WYBRANE PROBLEMY INŻYNIERSKIE
NUMER 2
INSTYTUT AUTOMATYZACJI PROCESÓW TECHNOLOGICZNYCH
I ZINTEGROWANYCH SYSTEMÓW WYTWARZANIA

Ciprian CIOFU[1*], Uvel PINTILIE[2], Dumitru NEDELCU[1]

[1]"Gheorghe Asachi" Technical University of Iasi-Romania, Department of Machine Manufacturing Technology
[2]SC Termoform SRL Iasi
[*] ciprian.ciofu@gmail.com

QUALITY MANAGEMENT OF INDUSTRIAL PRODUCTION IN FIELD OF MACHINE MANUFACTURING

Abstract: In the current economic situation, the diversification and competitive of the products offer, globalization of the markets, a continued growth of customers' requirements, improve a product quality, increasing the technical level and improving manufacturing technologies. For all of companies it is a priority to satisfy those customers and market requirements. In the article the main issues related with the evolution of ways of ensuring products quality like: availability-reliability-maintenance relationship, measuring quality aspects through quality characteristics, quality economy in terms of quality costs and quality control, were considered and analyzed. Recommendations for improving of production quality process such as: continuous improvement of product technological conception and constructive one using advanced processes, increasing concerns for quality assurance embodied in the increasing of production prevention costs in total, in parallel with decreasing the latter and continuous training of staff were presented.

1. Introduction

Nowadays, the diversification and fast renewal of offered goods, the continuous growth of customers' requirements, product quality: improve in all of economic sectors, raise of technical culture. An improvement of manufacturing technologies is a priority for all industrial enterprises.

In a last period the quality has evolved from a simple accessory to a defined element of the product. This evolution explained major changes in the global economy, [Stanciu, R., 2006]. The process of increasing the importance of quality, shown in the organization of technological process and providing quality control of industrial production was determined both, by intensifying competition and a continuous growth of customers' requirements. Increasing complexity of industrial products and processes of production is determined by revolutionizing production systems by introducing large-scale computing, development and flexible manufacturing systems using leading worldwide technologies, [Sava, O., 2010].

In order to keep the control of industrial processes, more complex integrated systems have been developed for production. It is obvious that the success of a company is based on the

adaptability requirements of fast growing companies in diverse market, providing quality products with a competitive price.

The quality of industrial products has a complex and dynamic character; this is a consequence of increasing number of properties and enriching the substance of their quality. Product quality is the quality of the final form of industrial production processes. It summarizes the technical performance, availability, economy and social determinant.

Classification of features to an appropriate function as parts of quality is shown in Figure 1, [Ceausu, I, 2003].

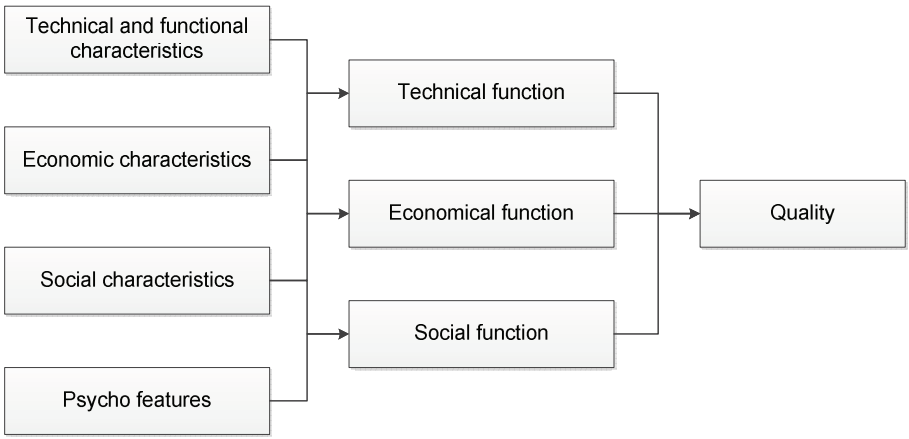

Fig.1. Classification of quality characteristics

The functions of the quality are determined by the features and show its complex character, Figure 2, [Ceausu, I., 2003].

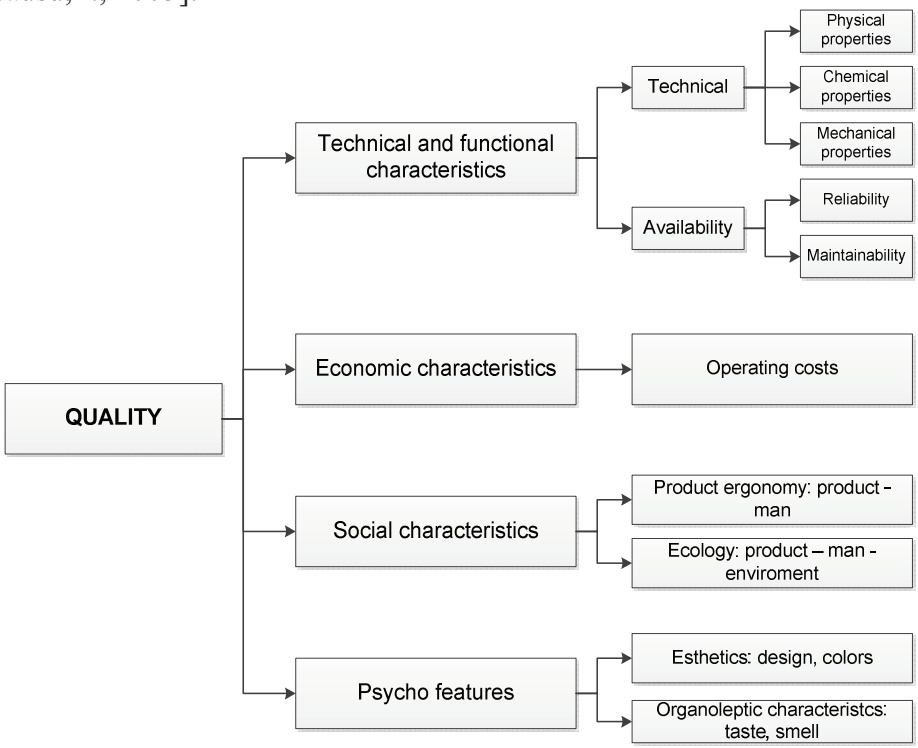

Fig.2. Relations between features, functions and quality

Quality has a dynamic and evolving aspect because it is connected closely with the practical needs in terms of both, intensification and extensivity. Dynamism of the quality is influenced by scientific and technical progress, increasing consumer demands and competitiveness of technology. An economic unit involves all departments, from research one up to process control and sales, and represents a key to obtain high quality products. Quality management is based on the quality policy. Moreover, its activities refer to planning, keeping under control, quality assurance and improvement.

1. How to ensure product quality? Indicators and measuring methods

The main stages in the evolution of the methods of quality products can be as follows:

- Quality assurance through the control to the ultimate product and compliance with specifications;
- Quality assurance through the statistical methods, which is based on statistical rules and a given priority to technical field;
- Quality assurance through a staff motivation, which is based on teamwork and on a program called "zero defects".

Additionally, in recent years methods of quality assurance for the products have been developed, by integrating concepts of quality, which are based on both, customer approach and training of all employees in every department. The evolutions of these methods of ensure product quality have been achieved. Promotion of excellence in quality concepts with emphasis on total control expert, total quality and involvement of all stakeholders as well as production of an economic unit has been reached. Mostly used indicators for products quality measurement are presented in Table 1.

Table 1. Indicators of the products quality

No.	Name of indicators	Related equations
1	Partial indicators	Express a set of measurable characteristics of the product. For appropriate determination, units of measurement parameters were used.
2	Indicators that express this part of high quality of the products is in total number of products. *For homogeneous production the medium quality coefficient ($\bar{c}$), quality factors (K_{c0}'K_{c1}) and quality index factor calculated on the basis of unit price of the highest quality products are used. (I_{Kc}). The process of improving the quality of the products is determined by subtracting 100 from the value I_{Kc}.*	$\bar{c} = \frac{\sum c \cdot q}{\sum q}$; $K_{c0} = \frac{\sum q_0 p}{\sum q_0 P}$ $K_{c1} = \frac{\sum q_1 p}{\sum q_1 P}$ $I_{Kc} = \frac{K_{c0}}{K_{c1}} \cdot 100$ where: c express quality of classes or sorts, q - an amount of products corresponding to each class or sort; K_{c0}'K_{c1} the quality factors which represent the actual unit cost calculated on base of the best product quality; q_0,q_1 - factors of a production amount of different qualities, p - the unit price of the products with different quality, P - the unit price of the highest quality products.

3	Indicators scraps - scrapped production value (R_v); - scrapped production rate (r_p); - recorded loss of enterprise value of the casting of the production (P_r); - The percentage of scrapped production losses (p_r)	Indirectly characterized product quality, reflecting the organization and progress of the production process. $R_v = \sum q_{rd} \cdot c + \sum q_{rm} \cdot c_{rm}$ $r_p = \frac{R_v}{\sum q \cdot c} \cdot 100$ $P_r = R_v - S_{rec}$ $p_r = \frac{P_{rlot}}{\sum q \cdot c} \cdot 100$ where: q_{rd} is a definitely scrapped production quantity, c represents the unit cost of product; q_{rm} - the amount of a solved scrap; c_{rm} - a unit cost of remediation; q - the quantity of good of manufactured products; S_{rec} amounts recovered by the company; q - the output produced by enterprise ; c represents unit cost of product.
4	Indicators of consumer complaints	*- quantity of the products or advertisements refused to receptive during the warranty period and their value;* *- share of quantity or value of the products in total output refused or complained;* *- costs for refused or reclaimed remediation of the products.*

The main, practical methods for measuring the quality: experimental method, expertise method, sociological and statistical methods.

If the bases of assessments of the products are tests or mechanical or physical-chemical measurements, experimental method were used. The method used for the assessment for expertise of the quality characteristics cannot be measured. Sociological methods are based on results obtained from investigations carried out in a critical number of beneficiaries. Statistical method is the most complex and widely used in mass production. It is based on probability theory and mathematical statistics.

3. Analysis of quality indicators in the industrial production SC Thermoformed SRL Iasi

Company Thermoformed SRL Iasi, is Romanian industrial partner of the Technical University "Gheorghe Asachi" of Iasi, Faculty of Machine Building and Industrial Management, Department of Machine Building in these research projects.

Due to position of Thermoformed SRL Iasi on the market and complex activities, product quality is one of the fundamental objectives of management and organization of this business unit. Virtually all departments and all levels of the organizational structure of the enterprise are involved in the process to ensure product quality.

General Director of the Company has established the following strategic objectives of quality:

- Compliance with the manufacturing requirements and national regulations and international standards in the production area;
- Ensuring full and consistent permanence between customer needs and requirements, technical level and the quality for manufactured products, through maintaining a continuous relationship with customers and subcontractors of the company;
- Implementing a quality system;
- Providing resources;
- Ensuring an adequate level of qualification and training of all the staff in the unit.

Analysis of quality indicators of industrial production in the SC Thermoformed SRL Iaşi was performed in theoretical and practical examples. The following indicators were used: technical equivalence ratio and generalized weighted average, indicators of production and finally, scrapped indicators of refusals beneficiaries [Dumitrean, E., 2002, Verboncu, I., 2001].

If the products are divided into quality classes, for quality analysis and quality weighted average in case where differentiated products are not graded, technique of equivalent coefficient should be used.

In the SC Thermoform-SRL Iaşi manufactured products are not differentiated by quality classes, the analysis was made with quality coefficient given by an equivalent technique, Equation 1:

$$\overline{K_c} = \frac{\sum q_i \cdot I_e}{\sum q_i} = \frac{Q_e}{\sum q_i}, \quad (1)$$

where: q_i is the quantity of products in each grade, I_e represents equivalent index and Q_e is the equivalent of production. Production can be transformed into production of first quality by using Equation 2.

$$I_e = \frac{P_i}{P_1} \cdot 100, \quad (2)$$

where: P_i is the price of product *I,* and P_1 represents the price high quality product "*I*". In order to achieve product analysis, a representative unit was chosen. Necessary values of calculations are presented in Table 2 and Table 3.

Table 2. Quality, quantity and value of the products

Quality	Quantity [thousands pieces]		Selling price, [RON/piece]	Products values, [thousands RON]	
	2009	2010		2009	2010
I	5234	6543	23	120382	150489
II	4355	6567	21	91455	137907
III	2356	1233	19	44764	23427
Total	11945	14343	-	256601	311823

Table 3. Equivalent index and equivalent production

Production value index , [%]	Production Structure, [%]		Equivalent index	Production equivalent [thousands RON]	
	2009	2010		2009	2010
122,8	41	52	1	120382	150489
102,56	32	36	0,91	83224	125495
67,1	27	12	0,90	40287	21084
	100	100	-	243893	297068

In the presented tables increasing amounts of manufactured product production structure considered representative of the quality I and II were collected. The final quality is a reduction of the quantity produced due to diminished market demand, especially the foreign one. Analysis of production quality in whole unit by taking into account the first three products with substantial production volume was presented in Table 4.

Table 4. Analysis of the quality of production unit

Product	Production structure, [%]		Product Quality Coefficient K_i		Generalized weighted average K_G		
	2009	2010	2009	2010	2009	2010	recalculate
1	39	37	1,6	1,4	0,624	0,523	0,610
2	27	25	1,5	1,6	0,421	0,401	0,402
3	34	38	2	1,9	0,467	0,507	0,523
Total	100	100	-	-	1,512	1,431	1,535

Table 4 presents a noticeable change in the weighted average due to widespread production structure which means that the share of the product has an average unit shoddy quality; the "3" product with production structure from 34% to 38% has a quality inferior average 1,512. Analyzing influence of product quality coefficient is concluded that more effort is required from the unit in scope of supplies high quality raw materials, in use of a highly qualified workforce, fixed assets with a higher yield and a good operation state.

Scrapped production indicators reflect the level of the production processes organization and development. In case of using these indicators, production and scrap received in manufacturing good are shared. Table 5 shows the corresponding output values of production, scrapped and solved. Also the product unit costs and cost of the unit remediation are here presented.

Table 5. A made, scrapped and solved production

Indicators	2009	2010
Produced with [thousands pcs]	9829,500	7650,300
Production finally scrapped, [thousand pcs]	635,900	425,800
Production remedied [thousand pcs]	234,500	244,600
Unit cost of product, [Lei]	21	23
Unit cost of remediation, [Lei]	19	20

For two years period of research, taking into account the following parameters, were calculated: production value scrapped, scrapped production rate, the losses recorded in the casting of the production unit and the percentage of loss for production scrapped. All calculated parameters are presented in Table 1. The calculated values are presented in Tab. 6.

Table 6. The calculated values

Indicators	2009	2010
Scrapped production value,Rv [thousand]	17809,4	14685,4
Percentage rp scrapped production [%]	9,46	9,14
Amounts recovered Srec unit,[thousand]	8012,3	8223,1
Losses of production scrapped, Pr [thousand]	9797,1	6462,3
The failure rate of production scrapped pr [%]	4,7	3,6

In Table 6 is a noticeable drop in scrapped production value in 2010 compared to 2009, and compared with a decrease in the value of manufactured products. This causes an increase in the percentage of scrapped production. Reduce of losses in scrapped production in 2010 compared to 2009 due to increasing amounts was recovered by the unit.

In category of claims indicators are: the amount of the products rejected by the beneficiaries, the share of rejected products in the total quantity of production, costs of remediation of the products rejected by the beneficiaries. The values of these indicators are presented in Table 6.

Table 7. Indicators of values refusals by beneficiaries

Indicators	Period		Dynamics, [%], 2010/2009
	2009	2010	
Production delivered, [thousand pcs]	9428,1	7469,1	79,22
The amount of products rejected by the recipient, [thousand pcs]	160,277	106,974	66,74
Share of total production declined, delivered [%]	1,69	1,43	84,61

Table 7 presents a decrease of the products declined in 2010 and compared to 2009. This decrease can be explained both, by increasing quality and production within the unit and by increasing the availability of equipment within the unit.

4. Conclusions

The made analysis was very useful. After analysis of achieved results, conclusions were made and implemented into economic unity. It will focus on gaining new market segments with ensure a proper level of production from qualitatively as well as quantitatively. Also requires a greater effort from the unit in scope of supplies high quality raw materials, in use of a highly qualified workforce, fixed assets with a higher yield and a very good working order. Special attention will be given to lowering production scrapped, which will decrease the unit price of the product. The technical endowment of Quality Implementation Unit and increase the unit's priorities will be implemented in the next period.

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