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SYSTEM SAFETY: HUMAN - TECHNICAL FACILITY – ENVIRONMENT
6(1), 2024, pp. 439-448

PROCESS IMPROVEMENT USING SELECTED QUALITY MANAGEMENT METHODS

DOI: 10.2478/czoto-2024-0045
Received: 08/12/2024
Accepted: 30/12/2024

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Abstract: A key element of any quality management system is continuous improvement and a systematic approach to managing non-conformances. The aim of this paper is to use selected statistical methods and quality control techniques to present a way in which an organisation can achieve quality improvement. The 8D methodology was used to solve the observed problem, which was a customer complaint due to a nonconforming dimension on a Brake Bracket product using a structured eight-step Plan-Do-Check-Act (PDCA) approach to problem solving. The subject of the analysis in Knott spol. s.r.o. is the product Brake holder 300x60 S-Nocken /AGS/ABS/. Using the 8D methodology and supporting tools such as the Ishikawa diagram or 5Why, the root cause of the problem was identified and permanent corrective actions were planned and implemented as recommended in the 8D report to reduce the likelihood of the problem recurring and increase customer satisfaction.
Keywords: quality control; complaints; 8D report; brake production process; problem solving

1. INTRODUCTION

The quality requirements were in the last time expanded to the point where quality in form as quality management become the decisive factor in company management. Implementing the quality standard allowed maintenance of one's position in the market, gaining a competitive advantage, and the ability to compete in the sector (Zgirskas et al., 2021).

The Global 8D Aikens defines as a problem-solving methodology that strives to identify and eliminate root causes of failure after the fact. The Global 8D problem-solving methodology was originated by the US government following World War II as MIL-STD 1520 and was later adopted and improved by the Ford Motor Company. The Failure Mode and Effect Analysis (FMEA) attempts to anticipate and correct problems before they occur (Ignáczová, 2016;Uslu and Tas, 2022). Global 8D deals with the modes and causes of

failure after the fact. Once used, Global 8D results can help improve the quality of future FMEA analysis of a product, process, or service (Aikens, 2011).
Global 8D is a methodology to identify and eliminate the root causes of failure and then implement permanent corrective actions to prevent a recurrence. The method is also designed to evaluate the effectiveness of control mechanism failures that allowed the problem to escape undetected in the first place (Aikens, 2011). The method is typically used within the organization and its results can be presented to the customer as quality control (Andrássyová et al., 2011; Kumar and Adaveesh 2017). The output of 8D method is 8D Report based on the multi-stage work of the entire team,. which uses effective methods and tools for quality management or improvement (Dziuba et al., 2021).
The primary objective of the 8D methodology is to implement and consolidate corrective actions in relation to the quality management system. It comprises eight stages that set out a procedure to follow an established pattern (Uslu and Tas, 2020; Kumar and Adaveesh, 2017; Dziuba et al., 2021). Each of them must be recorded in a document called 8D Report (Pacana and Czerwinska, 2020).
A novel contribution identified in this case study for quality management that has not been mentioned in the previous studies mentioned in the preceding paragraph is the combination of a number of quality management tools, in particular Pareto analysis, the Ishikawa diagram and the five reasons technique. Many literatures recommend using either the Ishikawa diagram or the 5 Whys to find the root cause, but combining them (as in this case study) will produce more favourable outputs that result in the creation of a synergistic process. The quality of the process has improved because the root causes of the problems have been identified and eliminated.
The purpose of this case study is to resolve a customer complaint that consisted of identifying a tapered hole after milling. This hole was causing a problem for the customer, who was unable to press another necessary part into it.

2. MATERIALS AND METHODS

The aim of the study is to improve quality to meet expectation of customers. For analysis, monitoring and improvement project the product Brake Bracket was selected and 627 units were claimed and the customer always returns the entire delivery.. As the most appropriate method, the 8D methodology has been applied. The study was carried out at an organisation in western Slovakia that manufactures brakes and braking systems. The customers’ requirements for quality in automotive production are very strict. The project's issue has been an improvement of brake production process by using the 8D methodology. The Global 8D problem-solving methodology was originated by the U.S. government following World War II as MIL-STD 1520, and was later adopted and improved by the Ford Motor Company. The 8D methodology was used to analyse the problem, which allowed identifying a critical cause of the defect and helped eliminate it. The 8D methodology includes an 8D report consisting of eight steps, as shown in Figure 1:

- Team formation
- Problem description
- Interim containment actions
- Root cause analysis
- Corrective actions
- Validate corrective actions

- Identify &implement preventive actions
- Team &individual recognition

Fig. 1. 8D Problem solving approaches (www.whatissixsigma.net, 2024)

The primary objective of the 8D methodology is to implement and consolidate corrective actions concerning the quality management system. It comprises eight stages that set out a procedure to follow an established pattern.

Global 8D employs a gateway step (D0) followed by eight discipline steps (D1 – D8). (Uslu and Tas, 2022; Dziuba et al., 2021; Lestyászka and Nováková, 2016).

Gateway step discipline D0 – Prepare for Global 8D. This step confirms that the Global 8D methodology is needed. Symptoms are documented, showing that a problem has occurred, and a formal assessment is performed to justify the deployment of the resources required to perform a team-based cross-disciplinary problem solving effort. Immediate damage control is taken in the form of emergency response actions to prevent further undesirable consequences.

Discipline D1 – Create an interdisciplinary problem-solving team D0. The problem solving team should consist of individuals who have the knowledge, time, authority, and skills to solve the problem and follow through by implementing corrective actions. The team composition should be cross-functional and include representation from all areas that need to be involved in containing, analysing, correcting, and preventing the problem at hand.

Discipline D2 – Define the problem D1. The team might describe the problem as specific as possible, including such details. (Who suffers if the problem goes unsolved; What is the cost of not solving the problem; when was the problem discovered, how was it found, where was it found, and by whom; a description of the failure mode and rate; and any metrics and measures relevant to the problem situation.)

Discipline D3 – Contain the problem. In this discipline, the team depends on the issue to contain it. Intermediate containment actions are developed and implemented. The measures are to protect customers from the problem until permanent corrective actions

can be taken. For example, all production that has been potentially affected by the problem should be isolated for detailed inspection. Those that have been shipped may need to be recalled, and those still in the manufacturing facility placed on hold until the problem has been fixed. The team needs to verify the effectiveness of these actions.
Discipline D4 – Identify root causes and escape points. During the fourth discipline, the problem solving team identifies all potential causes and gathers as much evidence as possible to reliably test each potential cause against the problem data. When a cause-and-effect relationship is established, a detailed description of how the cause led to the failure is formulated. At this juncture, an escape point is identified where the control mechanism broke down and allowed the problem to go undetected. The escape point is identified as the first control point following the root cause. This constitutes the earliest opportunity to expose the problem if the control point had been effective. Once all root causes and escape points have been identified, the team can generate possible alternatives for corrective action.
Discipline D5 – Develop permanent corrective actions (PCAs). Discipline D5 is concerned with choosing permanent corrective actions and documenting the rationale for each. The team confirms that the recommended PCAs will solve the problem and will not produce any negative consequences. The implementation of PCAs can require a preliminary evaluation and, in some cases, a small pilot study. During this step, PCAs must also address control issues posed by the escape point.
Discipline D6 – Implement permanent corrective actions. In discipline six, the team implements the PCAs identified in discipline five. Data are collected showing that corrective actions effectively prevent a recurrence of the root cause. This includes a demonstration of how the escape point control mechanism has been improved in its capability for early detection.
Discipline D7 – Prevent recurrence. Preventing recurrence of the problem requires expanding the scope of the PCAs and controls to apply to other similar products, processes, or services. The standardisation and deployment of corrective actions across all products or services that might be subject to the same or similar problem leverage the problem-solving effort, becoming a preventative and proactive measure across the production facility.
Discipline D8 – Give the team credit. The last step of the Global 8D process is formally recognising the collective efforts of the problem-solving team and formally approving its report. Achievements should be widely publicised, and the acquired knowledge and learning should be freely shared.

3. RESULTS

The study was conducted in a company producing brakes and braking systems. As mentioned above, the quality requirements of automotive production customers are very strict. The monitored product is the brake bracket.
D1 - Creating a team First, you need to create a team of staff who know the product that is the subject of the complaint. This team includes the quality manager, the head of the quality department, the chief technologist and other personnel involved in the product manufacturing processes. The team then identifies a team leader and assigns team roles to the other members.
D2 - Description of the problem The problem of the product that was the subject of the complaint consisted in a mismatched dimension Ø30H7. It was located on the product in

the lower right corner at the first operation. The problem consisted in the formation of a conical hole after milling (Figure 2). For the clarity of the above problem and better imagination, we present the resulting conical hole in the figure 2.This tapered hole was not satisfactory for the customer because he could not press the next required part into it. This is a critical situation and must be addressed immediately as the customer cannot use the parts supplied to complete their product. By not addressing this problem, the organisation may lose this customer.

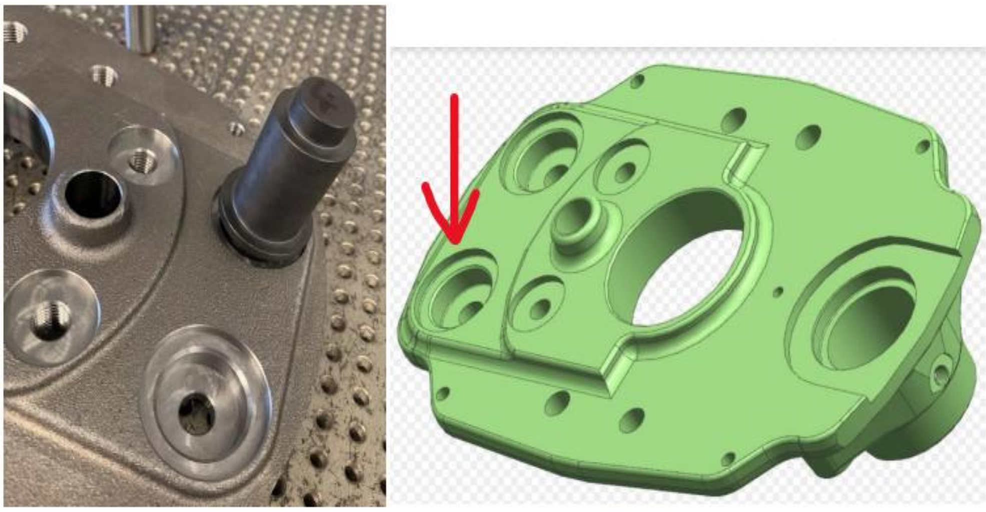

Fig. 2. Tapered hole after milling (product error position) (Šimko, 2023)

D3 - Developing an interim plan of action A very important step is for the company to come up with an interim plan of action. As a measure, a deviation was agreed with the customer, which brought the usability of the claimed items. The original deviation for Ø30H7 dimension was (29,997 - 30,030) mm and after agreement with the customer after the non-conforming products were claimed, the new deviation was (30,000 - 30,021) mm. Out of the 627 units claimed, 605 units were reused due to the agreed deviation with the customer.

D4 - Identifying Root Causes The main task of this section is to identify the root causes of the problem under investigation and possibly eliminate those causes that can be ruled out after closer examination. The identification of these root causes is a prerequisite for determining a permanent remedy for the problem. In the analysis phase, a cause and effect diagram (Ishikawa diagram) (Figure 3) is used, which can be applied to gather information about the product and the possible causes of the taper hole. Material, people, tools, environment and machinery were identified as the main causes, in which other sub-causes were then identified that could have had an impact on the main problem of non-conforming products. The constructed Ishikawa diagram shows us graphically the individual causes, which is very convenient for the team that has been assembled to solve the problem that has arisen. The visual aspect of the diagram helps to increase the imagination of the team, resulting in many more stimulating ideas that can be recorded in the diagram. Once the diagram was constructed, the team dissected each cause in detail and decided which could be considered important and which could be excluded.

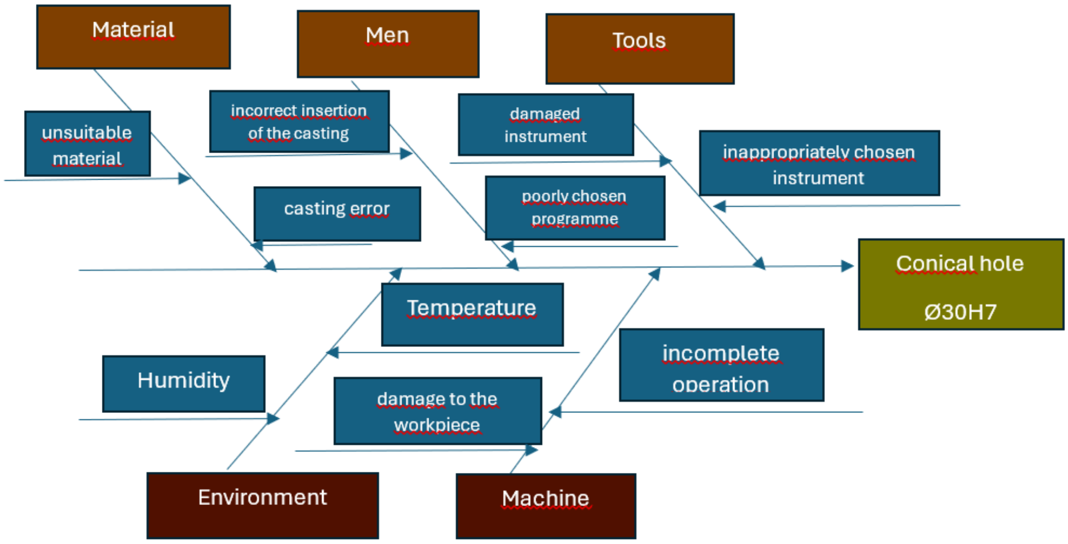

Fig. 3. Ishikawa diagram (Šimko, 2023)

Of the identified causes of non-defects, a step-by-step investigation and verification by team members rejected material-related causes, as the castings delivered passed the initial inspection upon receipt from the supplier. Causes related to the environment were ruled out after checking in the part of the brake bracket manufacturing site (machine shop), as all conditions were within standard. Another cause, which included the sub-causes of incorrect casting insertion and poorly selected program, were incompatible with respect to the nature of the defect and were therefore also excluded. Damage to the workpiece was ruled out because each operation was followed by an inspection in the inspection department, through which the damaged piece would not have passed, just as a workpiece with an incomplete operation would not have passed, for which reason both cases were ruled out. The tooling that was in the CNC machine on which the brake bracket manufacturing process was taking place has a prescribed life cycle for the tools used for machining, and thus is changed regularly. The cause of the poorly selected tool could not be ruled out, due to the non-use of a different type of tool in the machining process. After eliminating the causes that were not behind the main problem of non-conforming products, a possible cause was identified that was responsible for the defect on the products. In order to identify the identified cause and clarify its nature, it is appropriate to use the 5WHY method.

The 5WHY method applied to the identified possible cause of the defect in non-conforming products:

Why? -> It is not possible to press a part into a milled hole Ø30H7.

Why? -> The milled hole is conical.

Why? -> The selected tool is not suitable for the intended use.

Why? -> The hole milled does not meet the requirements.

Why?-> The tool selected is unsuitable.

D5 - Choosing a permanent corrective action Once the cause has been identified, an appropriate corrective action must be chosen to eliminate the occurring defect on the non-conforming products. As a corrective measure, the original universal cutter (Figure 4) in the CNC machine is replaced with a finishing cutter (Figure 5) that should meet the conditions to complete the operation as required without any defects. To give a better idea, Figure 5 shows the finishing cutter that was the corrective measure. This finishing cutter subsequently proved to be the right solution as the number of non-conforming pieces due to the wrong hole was reduced to 2 pieces in a month. Another advantage is that it can be used in other processes and on other products that the organisation under review produces.

Fig. 4. Universal cutter (Šimko, 2023)

Fig. 5. Finishing cutter (Šimko, 2023)

D6 - Implementation of corrective measures The plan for the application of corrective measures consists of testing the finished milling cutter, which will be clamped in the CNC machine and used for the milling operation of the Ø30H7 dimension. Subsequently, a certain number of finished products will be checked in the inspection department to verify the effectiveness of the corrective measure and to avoid the occurrence of non-conforming products.
D7 - Design of preventive measures and their verification Currently the product is not in production, while the production of the next batch ordered by the customer is scheduled for August this year. After detailed identification of the problem and its corrective measure and consultation among all team members, a high probability of success can be stated after applying the corrective measure of replacing the original universal cutter with a finishing cutter. This corrective measure has a high probability of eliminating the problem with the Ø30H7 tapered hole, which was the main subject of the customer's complaint. As a precautionary measure, a finishing cutter will be introduced into the production process of the brake bracket with the milling of the problematic dimension that caused the non-conforming products. This finishing cutter is more efficient and can be used in similar processes on other products.
D8 - Conclusion, team recognition To improve similar processes, KNOTT spol. s. r. o. included the finishing cutter, which was a corrective measure in the brake holder production process, in its production processes. Identifying the cause of the non-conforming products and then finding a corrective measure would not have been possible without the admirable commitment and cooperation of all team members.

4 DISCUSSION

However, the 8D methodology can be considered as a conventional method, but if we combine the 8D methodology with the 5 Why and Pareto analysis (in this case), then we can consider this presented solution as synergy and innovation. As can be seen in Figure 6, the framework as a new system standard for product quality improvement is shown here. It is a graphical presentation of step sequence for the 8D method in the context of the PDCA cycle and continuous improvement.

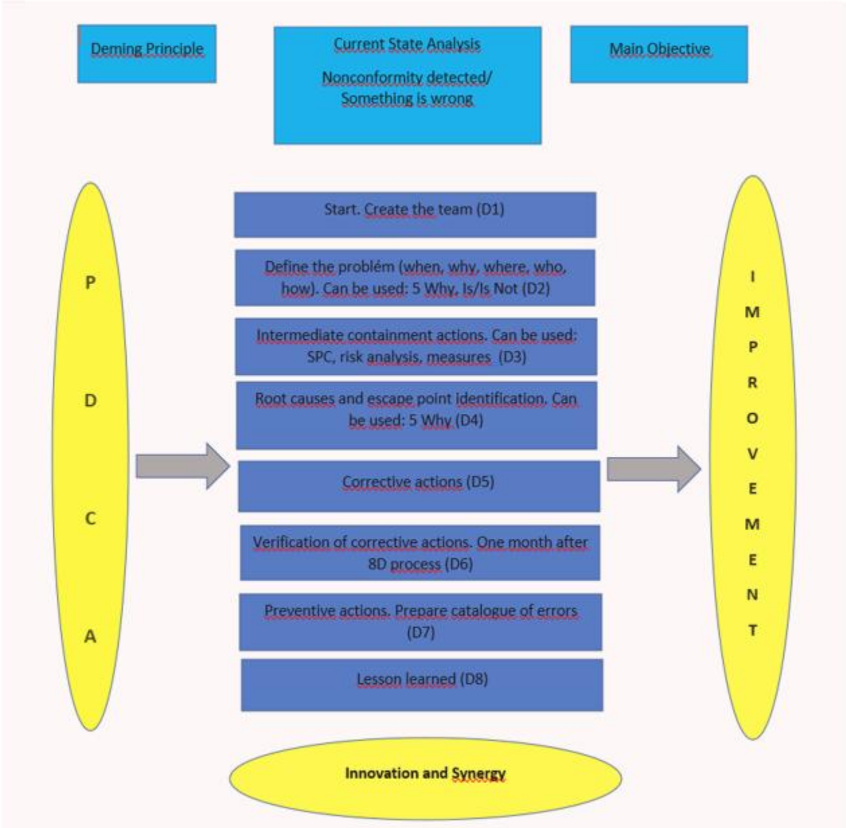

Fig. 6. The framework as a new system standard for improving the quality of a product (Lestyanszka et al., 2023)

With an interval of one month, the manufactured brake brackets were monitored and a new Pareto analysis was performed, proving that the corrective measures introduced were effective, as the tapered hole problem occurred only twice (Fig. 7). This problem is shown as number 7 in Figure 7.

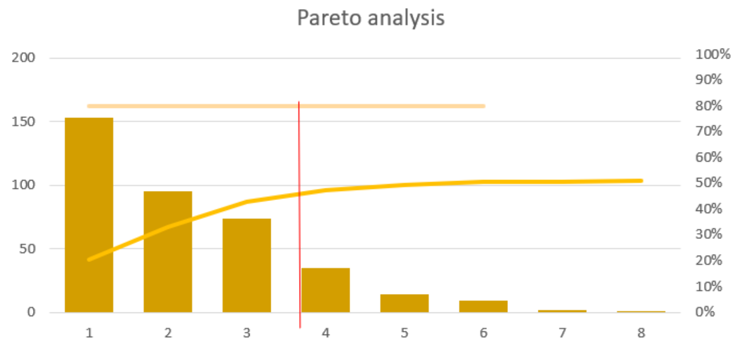

Fig. 7. Pareto analysis (source: authors)

Based on these findings, we can conclude that there has been a substantial reduction in the number of defects from the original 627 pieces with incorrect taper holes to 2 pieces. This achieved result also guarantees the satisfaction of the customer who, without the organisation making changes in relation to the corrective actions implemented, would not be able to complete their products and the organisation would lose this cooperation with the customer in the future.

Although the 8D method is a conventional method, the combination of tools used in each step makes it an innovative method that ultimately and when used correctly improves the

quality management system of the organization so that its positive effect can be seen in reducing non-delivery, in quality assurance and improvement, in teamwork and employee involvement and ultimately is visible in the competitiveness of the organization.
The combination and implementation of used quality improvement methods and tools was crucial to identify problem, to suggest the solution and to achieve the continuous improvement and increases the effectiveness of the system. We propose that as a further method modification can be applied Pareto analysis . Subsequently, as new modification of presented procedure, Shewhart's control charts could be used to confirm the process stability or process capability evaluation.
The 8D method used in the organization and presented in this research is an excellent tool for preventing defects from recurring as claimed. by the PPM (parts per million) results but also by related costs (Krajnc, 2012).
This is confirmed by main findings of (Dziuba et al., 2021) in their case study with a similar problem in an enterprise that uses metal stamping technologies to manufacture products for the automotive and home appliance industries. It concerned the exceeding of length tolerance for the guide section from one hole to another (43+/-0.02). The 8D report was used to analyze the problem, which allowed identifying an important cause of the defect and lehped eliminate it. Another case study completed by (Alexa and Kis, 2016) shows the problems that are occurring with the customer. The customer received a delivery with delivery note 114643176, dated 06/27/2015 regarding this delivery for delivering customer complained, the fact that the packaging finished goods did not comply with its specifications. Improvements implemented in this case study were implemented in the company. After the analysis in this study on quality assurence in the logistics department of the factory, it ensures the production of sensors quality, preventing defects, if any of these defects are ways to improve in order to avoid recurrence.

5. CONCLUSION

Solution to a product complaint of a brake holder, whose problem was the creation of a tapered hole in the prescribed Ø30H7 dimension in operation No.1, where it was suggested to replace the original universal cutter with a finishing cutter. The original universal milling cutter was more suitable in terms of production variety, but after evaluation by the team, it was decided to replace it as a corrective measure. The difference between the universal milling cutter and the finishing cutter is 30€/pc versus a price of over 100€/pc. The price difference in machining costs according to the data from the system are higher by 1,68€/pc only based on the impact of using the finishing cutter and the adequate time extension of the production process. This milling machine replacement is economically more costly to produce, but after eliminating the occurrence of non-conforming products by applying a corrective measure, the occurrence of complaints and thus the unnecessary costs associated with it are avoided.
With regard to the prospect of future use, we consider that this method is applicable and applicable in various manufacturing sectors, not only in the automotive industry. It is also possible to complement the steps of this method with, for example, the Is/Not Is method. Subsequently, as a new modification of the presented procedure, Shewhart's control charts could be used to confirm the process stability or process capability evaluation. Subsequently, as a new modification of the presented procedure, Shewhart's control charts could be used to confirm the process stability or process capability evaluation.

We can conclude that the implementation of the 8D method is extremely important for improving quality and meeting the needs of customers in the automotive sector. By selecting and modifying this method according to the needs of the specific company and the selected product or process, it is possible to make the production process more efficient. It can be successfully used as part of an innovative way to reduce misunderstandings and the loss of information during the data exchange and for standardizing the process of the information flow in complaint management (Behrens et al, 2007.

ACKNOWLEDGMENTS

The paper is part of a project within the Young Researchers Support Programme *„A set of competencies needed in the implementation of MIS in the context of Industry 4.0“.*

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