TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

ACTA TECHNICA NAPOCENSIS

Series: Applied Mathematics, Mechanics, and Engineering
Vol. 65, Issue Special I, February, 2022

ASPECTS ON THE ANALYSIS AND QUANTIFICATION OF THE QUALITY OF PRODUCTS, WORKS AND SERVICES (II)

Florin-Ștefan PETCU, Adrian IOANA, Claudiu NICOLICESCU, Monica IORGA (CRĂCIUNICA), Bianca Cezarina ENE, Dumitru DEONISIE

Abstract: *The article discusses a new concept of production and quality management, namely the concept of Products / Works / Services (P/W/S), much more comprehensive than the usually used in the literature, that of goods and services. The article presents and analyzes a relevant method of analyzes and quantification of the quality of Products / Works / Service, namely the Diagram of Quality Circles (DQC). This method highlights and analyzes 3 important components of quality: quality of use (qU) - is the quality required by the beneficiary; quality of the conception (qC) - is the projected quality; quality of the manufacture (qF) - is the quality of execution itself. Based on these 3 components of quality and implicitly of the inconsistencies between them, 7 areas of nonconformities are defined and analyzed. Each of these areas is characterized and analyzed in terms of the implicit consequences on the quality of a Product / Work / Service. They are also defined mathematically. In direct connection with the Diagram of Quality Circles, the article presents and analyzes the mechanism of an apparent economic paradox from the point of view of the choice of a P/W/S by the client.*

Key words: *Quality Circle Diagram; Production Management; Quality quantification.*

1. INTRODUCTION

Paraphrasing a well-known biblical saying "If there is no love, there is nothing!" which belongs to the Apostle Paul and not to Marin Preda, as many consider wrong, the authors subscribe this article to the statement "If there is no production, there is nothing!"

In this context, the quality of production and implicitly the methods of its analysis and quantification has a special importance [1,2]

Quality Circle Diagram (DQC) is a very effective tool of analyzing and quantifying the quality of Products/Works/Services - a new concept specific to production management and quality management, much more comprehensive than the term usually used in the literature, that of goods and services [3,4].

The research in the field, at national level, is, unfortunately, mainly at theoretical level. An important goal is to consider unconventional technologies in various fields. Thus, according to [8]] "Each technological method need to complete a technological process that represents an independent component which must, however, meet theprecise requirements impose to the process equal system. The systemic approach tends to become a general method of thinking, pertaining to all sciences, yet having a particularly efficient impact on technological sciences. The

essential character of the systemic approach consists in its preference for the whole over the component parts, on the one hand, and in the special attention it pays to the study of the constantly changing possible connections between the components of the system, on the other hand."

2. QUALITY CIRCLE DIAGRAM (DQC)

Among the many components of the concept of quality (another aspect of the special complexity of this concept) are distinguished by their importance the following three [5-7]:

- Quality of use (qU) – is the quality required by the beneficiary.

- Quality of conception (qC) – is the projected quality
- Quality of manufacture (qF) – is the quality of execution itself.

Based on this three important components we can define a "qualitative" relationship of quality (Q):

$Q = q_U \bullet q_C \bullet q_F$

The quality circles diagram is a conceptual model for analyzing the quality of Products/Works/ Services (P/W/S) which highlights the inconsistencies between the three important types of quality, namely:

1. Quality required by the beneficiary (qU) - "expressed and implicit requirements" of customers, as defined in SR ISO 8402:1995 .
2. Designed quality (qC) - refers to the designed parameters.
3. Achieved quality (qF) – reflects the performance P/W/S in operation.

Between the three types of quality, the following categories of discrepancies can appear mainly, highlighted synthetically in figure 1

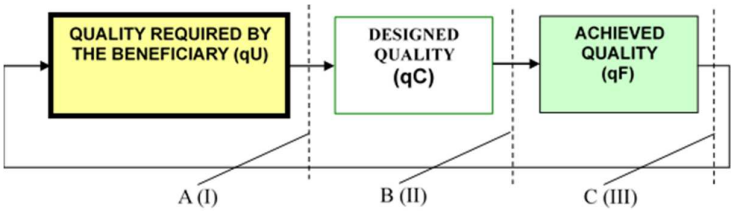

Fig. 1. Types of quality and inconsistencies between them
A – Order (I) discrepancies – between (qU) and (qC).
B – Order (II) discrepancies – between (qC) and (qF).
C – Order (III) discrepancies – between (qF) and (qU).

These discrepancies lead to appearance of non-conformity areas, areas highlighted in the diagram of quality circles, figure 2.

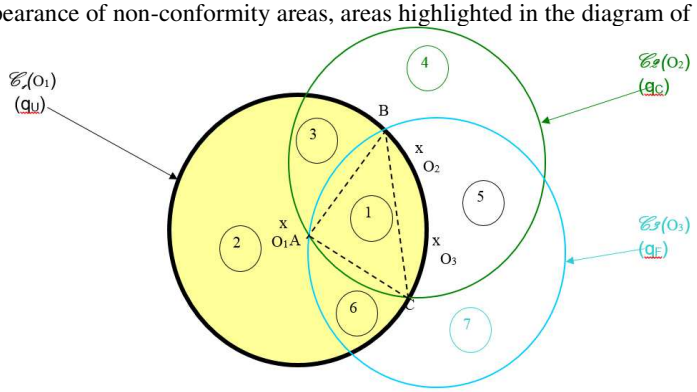

Fig. 2. Diagram of quality circles
C_1 (O_1) – The circle of quality required by the user (customer), (qU)
C_2 (O_2) – Quality circle designed (projected), (qC)
C_3(O_3) – Manufactured quality circle (achieved), (qF)

The specific characteristics of each non-compliance area are summarized in table 1.

Table 1

Characteristics of non-compliance areas in the quality circle diagram

Nr. crt.	Nr. area	Name of area	Characteristics of the area	Remarks
1.	(1)	*Compliant quality (optimal area*	*Customer requirements are fully designed and realized*	*TOTAL* quality
2.	(2)	*Unsatisfied* customer *requirements*	The requirements expressed by customers are *unpredictable and unfulfilled*	*Total lack of quality* (P/W/S *"harmful"*)

3.	(3)	*Defective* area *(realization non-conformities*	Customer requirements have been designed but not met	Defective products *in workmanship ("quasi-scrap")*
4.	(4)	*Unnecessary quality* area	Features *designed without being requested by customer or realized*	*Possibly to make a prototype (or small series) for market testing*
5.	(5)	*Excess quality* area *(super quality*	Features *designed and executed, but not required by customers*	*Testing and "educating" the marked-conquering new market segments and eliminating competition*
6.	(6)	The area *of "Wonders" (fortuitous, or intentional)*	Quality required, *not designed*, but achieved	*Execution saved the design*
7.	(7)	*"Quality waste"* area	Features *not required* by customers, *not designed, but realized*	*Unjustified production costs*

3. MATHEMATICAL DEFINITION OF AREAS OF NON-COMPLIANCE

Based on the notions specific to set theory, the areas of non-conformity presented and characterized previously ((1); (2);...(7)) can be defined according to the following relations:

(1) = {C_1 (O_1)} ∩ {C_2 (O_2)} ∩ {C_3 (O_3)} ⇔
(1) = C + P + F

where:

(1) – is the Quality Compliant area (optional area) - customer requirements are designed and relized in full (Total Quality).

{C_1(O_1)} – is the set of points in the quality circle required by the user (customer), (qU).

{C_2(O_2)} – is the set of points of the circle of the quality conceived (designed), (qC).

{C_3(O_3)} - is the set of points of the quality circle manufactured (achieved), (qF)

C – is the quality required by the customer

P – is the projected quality

F – is the manufactured quality

(2)= {C_1 (O_1)} – {{C_2 (O_2)} U {C_3 (O_3)}} ⇔
(2) = C – P – F

where:

(2) – is the area of unsatisfied customer reqirements. Requirements expressed by customer are unpredictable and unfilfilled (total lack of quality, "harmful" P/W/S).

The rest of the notations are known.

(3) = {{C_1 (O_1)}∩{C_2 (O_2)}} – {C_3 (O_3)}} ⇔
(3) = (C + P) – F

where:

(3) – is the area with defects (non-conformities of realisation). Customer requirements have been designed but not met (products with "quasi-scrap execution defects").

(4) = {C_2 (O_2)} – {{ C_1 (O_1)} U {C_3 (O_3)}} ⇔
(4) = P – C – F

where:

(4) - it is the area of unnecessary quality. Represents features designed without being requested by customers or made (possibly to make a prototype - or small series - for market testing).

(5) = {{C_2 (O_2)} ∩ {C_3 (O_3)}} – {C_1 (O_1)} ⇔
(5) = (P + F) – C

Where

(5) – it is the area of the excess quality (superquality). Features designed and executed, but not required by costumers (testing and "education" market - conquest of new market segments and elimination of the competition

(6) = {{C_1 (O_1)} ∩ {C_3 (O_3)}} – {C_2 (O_2)} ⇔
(6) = (C + F) – P

Where

(6) – it is the area of "wonders" (fortuitous, or deliberate). Represents the required quality, not designed, but achived (execution saved design)

(7) = {C_3 (O_3)} – {{C_1 (O_1)} U {C_2 (O_2)}} ⇔
(7) = F – C – P

Where

(7) – it is the area of the "quality waste". Represents the properties not required by customer, not designed, but realized (leads to unjustified production costs)

Areas (2) and (7) are areas of major non-compliance. Ideally, these two areas should be eliminated

This situation, of eliminating the areas of major non-conformities (2) and (7), from the point of

view of quality circles diagram would correspond to the overlap of the three centers (O_1; O_2; O_3) of the quality circles (situation in which the three circles of quality would become concentric circles)

The optimal area (1), triangle ABC (called the conformance, or total quality triangle) is directly dependent on the following two aspects:

- Differences (non-conformities) between the product made and its design (area (4) and (7)), on the one hand, and on the other
- Differences (non-conformities) between product design and market requirements (areas (5) and (6)).

The larger these differences (the areas mentioned: (4), (7), (5) and (6) are larger) will result in a smaller optimal area (1), a negative aspect that must be avoided and counteracted

In conclusion, it is desirable for area (1) to increase (to be maximum), which corresponds to the reduction fo areas (4), (5), (6), (7), ie:

(1) ↑↑ ⇔ ↓↓ (4);(5);(6) ;(7)

In order to increase efficiency in terms of quality, any economic agent must improve each of the three types of qualities (qU; qC; qF).

In other words, the three quality circles must become concentric, thus obtaining the ideal quality and total customer satisfaction

The quality circle diagram (DQC) can also provide arguments (explanations) regarding the concomitant existence on the market of several P/W/S leading to an apparent economic paradox in terms of the following aspects:

- All P/W/S have the same function.
- P/W/S have significantly different perfoermances.
- P/W/S are sold at very different prices.
- BUT (here is the apparent economic paradox) all these P/W/S are sold.

The ”cause” (explanation) of this apparent economic paradox is provided by the area of the circle of requirements (qU), an area that is not the same for all customers.

The main scheme of the conditions of appearance of this apparent economic paradox is presented in figure 3.

Achieving customer requirements as buyers is quantified by the benefits they (customers) gain from using that P/W/S.

Consequently, each buyer will chose that P/W/S for which the difference between the price paid and the benefits obtained is minimal (ideally there should be even a ”negative difference”).

Figure 4 shows schematically the mechanism of choice of a P/W/S by a customer (beneficiary).

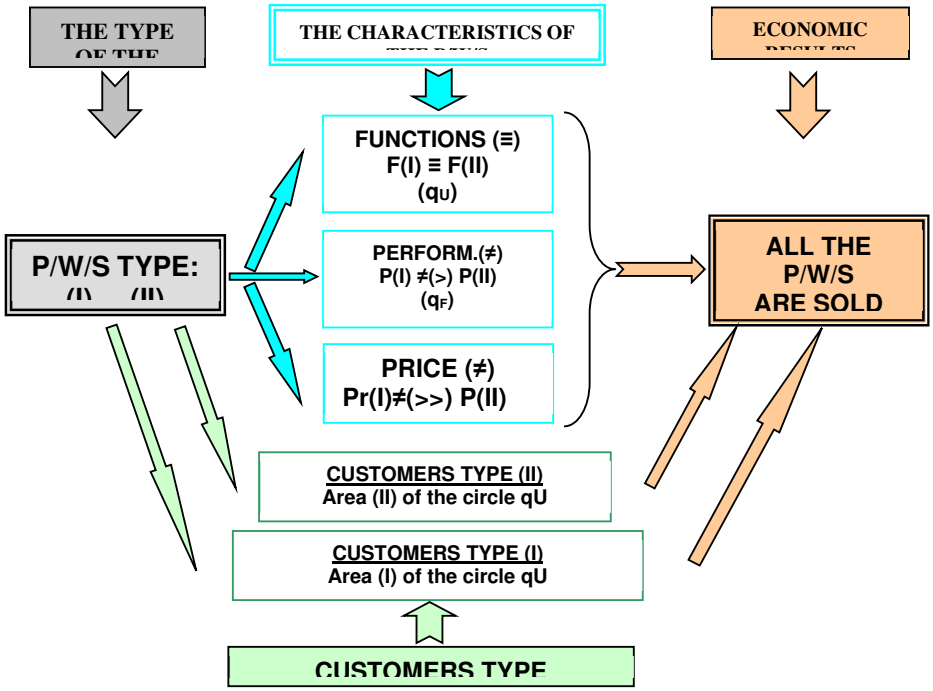

Fig. 3. The scheme of the mechanism of an apparent economic paradox

Fig. 4. The machanism of choice of a P/W/S by the customer

4. CONCLUSIONS

The concept of Products/Works/Services (P/W/S), specific to both production management and quality management, is much more comprehensive than the terms used in the literature, that of goods and services

The Quality Circles (DQC) is a good and efficient tool for analyzing and quatifying the quality of P/W/S.

Based on the discrepancies between the main components of the quality of the P/W/S (quality of use qU - is the quality required by the beneficiary; quality of design qC - is the quality designed, quality of manufactures qF - is the quality of execution itself), are identified, defined and analyzed 7 areas of uncertainty and their implications for the marked and customers. By applying this method, we can identify in the market an economic paradox which refers to the choice by a client (or a client cathegory) of a certain assortment of P/W/S from several totally different assortments, both in terms of quality and selling price.

5. REFERENCES

[1] Olaru, M., *Managementul calităţii*, Ed. Economică, Bucureşti, Romania (1999).

[2] Ioana, A., Semenescu, A., Marcu, D., Ghiban, A., Alina Nicoleta Colan, *Managementul Calității. Teorie şi Aplicații*. Editura Matrix Rom, Bucureşti, Romania (2013).

[3] Ioana, A., Managementul Producţiei în Industria Materialelor Metalice. Teorie şi Aplicaţii. Ediţia a II-a, revizuită şi îmbunătăţită, Editura Printech, Bucureşti, Romania (2016).

[4] Costoiu, M., Ioana, A., Semenescu, A., Marcu, D., Polifroni, M., *Management possibilities for increasing the electric steel quality*, 22ND INTERNATIONAL CONFERENCE ON INNOVATIVE MANUFACTURING ENGINEERING AND ENERGY - IMANE&E 2018, Book Series:MATEC Web of Conferences, Volume:178, Article Number:08008,DOI:10.1051/matecconf/201817808008, Chisinau, R. Moldova (2018).

[5] Ioana, A., Constantin, N., Dragna, EC, *EAF optimal managing elements*, Book Series: IOP Conference Series-Materials Science and Engineering, Volume: 163, UNSP 012004, DOI: 10.1088/1757899X/163/1/012004, WOS:000399755300004, Hunedoara, Romania (2017).

[6] Ioana, A., Semenescu, A., Preda, C.F., *Elements of Quality Analysis in Metallic Materials Production*, Trans Tech Publication, Material Science & Engineering, Periodical Applied Mechanics and Material, Vol. Engineering Solution and Technologies in Manufacturing, DOI: 10.4028/www.scientific.net/AMM.657.881 Switzerland (2014).

[7] Radu, C., Stanciu, R., *Elemente de management industrial*, Ed. Bren, Bucureşti, Romania (2001).

[8] Titu, A.M., *Nonconventional Technologies - a Great Future*, Nonconventional Technologies Review Vol. 25 no. 1, Sibiu, Romania (2021).

Aspecte privind analiza şi cuantificarea calității produselor, lucrărilor şi serviciilor (II)

Rezumat: *Articolul discută un nou concept de producție şi management al calității, şi anume conceptul de Produse / Lucrări / Servicii (P/W/S), mult mai cuprinzător decât cel folosit de obicei în literatură, cel de bunuri şi servicii. Articolul prezintă şi analizează o metodă relevantă de analiză şi cuantificare a calității Produselor/Lucrărilor/Serviciului*

și anume Diagrama Cercurilor de Calitate (DQC). Această metodă evidențiază și analizează 3 componente importante ale calității: calitatea utilizării (qU) - este calitatea cerută de beneficiar; calitatea concepției (qC) - este calitatea proiectată; calitatea fabricației (qF) - este calitatea execuției în sine. Pe baza acestor 3 componente ale calității și implicit a inconsecvențelor dintre ele sunt definite și analizate 7 zone de neconformități. Fiecare dintre aceste domenii este caracterizat și analizat din punct de vedere al consecințelor implicite asupra calității unui Produs / Lucrare / Serviciu. Ele sunt, de asemenea, definite matematic. În legătură directă cu Diagrama cercurilor de calitate, articolul prezintă și analizează mecanismul unui aparent paradox economic din punctul de vedere al alegerii unui P/W/S de către client.

Florin-Ștefan PETCU, Phd. Student, University POLITEHNICA Bucharest, Department Engineering and Management of Obtaining Metallic Materials, E-mail: petcu.stefan25@gmail.com, Phone: +40 727873628, Adress: Bucharest, Street Salaj, no. 355A;
Adrian IOANA, Phd. Proffesor, University POLITEHNICA Bucharest, Department Engineering and Management of Obtaining Metallic Materials, E-mail: adyioana@gmail.com, Phone: +40771398698, Adress: Bucharest, Street Crangasi, no 12;
Claudiu NICOLICESCU, Phd. Student, University POLITEHNICA Bucharest, Department Engineering and Management of Obtaining Metallic Materials, E-mail: nicolicescu_claudiu@yahoo.com, Phone: +40740231587, Adress: Drobeta Turnu Severin, Street Calugareni, No. 1
Monica IORGA (CRĂCIUNICA), Phd. Student, University POLITEHNICA Bucharest, Department Engineering and Management of Obtaining Metallic Materials, E-mail: monicaiorga1@yahoo.com, Phone: +40784476928, Adress: Bucharest, Street M.E. Buteica, no. 12;
Bianca Cezarina ENE, Phd. Student, University POLITEHNICA Bucharest, Department Engineering and Management of Obtaining Metallic Materials, E-mail: biancaene80@gmail.com, Phone: +40721608207, Adress: Stefanesti, Street Bucuresti-Pitești, no. 158;
Dumitru DEONISIE, Phd. Student, University POLITEHNICA Bucharest, Department Engineering and Management of Obtaining Metallic Materials, E-mail: miradeonise@yahoo.com, Phone: +40766252553, Adress: Pitesti, Street Tudor Vianu, no. B2A;