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IMPROVING THE SYSTEM OF LOGISTICS MANAGEMENT AND SIGNALING, IDENTIFICATION, CLASSIFICATION OF NONCOMPLIANCE IN THE WATER BOTTLING INDUSTRY

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Abstract

Starting from the Kaizen approach which aims at continuous improvement, the study synthesizes the information regarding the classification, identification and reporting of defects and all types of non-compliance encountered during the manufacturing process in the food industry, particularizing on a water bottling process. Starting from an optimized logistic system model within the organization, the article deals with the non-conformities on the material and informational flow system, or for technological equipment (machines, equipment and installations). A chi-square test was performed to evaluate the occurrence of defects in different equipment of the technological process. The study is a tool to keep under control the problems that appear and can be constituted in a standard or an internal procedure of the company applicable when a non-compliance is identified. The analysis is carried out to show how to facilitate the signalling, identification, classification, isolation and evaluation of the non-compliant product or service in order to prevent non-quality. The methodology is an effective and efficient tool in preventing non-conformities.

Key words: *defects, industry, non-compliance, quality, statistics, water bottling.*

INTRODUCTION

Definitions of quality improvement are based on the concepts formulated by J.M. Juran in the 50s (Ionescu Luca, 2007), according to which quality improvement processes are carried out in parallel with quality control processes, constituting an additional component of quality control and does not replace it. It focuses on human resources, in the sense of organization, communication and coordination of functions within the company (Achim et al., 2008).
Masaaki Imai developed the guide "Kaizen, the key to Japanese competitive success" which highlights the main specific techniques of Kaizen management, namely: strategic thinking of profit on activities, management of customer needs, visionary control strategies at the level of processes in the organization and management of the supply chain etc. (Imai, 1986). The Kaizen policy is based on the process oriented towards the development of continuous improvement techniques and strategies, with the help of all the organization's staff from all departments and hierarchical levels (Imai, 2013).
Total Quality Management (TQM) combines the philosophy and principles of Deming and Juran on probabilistic/statistical process control. TQM is defined as an ongoing effort of the management and employees of an organization to ensure customer loyalty and satisfaction, as Fornell says: "one happy and satisfied customer brings with him ten new customers, while one disappointed individual it will spread word of mouth and spoil more of your existing customers as well as potential customers" (Fornell, 2007).
Quality can be measured in several terms, such as: durability, reliability, usability. Total quality management is a structured effort of employees to continuously improve the quality of products and services through appropriate feedback and research. Ensuring the superior quality of a product or service is not the responsibility of a

single member (Oprean, 2006), requiring the involvement of all employees. "Kaizen" philosophy means continuous improvement involving everyone without spending a lot of money (Imai, 1997).

TQM is among the key tools that are often used to facilitate the implementation of the Kaizen process, being a form of management policy that can be used to work alongside these principles (Stoller, 2015).

In present, in food industry, according to article 5(1) of Regulation (EC) No 852/2004 of the European Parliament and of the Council of 29 April 2004 on the hygiene of foodstuffs requires that all food business operators implement and maintain a procedure based on the HACCP principles (EC Regulation 852/2004). The HACCP system is a program for managing the quality and safety of food products that uses techniques to control the stages considered critical points in the process. The system is based on data from specialized literature and has as a priority the prevention of non-compliance related to their food safety and sanitary security. Through its implementation, the dangers, and corrective measures to ensure their control are reviewed (Glevitzky et al., 2019). HACCP programs include measures aimed at preventing and reducing the number of inspections, respectively the number of analyses of finished products.

The signalling, identification, documentation, isolation, evaluation, treatment of the non-compliant product or service aims to reduce the exposure to losses (Bhatti, 2020).

The research carried out within the company confirms the need to analyse the existing problems within the organization in a centralized form and with a certain frequency, namely the notification of the involved functions and the rechecking after the removal of the non-compliance. To resolve non-compliance of any kind in the entire organization (material, informational or technological), there is the self-quality matrix tool (Self-Quality Matrix - SQM, or Auto-Quality Matrix - AQM) to keep under control the problems that have arisen, and for the product there are standards for verification and quality assurance.

The paper presents a useful tool for reporting, identifying and documenting non-compliance in the bottled water industry that can be extrapolated and adapted to any organization, from any field of activity. The aim of the study is to identify and report the problems arising on the material, informational or technological flow in order to be able to establish the levels of competence, the working tools and the methods of solving and preventing them. It can constitute a standard, an internal procedure of the company applicable when non-compliances are identified.

DESIGN AND OPERATION OF A LOGISTICS SYSTEM

The operation of logistic systems within the organization must be permanently optimized along with the quality of the products and services offered. This is only possible through the continuous improvement of all processes in the company. In this sense, an important role also belongs to the employees involved in the organization of the logistics system, starting from supply to sales based on the optimization of the flow of information and material (Bulat, 2018; Cernăianu, 2015).

The study includes logistics management methods that can serve as examples and possible high-quality tools or solutions as part of the continuous improvement process. The logistic system is a cohesive system that contains the material flows and all the elements that accompany them (Turcov et al., 2005).

In Figure 1, an adaptive logistic system is proposed with interconnections between its subsystems and the relationships developed with the external environment.

On the external input flow, we have the suppliers and logistics, and on the other side there are the customer orders. From a qualitative point of view, product admissibility criteria are imposed on suppliers, they are being accepted following an evaluation and selection through questionnaires or audits.

Quality barriers on products, whether they are raw materials, semi-finished products or finished products, are imposed from the reception of the products, in production and to the control of the finished product.

In order to solve non-compliances of any kind, (material or informational), there is the self-quality matrix tool to keep the problems under control, and for the product there are standards for verification and quality assurance.

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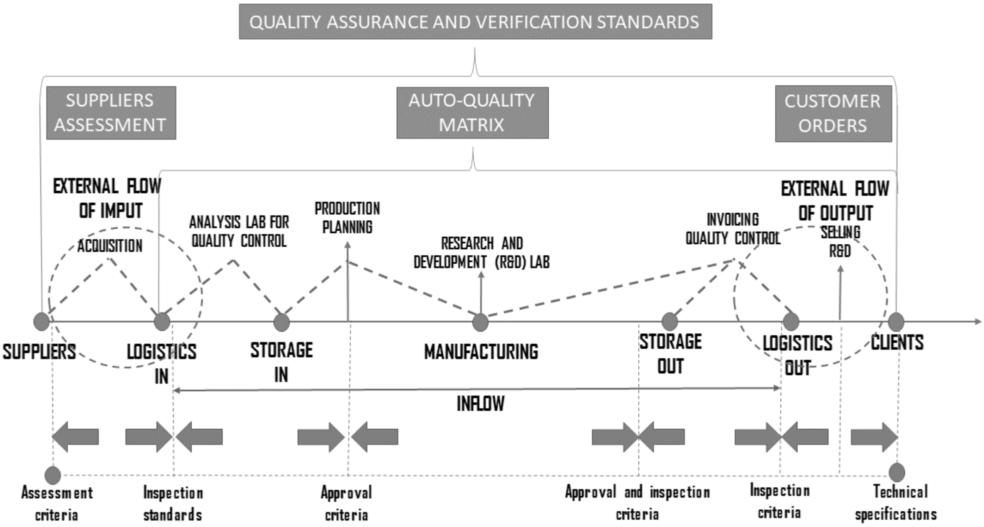

Figure 1. The micrologistics system within the company

The micrologistics system proposes the organization of activities aimed at optimizing material and informational flows. Currently there is a wide range of logistic management methods specific to modern production systems, which aim to reduce costs. Among the logistic progress mechanisms and techniques used in industrial engineering, we mention: Enterprise Resource Planning (ERP), Supply Chain Management, supply - delivery strategies, manufacturing cells, Supplier Relationship Management, business and strategic development operations, Continuous Improvements (Kaizen, Lean Manufacturing, Six Sigma, Total Quality Management), Customer Relations Service. An adaptive logistic system with interconnections was set up, simplifying the organization of activities with the aim of directing and optimizing material and information flows.

THE DESIGN AND SCOPE OF THE SELF-QUALITY MATRIX

The Self-Quality Matrix is a "tool" that helps to visualize the quality level of each section/ service in part and its evolution. Self-Quality Matrix is a technique to identify where the defect is created and detected in the manufacturing process. SQM is based on the visual inspection of the quality level of the product, service, or production line. At the same time, it helps to identify non-conformities as close as possible to the section/area that generates them and makes staff aware of the concept of self-quality. Also, non-conformities are dealt with directly in GEMBA, together with the staff involved.

For the continuous improvement of self-quality in the company, the self-quality matrix was built on the material flow (SQM Gemba Productive), on the information flow (SQM Gemba Services), respectively the self-quality matrix for technological equipment (equipment, machinery and work installations)/per department.

The Self-Quality Matrix is built on the kaizen principle: "Don't receive, don't do, don't pass on!". The Self-Quality Matrix not only shows the formation and detection of defects, but also provides a visual basis for acting on them. A company using SQM for every defect/non-compilances they encounter will not only help gain deeper insights, but also by forcing them to map or model their processes and value streams.

To create the Self-Quality Matrix, the main "suppliers" of non-conformities, of the departments involved in the material flow, must be identified on the supplier-client relationship ("Where did the non-compliance occur?"). They can be identified depending on the place where the non-conformity is generated.

Table 1. Internal or external source of non-conformities

External suppliers	Internal suppliers	DMP	Production	Bottling	DPF	Source
Suppliers of non-conformities from outside the company	Indirect internal suppliers of non-conformities	Raw materials warehouse	PET preform blowing section	Bottling section	Finished products warehouse	Water source

Regarding the identification of the main "suppliers" of non-conformities, of the departments involved in the material flow, on the supplier-client relationship ("Where did the non-compliance occur?"), they can be:

- External suppliers - suppliers of non-conformities from outside the company;
- Internal suppliers - indirect internal suppliers of non-conformities (Table 1).

At the same time, the main "clients" of the non-conformities can be identified, by asking: "Where was the non-compliance found?".

Table 2 shows the structure by areas/ departments of the spring water bottling unit and the possible areas/sources where non-compliances can be identified.

Table 2. Structure/areas within the organization

DMP	Raw and auxiliary materials warehouse
Production	PET preform blowing section
Bottling	Bottling section
DPF	Finished products warehouse
QC	Quality control department
Internal customer	Research and development, logistics, and others
External customer	The end customer

Table 3 presents the classification of the main types of SQM non-compliances, which can be identified on the material and informational flow.

Table 3. Types of non-compliance at SQM material and informational flow

Nr.	Material flow non-compliances	Non-compliances for technological equipment	Non-compliances on information flow
1	Product loss	Blow Molding Machine - PET	Basic information is missing
2	Non-compliant documents	Water Pump	Missing atypical information/ incomplete information
3	Product with foreign taste and smell	Filling Machine	Incorrect information
4	Product with impurities	Capping Sealing Corking Machine	Unclear information
5	Contaminated product	Labeling Machine	Delayed information
6	Non-compliant product due to the machine	Sealing Shrink Wrapping Machine	Back order/out of stock
7	Sufficiently non-carbonated/non-zoned product	Pallets Wrapping Machine	Order late/finished product missing/raw material in stock
8	Non-compliant packaging	Tracee / conducted	Order late/finished product missing/raw material missing
9	Non-compliant labels	Bottle Conveyors	Back order for raw material/back order
10	Different color product	Ozone generator (Air Tree-Ozone Technology)	Missing documents
11	Lack of quality documents	Plate filter	Missing customer information
12	Non-conformity when making boxes, palletizing	-	Delayed customer information
13	Missing in management	-	Various
14	Missing labels/double labeling	-	Information overload
15	Failure to meet admissibility criteria	-	Erroneous services
16	Technical non-compliance	-	Unsatisfactory service quality
17	Other defects	-	Delayed services
18	-	-	No Services
19	-	-	Errors in operation

The Self-quality matrix per material flow involves the daily collection by operators of data related to the identified non-compliances, by completing the "Self-quality matrix (SQM)" sheets and mentioning the non-compliances in the "Material flow SQM column". Later, the non-co compliance can be selected and analyzed together with the operators involved in the flow, and the weekly analysis of the non- compliances is carried out together with the heads of sections/departments.

The Self-Quality matrix per information flow works similarly through the daily collection by employees of data related to the identified non-conformities entered in the "SQM" files in the "SQM information flow/per department" column. A weekly or bimonthly analysis of the data collected on the Self-Quality Matrix informational flow is carried out, along with the selection of problems that repeatedly generate non-conformities, their analysis, together with the operators involved.

The Self-quality matrix per flow of technological equipment (equipment, machinery, and work installations) on each section works in a similar way. The non-conformities related to the technological equipment are entered in the revision sheets of the machines and analyzed periodically, depending on their severity.

The operating stages of the Self-Quality Matrix are represented by the daily collection by operators of data related to the identified non-compliances, the daily transcription of the non-conformities reported on the SQM panel, the selection of the "problem of the day", the analysis of the "problem of the day" together with the operators involved in the flow and training, together with the weekly or bimonthly analysis of non- compliances together with the heads of departments.

The self-quality matrix tool is designed with the aim of keeping the problems under control by identifying and signaling problems in the material, informational or technological flow, establishing competence levels, work tools and methods for solving and preventing them. It can constitute a standard, an internal procedure of the company applicable when a non-conformity (problem) of any nature is identified.

The research can be applied in all departments involved in material flow (production, storage, logistics, but also in support services: technical, quality, laboratory, research and development), as well as in those involved in information flow (support services for material flow: technical , quality, laboratory, research and development, along with support services within the company: procurement, logistics, economic, financial, back-office sales, human resources, IT, administrative). Subsequently, the analysis and resolution of problems can be carried out within each department of the company where a non-compliance was reported, at the departmental or general meeting.

STATISTICAL ANALYSIS OF THE EQUIPMENT FAILURE INCIDENCE

The maintenance of machines and equipment involves the control of noncompliance related to the functioning problems that may arise in production. In the manufacturing process, the good operation of the machinery is essential to achieving the objectives of production and to obtaining safe, quality products. Thus, in a competitive economy, safety management is a critical component for quality and safe production (Glevitzky et al., 2019).

In the production process, the proper functioning of machinery and equipment is essential for achieving production goals and for obtaining quality and safe products.

Defects and their history are good indicators of equipment maintenance. The antecedents of equipment failure can cost a lot; therefore, it is necessary to anticipate them or find their causality (coincidental or which justifies a more detailed investigation) for corrective or preventive actions in the company.

Using the chi-squared test (χ^2 test), it was checked whether the calculated probability of occurrence of noncompliance (defects) in production equipment differs significantly from the theoretical probability of their presence. So, the chi square test (χ^2) can be used to assess a relationship between two of these categorical variables, that is, to determine whether there is an association between them (Greenwood & Nikulin, 1996).

The technical equipment of the factory were about 18 years old; they were purchased from the same supplier and being used under the same conditions. Is the lower number of equipment failures in the technological process real and natural? Or failures with a higher frequency are caused by faults in the use or design of the machines. It should be noted that the appearance of several defects in other machines can be determined by a piece of equipment on the production line before it or is caused by other factors and is not accidental. All the noncompliance encountered appeared in the context of the normal annual use and maintenance of the machines used in the process. The question is whether there is a need for a higher frequency of interventions related to equipment maintenance.

From the total of 25 defects in the last 5 years, the results for each type of technical equipment are shown in Table 4.

Table 4. The results of the calculation of the chi-squared test for the occurrence of technological equipment defects in the process

Machinery (Equipment)	PET Bottle Blowing Machine	Water Pump	Filling Machine	Capping Sealing Corking Machine	Labeling Machine	Sealing Shrink Wrapping Machine	Pallets Wrapping Machine	Total
Number of defects	2	2	9	4	5	3	0	25
$F - n \times p$	-1.5725	-1.5725	5.4275	0.4275	1.4275	-0.5725	-3.5725	-0.0075
$(F - n\times p)^2/n\times p$	0.6922	0.6922	8.2457	0.0512	0.5704	0.0917	3.5725	13.9158

F - the frequency of defects; n - the sum of incidence of defects.

If, according to the hypothesis, all seven technological equipment from the production process that operate simultaneously under the same conditions, the probability that one of them will be out of order is p = 0.1429. The mathematical expectation related to the presence of the number of defects is $M(n) = n \cdot p = 3.5725$. For $\nu = 6$ degrees of freedom and the value χ^2 computed = 13.916 we find a significance level (α or p-value) less than 0.50, but greater than 0.25 (Gluck, 1971). This means that the chi-square value would occur simply by chance between 25% and 50% of the time. We can conclude that the variables are not independent of each other and that there is a statistical relationship between the categorical variables.

These results can lead to rejection of the null hypothesis, and we will admit that the difference between the number of defects is not accidental. So, we have enough arguments to support the need for a detailed analysis of all the causes that lead to such many defects, especially in the filling machine, capping-sealing-corking machine and labelling machine.

CONCLUSIONS

The Self-Quality Matrix can be a standardized process that takes on real potential in the context of implementation within organizations that emphasize the remediation of non-compliances and continuous improvement. The Self-Quality Matrix tool focuses on quality, respectively the importance for customer satisfaction and evaluates robustness. At the same time, it evaluates the manufacturing and inspection processes against the potential or actual severity of the problem. This tool allows a real positive impact on customer satisfaction by acting to identify and signal problems arising on the material, informational or technological flow. At an advanced level of implementation, the self-quality matrix becomes an effective and efficient tool in preventing non-conformities.

The chi-square test was performed to evaluate the occurrence of defects in different equipment of the technological process of the water bottling industry, meaning there is a definite, consequential relationship between the occurrence of defects in production equipment reported to the theoretical probability of their presence.

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