ULBS

Universitatea "Lucian Blaga" din Sibiu

Interdisciplinary Doctoral School

PhD Domain: Engineering and Management

RESUME OF THE PHD THESIS

CONTRIBUTIONS REGARDING THE IMPROVEMENT OF THE QUALITY MANAGEMENT SYSTEM OF A CERAMIC INDUSTRY COMPANY

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CONTENT

Keywords: quality, quality management system, ISO 9001:2015, risk management, PDCA Cycle, Ishikawa Diagram, 8D Method, continuous improvement, real-time monitoring platform of the quality management system.

INTRODUCTION

The topic addressed in this doctoral thesis is entitled **"Contributions regarding the improvement of the quality management system of a ceramic industry company"** and aims to optimize the quality management system existing within the organization considered by establishing and implementing measures in order to improve and monitor in real time this system.

The choice of this research topic results, on the one hand, from personal desire, as an employee of S.C. APULUM S.A., to improve the current management system within the organization and, on the other hand, from the awareness of the importance of quality management system in an organization whose main activity is production, because in the current economic context, quality is associated with competitive advantage, thus, organizations that want to maintain their market position through excellence must consider the quality concept as something natural (Gresoi, 2009[1]).

Economic development, as well as the market economy can be characterized on a global scale by the high pressure exerted on organizations by both customers and society itself, both with high requirements for continuous improvement of the company to maintain its market position. In order to meet both general and specific customer requirements, a company must continually increase the quality of its products and services, because quality is and it will remain the deciding factor for stable economic growth (Simanová and Gejdos, 2015[2]).

Quality management has become an integral part of organizational management for most organizations, its main goal being to achieve and maintain a high level of performance within the company, as well as maintaining the competitiveness of the entire organization in the market (Simanová și Gejdos, 2015[3]). Therefore, gaining a competitive advantage allows the organization to create a defensive position against its competitors, thus differentiating itself from them (Azizi et al., 2016[4]).

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[1] Gresoi, S., Managementul calității, Editura Pro Universitaria, București, România, (2009)
[2] Simanová, L., Gejdos, P., The Use of Statistical Quality Control Tools to Quality Improving in the Furniture Business, Procedia Economics and Furniture, vol.34, pp. 276-283, (2015)
[3] Ibidem
[4] Azizi, R., Maleki, M., Moradi-Moghadam, M., Cruz-Machado, V., The impact of knowledge management practices on supply chain quality management and competitive advantages, Management and Production Engineering Review, vol. 7, nr. 1, pp. 4-12, (2016)

The quality management system based on ISO 9001 has been widely accepted as a driving force for improving the performance of organizations (Usman et al., 2019). ISO 9001: 2015 is a globally applicable standard that provides the necessary resources to help an organization to improve its performance based on the PDCA (Plan-Do-Check-Act) principle to achieve continuous improvement (Betlloch-Mas et al., 2019[5]).

At the same time, the current version of the ISO 9001 standard, respectively the one from 2015, clarifies very well the concept of "risk-based thinking". According to this edition, in addition to the basic processes, risk management must also include the "external supply of goods and services". Including the risk management concept since previous editions, the ISO 9001 version published in 2015 clarifies this concept by integrating it into the management system. A risk-based thinking in a company is a thinking based on a procedural approach, being an integral part of the processes, its purpose being to prevent the occurrence of risks, but also to identify improvement opportunities, also called positive risks (Sârb et al., 2020[6]).

Going into details, risk management refers to a structured process that involves actions or activities undertaken in order to reduce the chances of occurrence of unwanted events and/ or mitigate their effects in case of occurrence (Santos and Rébula de Oliveira, 2019[7]). Also, ISO 31000 standard has been developed in the risk management field. It provides principles and guidelines for risk management.

The research aims to improve the quality management system within the company S.C. APULUM S.A. by establishing and implementing measures to improve and monitor in real time this system.

Thus, the **following objectives** were established:

O1. Perform a bilbiographic study;

O2. Analysis of the quality management system implemented within the organization S.C. APULUM S.A. by using specific techniques and tools;

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[5] Betlloch-Mas, I., Ramón-Sapena, R., Abellán-García, Pascual-Ramírez, J.C., Implementation and operation of an integrated quality management system in accordance with ISO 9001:2015 in a dermatology department, Actas Dermosifiliogr., vol. 110, nr. 2, pp. 92-101, (2019)

[6] Sârb A., Burja Udrea, C., Itul, L., Popa, M., The improvement of a quality management system by applying risk management, Annales Universitatis Apulensis Series Oeconomica, nr. 22, vol. 2, pp. 112-125, (2020)

[7] Santos, R.B., Rébula de Oliveira, U., Analysis of occupational risk management tools for the film and television industry, International Journal of Industrial Ergonomics, vol. 72, pp. 199-211, (2019)

O3. Centralization, processing and analysis of data obtained from the application of specific techniques and tools;
O4. Improving the quality management system within S.C. APULUM S.A. by establishing and implementing measures for real-time improvement and monitoring.

The study was conducted in an organization named S.C. APULUM S.A. Founded in 1970 in the city of Alba Iulia, S.C. APULUM S.A. is the most important producer in the field of ceramic industry in Romania and in South-Est Europe, with a diversified production: household and HoReCa porcelain articles, decorative objects, frills (Sârb et al., 2018[8]; Sârb et al., 2019[b9]).

The "Apulum" brand is the guarantee of quality porcelain, supported by the experience of over 50 years of existence, a brand whose credibility results from the main strengths of the organization: quality of raw materials used, modern technology, staff structure, the price-quality ratio perfectly adapted to customer`s requirements, modern and dynamic management, adaptable to the changes that may occur in the internal and external business environment (Sârb et al., 2019[a10]; Sârb et al., 2019[c11]).

STRUCTURE AND CONTENT OF THE DOCTORAL THESIS

This doctoral thesis is structured in nine chapters divided into both subchapters and sub-subchapters for easy understanding and reading. Also, each chapter concludes with a subchapter of partial conclusions, which have the role of highlighting the main issues addressed.

Chapter I, entitled "*The current state of knowledge*" addresses notions from the literature regarding the emergence and definitions of the quality concept, risk management information, international standardization in the fields of quality and risk management, ISO certification and quality assessment of an organization.

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[8] Sârb, A., Itul, L., Popa, M., Study regarding the customer satisfaction and confidence analysis by the implementation of quality management system in S.C. APULUM S.A., Proceedings of the 9th International Conference of Doctoral Students and Young Researchers, Emerging Markets Economics and Business. Contributions of Young Researchers, nr.6, pp. 222-225, (2018)
[9] Sârb, A., Glevitzky, I., Itul, L., Popa M., The improvement of quality management system in a porcelain factory, MATEC Web of Conferences, vol. 290, pp. 1-11, (2019[b])
[10] Sârb, A., Itul, L., Popa M., Changes occured in a porcelain factory due to quality management system implementation, Oradea Journal of Business and Economics, vol. 4, nr. 1, pp. 47-55, (2019[a])
[11] Sârb, A., Itul, L., Goleanu, A., Popa M., Improvement of product quality in a porcelain factory, Journal of Environmental Protection and Ecology, vol. 20, nr. 4, pp. 1987-1994, (2019[c])

Therefore, according to the literature consulted in order to write this chapter, over time various definitions of quality have emerged, these being highlighted in table 1.1 of the thesis.

Another important concern is the evolution of quality over time. In this sense, figure 1.1 presents the 4 important stages, respectively: inspection, quality control, quality assurance and total quality management.

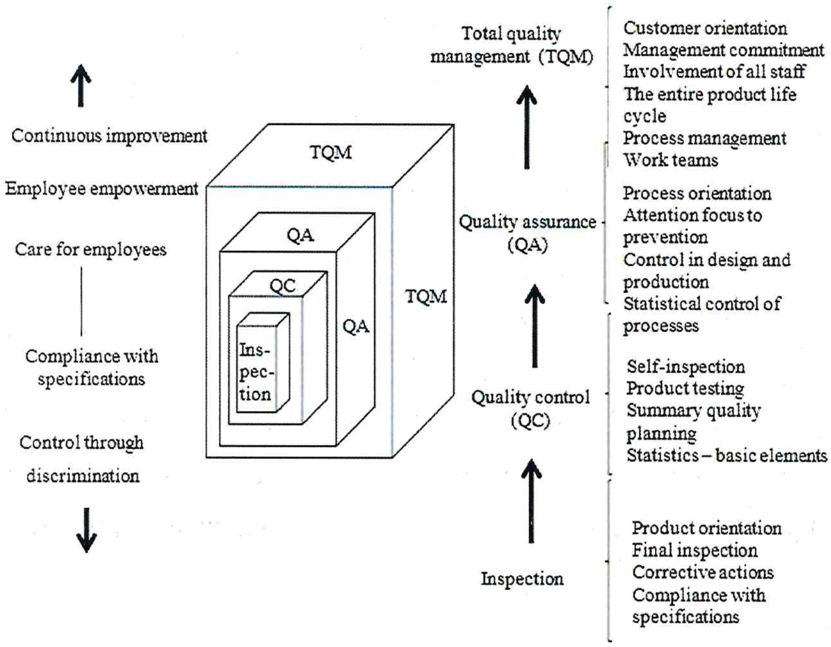

Figure 1.1 The evolution of quality over time

Source: Oprean and Kifor, 2002[12]

The identified stages are defined as follows: quality inspection - assessment of conformity by observation and judgment, accompanied, as appropriate, by measuring, testing or comparison with the gauge (Oprean et al., 2012[13]), quality control - part of quality management focused on meeting quality requirements (Oprean, 2005[14]), quality assurance - part of quality management focused on providing confidence that quality requirements will be fulfilled (Oprean and Kifor,

[12] Oprean, C., Kifor, C.V., Managementul Calității, Editura Universității „Lucian Blaga" Sibiu, România, (2002)

[13] Oprean, C., Kifor, C. V., Suciu,O., Alexe, C., Managementul integrat al calității, Editura Academiei Române, București, România, (2012)

[14] Oprean, C., Managementul calității, Editura Alma Mater, Sibiu, România, (2005)

2002[15]) and total quality management - an integrated set of activities aimed at establishing and controlling work processes, managing resources, conducting evaluations and continuous improvement (Carey, 2018[16]).

Chapter II, entitled "*Research methods and techniques*", presents various methods and techniques described in the literature in the fields of quality management and risk management, as well as specific techniques and tools for data analysis, interpretation and modeling.

Following the analysis of the described techniques and tools, it was concluded that, within the doctoral thesis, for data analysis and improvement of the quality management system the next tools are best suited: *SWOT Analysis*, *PDCA Cycle*, *8D Method*, *5Why Technique*, *Ishikawa Diagram*, *Brainstorming Technique*. The following techniques and tools are proposed for risk identification, analysis and assessment: *SWOT Analysis*, *Brainstorming Technique*, *Interview Technique*, *Risk Matrix, Severity*, *Detectability* and *Probability* criteria and for the processing of data obtained from quality surveys, the use of the *Weka Technique* is required.

At the same time, this chapter highlights a first contribution regarding the optimization of the *Probability* scale by introducing a new value, this being preceded by the elaboration of the *Risk Matrix* and by the renaming of the considered risk categories.

Chapter III, entitled "*Analysis of the quality management system in a ceramic industry company*", presents a description of the organization where the case study was conducted, providing details on both the company's history and identification data, as well as the quality management system implemented and the procedural approach of this system.

Thus, an important contribution in the doctoral thesis is the process map developed at the organization level and illustrated in figure 3.1.

[15] Oprean, C., Kifor, C.V., Managementul Calității, Editura Universității „Lucian Blaga" Sibiu, România, (2002)
[16] Carey, R.B., What Is a Quality Management System and Why Should a Microbiologist Adopt One?, Clinical Microbiological Newsletter, vol. 40, nr. 22, pp.183-189, (2018)

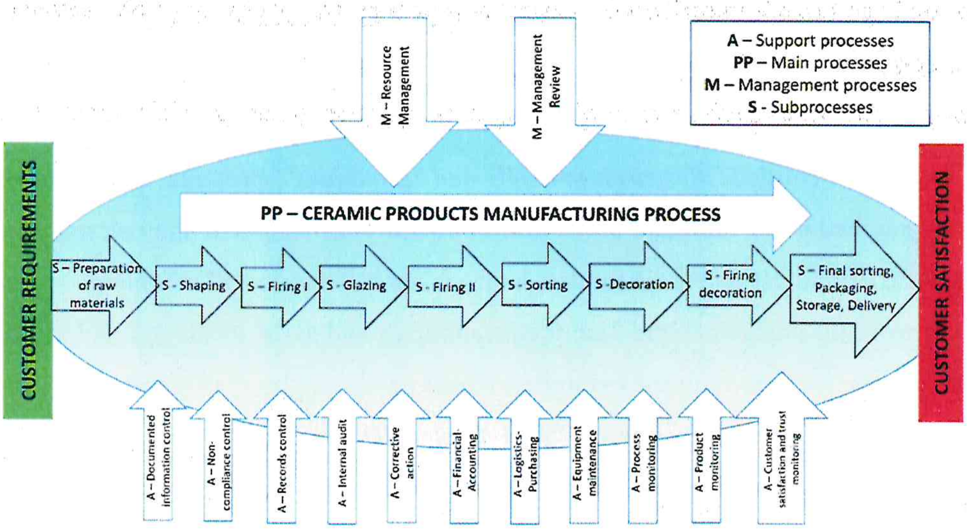

Figure 3.1 The process map belonging to S.C. APULUM S.A.

Source: own contribution

Figure 3.1 shows the process-based approach of the quality management system within S.C. APULUM S.A. In this context, three categories of processes were identified:

1. Management processes - Resource management, Management review;

2. Main processes - this section includes the technological process of manufacturing of the ceramic products which is divided into the following subprocesses: Preparation of raw materials, Shaping, Firing I, Glazing, Firing II, Sorting, Decoration, Firing decoration, Final sorting, Packaging, Storage, Delivery.

3. Support processes - Documented information control, Non-compliance control, Records control, Internal audit, Corrective action, Financial-Accounting, Logistics-Purchasing, Equipment maintenance, Process monitoring, Product monitoring, Customer satisfaction and trust monitoring.

Chapter IV, entitled "*Contributions regarding the implementation of the quality improvement methods in the quality management system*" presents the application of specific quality management methods in order to improve aspects resulting from the application of quality management functions on the quality management system considered.

Therefore, following the usage of the quality functions, namely quality planning, quality monitoring and quality improvement, the decision-making subprocesses within the quality management system were identified. These subprocesses were analyzed, the results highlighting two non - compliances and a possibility for improvement.

The first non-compliance concerns the lack of priorities for analyzing improvement opportunities. In other words, the priorities for analyzing these opportunities are not defined within the organization. Therefore, there is a risk that those opportunities that bring more added value will be delayed, because there are no established criteria to apply in all cases. At the same time, the improvement opportunities of some employees may be analyzed more quickly than those of other employees, which may lead to conflicts between employees or even lack of involvement of some of them. Therefore, the PDCA cycle was applied to solve this nonconformity.

The second nonconformity concerns the planning of improvement actions. Going into details, the planning of these actions is not documented, as a result there is no record of these actions regarding the duration of implementation, the necessary resources (human and/ or financial), implementation responsibilities and, if necessary, those responsible for making the changes required in existing documented information/ creating new documented information. At the same time, risk management on improvement actions is not applied. The solution of this nonconformity was achieved by applying the *8D Method*. Following the application of this method, within the Discipline 6: Validation of permanent corrective actions, the first need to design a real-time monitoring platform of the quality management system was identified.

Because quality functions highlight the possibility of improving a decision-making subprocess in the quality management system, this issue was addressed in **Chapter V**, entitled "*Contributions to the implementation of machine learning techniques in the quality management system*". For this purpose machine learning tools, like *Weka software*, are applied to obtain predictions for the next 12 months (year 2021) on the trend of occurrence of the most common defects established following the analysis of the data from quality surveys conducted during 2019-2020 for three product groups: cups, pressed plates and jiggered plates.

The predictions were carried out based on the algorithms available in the *Weka software*, the results obtained highlighting the instability of the process regarding the occurrence of defects, so choosing the prediction that is closest to reality is difficult to make. However, a graph was selected for each product group (Figures 5.1-5.3) that presents the closest forecast compare to the graph corresponding to the initial values.

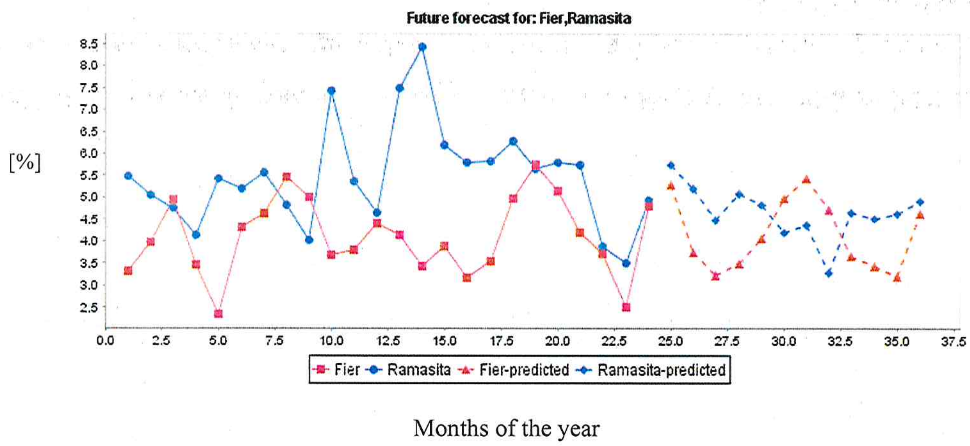

Figure 5.1 Mugs defects forecasting - M5Rules algorithm

Source: own contribution

From the analysis of the graph it can be seen that the initial values related to the considered defects show unstable values, so that in the case of both iron and bits the real values recorded irregular increases and decreases. With regard to iron, the lowest values were recorded in May 2019 (2,33%) and November 2020 (2,50%), while the highest values were recorded in August 2019 (5,47%) and July 2020 (5.75%). For bits, the lowest values were recorded in October and November 2020 (3,89%; 3,50%) and the highest values were recorded in January and February 2020 (7,50% and 8,42%).

The prediction values illustrated in Figure 5.1 show, like the actual values, irregular increases and decreases, which further indicates an instability of the process regarding the occurrence of defects. Also, in the case of iron, the predicted values are inside the initial range, the minimum value being 3,19% in November 2021 and the maximum value being 5,44 in July 2021. The latest value is with 0,31% lower than the actual maximum value. With regard to the second defect considered, bits, the minimum predicted value is less than the minimum initial value by 0,22%, registering the value of 3,28%. At the same time, the maximum value predicted shows a considerable decrease compared to the maximum real value of 2,67%, registering a value of 5,75%.

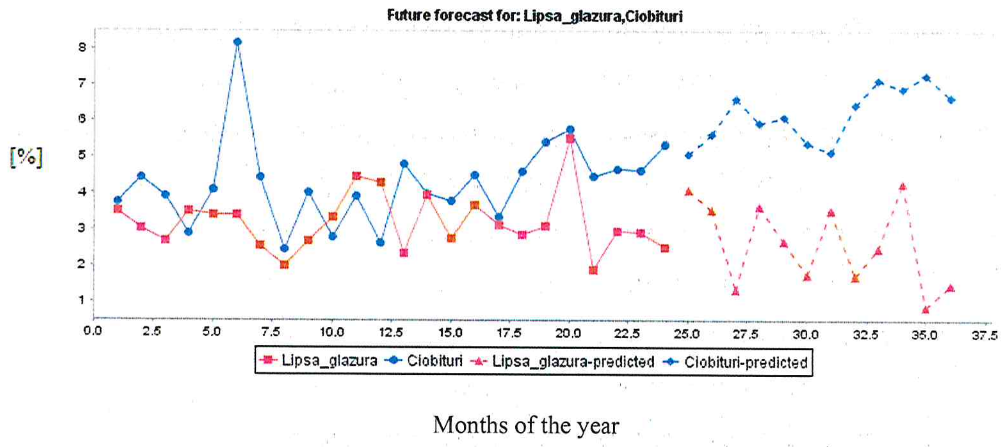

Figure 5.2 Pressed plates defects forecasting - Gaussian Process algorithm

Source: own contribution

Figure 5.2 shows that the initial values for defects considered for this product group, missing glaze and chiped, are different for each month. At the same time, successive increases and decreases can be observed, both more sudden and slower in the values of the two defects. The real values related to the missing glaze are quite grouped, most of them being between 2 - 4%, exceptions being identified in November 2019, December 2019, August 2020 when the highest values were registered, namely 4,46 %, 4,29%, 5,52% and in September 2020 when the lowest value was recorded, respectively 1,88%. Regarding the chipped, the lowest value is 2,44%, being identified in August 2019 and the highest value is 8,15% in June 2019. Values close to the minimum value were also identified in April 2019, October 2019 and December 2019, these being 2,89%, 2,77% and 2,62%. In 2020 the lowest value was 3,34%. The rest of the months recorded values between 3% - 5%, except for the maximum value and the values of 5,40%, 5,76%, 5,33% recorded in July 2020, August 2020 and December 2020. It can be observed that if in the first year considered, 2019, the lowest values were identified, in the following year, 2020, the highest values were identified.

The prediction resulting from the application of Gaussian Process algorithm illustrates different values each month for each of the two considered defects. For missing glaze, the highest value was registered in October 2021, this being 4,27%, and in the following month, in November 2021, the lowest value was registered, respectively 0,86%. The minimum predicted value is with 1,02% lower than the initial minimum value. Also, other values lower than the initial minimum value were predicted in March 2021 (1,33%), June 2021 (1,77%), August 2021 (1,71%) and December 2021 (1,49). %). The predicted maximum value is lower than the initial maximum value by 1,25%. In the case of chipped, the minimum value of the prediction is 5,08% and it is found in January 2021, while the maximum value of the prediction is 7,26% in November 2021. Therefore, both values identified in the prediction fall between the initial minimum and maximum value.

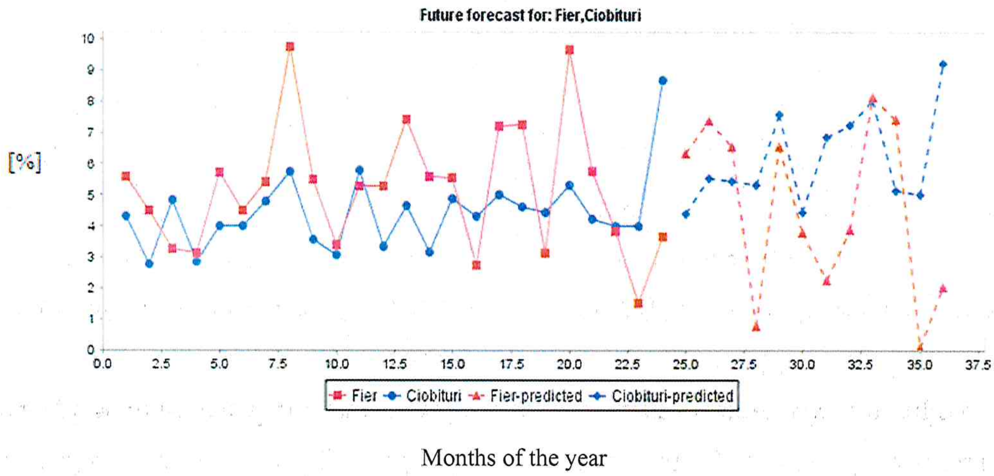

Figure 5.3 Jiggered plates defects forecasting - Gaussian Process algorithm

Source: own contribution

The graph illustrated in Figure 5.3 shows that the actual values for the defects considered for this product group show most of the months increases and decreases, more sudden or slower.

Therefore, in the case of iron, very close values are identified in March-April 2019 (3,29% - 3,13%), November-December 2019 (5,29% - 5,27%), February-March 2020 (5,58% - 5,56%) and May-June 2020 (7,22% - 7,25%). At the same time, there are two high increases (9,75% and 9,67%) in August 2019 and August 2020. The value recorded in August 2019 represents the maximum value and the value recorded in November 2020 represents the minimum value, respectively 1,50%. In the case of chipped, it can be observed that the same value, respectively 4,00%, was recorded both in May-June 2019 and October-November 2020. The lowest value, respectively 2,80%, was registered in February 2019, while the highest value, 8,67%, was registered in December 2020.

The analysis of the graph presented in figure 5.3 highlights that values predicted for the next 12 months are different, both for iron and chipped. For iron, the lowest value, 0,09%, is predicted in November 2021 and it is with 1,41% lower than the initial minimum value and the highest value, 8,10%, is predicted in September 2021 and it is with 1,65% lower than the initial maximum value. Also, the chart shows two sharp declines of the values, from March to April and from October to November, as well as two sharp increases from April to May and from August to September. In terms of chipped, the lowest predicted value is 4,39% in the first month of 2021 and the highest value is 9,23% in the last month of the year. Both values indicate increases of the value of chipped for 2021, the first by 1,59% compared to the initial minimum value and the second by 0,56% compared to the maximum value recorded in the period 2019-2020.

In order to validate the algorithms chosen for each product group, it is intended to compare the data obtained with the real values for 2021.

Chapter VI, entitled "*Contributions regarding the application of risk management techniques in the quality management system*" addresses risk management on the quality management system by applying characteristic subprocesses (identification, analysis, assessment, treatment, monitoring and review of risks) to specific requirements of the quality management system described in the reference standard ISO 9001: 2015 and applicable in the porcelain factory.

By using *Brainstorming* and *Interview techniques*, 35 risks have been identified that may affect the proper functioning of the quality management system.

Subsequently, the risks were analyzed using the following three criteria: *severity*, *detectability* and *probability*. Thus, each risk was assigned different values specific to the criteria considered.

The risk assessment was performed using the *Risk Matrix Method*. Thus, after calculating the *Value of Risk Level* by multiplying the *severity*, *detectability* and *probability* values assigned to each risk in the previous subprocess, the risks were assessed by placing them in one of the four categories considered, respectively: low risk, medium risk, high risk and critical risk.

The risk assessment indicates the need to treat 19 risks, which are classified as medium, high and critical risks. In this regard, a *Risk Management Plan* has been developed and implemented, which includes, in addition to the risk management actions the responsible employees for the implementation of these actions and deadlines. It is observed that in case of 10 risks, representing 52,6% from the treated risks, the same treatment action was identified, namely the creation and implementation of a real-time monitoring platform of the quality management system. Subsequently, the treated risks were re-analyzed and re-evaluated using the same criteria (*severity*, *detectability*, *probability*), the results showing that 18 risks were classified as low risks, which can be accepted and 1 risk was included as high risk, before being classified as critical risk. Therefore, only one risk was subject to additional treatment actions. In this case, an additional *Risk Management Plan* has been developed. After the implementation of the additional actions, the considered risk was re-analyzed, respectively re-evaluated, being included in the category of low risks. Although initially, the implemented treatment actions had an efficiency of 94,7%, after considering the additional actions, their efficiency increased to 100%.

A *Risk Monitoring and Review Plan* has been developed for a regular monitoring and review of the risk management process and its results. This plan provides an overview of the risk management of the quality management system within the considered organization.

Chapter VII, entitled "*Designing a real-time improvement tool of the quality management system within a company in the ceramic industry*", presents, in the first part, the main needs that led to the decision to design such a platform and in the second part the actual design of the platform.

The need to design the real-time monitoring platform of the quality management system results both from the previous chapters of the thesis (chapter 4, chapter 6) and from the need for continuous improvement of this system.

Thus, the platform aims to improve the quality management system by accessing and monitoring in real time all the processes integrated in this platform. The design started from the correspondence between the requirements of ISO 9001: 2015 and the specific processes within the organization, so that the compliance with these requirements can be verified in real time. Initially, some of the processes specific to the quality management system were selected, but after validation, if it is concluded that the platform fulfills the identified needs, all the processes of the quality management system applicable within the organization will be considered.

The considered processes are carried out through documented information specific to the quality management system elaborated within the organization, namely: *system procedures*, *working procedures*, *technological procedures*, *technological instructions*, *control instructions*, *analysis instructions*, *control plans*, *analysis plans*. Therefore, the real-time monitoring platform of the quality management system will include documented information describing the processes considered.

The platform will allow the dissemination, withdrawal and archiving of documented information, the first two actions will be notified by e-mail to the persons to whom they apply. Also, the documented information refers to various quality records, which will be uploaded to the platform. It will allow the completion and validation of the entered data. If wrong data will be introduced during the completation of a record, they may be modified by the approval of the department manager. At the same time, the platform will allow searching for a document by using the search function, as well as printing the uploaded documents.

The platform will be structured in 26 sections, which represent the existing departments in the organization. Thus, by accessing a section - for example Sales department - all the information specific to this section existing on the platform will appear (figure 7.1).

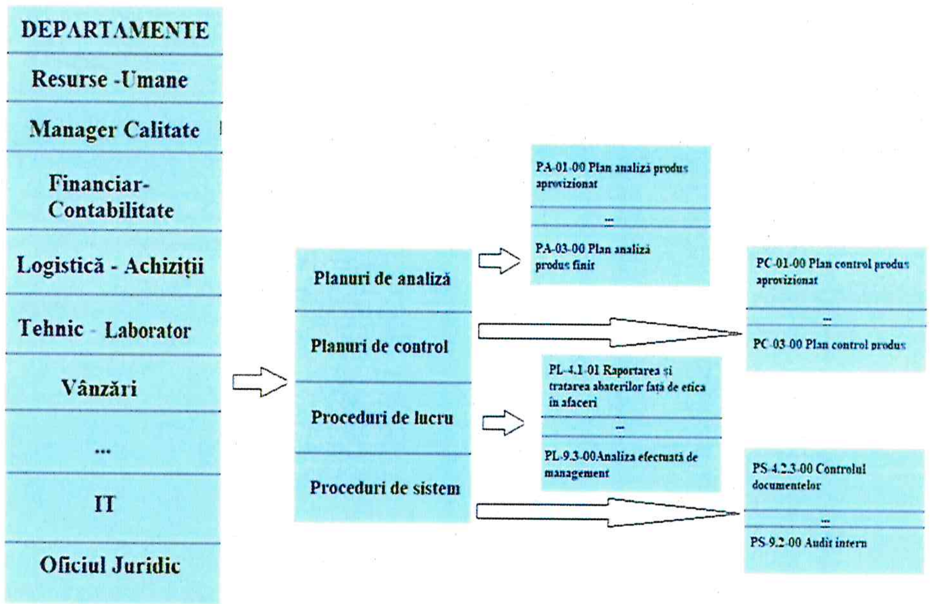

Figure 7.1 Conceptual design of the real-time monitoring platform of the quality management system – Accessing the Sales department

Source: own contribution

Access will be possible through user/ administrator accounts, depending on the responsibilities of each employee. To log in to the platform, users will need to enter their ID number in the dedicated section, while administrators will enter both a username and an appropriate password, in terms of length and composition.

The security of the entered information will be ensured by active firewall and antivirus, as well as by the backup of all servers and databases, both locally and in cloud. In order to ensure the sustainability of the real-time monitoring platform of the quality management system, at its design, it was decided to realize a combination of elements of modern WEB technologies and open source relational databases. Thus, the design of the platform was done using the following programming languages *Cascading Style Sheets* (CSS), *HyperText Preprocessor* (PHP), *JavaScript*; markup language *HyperText Markup Language* (HTML) and *MySQL* databases. In other words, the design of the graphical interface of the platform, as mentioned in figure 7.1, was done by using the *PHP* and *JavaScript* programming languages, generating the HTML version, readable by the browser and visible to the user, this being highlighted in figure 7.2

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▼ <body> overflow
  ▼ <div class="container"> overflow
    ▼ <div class="row"> flex
      ▼ <div class="col-md-12">
          <input id="namePag" type="hidden" value="pagIntroducere">
        ▶ <header class="header"> … </header>
        ▶ <div class="container"> … </div>
          <hr>
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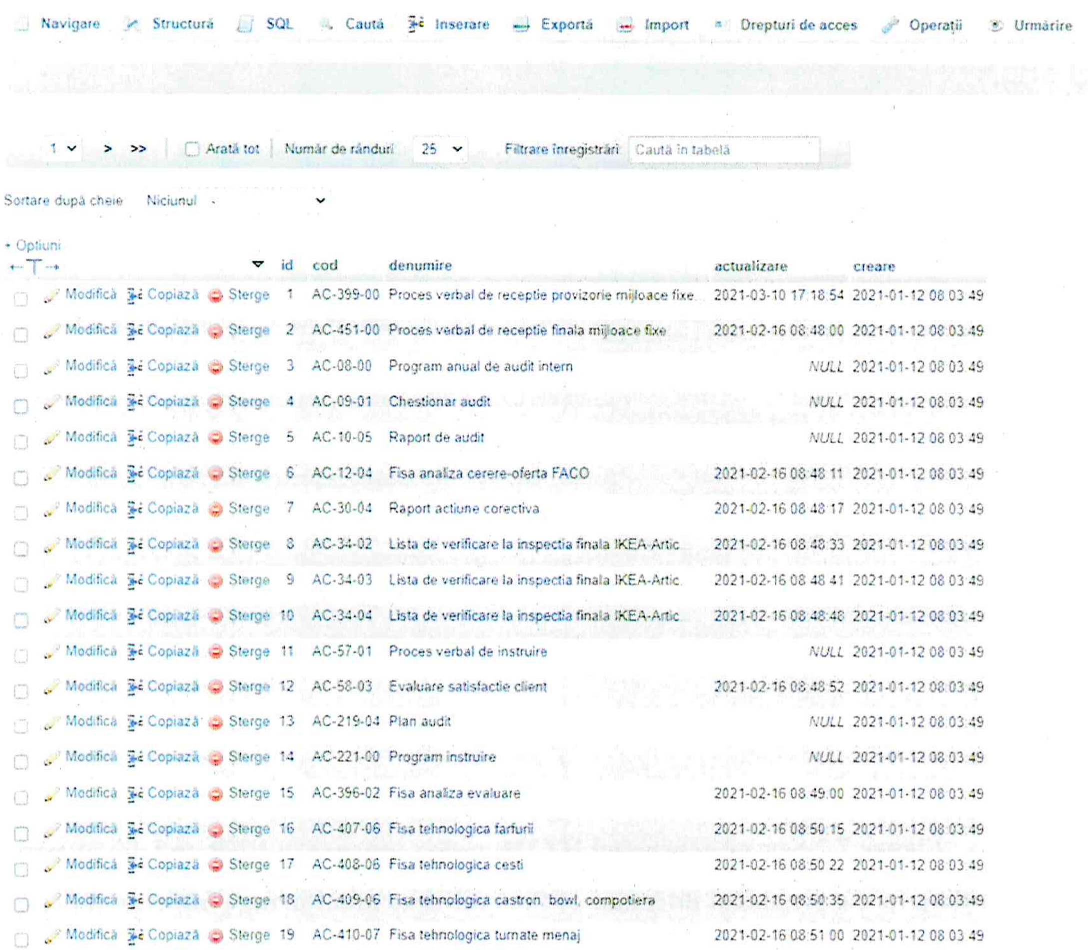
Figure 7.2 Server generated HTML code sequence in PHP and JavaScript corresponding to the graphical interface of the real-time monitoring platform of the quality management system

Source: own contribution

The next step after the creation of the graphical interface was the design of the documented information and the related records using *PHP* programming language. The style used (text size, colors, font, borders, spacing, alignments) was realized with the help of *CSS* language.

The management of the databases resulted from the design of the real-time monitoring platform of the quality management system is provided by *MySQL* and the graphical interface used to manage these *MySQL* databases is *PHPMyadmin.* An example of *MySQL* database viewed in *PHPMyadmin* is shown in Figure 7.3.



			id	cod	denumire	actualizare	creare
Modifică	Copiază	Șterge	1	AC-399-00	Proces verbal de receptie provizorie mijloace fixe	2021-03-10 17:18:54	2021-01-12 08:03:49
Modifică	Copiază	Șterge	2	AC-451-00	Proces verbal de receptie finala mijloace fixe	2021-02-16 08:48:00	2021-01-12 08:03:49
Modifică	Copiază	Șterge	3	AC-08-00	Program anual de audit intern	NULL	2021-01-12 08:03:49
Modifică	Copiază	Șterge	4	AC-09-01	Chestionar audit	NULL	2021-01-12 08:03:49
Modifică	Copiază	Șterge	5	AC-10-05	Raport de audit	NULL	2021-01-12 08:03:49
Modifică	Copiază	Șterge	6	AC-12-04	Fisa analiza cerere-oferta FACO	2021-02-16 08:48:11	2021-01-12 08:03:49
Modifică	Copiază	Șterge	7	AC-30-04	Raport actiune corectiva	2021-02-16 08:48:17	2021-01-12 08:03:49
Modifică	Copiază	Șterge	8	AC-34-02	Lista de verificare la inspectia finala IKEA-Artic	2021-02-16 08:48:33	2021-01-12 08:03:49
Modifică	Copiază	Șterge	9	AC-34-03	Lista de verificare la inspectia finala IKEA-Artic	2021-02-16 08:48:41	2021-01-12 08:03:49
Modifică	Copiază	Șterge	10	AC-34-04	Lista de verificare la inspectia finala IKEA-Artic	2021-02-16 08:48:48	2021-01-12 08:03:49
Modifică	Copiază	Șterge	11	AC-57-01	Proces verbal de instruire	NULL	2021-01-12 08:03:49
Modifică	Copiază	Șterge	12	AC-58-03	Evaluare satisfactie client	2021-02-16 08:48:52	2021-01-12 08:03:49
Modifică	Copiază	Șterge	13	AC-219-04	Plan audit	NULL	2021-01-12 08:03:49
Modifică	Copiază	Șterge	14	AC-221-00	Program instruire	NULL	2021-01-12 08:03:49
Modifică	Copiază	Șterge	15	AC-396-02	Fisa analiza evaluare	2021-02-16 08:49:00	2021-01-12 08:03:49
Modifică	Copiază	Șterge	16	AC-407-06	Fisa tehnologica farfurii	2021-02-16 08:50:15	2021-01-12 08:03:49
Modifică	Copiază	Șterge	17	AC-408-06	Fisa tehnologica cesti	2021-02-16 08:50:22	2021-01-12 08:03:49
Modifică	Copiază	Șterge	18	AC-409-06	Fisa tehnologica castron, bowl, compotiera	2021-02-16 08:50:35	2021-01-12 08:03:49
Modifică	Copiază	Șterge	19	AC-410-07	Fisa tehnologica turnate menaj	2021-02-16 08:51:00	2021-01-12 08:03:49

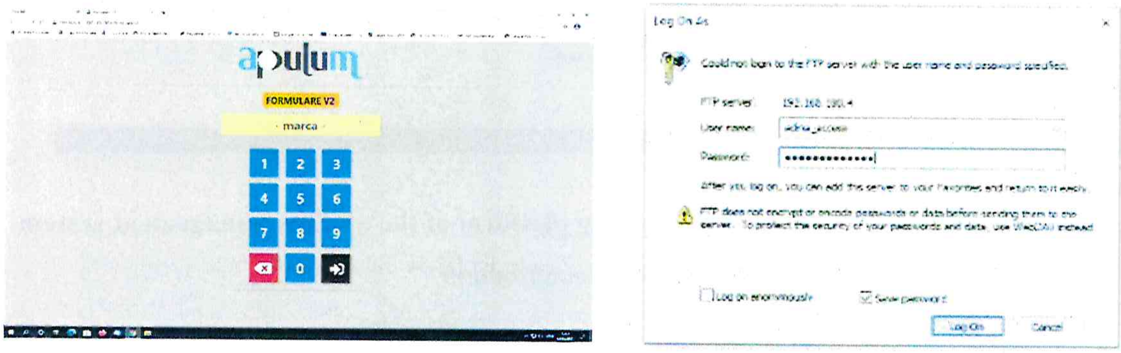
Figure 7.3 MySQL database viewed in PHPMyadmin

Source: own contribution

MySQL databases are saved on the *Apache HyperText Transfer Protocol* (*HTTP*) server. This is an open source HTTP web server, compatible with Unix, Microsoft, Windows and other platforms. Therefore, the platform will work through web browsers.

Chapter VIII, entitled "*Validation of the real-time improvement platform of the quality management system*" presents the strengths, weaknesses, opportunities and threats regarding the validation of the real-time monitoring platform of the quality management system, all these in the form of a *SWOT Analysis*. Also, this chapter highlights the results obtained after validation of the platform.

Thus, according to those mentioned in the previous chapter, access to the platform is achieved by username and password/ ID number, with different access levels (figure 8.1) for each head of department/ responsible for organizing the quality management system in each department.



a) user

b) administrator

Figure 8.1 Access to the real-time monitoring platform of the quality management system

Source: own contribution

Also, the platform has a section dedicated to each department within the organization, this being highlighted in figure 8.2. Thus, within the platform it can be observed the existence of 26 sections specific to existing departments.

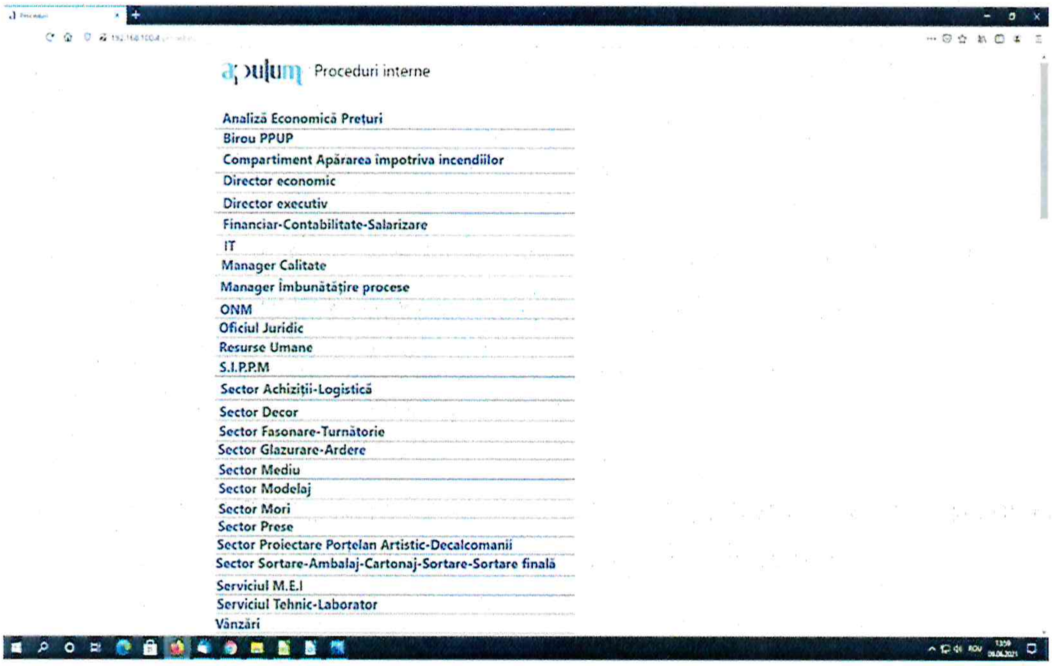


Figure 8.2 Sections of the real-time monitoring platform of the quality management system

Source: own contribution

Accessing any section of the platform displays the categories of documented information applicable to the selected section (*control plans*, *analysis plans*, *system procedures*, *working procedures*, *technological procedures*, *technological instructions*, *control instructions*, *analysis instructions*). Also, the platform allows access to each category in order to show all the documented information applicable to the category considered. After selecting a category of documented information, the platform presents a list of all applicable procedures, this being highlighted in figure 8.3. By clicking on the title of the procedure from the list, the user can view its content in pdf format.

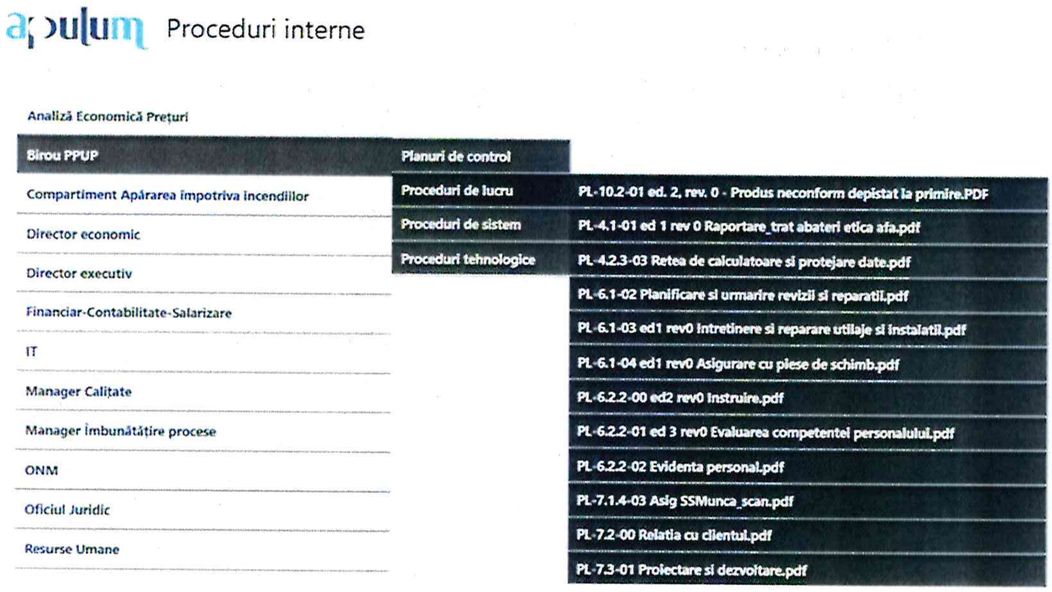


Figure 8.3 Documented information applicable to the considered section

Source: own contribution

Also, the validation of the platform fulfills the needs that led to its design. For example, the platform facilitates the application of risk management to improvement actions by uploading the procedure that describes how to treat risks and opportunities on the platform and the ease of access it by employees of the organization with responsibilities in this regard. Another example refers to the fact that, by creating the platform, some organizational knowledge has passed in electronic format by uploading them on the platform, this replacing the classic process of their dissemination based on signature from all representatives of the quality management system within each department, thus helping to reduce time and energy required for distribution. In electronic format, the visibility of the information contained in the considered knowledge is ensured, even after long periods of time and frequent use.

Another example is the control of documented information through the platform. Therefore, when a documented information is updated, the old edition is replaced by the new edition. At the same time, the platform contributes to the improvement of the various processes specific to the quality management system by uploading the documented information developed in this regard on the real-time monitoring platform and ensuring the possibility of completing them online, which helps to reduce time allocated to the respective processes. Also, the documented information uploaded on the platform are saved on one of the organization's servers for this purpose, thus ensuring their storage for a set period of time.

The last example is the efficiency of the audit process determined by the transposition of the specific documentation on the platform, thus ensuring the possibility of completing it in electronic format and, if necessary, dissemination, which reduce the time allocated to this purpose and ensure traceability of the audit process.

Chapter IX entitled *"Conclusions and future research directions"* contains the final conclusions of this thesis, as well as the main future research directions.

Within the doctoral program, 7 papers were elaborated as first author, being published as follows: 2 papers in journals indexed in Clarivate Analytics, 1 paper in a journal being indexed in Clarivate Analytics, 3 papers in journals indexed in international databases and 1 paper in the volume of a conference. Also, during this period, I participated at 6 international conferences.

CONCLUSIONS AND FUTURE RESEARCH DIRECTIONS

The research carried out in the doctoral thesis aimed to improve the quality management system existing in a ceramic industry company by establishing and implementing measures to improve and monitor in real time this system.

The objectives set to achieve the established goal are:

- Perform a bibliographic study;
- Analysis of the management system implemented within the considered organization by using specific techniques and tools;
- Centralization, processing and analysis of data obtained from the application of specific techniques and tools;
- Improving the quality management system of the ceramic industry company by establishing and implementing measures for real-time improvement and monitoring.

At the same time, the doctoral thesis presents a new approach in the field of risk management integrated within the quality management system.

General conclusions

- The concerns of quality specialists regarding the development of quality systems and techniques are reflected in the rich literature existing in the approached field. A comprehensive bibliographic analysis was performed by studying a number of 262 references, the information being structured and centralized according to the keywords generated by the terminology addressed in this chapter.
- Following the analysis of the techniques and tools presented in Chapter 2, it was concluded that, in the doctoral thesis, for data analysis and improvement of the quality management system best suited are the following: *SWOT Analysis*, *PDCA Cycle*, *8D Method*, *5DE CE Technique*, *Ishikawa Diagram*, *Brainstorming Technique*. The following techniques and tools have been proposed for risk identification, analysis and assessment: *SWOT Analysis*, *Brainstorming Technique*, *Interview Technique*, *Risk Matrix*, *Severity*, *Detectability* and *Probability* criteria and for processing of data obtained from quality surveys, the use of the *Weka Technique* was required.
- Following the organizational analysis resulted the need for a procedural approach of the entire quality management system, so the process map of the considered company was elaborated. This approach allows the identification of existing types of processes and their interaction.
- The analysis of the quality management system was performed through three functions of quality management, being identified the decision-making subprocesses. The results show two nonconformities that require the application of the techniques identified in Chapter 2. They are: lack of priorities for analyzing the improvement opportunities and lack of documentation of the process regarding planning of the improvement actions. The first nonconformity was solved by applying the *PDCA Cycle*, where in the first stage -*Plan*- the root cause of the lack of priorities for analyzing the improvement opportunities was analyzed, using *Ishikawa Diagram*, in terms of *5M* (Management, Medium, Method, Man, Material), identifying 8 root causes. Also in this stage, using the *Brainstorming Technique*, corrective actions were established for each root cause identified. The second stage -*Do*- highlights the fact that all the previously established corrective actions have been implemented within the set deadlines, while the next stage -*Check* - presents the results of the re-evaluation of the considered subprocess. The last stage -*Act*- establishes the actions that will be maintained permanently. The second nonconformity was treated by applying the *8D Technique*. Thus, the first two disciplines provide details on team building and description of the problem considered, discipline 3 establishes temporary actions necessary to be implemented until the root cause is identified, which is addressed in discipline 4. Also, in this discipline, the *5Why*

technique is applied in order to identify the escape point. Subsequently, corrective actions are established in discipline 5, which are validated in discipline 6. Discipline 7 presents the actions identified in order to prevent the recurrence of the problem and the last discipline refers to celebrating the success of the team, recognizing the merits of each member.

- Following the analysis of the considered subprocesses it was identified the possibility of improving the subprocess called "Identification and treatment of non-compliant product". For this purpose, the data from quality surveys carried out in 2019-2020, for three product groups, namely cups, pressed plates and jiggered plates were analyzed. The results of the analysis highlight various quality defects belonging to ceramic products.
- Subsequently, machine learning tools, *Weka software*, were applied to obtain predictions on the evolution of the most common defects specific to each product group for the next 12 months. The initial values of the defects considered for each product group highlight the instability of the process regarding the occurrence of defects, so that it is quite difficult to decide which prediction is closest to reality. However, a graph has been chosen for each product group that presents the closest forecast compare to the graph corresponding to the initial values, with the fact that data obtained for the next 12 months will be compared with the actual data recorded during this period to determine whether the chosen algorithms can be used to improve the subprocess considered.
- Following the analysis of the quality management system by applying risk management, using techniques described in Chapter 2, the risks that may influence the effectiveness of the quality management system have been identified. A new approach has been proposed in the field of risk management by optimizing the *Probability s*cale, the *Risk Matrix* and the risk classification system within the considered company. The application of risk management within the organization highlights the need to create a tool in order to control and improve the quality management system.
- The analysis of the quality management system generated the need to design a platform, which would create a correspondence between the requirements provided in the reference standard, respectively ISO 9001: 2015 and the processes within the organization.
- The design of the platform took into account the existing departments, the access mode and the way of securing the information.
- The validation of the platform fulfills the purpose and the objectives proposed in the thesis, achieving the continuous improvement of the quality management system. Although the platform was created according to the needs identified within the quality management system implemented

in the considered organization, it provides a starting point for all organizations which want to improve their quality management system by creating and implementing such a platform. At the same time, this platform represents a novelty in the field of quality management, because in the literature consulted for the purpose of writing this thesis there is no information on the existence of such a platform.

Original contributions

This doctoral thesis includes the following personal contributions:

- Analysis of the literature in the field of quality management and risk management;
- Optimizing the *probability* criterion by introducing a new scale;
- *Risk Matrix* drawing up;
- Establishing risk categories according to the *Value of the Risk Level*;
- Organizational analysis based on a procedural approach within a company in the ceramic industry;
- Elaboration of the process map at the organization level;
- Own interpretation regarding the application of the quality management principles;
- Analysis of the quality management system by applying three functions of quality management, namely: quality planning, quality control and quality improvement. In this context, the following actions were taken:
    - Analysis of decision-making subprocesses within the quality management system;
    - Treatment of nonconformities identified following the above mentioned analysis by applying specific quality management tools, such as: *PDCA Cycle* (which includes *Ishikawa Diagram* and *5M* - Management, Medium, Method, Man, Material) and *8D Technique* (containing *5Why*);
    - Improving a decision-making subprocess within the quality management system, called "Identification and treatment of non-compliant product". For this purpose, the following were performed:
        - Analysis of data obtained from quality surveys conducted during 2019-2020 for the following product groups: cups, pressed plates and jiggered plates in order to identify the most common defects for each product group;

        - Application of a machine learning tool (*Weka software*) to obtain predictions on the evolution of the most common defects/ product group for the next 12 months (respectively for the year 2021);
        - Analysis of the graphs resulted from the application of the algorithms available in the *Weka software* and choosing that graph whose prediction is most similar to that of the initial graph, for each product group;
- Analysis of the quality management system by applying risk management. In this context the following have been realized:
    - Application of *SWOT Analysis* on the quality management system in order to identify the strengths, weaknesses, opportunities and threats existing at the management system level;
    - Identification of the risks that can influence the effectiveness of the quality management system by using specific risk management techniques - *Brainstorming Technique* and *Interview Technique*;
    - Risk analysis using the following three criteria: *severity* (S), *detectability* (D) and *probability* (P);
    - Risk assessment by calculating the *Value of the Risk Level* and classifying each risk in one of the 4 categories highlighted in the *Risk Matrix*, namely: low risk, medium risk, high risk and critical risk;
    - Elaboration and implementation of the *Risk Management Plan* for the treatment of medium, high and critical risks (establishing treatment actions, responsibilities and implementation deadlines);
    - Reanalysis of treated risks by using the same criteria as in the analysis process;
    - Reassessment of treated risks by using the same procedure as previously described in the assessment process;
    - Establishing additional risk management actions, thus drawing up an additional *Risk Management Plan*;
    - Reanalysis and reassessment of risks following the implementation of additional treatment actions by applying the same procedure described above;
    - Drawing up graphs on the variation of the three criteria considered in the subprocess of the identified risk analysis (*severity*, *detectability* and *probability*);

- Elaboration of the *Risk Monitoring and Review Plan* for the purpose of continuous monitoring and periodic review of the risk management process and its results;

- Improvement of the quality management system implemented within a ceramic industry company by:
  - Identification of the need to design a real-time monitoring platform of the quality management system within the considered organization;
  - Design a real-time monitoring platform of the quality management system using the following programming languages: *Cascading Style Sheets (*CSS), *HyperText Preprocessor* (PHP), *JavaScript;* markup language: *HyperText Markup Language* (HTML) and *MySQL* databases.
  - Elaboration of the *SWOT Analysis* regarding the validation of the real-time monitoring platform of the quality management system in order to identify strengths, weaknesses, opportunities and threats;
  - Actual validation of the real-time monitoring platform of the quality management system;

The above mentioned contributions have a particular importance both in the field of quality management and in the considered organization.

Future research directions

The main directions to be addressed in the future are:

- Comparison of data obtained from the application of machine learning tools with actual data for 2021 in order to determine whether the algorithms chosen for each product group can be used to improve the subprocess considered, namely "Identification and treatment of non-compliant product" by preventing nonconformities that may occur in the manufacturing process;
- Extending the application of *Weka technique* to several defects specific to ceramic products, not only to the first two defects considered to be the most common;
- Optimizing the real-time monitoring platform of the quality management system by considering all the processes specific to the quality system applicable within the organization;

- Studying other machine learning tools that allow defects forecasting, apply these tools and compare the new predictions with predictions already obtained from the application of *Weka software*;
- Developing a user guide for the real-time monitoring platform of the quality management system.

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