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MANAGEMENT THROUGH PROCESSES IN SMES USING QUALITY 4.0.

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Abstract: *In our modern world being competitive is more challenging than ever and all the actions taken by companies leads around Industry 4.0. This paper proposes to implement a method that enhances the transition of SMEs to Industry 4.0 through Quality 4.0. Starting from SME's processes and specific quality tools: Six Sigma, Pareto analysis, 5Whys, using recent industry findings, respectively the new principles of Quality 4.0, a sustainable strategy that may help transition of a SME through automation and digitalization to become a smart company has been focused. As a result of the study, an improvement of the performance indicators of the processes was observed, however, it is necessary to repeat the methodology until the proposed performance targets are reached.*
Key words: *Six Sigma, Pareto, 5Whys, Quality 4.0, Industry 4.0, ISO 9001.*

1. INTRODUCTION

Digital technology is related to new, intelligent, automated platforms through which we can transmit and obtain data [1] Internet of Things (IoT) and Cloud Computing [2] Biometrics [3] and their integration leads to increasing competitiveness and efficiency, which ensures progress.

The 2021 Annual Monitoring Report on EU Member States DESI Study 2021 [4] places Romania at the end of the ranking in terms of the integration of digital technologies. The most known methods of improvement processes and competitiveness have in common finding of the main cause that leads to the appearance of defects: the Shainin method starts from the effects to find out the main cause and uses Pareto's principle. It is used more in manufacturing.

The 8D methodology uses 8 stages to find the main causes of the problems. It has been used for a long time in the automotive industry. The present study aims to use traditional tool Six Sigma that has a wider field of application to improve processes along with the new modern tools that enable automation - the new 8 quality principles [5]. Similar, Dina D. and Severin I. developed a method based on Six Sigma for process improvement in paper [6-7]. The chosen method is very suitable for the automotive industry; however, we will try to propose a similar method with a larger coverage area and that changes it to a smart company.

2. DESCRIPTION OF THE PROCEDURE

The 6 Sigma philosophy was first implemented at Motorola by Bill Smith and is a set of measures used for continuous process improvement. To implement Six Sigma and achieve the target of 3.4 defects per 1 million opportunities, 5 stages are followed (Fig. 1).

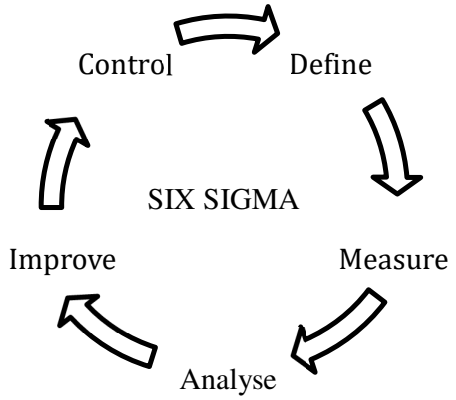

Fig. 1. Six Sigma Methodology

The study aims with the help of Six Sigma (DMAIC) to identify and define the main processes (Define), to measure their performance (Measure), to analyze the main causes of non-conformities (Analyze), to find solutions for solving them in the improvement phase (Improve) and then to ensure that the improvement solutions are effective in the control phase (Control).

The study was carried out within a company with over 20 years of experience in the service, rental, and sale of warehouse equipment in Romania. The company implemented the quality management system according to ISO 9001.

The study was attended by an IT interdepartmental team consisting of: Quality Management System Responsible QMS Resp., Sales Responsible SR, Supply Responsible SPR, Human Resources Responsible HRR, Service Responsible SVR, as well as the authors of the study.

The interdepartmental team IT together with the authors of the study, analyzed the main indicators that measure the performance of the processes and compared the obtained results with the expected results.

For the service activity, a wider analysis was made because the company pursues customer satisfaction and, in this area, the results obtained, respectively the Service Performance Indicator, strictly related to customer complaints, was low. An increase in complaints related to the long time it takes to solve the service request was also recorded.

2.1 Define

At the organization level, the following processes are identified and analyzed according to the ISO 9001:2015 and ISO 9004: 2018 standards [9, 10] and they are sequenced according to Table 1.

Table 1

The types of processes analyzed within the company.

Category	Processes
1. Management processes	1.1 Management Analysis 1.2 Risk analysis
2. Operational processes (products execution)	2.1 Sales 2.2 Service 2.3 Procurement
3. Supporting process	3.1 Human Resources

The process map containing the performance indicators for each process as well as the process responsible is available (Table 2).

2.2 Measure

The company has implemented and maintained the standard ISO 9001 and the quality objectives to be reached, therefore in the second phase the company measures periodically the performance of the above processes, as follows:

- Policy and objectives fulfillment rate - k_{ob}

$$k_{ob} = \frac{\text{achieved objectives}}{\text{targeted objectives}} \quad (1)$$

Interpretation:	low ≤ 0.5 medium $0.5 < k_{ob} \leq 0.7$ very good > 0.7

- Risk coefficient - k_{risc}

$$k_{risk} = \frac{\text{number of risks kept under control}}{\text{number of identified risks}} \quad (2)$$

Interpretation:	low ≤ 0.5 medium $0.5 < k_{risk} \leq 0.8$ very good > 0.8

- Sales performance indicator – k_{sales}

$$k_{sales} = \frac{\text{achieved target}}{\text{proposed target}} \quad (3)$$

Interpretation:	low ≤ 0.5 medium $0.50 < k_{sales} \leq 0.70$ very good > 0.70

- Service performance indicator - k_{serv}

$$k_{serv} = \frac{\text{number of requests received}}{\text{number of solved requests}} \quad (4)$$

Interpretation:	low ≤ 0.7 medium $0.7 < k_{serv} \leq 0.8$ very good >0.8

- Delivery delay control indicator – k_{orders}

$$k_{orders} = \frac{\text{number of orders received}}{\text{number of placed orders}} \quad (5)$$

Interpretation:	low ≤ 0.5 medium $0.5 < k_{Orders} \leq 0.70$ very good >0.7%

- Absenteeism rate - k_{abs}

$$k_{abs} = \frac{\text{number of days of absence}}{\text{number of working days per month}} \quad (6)$$

Interpretation:	$k_{abs} \leq 0.02$ acceptable $k_{abs} > 0.02$ high

Table 2

Process Map.

Process	Inputs	Output	Responsible	Indicator	Checking Period
1.1 Management analysis	Policy and objectives Corrective Actions Stage	Improvement plan	QMS Resp.	Policy and objectives fulfillment rate - k_{ob}	Semester
1.2 Risk Analysis	Risk identification list	Risk register	QMS Resp.	Risk coefficient - k_{risc}	Monthly
2.1 Sales	Sales target	Sales improvement opportunities	SR	Sales performance indicator - k_{sales}	Quarterly
2.2 Service	Service list	The service list with the resolved claim	SVR	Service performance indicator - k_{serv}	Monthly
2.3 Procurement	Supply requirement	Supply requirements filled in	SPR	Delivery delay control indicator - k_{orders}	Monthly
3.1 Human Resources	The attendance form	Completed attendance form	HRR	Absenteeism rate -k_{abs}	Monthly

QMS Resp. - Quality Management System Responsible, SR - Sales Responsible, SVR - Service Responsible, SPR - Supply Responsible, HRR - Human Resources Responsible.

However, to keep up with the new trends of digitalization and transition to Industry 4.0, it is necessary a processes approach through the Quality 4.0 vision and through the 8 new predefined principles of quality management, respectively following the guidelines that define the new quality and how it should be integrated in a company's processes.

Quality 4.0 represents, as a new definition of quality arises from recent research: the leveraging of technology with people to improve the quality of an organization, its products, its services, and the outcomes it creates. Therefore, to improve the performance of the organization, we will consider the following 8 new principles to define Quality 4.0 as CQI stated in 2021:

1 The advantage offered by a process to allow the interested parties, including the clients, to be provided with added value (ex-additional records regarding its evaluation, a.s.o) Briefly: Added value.

2 The opportunity of a process to record data both vertically and horizontally to improve performance. Briefly: Vertical and horizontal recording.

3 The smart networks created must be continuously assessed in terms of risk and transparency because they exceed the traditional limits and interdisciplinary collaborations must be established. Briefly: Risk assessment of smart networks horizontal recording.

4 The automation of certain human activities is constantly changing. Briefly: Automation.

5 Mutual trust regarding the use of data, storage and how organizations use the data collected. Mutual trust in system compliance and data usage. Briefly: Mutual trust.

6 Processes based on continuous and fast learning, on predictability. Briefly: Adaptive learning.

7 The value of process data (these must be identifiable, defined, and able to provide future benefits), Briefly: The identified data is a strategic asset.

8 Symbiotic relationship between humans and machines to improve companies' processes (e.g. virtual reality, augmented reality, artificial intelligence). Briefly: Technology and intelligence combined.

2.3 Analyze

In the third phase, interdepartmental team together with the authors of the study, analyzed the main indicators that measure the performance of the processes and compared the results measured with the target results in the Table 3.

In addition, there was a 15% increase compared with the previous period in the complaints of dissatisfied customers with the duration of service request interventions. A way was sought to reduce them as well as to increase productivity, respectively the k_{serv} service performance indicator.

For the service activity, a brainstorming analysis was proposed between the members of the service department, the Service Department Responsible and the authors of the study. The service requests were identified, grouped according to the complained defect, then the Pareto method was applied.

Table 3

Analysis of performance indicators.

Process	Target indicator	Measured Value	Target Value
1.1 Management analysis	Policy and objectives fulfillment rate - k_{ob}	0.7	> 0.7
1.2 Risk Analysis	Risk coefficient - k_{risc}	0.67	> 0.80
2.1 Sales	Sales performance indicator - k_{sales}	0.67	> 0.7
2.2 Service	Service performance indicator-k_{serv}	0.7	> 0.8
2.3 Procurement	Delivery delay control indicator - k_{orders}	0.68	> 0.7
3.1 Human Resources	Absenteeism rate - k_{abs}	0.021	≤ 0.02

A number of 1325 service requests were identified (September 2021- December 2021) with following defects summarized in Table 4. To identify the key problems and make effective decisions in the future, the Pareto analysis was performed (according to which 80% of defects are due to 20% causes) and the cumulative frequency of defects was calculated to establish the causes in Table 5.

Table 4

Identified Defects.

No.	Defect Type	Number
1	Filters	542
2	Used wheels	430
3	Steering system	65
4	Braking system	71
5	Mast problems	76
6	The electrical system	82
7	Seat sensor	59

Table 5

Calculation of the cumulative frequency of defects.

Defect Type	Defect number	Cumulative defect frequency %
Mast problems	542	40.91
Used wheels	430	73.36
The electrical system	82	79.55
Filters	76	85.28
Braking system	71	90.64
Steering system	65	95.55
Seat sensor	59	100

It was observed that 20% of defects, respectively Mast Problems and Used wheels are responsible for 80% of service requests.

The most common problem encountered in the study with the Mast was the problem with raising it, respectively with the execution of the different types of movements and within the limits for which it was designed. The second most common problem encountered was used wheels. They can cause serious injuries by tipping under the load in use.

Following these observations, the graph in Fig. 2 was obtained:

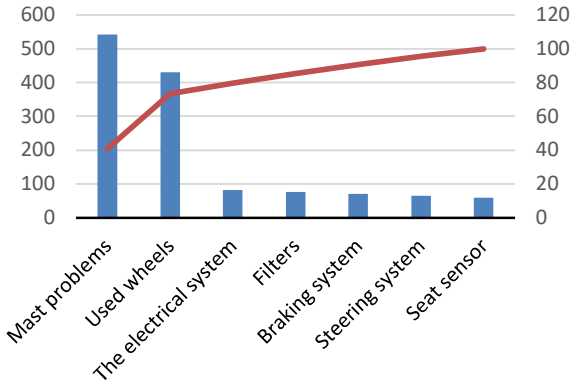

Fig. 2. Data analysis with the Pareto method

To analyze the main causes that produce these defects, the authors of the study together with the members of the service department applied the 5WHY method in Table 6**.**

Table 6

5WHY method.

Encountered problems	**Mast problems**	**Used wheels**
Cause 1	not working	the tires fall
Cause 2	displaced, defective sections	handling of irresponsible equipment
Cause 3	mast and mast rollers	improper working conditions
Main Cause	aging, heat, broken cables	their recommended pressure is not considered
Preventive action	to check the mast and rollers periodically	checking compliance with recommended pressure conditions

2.4 Improve

The next phase of 6 Sigma was followed further. For the service activity, a form was drawn up with the aim of being completed by the client periodically as a preventive action, to ensure the predictability of the occurrence of the above defects and to be able to schedule a service in advance to avoid overloading the activity the department. The customer is going to periodically record the measurements made in this form (Table 7).

Table 7

Daily checkup form for customers.

Date: ../../…. Daily check (operation)		Roller and mast checking	Checking compliance with recommended pressure conditions
Equipment 1		x	x
Equipment 2		x	x
Equipm. n		x	x
STATUS	OK	ok	ok
	NO (description)	equipment 2 anointment	no
Requires service schedule		yes	no

For all processes, Interdepartmental Team together with the authors of the study formulated a plan with improvement proposals, analyzing the achievement of the value of the established process indicators as well as the association of the new principles of Quality 4.0, in the Improve phase.

The implementation of the centralized measures above will lead to the improvement of the organization's processes and therefore to the increase of customer satisfaction, the improvement of quality and the increase of the organization's performance. Innovation, transformation, and globalization can be initiated, and their implementation becomes a necessary condition in any company. A Plan with improvement proposal was made and for every proposal a corresponding Quality 4.0 principle was associated for all the 6 objectives proposed as follows:

Objective 1: Increasing the degree of fulfillment of the policy and objectives - k_{ob}

- Process: Management analysis
- The Associated Quality 4.0 principle: Proposed solution is in the area of the

Principle 1 to create Added Value by providing ease of use
- Improvement measure: Development of a program in which the k_{ob} policy and objectives can be pursued at any time.
- Responsible: QMS Resp.Director
- Performance measurement method: $k_{ob} > 0.7$
- Deadline (months): 6

Objective 2: Improving - k_{risc}
- Process: Risk analysis
- The Associated Quality 4.0 principle: The proposed solution is in the area of Principle 3, to record data both vertically and horizontally; the awareness of those involved will increase.
- Improvement measure: Improvement tools should be provided to keep up with customer requirements.
- Responsible: QMS Responsible Director
- Performance measurement method: $k_{risc} > 0.80$
- Deadline (months): 1

Objective 3: Sales growth – k_{sales}
- Process: Sales
- The Associated Quality 4.0 principle: The proposed solution is around Principle 1, respectively Added value for the customer and Principle 4, respectively automation and facilitating the sales process to the customer.
- Improvement measure: Easy communication interface between seller and customer possibly in the cloud to increase sales volume
- Responsible: SR Director
- Performance measurement method: $k_{sales} >0.7$
- Deadline (months): 3

Objective 4: Growth of k_{serv} indicator
- Management analysis: Management analysis
- The Associated Quality 4.0 principle: The proposed solution is around Principle 1 Added value to customers
- Improvement measure: Interface between service and customer for better schedule
- Responsible: QMS Resp. SVR Director
- Performance measurement method: $k_{sales} >0.7$
- Deadline (months): 1

Objective 5: Improving of k_{orders} indicator
- Process: Procurement
- The Associated Quality 4.0 principle: The proposed solution is around Principle 6, respectively to ensure predictability, depending on periods
- Improvement measure: An estimate per period can be made
- Responsible: SPR Director
- Performance measurement method: $k_{orders} > 0.7$
- Deadline (months): 1

Objective 6: Reducing of Absenteeism rate k_{abs}
- Process**:** Human Resources
- Human Resources: The proposed solution is around the Principle 8, respectively combined technology.
- Improvement measure: Tools for flexibility and working in cloud must be provided, given the pandemic situation and the rate of absenteeism.
- Responsible: HRR
- Performance measurement method: $k_{abs} \leq 0.02$
- Deadline (months): 1

2.5 Control

Following the application of the above measures, an improvement was achieved in the performance indicators of the processes followed above. However, after one month from the application, the improvement measures are still in the implementation phase, and it is not possible to formulate a conclusion that considers all the above indicators. The obtained data were centralized in Table 8.

Table 8

Performance indicators before and after deployment.

Process	Target indicator	Measured value	Target Value	Values obtained
1.1 Management analysis	k_{ob}	0.7	>0.7	-

1.2 Risk analysis	k_{risc}	0.67	> 0.80	0.75
2.1 Sales	k_{sales}	0.67	> 0.7	-
2.2 Service	k_{serv}	0.7	> 0.8	0.75
2.3 Procurement	k_{order}	0.68	> 0.7	0.7
3.1 Human Resources	k_{abs}	0.021	≤ 0.02	0.02

In Fig. 3 a graphic representation of values before and during implementation shows a slight improvement of the processes.

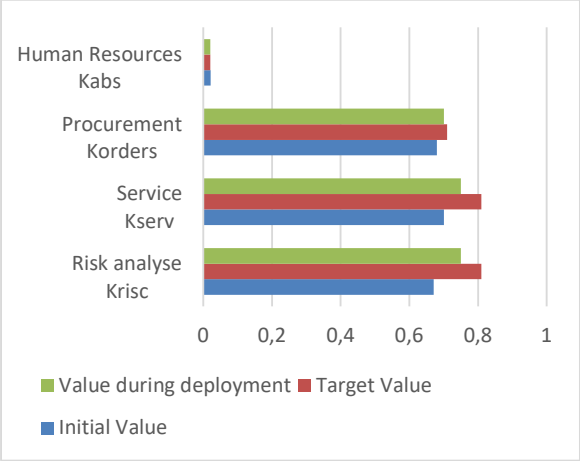

Fig. 3. Measures before and during implementation.

Fig. 4. App graphic interface for evolution's processes.

Quality 4.0 is related also, to everything that helps to improve through digitalization, therefore after the associated and applied measures above, an App was proposed to be implemented where the evolution of the organization can be followed anytime, and conclusions be drawn instantly, grouped by the process's evolution as in Fig. 4.

3. CONCLUSIONS

The study has a series of limitations, because within the company we select only a part of the organization's processes considered critical in carrying out the activity. Also, as the proposals were still in the implementation stage, the results of the study need to be validated. Preliminary study has confirmed that the model can be looked like a process improvement method and should be considered within the SME framework, fully applied, and then iterated step-by-step towards the desired results.

Processes are created around people and repeated errors or difficulty in decision making cand lead to low productivity. Defective machines cause delays, higher operating costs, too.

Therefore, the improvement of the processes can be achieved by ensuring a better circulation of data and by implementing measures that can ensure predictability and at the same time eliminate redundancies that leads to the transitions to the Quality 4.0. model.

This can be the starting point for future research, in which other processes, starting with those with a significant impact on the activity, can be documented, such as: equipment control, document control etc.

The results obtained will be capitalized and monitored using the App proposed. The App will be based on the system documentation, respectively the reviewed processes of the organization, together with the values the main monitored indicators versus their targets. The application is intended to be intuitive, easy to follow, user-friendly to allow the analysis of the organization's evolution. The future integration of other applications is desired, too.

In this way, the trend of transforming into digital the company's document system and the processes is supported. Certainly, there are expected many problematic issues and initial drop-off productivity, staff satisfaction, customer satisfaction, but on medium and long term these approaches appear mandatory even for SMEs.

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MANAGEMENTUL PRIN PROCESE IN IMM FOLOSIND CALITATEA 4.0

În lumea modernă, a fi competitiv este mai dificil ca niciodată și toate acțiunile întreprinse de companii conduc către Industria 4.0. Această lucrare propune implementarea unei metode care să îmbunătățească tranziția IMM-urilor către Industria 4.0 prin Calitate 4.0. Pornind de la procesele IMM-urilor și instrumentele specifice de calitate: Six Sigma, analiza Pareto, 5Whys și folosind descoperirile recente din industrie, respectiv noile principii ale Calității 4.0, o strategie durabilă a fost urmarită, care poate ajuta la tranziția unui IMM prin automatizare și digitalizare către o companie inteligentă. În urma studiului, s-a observat o îmbunătățire a indicatorilor de performanță ai proceselor, totuși, este necesară repetarea metodologiei până la atingerea obiectivelor de performanță propuse.

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