Methods and Tools of Quality Management

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Abstract: *Today's industry is facing increasing competition and a rapid pace of technological change, which requires effective quality management to achieve optimal results from manufacturing processes. This paper explores the methods and tools that contribut e to quality improvement in manufacturing and their relevance to the sustainable development of a manufacturing organization.*

Keywords: *quality, quality management, quality management tools, cause and effect diagram.*

INTRODUCTION

Nowadays, quality is a key success factor for an organization, and therefore it is necessary to constantly innovate and adapt quality management methods to new trends and challenges. In this context, a range of methods and tools that serve to ensure and improve quality in various business sectors are examined in detail.

From the point of view of production organizations or organizations offering services, the management of companies is becoming more and more aware that high quality can affect not only the final product as such, but also the costs of its production (Paulová, 2018). If the organization has a high level of quality as a whole, this will always be reflected in customer satisfaction. If the organization achieves low production costs, it is usually more competitive, because the customer demands the highest possible product or service quality, but the lowest possible price (Nenadál, 2018). However, the management of the organization must effectively apply any internal change that it wants to improve individual processes or departments. The motivation of workers in individual departments is very important so that all introduced changes work properly. There is an enormous number of organizations offering the same services or products today, but many organizations take this as a motivation to keep improving, because everyone wants to become more than just an imaginary unit in their field on the market (Hotový, 2022).

In production organization, quality management is a critical factor for achieving efficient production, minimizing waste and meeting customer expectations. Focusing on quality management methods and tools in this area is essential for sustainable development and consolidation of competitiveness in the market.

MATERIALS AND METHODS

If an organization wants to hold market leadership from a position of leadership, it must strive to minimize complaints and their possible future occurrences. Customer complaints do not only carry with them an economic cost, as dissatisfied customers have a large choice of suppliers to work with in every sector of the market today. Using a cause and effect diagram, with the help of the organisation's staff, we will identify the cause of the specific problem of the parameter being complained about, which we will need to stabilise and propose an action plan for specific measures. Once the action plan has been developed, we will examine whether the steps have been applied, as well as their impact on the results of the work by producing, testing and evaluating the parameters of the new samples. After evaluating the stability or instability of the process, the next step will be to determine the cause of our problem, which we will use a cause and effect diagram to solve. Using the brainstorming of the entire participating team, we will construct an Ishikawa diagram where we will construct the main axis and determine the main categories of the causes of our problem. In our case, we will follow our own categories, which will be eight instead of the basic five (Hrubec, Virčíkova et al., 2009). In each category, we will gradually analyse all the possible input causes and use cause decomposition to reveal all the root causes of our problem, which is inadequate mechanical strength. Then again, according to brainstorming and according to empirically given facts thanks to the experience of PPC Čab, Inc. employees, we will score the root cause of the problem (Hotový, 2022).

Corrective measures

In the corrective action section, once the cause of the problem has been successfully identified, an action plan is set out, presenting the implementation of changes to all problem factors, together with a description of the action, the date the solution will start, the date of implementation and the persons responsible. The action plan shall be presented to all responsible persons and shall be rigorously implemented and monitored by all these persons. This is a very important aspect, because a dishonestly applied action plan has no real functionality. The action plan will be filled in piecemeal after the implementation of each measure and will be evaluated after completion. After the application of the action plan, a new supply of insulators will be produced, followed by a customer quality check again after production to release the new supply and assure the customer that it was an accidental error.

RESULTS

Characteristics of the organisation

PPC Insulators is a leading manufacturer, supplier and technology leader of state-of-the-art insulators for outdoor lines and substations. Traditional porcelain insulators originated in the late 19th century. They were further developed in-house at PPC through isostatic manufacturing technology, which replaced plastic technology, enabling the production of high quality products with efficient design, tightest tolerances and shorter production times. Up to 1200kV AC and 1100kV DC. PPC Insulators organization has over 130 years of experience in the electrical porcelain industry, over 800 employees in 8 countries, a production capacity for insulators of approximately 35,000 tons, 4 manufacturing plants, and 74 countries with direct sales (https://www.ppcinsulators.com/sk/about-us/).

Characteristics of a customer complaint

In the second half of the year 2021 in the company PPC Čab a.s., a situation of non-conformity of the products to the drawing documentation occurred during the verification of the quality of delivery by the customer itself. According to the standard intended for testing and according to the customer's specifications, the products from the delivery should have adhered to the required mechanical bending strength. This was an order for 218 pieces of products, with 3 randomly selected pieces from the delivery being subject to verification. Repeated double checks were carried out according to the relevant standards, where the products equally failed to meet the same parameter. The requirement of the organisation was to evaluate the measured data in a first step, then to make a statistical evaluation of the mechanical strengths on the test insulators, which are manufactured only for the purpose of monitoring the mechanical strength. For this we will use samples manufactured between 2017 and 2021. Using control charts, we will track the stability of the process. Since the customer refused to take delivery of the entire shipment because of this situation, which according to the standard in this case has to be completely reinforced, he has to be assured that this was only a random error and the process is stable in the long term. The customer is only interested in a new manufactured delivery if information on the stability of the process, an explanation of the cause and the elimination of the problem on his delivery is provided.

For mechanical strength testing, a testing device with valid calibration by Slovak Legal Metrology, designated as KTS-353, is used. It is a device used to perform mechanical tests in bending or torsion. When carrying out a test on this equipment, the insulator must be mounted on a rigidly fixed frame capable of withstanding the loads imposed on the insulator during the test.

Cause and effect diagram

After evaluating and analyzing the data, we use a cause and effect diagram to solve the problem. Thus, we will trace the individual transitions and relationships between processes and the activities performed on them. In our case, part of the problem solved in the diagram will be the mechanical strength of the product. We will choose our own cause areas and these are insulator, firing, cutting, cementing, fittings, people, mechanical testing and storage.

Fig. 1 Isolator C60-250

Fig. 2 *Test equipment KTS-353*

Thus, after analyzing all the sub-areas through brainstorming, we can say with certainty that the fault occurred in the case of cementing technology by human factor. Using the findings that the same cementing technology is applied to the vast majority of the products produced, we have focused and our next goal is to monitor and suggest measures to improve the process. Since, with the help of control charts, we can observe a recent downward trend in the hiring period of new workers, we can also argue that the experience and training of the cementing process workers has a very significant impact on the final results of mechanical strength.

Thus, the new produced sample of 20 pieces of product C60-250, will be cemented under the supervision of control of adherence to work instruction and all process times. In the case of human-influenced technology on the cementing process, various factors such as mixing times or the volume of cement used were controlled.

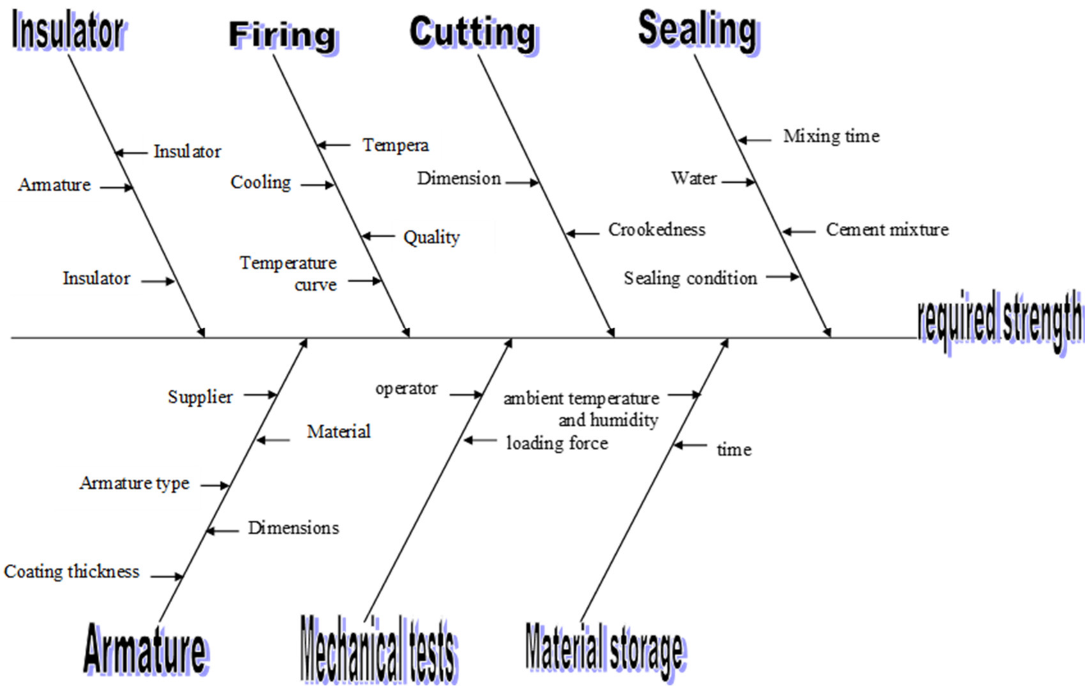

Fig. 3 Elaborated cause and effect diagram

Corrective measures

After applying the cause and effect diagram, using the argument that the cementing process has a significant effect on affecting the mechanical strength of insulators, we can say that the technology does not show any anomalies in the long run, rather the downward trend is influenced by the human factor. Therefore, on the basis of these analyses and all the information obtained, we have developed an action plan, which we have also applied to production.

In the category of people, we have proposed as grow of this part the training of workers. Continuous improvement of the work instruction and knowledge of the workers has a positive effect on every process in the long term. The process category, points to important factors such as timely and proper calibration of gauges, introduction of new elements to monitor compliance with the technological process or introduction of various forms filled out by the workers and checked by the department master or process owner.

In the technology category, since no negative phenomena on the quality of the recipes were detected, we proposed to develop a form of earning the mixture according to the different variations, prepared by the workers themselves. Likewise, during this period, to increase the control of the earned mix of each shift in the in-house laboratory, thus controlling the individual work shifts. During the period of application of the action plan, 20 new porcelain samples were planned to be produced in the planning department, where, during the process of cementing these samples, the plan had already been applied.

Table. 1 *Action plan developed*

Action plan								
Name of the measure	**Description of the measure**	**Responsible person 1**	**Responsible person 2**	**Responsible person 3**	**Start date**	**Date of implementation**	**Monitoring**	**Notes**
People	Retraining process workers from relevant work instructions	Process masterfully	Process Engineer		1.9.2023	10.9.2023	Process Engineer	
	Retraining process workers from operating procedures	Process masterfully	Process Engineer		1.9.2023	10.9.2023	Process Engineer	
	Modification of work instructions and operating procedures	Process Engineer	Quality manager		1.9.2023	8.9.2023	Quality manager	
Process	Calibration of all measuring devices	Process masterfully	Metrologist	Quality manager	1.9.2023	24.9.2023	Quality manager	
	Introduction of light signaling	Process masterfully	Technologist	Metrologist	1.9.2023	24.9.2023	Metrologist	
	Introduction of a form for recording the beginning and end of time	Process masterfully	Technologist	Process Engineer	1.9.2023	2.9.2023	Quality manager	
Technology	Development of technological composition	Technologist	Process Engineer	Quality manager	1.9.2023	13.10.2023	Quality manager	
	Introduction of increased control	Process masterfully	Head of the laboratory		1.9.2023	2.9.2023	Check once a day	
	Monitoring compliance with the technological procedure	Process masterfully	Technologist	Process Engineer	1.9.2023	10.9.2023	Check once a day	

Statistically regulated processes, whereby a company can use measured data to monitor the stability of a selected process, are now a key indicator not only of the quality of the process as a whole, but also of random errors due to unpredictable factors. Using control charts, we have found in our case that the mechanical strength process is statistically regulated over a long period of time, however, insufficient control of the individual processes that affect it can lead to random errors, which in this case were found by the customer. It can be argued that if samples had been taken during the verification process that had met all the requirements of the customer's drawings and specifications, the subsequent claim would have had a cost to the company several times higher than at this stage. The downward trend in the mechanical strength results depicted by the control charts may have alerted the company early on that increased scrutiny and focus on the process was needed.

CONCLUSION

From the results of the work it is evident how significant the cementation process in our case has on the resulting mechanical strength of the product. Therefore, we recommend that the action plan developed by us be continuously monitored in order to control this process. Long-term training of the workers, for example, according to a planned adaptation of the work instructions into pictorial form, can have a very significant positive impact in the future in terms of lower costs for low-quality products or a poor customer experience.

It is also very important to monitor and develop new technologies and innovations that can have a positive impact on eliminating or at least minimising the negative human factor in any process.

By evaluating individual non-conforming products and then statistically evaluating the stability of the mechanical strength process, we used one of the seven old quality management tools, the cause and effect diagram, to address the reason why the problem occurred. Using years of employee experience, one of the most valuable assets of any company, we consulted the critical points where a random error could have occurred in the process, since the process, although trending downward, is statistically under control. After analysing all the critical points, such as monitoring the fracture under a microscope for the presence of impurities or various inhomogeneities, talking to the supplier of the fasteners regarding the mechanical strengths and their attestation, and many others, we came to the conclusion of a possible non-compliance with the technology on the cementing process. With the help of an action plan, corrective measures were proposed and applied in a timely manner, whether it was the various calibrations of gauges or the establishment of new technological elements, to facilitate the monitoring of the quality of the process. The cementing process can be significantly influenced by the human factor, as it is a process where the worker prepares the cement mix himself according to a recipe. Worker error can be highly variable, whether it is the accuracy of each ingredient in preparation or the mixing times of the mixture.

During the application of the action plan, new samples were produced for the customer because we had excluded the influence of another factor in the earlier production process. During the solution and application, we had enough time because the products arrived at our process after more than a week, as it is a more complex production with longer times on each process.

In conclusion, the company needs to continue to monitor and evaluate the process statistically, because although the regulatory charts have shown that the process is under control, the lack of addressing the downward trend in recent years may result in significantly increased quality costs and other problems in the future.

In today's competitive environment, it is imperative that manufacturing organizations continuously innovate and adapt their quality management methods and tools. Effective quality management in manufacturing is the key to achieving outstanding results, customer satisfaction and sustainable organizational development.

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