cannot be reintroduced into a manufacturing process;

- Technological losses, the smaller the technological losses the more efficient is the process.

The balance is calculated based on the law of mass conservation: the sum of masses of all input materials is equal to the sum of masses of materials resulting from the process.

Depending on when it is made, the material balance for a manufacturing process can be pre-calculated and post-calculated. The material balance can be compiled for each part of the technological process (partial balance) or for the whole technological process (total balance).

► **Energy resource** has an important role in carrying out any manufacturing process, as it involves consumption of a certain amount of energy. The energy required is generally transmitted from outside in the system as electric or thermal energy. From the energy input, only one part becomes useful energy, the rest representing energy losses.

The amount of energy required is calculated using the energy balance, which is based on the law of energy conservation and is expressed by the following formula:

$$Ei = Eu + Ep \qquad (2)$$

where:

Ei - energy input (available), in kWh

Eu - energy used, in kWh

Ep - energy losses, in Kwh

An energy balance is expressed in a single form of energy (kWh).

Energy losses are determined by:

- the equipment constructive–deficiency, machinery that are used morally or obsolete;
- the technical condition of the equipment;
- the raw material and materials quality,
- energy imperfections of technological lines.

Like the material balance, the energy balance can be pre-calculated or post-calculated, partially or totally

RESULTS AND DISCUSSION

In the current case, our main goal is to optimize production by reducing costs at SC Famos SA.

The research was based on the use of brainstorming techniques and multi-criteria analysis in order to identify the optimization method with the greatest applicability in wood processing industry.

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

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.

The analysis and monitoring of industrial processes related to manufacturing systems in terms of the used technologies must highlight in which way these systems are the ability to easily adapt to the new production tasks by using their own technological lines.

If these capacities do not exist or do not meet the requirements, even by adapting to the type of production and products produced, then they will be subject to an advanced upgrading, which will ultimately lead to industrial automation, cybernetization and robotization of the operating processes. This is a definite step to optimizing the technological flow to respond changing market and customer desires in relation with quantity and quality of products. New technologies are the result of human creativity, innovation and technical progress and aiming to increase the production flexibility, product quality with positive impact on the quality of the professional life and environment.

CONCLUSIONS

The proposed optimization solution is efficient for furniture industry in Romania which represents a real vehicle for the national economy and a viable solution to the problem of irrational or exploitation of wood and unjustified wood raw material export. It is possible to conclude for an export for added value of high finished products and in the case of Romanian wood and by low to forbid the export of no processed wood. The lack of this solutions brings possibilities of cargo valences, by offering to the foreign companies the opportunity to bring added value.

1. In the scientific researches carried out in this article on the TQM and Six Sigma method with application in wood processing, it was concluded that researches of this type are relatively low / or probably less popular, especially in our country or abroad (books and article found.
2. The TQM method applied to the technological flow could positively influence the quality and cost of wood products satisfying the client’s desires and exigencies.
3. As a result of the above, we find that the current state of knowledge in the field of mechanical woodworking has reached a very high level in terms of: technology, machine tool and tooling system, optimization solutions of the processing process on various criteria technical. There are information databases on technical research and inventions in the field of wood processing technology and wood-based products.
4. The quality and value of products depends greatly on the machinery and equipment performance, the organization of the manufacturing processes. Thus, this analysis will came with some proposals, like:

- jointing some stages from technological flow this will lead to removal of classical equipment (which perform simple operations), with high energy, time and raw materials consumption. By retrofitting and/or replacing those with CNCs will optimize the above mentioned consumptions.
- focusing on the production with high added value products and by retrofitting the production lines with high-tech and specific machines (Veneer Panning Machine, Edge Panning Unit, Panels Cutting Aggregate) will increase the quality of product finishing, minimizes the scraps and the quantity of waste (Rohan 2014).
- acquiring new machines replacing the old ones increase the production capacity, maximize productivity and eliminate the tight places (stocks in the production stream) (e.g. spraying rooms).
- increasing the efficiency of wastes utilization resulted from the technological process and reduction of their footprint on the environment by acquiring an exhaust system (Lobonț and Zerbes 2014) and also a wood regasification plant with a generator for producing electric power. In the researches that stand at the base of this article result that in the furniture production the largest share in the production cost is after the raw materials the energy costs. The price per unit of energy is the highest for the energy produced from gas (Table 1) and which is used predominantly for the drying of wood and for gluing presses. The lowest price is the production on own by burning waste resulted from the production process and turning it into energy and that can be used also for the same machines.
- reducing working time and auxiliary time by acquiring elevators and machines for flipping and handling wood panels which lead to increase in labor efficiency.

The new technologies are the result of human creativity, innovation and technical progress and aim both at increasing product flexibility and product quality, reducing consumption and, implicitly all the costs, and increasing the quality of professional life and protecting the environment.

The easier it is to maximize the profit through the implementation of new advanced technologies, the quicker it is to lower the operating costs and the significant recovery of investments, which will result in a change of operating mode: "working smarter not harder".

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