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Manufacturing requirements and quality control of critical mechanical parts as part of a more efficient production process

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ABSTRACT:
This research aimed to find out how the manufacturing requirements of critical parts and their quality control affect the production process, how the requirements are determined, and how quality control is implemented. Qualitative research methods were used in this research. The primary data consisted of interviews.

According to the research results, manufacturing requirements of critical parts and their quality control affect the production process. Without sufficient measurements and proper investigation based on the finished mechanical parts received from the suppliers, the production process can have a considerable impact. The faulty mechanical parts can cause the process to suffer to produce final products in the factory, and line stoppage may happen. It is also seen that these measurements improve the effectiveness and efficiency of the production process. The requirements were determined based on the specification of the finished parts, the equipment, and the workforce available. Collaboration with suppliers is used in some cases to determine the requirements. With enough crew and good testing equipment, the company is able to take preventive actions to ensure a flowing production process. Quality control was implemented in the production process using specialized testing and inspection tools and strict quality control procedures. Those tools give more detailed answers so that the currently faced quality issues can be solved, and thus, similar problems will not occur in the future. Also, in order to perform adequate quality control, the production team must collaborate and communicate effectively.

The core issues of manufacturing-based definitions of quality, which focus on the supply side of the equation, are engineering and manufacturing processes. The results are only partially generalizable because this research was a case study. However, results can be utilized in the target organization, at least to some extent, so there are some practical implications in the research too.

KEYWORDS: Supplier quality, Supply chain quality, supplier performance

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1 Introduction

The subject I am researching is topical and necessary for companies because, without a sufficient level of requirements and quality control, problems occur more in the production process. Large companies have many subcontractors around the world. If there are no consistent requirements for subcontractors, it may be reflected in other company functions. When the requirements and quality control are at a good level, the company does not have to use extra resources for inspection when goods arrive from subcontractors. Preparing successful manufacturing requirements and quality control benefits the company in the long run so that the additional costs arising from the preparation and control are not significant. The theoretical background of this thesis work is focused on quality management. Supplier quality-related research is used too. Both are part of industrial management, the general field of science in this research.

1.1 Objectives and research questions

This thesis aims to find enough information about quality tools and the factory's performance to answer the research questions about quality control and requirements. The main point of this thesis is to understand, when speaking about quality control of critical mechanical parts, what quality tools are available, and what may be the right ones for a specific industrial company. Furthermore, one of the objectives is to analyze how the manufacturing requirements that have been sent to the supplier and the quality control after that affect the production process in the factory itself. The research questions will be covered in the last conclusion chapter.

The objectives will be achieved by answering the following research questions:

- How do the manufacturing requirements of critical parts and their quality control affect the production process?
- How are the requirements determined?
- How is quality control implemented?

1.2 Background information and limitations

Contrary to conventional characteristics like worth, momentum, and size, "quality" lacks a generally agreed-upon definition. However, practitioners are leaning toward this style aspect more and more. According to their definition, quality can be described as various signals or signal combinations, some of which have been studied in-depth in the academic literature and others that have received only scant attention. The majority of quality is associated with profitability. (Hsu, J., Kalesnik, V. & Kose, E. 2019)

Engineering and manufacturing procedures are the main topics of manufacturing-based definitions of quality, concentrating on the equation's supply side. Although this method acknowledges the consumer's interest in quality, it places its significant focus internally because a product that deviates from specifications is likely to be poorly manufactured and unreliable, offering less satisfaction than a correctly constructed one. Quality is defined as making engineering and production control more accessible. This has caused an emphasis on reliability engineering on the design side and an emphasis on statistical quality control on the manufacturing side. Both methods aim to identify deviations as early as possible. The first one examines a product's fundamental parts, identifies potential failure modes, and suggests alternate designs to increase reliability. The second one uses statistical techniques to identify when a production process performs outside acceptable limits. (Garvin, D. 1984)

In this thesis work, quality is defined around manufacturing, and therefore quality entities like transcendent, product-based, user-based, and value-based approaches have been left out. Some other approaches can be covered shortly, but the main focus stays on manufacturing.

I have worked with quality for many years. It is closely linked with supply chain management and, therefore, a pretty familiar field and function. There are many things that need to be considered when talking about quality. It is not just the specific tools that

have been created over the last years but also the processes and proper measurements that you have to use with your services and products in order to get good level in quality.

1.3 Structure of the study

The structure of this thesis work is following. In the first chapter, I give an introduction and present the objective of the thesis. Then, in chapter two, there is a literature review. In the literature review, I will analyze specific quality tools and what is included in the quality. After that comes methodology, where I analyze how the data was gathered and which style was used.

After the literature study and methodology in chapter four, an analysis will be completed that dives into the functions of the case company. How have certain quality processes been performed, and what are the upcoming developments in the company and factory itself? Finally, I will try to understand what is seen as the main points from the quality and value points of view.

The outcomes of the analysis and the entire thesis will be summarized in the conclusions chapter after the analysis.

2 Literature review

In the literature review, I focus on different quality tools and standards and how those can be used in the industrial field and even in a specific factory. It needs to be determined how to proceed with certain tools when you are analyzing your own performance compared to when you are analyzing others like suppliers. The investigation also covers things like relationships with sub-suppliers. The mechanical parts of the case company rely on the performance of many sub-suppliers. Thus, we must have proper quality measures in place. The review part does not include the quality of materials, design, and tolerances.

2.1 Main quality tools for better overall performance

It can be concluded from the developed theoretical framework and hypotheses that buyers in particular industries could use supplier quality, performance delivery, and supply service as general crucial selection criteria when choosing their suppliers. Especially for suppliers who are already on the company's preferred supplier list because these criteria have a significant, positive effect, and tremendous influence in establishing long-term relationships. According to the investigation's conclusions and those of other academics, the traditional criteria approach based on lowest-cost bidding needs to be more supporting and robust enough in contemporary supplier selection methods. However, the buyer satisfaction as a whole appears to have a minor moderating impact on performance delivery, supply service, and cost to develop a long-term relationship between the customer and the supplier. (Vijayakumar, 2019)

Every issue has a problem below it. As a result, think about using this strategy when trying to solve a problem in the two phases: first, determine the problem's root cause(s), and second, look for strategies to get rid of these reasons and stop them from happening again. This two-step process might seem incredibly straightforward at first. However, it

is simple to undervalue the work required to occasionally identify a problem's root causes. However, once you've identified the real causes, getting rid of them is considerably simpler. Finding the root of a problem is, therefore, crucial. (Andersen and others, 2006)

8D (Eight Disciplines Problem Solving), 4Q (Four Questions), and RCA (Root Cause Analysis) are quality tools that are commonly used in the manufacturing and service industries to identify and address problems or defects in processes or products. These tools are designed to help organizations identify the root cause of issues and implement effective solutions to prevent them from occurring again in the future. These tools are commonly used in the Case company and therefore selected.

These quality tools are generally chosen based on the company's current policies and the organization's specific needs. In addition, they may be selected based on their effectiveness, ease of use, and compatibility with the organization's processes and culture.

If the process is the same after a problem has appeared, it will likely occur again. That is a tragic fact. However, it also means that if the difficult task of resolving those problems at their source is accomplished, such problems are not likely to recur. (Anjoran, 2022)

Every business can choose the best methodology, put it to use, and even combine a few to enhance its operations continuously. The proper methodology must be carefully chosen following the needs and demands of the business and then implemented in the proper process. (Shevtshenko, 2014)

In the car industry and other sectors that demand an organized approach to issue solving, like 8D which is described later on, problems are identified, corrected, and eliminated. The methodology helps improve products and procedures. Identifying the root cause concentrates on where the issue started. (Shevtshenko, 2014)

An efficient method for identifying a root cause, creating appropriate solutions to address that reason, and putting those solutions into practice is 8D. Fast resolution of consumer complaints was the emphasis of the 8D initiative. The first three processes should typically be completed and communicated to the consumer within three days. (Shevtshenko, 2014)

Shevtshenko (2014) presented each step of the 8D process in further depth:

- Planning phase: Lay out a strategy for resolving the issue and choose the necessary conditions.
- Employ a team: Create a team with experts in the product and process.
- Identify and explain the issue: Describe the issue in terms of who, what, where, when, why, how, and how many.
- Creating an interim containment strategy: Identify and implement containment measures to identify and isolate the issue from customers.
- Establish, recognize, and confirm underlying causes and escape points: Determine every plausible explanation for the problem's occurrence and why it went unnoticed at the time.
- Select and confirm Permanent Corrective Actions (PCA) for the Root Cause: Make sure the chosen corrective actions will help the client.
- Implement and validate PCAs: Select the best remedial measures and put them into practice. Long-term remedial measures.
- Prevent recurrence: Change management and operational policies, processes, and procedures to stop the occurrence of this and related issues.
- Gratitude to your team: properly thank the team for their contributions and acknowledge their group efforts.

The personnel involved in 8D problem solving want to continue working after receiving their initial training so they understand what 8D is and how to execute it. Since each challenge will be different, using the 8D approach to them in real situations can be

considered as a type of ongoing training that gives them chances to learn more and improve their skills. (Creative safety supply, 2022)

Additionally, there are choices for learning about 8D itself and the ideas behind that. The ability of employees to use the 8D issue-solving method will be further improved by assisting them in learning also other problem-solving concepts that are available. (Creative safety supply, 2022)

People can start using the 8D issue-solving method right now with only a brief introduction to what it is and how it functions. They can receive extra instruction and experience in the future to help them develop their skills and benefit the team as a whole. (Creative safety supply, 2022)

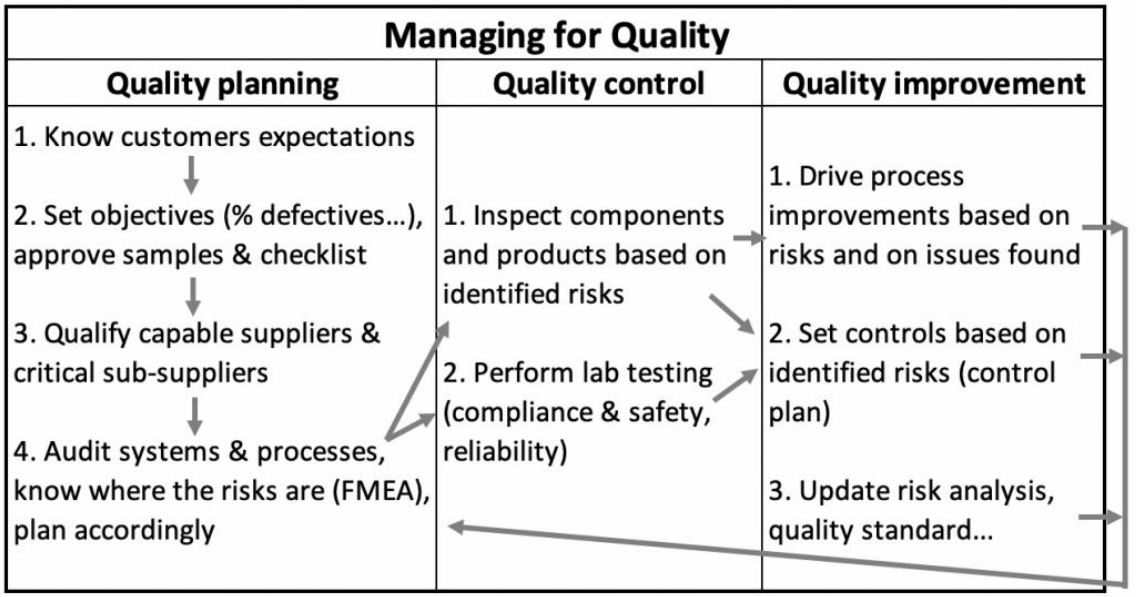

Figure 1. Managing for Quality (Anjoran 2022.)

Management of suppliers' quality influences the entire supplier lifetime, from initial certification to relationship termination. If you do not continuously invest in it and work with factories, quality can even decline instead of rising. A manufacturer needs more assistance from its customers, the less developed its quality management systems are.

You should be sure to identify who needs assistance if you are serious about the quality of your offering. (Anjoran, 2022)

The 4Q process, also known as the 4Q improvement methodology, was created and implemented in the ABB firm in 2009 to put an end to "religious" disputes between supporters of Lean, Six Sigma, PDCA, 8D, and other approaches which were competing which approach was superior to the others. The acronym 4Q stands for Measure, Analyze, Improve, and Sustain. A problem-solving approach like Six Sigma DMAIC is the 4Q process. The Define phase in 4Q is a component of the Q1 Measure as well as the initialization stage for a 4Q project. (Shevtshenko, 2014)

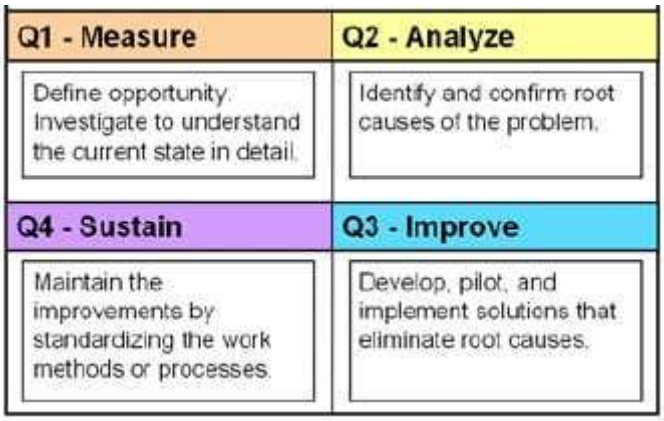

Figure 2. 4Q process (Shevtshenko 2014.)

Root Cause Analysis (RCA) is a method used to permanently identify the underlying cause of a problem or nonconformance to eliminate it through process improvement. RCA is a part of a more extensive problem-solving process and an integral part of continuous improvement in an organization. There are many methodologies, approaches, and techniques for conducting RCA, including events and causal factor analysis, change analysis, barrier analysis, management oversight and risk tree analysis. To conduct RCA, a small team is formed, including members from the business process/area of the organization that experiences the problem, a line manager with decision authority to implement solutions, an internal customer from the process with problems, and a quality improvement expert. The analysis takes about two months, during which equal emphasis

is placed on defining and understanding the problem, brainstorming its possible causes, analyzing causes and effects, and inventing a solution to the problem. (ASQ, 2022)

2.2 Internal quality tools

It is critical to pinpoint the internal quality management relationships that impact social, environmental, and economic sustainability performance dimensions. Improving management and employee interactions while integrating internal quality processes. Quality training demonstrates the businesses' capacity to produce the crucial resources needed to develop their sustainability activities further. (Alsawafi, A., Lemke, F. & Yang, Y., 2021)

Management decisions should consider the best asset configuration and be able to choose and set up resources to provide greater value than a single, isolated component. This requires looking into how much quality management systems aid in improving sustainability performance. In addition, the findings show that management relations are crucial for fostering other high-quality relationships, including those in employee relations and training (Alsawafi, A., Lemke, F. & Yang, Y., 2021).

Tools that are used internally and can be seen as quality tools are six sigma, lean six sigma, the fishbone diagram, and PDCA which is an abbreviation of a plan, do, check, act. These quality tools have a potential to be used externally as well.

There is also a DMAIC model for six sigma. The DMAIC model is a Six Sigma Road plan designed to raise the awareness of output from business processes. Define, Measure, Analyze, Improve, and Control are abbreviated as DMAIC. The twelve steps that walk you through the procedure will help you fill in these five parts. (leansixsigma, 2022)

Six Sigma DMAIC is a methodical, fact-based methodology that creates a "gated process" for project control as well as a strict framework for project management. When there is a large amount of data accessible and statistical tools should be used to solve the

problem, Six Sigma DMAIC is frequently used. Depending on how complex the problem and process to be changed are, the DMAIC project may take up to three months to complete. (Shevtshenko, 2014)

2.2.1 Benefits and disadvantages of internal quality tools

As mentioned previously, there are many tools to be used for better performance; therefore, this chapter analyzes a few of them.

Lean encourages work uniformity and flow, while Six Sigma focuses on eliminating waste (non-value-added processes and procedures) and improving process control. The line between Six Sigma and lean have blurred, and the phrase "lean Six Sigma" is being used increasingly frequently since process improvement necessitates elements of both methodologies to produce fruitful outcomes. (ASQ, 2022)

Lean Six Sigma is an evidence-based, data-driven improvement methodology that prioritizes fault prevention over defect discovery. Lowering variance, waste, and cycle time and encouraging the adoption of work standardization and flow boosts customer satisfaction and bottom-line results while giving businesses a competitive edge. Every employee should participate in it, which applies whenever there is variance and waste. (ASQ, 2022)

Team members can more accurately diagnose a disorder or problem by visualizing its root causes using a fishbone diagram rather than just focusing on its symptoms. It enables team members to establish consensus over the problem and its causes and separate the problem's content from its history. (MN, 2022)

Many businesses that have been working on quality improvement for 15 years and have seen excellent success by strongly emphasizing customer satisfaction and staff involvement have decided against adopting the Six Sigma methodology. A tour of their

headquarters reveals that each department has several scorecards that are displayed and used on a monthly basis. The tour of a factory whose management had fully embraced Six Sigma was described by a company's senior management as lacking a focus on inventory, with all the adverse effects that poor inventory management can have on organizational operating efficiencies. Instead of concentrating on inventory management or transportation, Six Sigma focuses on processes that might involve those inventories. (Raisinghani, M. S., Ette, H., Pierce, R., Cannon, G. & Daripaly, P., 2005)

2.3 External quality tools

A rising amount of research and industry evidence points to the necessity for buyers to actively manage the relationships among their suppliers in addition to their relationships with their suppliers. In a buyer-supplier-supplier relationship trio, the buyer, as the party with whom the contract is made, affects the suppliers' actions and interactions with one another. By considering the relationships in such a triangle, we can develop a broader and more practical understanding of buyer-supplier relationships. (Wu, Z., Choi, T. Y., & Rungtusanatham, M. J., 2010)

A supply manager must understand that interactions between suppliers will immediately affect how his or her own business is run. As a result, managing supplier-supplier interactions requires proactive measures. Additionally, the buying business must commit time and resources to manage supplier-supplier co-opetition because it is not always linked to greater supplier performance. However, the buyers receive immediate information about any potential operational issues the suppliers may have. It allows buyers to foster actual supplier-supplier competition and stronger buyer-supplier connections that make problem-solving more accessible and encourage learning and supplier capabilities development. (Wu, Z., Choi, T. Y., & Rungtusanatham, M. J., 2010)

So, one part of external quality is maintaining a good proactive relationship with suppliers. If this area is not properly maintained company can suffer in different ways, and

many of them are related to some parts of quality. Wu, Z., Choi, T. Y., & Rungtusanatham, M. J. (2010) mention that an operation's quality, delivery, responsiveness, pricing, and technical support are all indicators of how well a supplier performs in terms of supplying the requested goods to the customer.

2.3.1 Benefits and risks regarding to external quality tools

External driving factors are the items, circumstances, and events that take place outside of an organization and are, in general, outside its control. (MBA, 2022)

Each business makes great efforts to attract clients by providing better services, increasing customer satisfaction, and meeting their needs. The company's profit will be impacted if it is unable to get enough customers. Therefore, a company's earnings mainly depend on its clients, who base this on their interest and testing. A company must follow client interests and feedback. According to client demand, the company also changes its offerings regarding quality, price, and other factors. (MBA, 2022)

Based on risk management and mitigation principles, relevant testing activities, specific methodologies, and testing laboratory characteristics should be selected. The types of testing that are appropriate or necessary, whether to conduct the testing internally or externally, how to ensure confidence in the abilities of those conducting the activity, and, ultimately, the ability to rely on the results being reliable and accurate, must all be considered when making decisions. (Brauninger, 2018)

Brauninger (2018) considers these dangers:

1. The price of the test. Cost is undoubtedly a consideration in the decision-making process, but it should never precede other considerations.
2. Place and distance from the production plant logistics and location heavily influence the choice of a testing laboratory. Regardless of the other factors involved, if the testing facility is not sufficiently close or does not have courier service

capability or other means of rapid transport, it is likely that these factors will make this choice of laboratory inappropriate for routine testing, even though it may still be appropriate for confirmatory testing.

3. Quick turnaround for analyses. Another important risk element in the decision tree is the speed of test results, particularly in the food business, where many goods are easily spoilt. If the amount of time needed to achieve the results does not match the permitted product hold period, there is no benefit to the food producer. As a result, when choosing a laboratory, this should be a key consideration.
4. The quality and dependability of results from tests. Although it should go without saying, this risk is the most difficult to assess because there is little actual data to support it, and the right decision depends on implementing a practical risk mitigation approach.

There are also some issues with certain specific quality tools. For example, there are not many drawbacks when adopting 8D problem-solving techniques. The most important one is that it will demand that those who participate in problem-solving activities obtain instruction on how 8D operates (Creative safety supply, 2022).

People understanding this topic will also need to comprehend other closely linked concepts in addition to learning about the actual 8D issue-solving methodologies. Examples of these could be Pareto charts, process maps and fishbone diagrams. (Creative safety supply, 2022)

Finding real solutions to issues at work by applying the 8D concepts has numerous advantages. In order to address issues today and stop them from recurring in the future, the system is initially focused on identifying the underlying causes of concerns. (Creative safety supply, 2022)

Additionally, it is beneficial because it examines "Escape Points" to enhance the capacity to recognize failure should something go wrong again. This system's prevention loop aids in removing the circumstances that led to the failure in the first place. (Creative safety supply, 2022)

One of the key advantages of the 8D systems is that it employs a multi-step strategy to identify issues, develop and implement solutions, and stay focused on ensuring the issue does not arise again. This will help significantly decrease work issues once it is adopted over time, which will help to raise overall profitability. (Creative safety supply, 2022)

2.4 Quality tools in the supplier and subsupplier chain

If you buy products from external suppliers and need to guarantee the high quality, dependability, and safety of your products, you should concentrate on supplier quality control. (Anjoran, 2022)

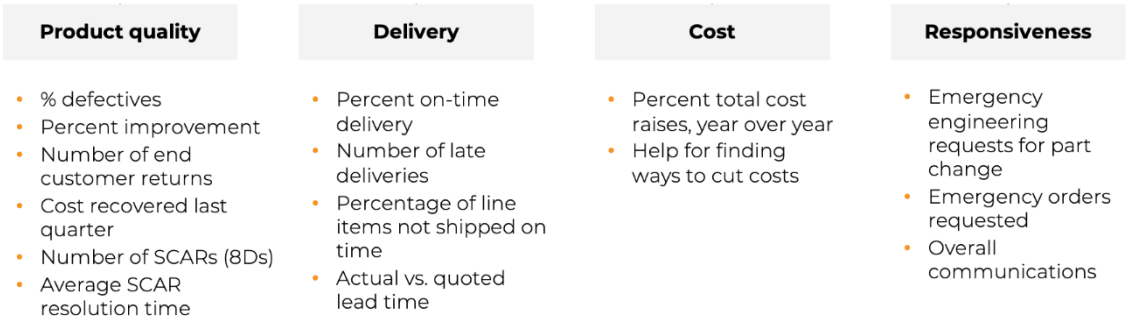

Figure 3. Supplier quality objectives (Anjoran 2022.)

It is extremely usual to track the percentage of defectives, cases where bad quality products were returned, and the number of major problems that resulted in a supplier corrective action request. Monitoring the price of quality that does not meet the expectations is also wise in supplier quality management. (Anjoran, 2022)

SUPERFICIAL COSTS (above the surface, easy to see and measure)	HIDDEN COSTS (below the surface, difficult to see and measure)
• Scrap	• Engineering time
• Rework	• Time to process CAPAs/SCARs (8Ds)
• Penalties & chargebacks	• Management time
• Incoming inspection rejections	• Line and field downtime
	• Increased inventory
	• Decreased capacity
	• Lost orders

Figure 4. Costs of poor quality (Anjoran 2022.)

Many businesses choose new manufacturers without influence from their quality department, instead letting their designers and purchasers do so. Furthermore, collaborating with the wrong partners can be seen in the results. (Anjoran, 2022)

Anjoran (2022) mentions following methods for gathering data to approve or disapprove a company when sourcing a new supplier:

1. The product's initial inquiries, such as "when will this display reach "end of life"?" and "do we need this plastic to be food grade approved to avoid paying for lab tests on every batch?" The appropriate question asked now could prevent much future work, expense, and time.
2. Asking initial questions about the source can help you determine whether you and they are a suitable fit. Both ways are involved. You should verify the capacity, that business seasonality would not be a problem and they are motivated to collaborate with you.
3. Desk examination of the supplier's information may consist of a quick look at general files or a quick Google search for any unfavorable comments. However, it frequently involves getting the specific information and assessing or verifying it.
4. Factory audits - visit the facility and evaluate the quality system and processes to identify the key risks associated with doing business with them. Furthermore, if

travel is prohibited, conducting audits remotely can be necessary. It is a better method compared to doing nothing.

5. Reliability testing on the supplier's product is important if you plan to buy a product that the supplier has already developed. You want to know how durable and reliable their product is by repeating significant stress tests.

You also need to ensure that a key supplier takes developing a new product seriously and follows the proper process, especially if the risks are high (for example, high production volume is approaching, significant exposure to safety problems, etc.). (Anjoran, 2022)

To put it simply, you want to make sure that the new product does not move directly from the prototype to the finished product. Ensure that both the process and product designs have been tested and validated. Risks are minimal if you create new products that are more similar to products which the manufacturer already produces. The likelihood of a quality disaster is particularly high if the product is very new. (Anjoran, 2022)

It would be best to ensure that the necessary processes are not skipped. Items like compliance and reliability tests, building up a quality plan, pre-production pilot runs, etc. are needed. (Anjoran, 2022)

Anjoran (2022) brings up two typical methods for monitoring supplier quality performance:

1. Product inspections at the supplier's facility: Does it make sense to wait for certain parts or goods to arrive before discovering quality issues if they were manufactured in China and shipped to you via an international shipping company? Most likely, you cannot return items for repair. In addition, you have certainly paid the goods. That is not something you look for. Therefore, you need to send an inspector to the factory to discover any problems before shipment if a huge amount of money is at risk.

2. Do you perform at least a fast check on products as they arrive at your location to ensure there are no issues?

Your suppliers will only work in a reactive, short-term mode if your quality staff only contacts them when there is a complaint. Long-term improvements are far more likely to occur if you take the time once a month or once every three months to assemble the various data you have gathered and send that report back to each supplier. Show that you are up to date and that you have goals for them to achieve. Concentrate on only one or two critical signs to send them a very clear message. Describe the effect it will have on the volume of business you provide them. When necessary, let them know that you are speaking to their competitors and potentially decreasing their share. This can be a potential motivator for supplier. (Anjoran, 2022)

Sub-supplier compliance with customers' corporate sustainability standards is an even more important aspect of sustainable supply chain management. Sub-suppliers are those players in the supply chain who have no contractual connection to the customer, also known as suppliers' suppliers or tier "n" suppliers. (Grimm, J. H., Hofstetter, J. S., & Sarkis, J., 2018)

Thanks to research, specialists can have a better understanding of the elements to consider when trying to integrate sustainability above the tier-1 supplier level. For example, to estimate the likelihood of a successful sub-supplier management outcome, specialists may evaluate generally known important success items. (Grimm, J. H., Hofstetter, J. S., & Sarkis, J., 2018)

Table 1. Critical success factors to the management of sub-suppliers for sustainability compliance (Grimm, J. H., Hofstetter, J. S., & Sarkis, J., 2018).

Critical success factors	**Description**
C1. Trust between customer and direct supplier	The trust between a buying firm and its direct supplier can be described by the relationship in which the two parties perceive each other as credible and kind (Doney and Cannon,

	1997). Trust is critical for strategic supply chain partnerships (Handfield and Bechtel, 2002).
C2. Trust between direct supplier and sub-supplier	Similar to the customer–direct supplier relationship, trust between the supplier and sub-supplier is considered a critical factor. Trust in this situation is defined in the same way as in C1.
C3. Customer's buyer-power (over direct supplier)	The customer's buyer power over its direct supplier is determined by a direct supplier's dependence on the customer's spend (Cox, 2001).
C4. Direct supplier's buyer-power (over sub-supplier)	Similar to trust as a double-link factor, buyer power can be defined in a similar context. Whereas C4 enables the customer to reveal a sub-supplier identity, a direct supplier's buyer-power is an important factor that allows for the greater customer–sub-supplier access for direct interactions. The joint approach of a customer's corporate sustainability standards requirements and direct suppliers' assistance combined with buyer power will result in higher response rates by sub-suppliers.
C5. Committed long-term relationship between direct supplier and sub-supplier	Well-established business relationships that partners consider so important that they require significant effort and resources demonstrate committed long-term relationships (Ganesan, 1994, Morgan and Hunt, 1994).
C6. Supply know-how of the customer	The supply know-how of the customer reflects the firm's comprehensive knowledge of its supply chain—including knowledge of procured products, related processes, and characteristics of sourcing markets (e.g., cultural specificities).
C7. Direct supplier's willingness to disclose sub-suppliers	C7 describes the willingness of the direct supplier to reveal its sub-suppliers to the customer.
C8. Involvement of direct supplier	The involvement of the direct supplier reflects a direct supplier's active mediating role in the sub-supplier management activities. The coordination and processing of the sub-supplier management initiative are not left to the customer itself; rather, the direct supplier's support is required.
C9. Perceived value for direct supplier	C9 focuses on the direct supplier's perceived value from the execution of sub-supplier management activities or further aspects in sub-supplier-related activities with the

	customer. Value can be described as a trade-off between benefits and sacrifices and includes both monetary and non-monetary elements (Walter et al., 2001, Walter and Ritter, 2003).
C10. Perceived value for sub-supplier	The sub-suppliers perceived value in being involved in its customers' initiatives can be defined similarly to C9. It can be the direct or indirect benefits that it recognizes, but a cost/benefit evaluation is probably needed.
C11. Low risk of supplier by-passing	The risk of supplier by-passing is the risk that the customer will terminate a business relationship with the direct supplier and start to source directly from the sub-supplier. This activity has also been defined as disintermediation in the literature (Rossetti and Choi, 2008, Spekman et al., 2002).
C12. Sub-supplier's capability to comply with requested sustainability standards	C12 focuses on sub-suppliers' sustainability performance and its ability to fulfill a customer's sustainability standards (e.g., working hours, wages, or biodiversity).
C13. Little geographical distance between supply chain partners	C13 refers to the geographical (physical) proximity between the locations of a customer, direct supplier, and sub-supplier.
C14. Little cultural distance between supply chain partners	The culture and society in which the supply chain partners are involved play important roles in the sustainability compliance dimensions (Awaysheh and Klassen, 2010, Hofstede, 1980).

2.5 Quality tools to be used in the buyer-subsupplier chain

Managing quality is one of the sub-suppliers' more evident potential drawbacks. Controlling the quality of components, you do not manage might be challenging. This is complicated because some suppliers are hesitant to reveal information about their sub-suppliers, making it much harder or impossible for you to verify the components and materials of sub-suppliers at their source. (Bruce, 2016)

It is typical for suppliers or trade firms to decline to reveal a sub-suppliers name and contact information. It would be best to rely only on the provider to convey your demands to sub-suppliers without their approval. (Bruce, 2016)

The process of sourcing various components and materials can tell that your specs or needs may change as they move up the supply chain from one person to the next. You can discover that sub-suppliers receive incorrect information even if you are quite clear about your expectations. (Bruce, 2016)

When a manufacturer tries to fix quality issues prior to shipping, delays may result. This difficulty is often made worse when sub-supplier-sourced components or materials are involved. (Bruce, 2016)

Your supplier may have specific expectations. However, that does not imply that sub-suppliers have the same standards set for them. It can be quite complicated if your supplier and any sub-suppliers have differing compliance criteria. (Bruce, 2016)

The difficulty of locating and engaging sub-suppliers is the key distinction between managing suppliers and sub-suppliers. Identification is made much more challenging by dynamic sourcing markets. The customer's sub-suppliers (i.e., suppliers) may change, causing the prior sub-supplier management efforts to be useless. (Grimm, J. H., Hofstetter, J. S., & Sarkis, J., 2016)

It is crucial not to overlook the relevant direct supplier when managing sub-suppliers. The direct supplier should not feel he is being disregarded or that he can avoid taking accountability for his source. So, overseeing sub-suppliers is now a part of our standard supplier management. (Grimm, J. H., Hofstetter, J. S., & Sarkis, J., 2016)

2.6 Quality standards

Standards are part of quality and environmental management and the quality toolkit. Therefore, standards will be covered in this chapter as an important part of quality.

An effective way for businesses to document the components of their quality systems is by using ISO 9000, a set of international standards on quality management and quality assurance. The foundations and terminology for quality management systems are laid out in this standard. They can be used by organizations of any size and are not exclusive to any sector of the economy. (ASQ, 2022)

ASQ (2022) mentions that the following standards are part of the ISO 9000 family:

- Requirements for Quality Management Systems, ISO 9001:2015
- Fundamentals and vocabulary for Quality Management Systems according to ISO 9000:2015 (definitions)
- ISO 9004:2018: Quality Management: Organizational Quality: Direction for Long-Term Success (continuous improvement)
- Guidelines for Auditing Management Systems, ISO 19011:2018

Implementing defined quality management principles forms the foundation of the ISO 9001: 2015 standard. These include relationship management, customer focus, leadership engagement of people, process approach, improvement, and evidence-based decision-making. According to the standard, an organization's effectiveness and efficiency in attaining its desired goals are influenced by its understanding of and management of processes. The organization can manage the interdependencies and relationships thanks to this "process" approach. (Oakland, 2020)

The international standard ISO 14001 outlines the criteria for a successful environmental management system (EMS). Instead of creating environmental performance standards, it offers a framework that an organization can adhere to. (ASQ, 2022)

As a voluntary standard that enterprises can certify, ISO 14001 is a member of the ISO 14000 family of environmental management standards. Incorporating it with other management systems standards, notably ISO 9001, can help the firm achieve its objectives. (ASQ, 2022)

An environmental management system is "part of the management system used to manage environmental elements, meet compliance duties, and address risks and opportunities," according to the International Organization for Standardization (ISO). An approach to continuous improvement known as plan-do-check-act (PDCA) can be utilized in conjunction with the ISO 14001 standard's structure. (ASQ, 2022)

Companies are looking for ISO 9000 certification hoping that the advantages are higher than the expenses. Gaining a larger market share, satisfying client demands, and enhancing process efficiency are a few of the motives researchers have discovered for pursuing registration. Others highlight achieving lower operational expenses, higher quality, competitive advantage outside, and internal benefits like better documentation and quality awareness. There are following main advantages of ISO 9000: cost reduction and/or increased profitability, enhanced operations, greater communication, and market expansion. (Stevenson, T. H. & Barnes, F. C., 2001)

There are a lot of complaints about the official certification process of ISO 9000. When ISO 9000 was created, the process around it was not well planned and it was thus complicated. Many experts think certification is far too expensive and more about getting formal high-quality credentials than chasing excellence. (Stevenson, T. H. & Barnes, F. C., 2001)

There have also been some other criticisms made. For instance, the individual standards bodies of the participating nations, who choose the organizations authorized to grant ISO 9000 certifications, were left in charge of the regulation and implementation of the standards. Once certification administrators are accredited, they must follow various rules, and depending on the administrators, different amounts of work may be necessary for certification. (Stevenson, T. H. & Barnes, F. C., 2001)

Quality management is a field in which organizations can get certifications. The achievement of many process related certifications is also viewed as a sign of quality for the certified organization. Quality certifications represent a bit broader category than certifications in other areas. (Gantz, 2014)

Although there is no matching organizational-level certification, businesses that use quality management or improvement approaches like Total Quality Management (TQM) or Six Sigma might have individual personnel who have several kinds of quality certificates. Organizations that are looking for certification often would like to demonstrate their commitment to quality management techniques. The requirements for quality management systems, proposals for improving the effectiveness and efficiency, and instructions on performing audits of such systems are all covered by broad standards like those referred to as ISO 9000. (Gantz, 2014)

To receive a quality certification, a company must follow some defined procedures and pay a fee. These certificates are intended to inform the public about the competence of the organizations. For instance, consumers may have a favorable opinion of certified businesses. In addition to giving them a competitive advantage, many contracts may require them to show external quality certificates. The certification procedure might also reveal inefficiencies or point out areas where business processes could be simplified and profitability increased. (Goel, R. K. & Nelson, M. A., 2020)

In comparison foreign innovations may be more affordable, enabling businesses even more to increase and maintain competitiveness or, in some situations, even beat domestic rivals. Quality-certified businesses can use certification benefits to find partners ready to work with foreign technologies and perhaps even acquire foreign technologies on more favorable terms. (Goel, R. K. & Nelson, M. A., 2020)

3 Methodology

3.1 Research method

Qualitative research methods seek to understand individuals' underlying meanings and experiences rather than just collecting and analyzing numerical data (Creswell, 2018). One standard way of collecting qualitative data is through interviews, which can be conducted in person or over the phone and structured or unstructured (Denzin, 2017).

Interviews based on questionnaires are structured interviews that use a predetermined set of questions. These questionnaires can be open-ended, allowing respondents to provide detailed responses, or closed-ended, requiring respondents to choose from predetermined alternatives (Creswell, 2018).

One advantage of using questionnaires in interviews is that they allow for more consistent and standardized data collection, as all respondents are asked the same set of questions in the same order (Patton, 2015). This can be especially useful for large-scale studies with many respondents, as it allows for more efficient data collection and analysis (Creswell, 2018).

However, it is essential to remember that using questionnaires may limit the flexibility of the interview and possibly constrain the respondent's ability to express themselves fully. It is, therefore, essential to balance the benefits of standardization with the potential disadvantages of rigidity. (Patton, 2015).

In conclusion, questionnaires-based interviews can be valuable for collecting qualitative data (Creswell, 2018). However, it is vital to consider the potential limitations of this approach and to ensure that the questionnaire is carefully designed to allow for a meaningful understanding of the experiences and perspectives of the respondents (Denzin, 2017).

The company's name will be anonymized in order to use the gathered information in this thesis.

The primary data-gathering method is the interview. This method is used because of the multidimensional nature of the research topic. In addition, it is easier for respondents to answer in interviews after fulfilling the questionnaires.

3.2 Data

Nine individuals were selected from a variety of job roles for interviews. A questionnaire was also developed and sent to each participant, which included the following questions:

- How aware are you of the process for conducting a root cause analysis (RCA) or a corrective action analysis (such as 8D or 4Q)?
- Have you ever participated in a root cause analysis (RCA) or a corrective action analysis (such as 8D or 4Q)?
- In your experience, how effective have root cause analysis (RCA) or corrective action analysis (such as 8D or 4Q) been at identifying and addressing the root cause of issues?
- How often are root cause analysis (RCA) or corrective action analysis (such as 8D or 4Q) conducted in your organization?
- In your opinion, what factors contribute to the success of a root cause analysis (RCA) or corrective action analysis (such as 8D or 4Q)?
- How will the process for conducting root cause analysis (RCA) or corrective action analysis (such as 8D or 4Q) change in the future?
- In your opinion, which method is the best for root cause analysis and corrective action analysis (such as RCA, 8D, or 4Q)?

After participants filled out the questionnaire, I arranged one on one interviews with them and went through the answers they had.

Table 2. Data (Interviews, 2022).

Data	Amount
Interviews	Average length 40 minutes
Questionnaires	9 Respondents
Documents	8D document, Quality manual

3.3 Analysis of the data

We need to analyze the data from this questionnaire to understand how well root cause analysis (RCA) and corrective action analysis (such as 8D or 4Q) are working in an organization. Here are some steps that should be considered:

We need to ensure the data is organized and ready to be analyzed. This may include sorting it into relevant categories, eliminating duplicate or incomplete responses, and correctly formatting it.

Next, we will do a map of where we are currently with the processes and where we want to go with them in the future. Again, it should be done based on the interviews and questionnaires that were available.

Finally, we will interpret the results and draw conclusions based on our findings. This may include identifying patterns or trends in the data and making recommendations for future action.

It is essential to choose the proper analysis techniques based on the research questions we are asking and the nature of the data.

4 Results

4.1 Case company

The case company is a global leader in innovation and technology with a history of over a century. The company has had a huge impact in developing electrification and automation.

The company has consistently invested in research and development, focusing on creating advanced technologies that drive progress. Nowadays, the company offers various products and services, from renewable energy solutions and electric vehicle charging infrastructure to robotics and digital services. There are four different business areas in a company structure.

Sustainability is getting more critical each year. The company is committed to reducing its environmental impact and helping its customers do the same by developing innovative technologies that enable more efficient and sustainable use of resources. The company tries to take sustainability to the supplier field, even more to ensure everything matches the global legislation. In addition, the company strives for qualitative consistency even though it has a wide range of suppliers in terms of material and location.

The case company has an operating model where it empowers business areas and divisions with full ownership and accountability for their strategies, performance, and resources while serving as the "glue" that holds the group together.

Overall, the company's commitment to technology, innovation, and sustainability positions it as a major player in the global marketplace and a driving force for change in a positive way.

4.2 Findings from the research questions

The findings in Table 3 indicate that the manufacturing requirements and quality control measures for critical parts significantly impact the production process. These measures are essential for ensuring that the final product meets the necessary specifications and is of high reliability and quality. The requirements for the production process are determined based on various factors, including the specifications of the finished parts, the available equipment and personnel, and industry standards or regulations. Quality control is implemented using inspection and testing equipment, strict quality control procedures, and effective communication and collaboration among the suppliers and production team. Overall, these findings suggest that careful and continuous attention to the manufacturing requirements and ongoing quality control measures for critical parts is essential for the success of the production process.

Table 3. Research questions and findings (Interviews, 2022).

Research question:	Findings (from interviews and other material):
How do the manufacturing requirements of critical parts and their quality control affect the production process?	The manufacturing requirements and quality control measures for critical parts affect the production process by ensuring that the final product is of high quality and reliability. These measures improve the efficiency and effectiveness of the production process. However, implementing measures takes time and effort, so you must be prepared. Choosing the right key performance indicators supports continuous improvement.
How are the requirements determined?	The requirements for the production process are typically determined based on

	factors such as the specifications of the finished parts, the equipment and trained personnel available, and relevant industry standards or regulations. The manufacturer, the customer, or a combination may establish these requirements. Sometimes, the requirements may also be determined through collaboration with suppliers.
How is quality control implemented?	Quality control is typically implemented in the production process through the use of inspection and testing equipment, as well as strict quality control procedures such as 8D. Effective communication and collaboration among the production team and suppliers manufacturing these parts are also essential in implementing effective quality control.

4.3 Currently used quality tools

Current high-quality tools are mostly focused on problem-solving. When these tools are used properly, suppliers examine their procedures more closely and identify any areas that can utilize improvement. The main quality tools used in the case company are 4Q, RCA, and 8D.

Everyone in the company knows that quality is an important part of the functions such as safety and environment. Even though everything is usually considered, the employees might need some assistance to understand items that need to be taken into account for the quality to be and remain good. Furthermore, while discussing good quality, it's

important to agree on what is considered good. So that there are no misunderstandings in this area, a clearly defined process must be followed and accepted throughout the organization. (Interview, 16.1.2023)

The 4Q method is related to quality and the prevention of future problems and was developed by the group of the case company. That is also one reason why this tool is used in the case company. It appears that this could be prioritized over other quality tools because it does not require as much effort from suppliers (Interview, 10.11.2022).

The 8D tool is really good and comprehensive, but if you want to benefit from it, you must spend a lot of time and effort on it. A badly prepared 8d report serves no one and thus becomes more of a problem for everyone because the root cause cannot be identified, and therefore it is difficult to eliminate (Interview, 14.12.2022).

The goal is to concentrate qualitative monitoring on mechanics at the case company. Improvements are being made to the mechanics since the needs for electronics and related components have been specified and organized already more effectively in the company. Nowadays, mechanics contains strict designs and tolerances that items must follow in order to be accepted. But it needs more comprehensive and long-lasting standards that would influence the entire procedure. Therefore, the case company should learn how to increase quality control and manufacturing requirements related to mechanics. Potential issues that could develop are less likely to happen when the suppliers know what we are expecting from them.

4.4 Current quality processes

The case company's standards are, for example, Quality management systems ISO9001, Environmental management systems ISO14001, Information security management systems ISO27001, and Occupational health and safety management systems ISO45001.

Case company, as a big multinational organization, has acquired a lot of standards so they can operate better globally.

The case company has a few separate teams that are handling quality processes. One is related to the case company's end customer and their issues, and the other focuses on quality processes related to local production. The team working with the end customers are trying to focus on which problems are related to functions on our side and what issues can be connected to the case company's suppliers and sub-suppliers.

The production quality team knows best who is responsible when something is wrong with quality. A lot of testing is included in the production, so the problematic part or function can be easily pinpointed. When targeting has been done with the help of the supply chain management team, quality issues are raised and forwarded to the right party.

Even though quality and procurement teams are working together to ensure supplier quality is on a good level, there may be better solutions. When procurement and the production quality team are committed to other tasks, there needs to be a way how to increase the monitoring of suppliers. Too little monitoring can lead to more problems because suppliers know when the case company does not do the investigation in the long run.

4.5 Quality topics in the Case company

One example of the 8D report can be found in Appendix 2. It outlines a problem that occurred during the production of a specific product, the Front Plate Wide, CT/VT Connectors, with a reference number of 640HE. The report states that the customer informed the poor quality of threads and required replacements for faulty parts.

An important part of this report is the thorough analysis and identification of the root cause of the problem. It is stated that the quality of the material used causes the problem and that there needs to be a defined quality control in place during the production process. This is a major thing because it shows how important it is to have effective quality assurance methods and procedures. The likelihood of occurring errors and problems increases without effective quality control procedures.

According to the statement, replacements for the faulty parts have been ordered. Before they are sent to the customer, a 100% visual inspection will be carried out to check that there will not be any problems. Even though this is a good temporary fix, it is crucial to consider how this problem will affect the supply chain in the long run. According to the corrective action part in the 8D, you should implement a quality control system in order to find failures before the shipment.

There were also other corrective actions listed, like training the operator to inspect the threads during the construction phase and implementing a random sampling process to check the threads during the manufacturing. These are significant tasks that try to show the underlying causes of the issue. It is critical to assess whether they will be sufficient to address the problem effectively and whether they will be sustainable over time. In addition, it would be beneficial to consider also further actions that can be used to improve the overall quality control process, such as employee training or adopting more advanced inspection and testing technologies.

The research also proposes looking into the possibility of threading the parts on a plate machine in the future, which would reduce issues of the material's quality. This is a crucial factor because it tackles the root cause of low-quality material and adopts a preventative strategy to avoid such problems.

The 8D report offers a thorough assessment of the issue, its root cause, and the steps taken to prevent it from happening again. In addition, for an even more comprehensive

and effective solution, it is crucial to evaluate and consider additional measures that can be implemented to improve the overall quality control process and conduct routine follow-ups to ensure that the implemented actions are successful and continuing.

4.6 Results from interviews and research

8D is a too complicated method for continuous quality follow-up. The systematic use of 4Q is the right method, forcing you to find a root cause and preventive actions. You will get the best possible outcome when first measuring, analyzing, finding improvements, and finally maintaining them by standardizing methods and processes. (Interview, 16.1.2023)

In order to be successful, you should put enough effort into quality measurements. It should not be only a routine process for filling different forms like 8D templates. It should be performed in a professional manner with people who have been trained properly. Also, close follow-up with the supplier in a timely manner is needed. Comprehensive reporting is also very important in order to get good quality. (Interview, 16.1.2023)

We should have a quality plan or inspection guide for all components which are relevant to our product quality. We should define conditions, classifications, if any, inspection objects like defects, and criteria to be used. Should have a clear document that has been provided to the supplier in concern and communicated well. Then close follow-up and proper reporting. (Interview, 22.3.2023)

There should be the right materials in place, and material quality should be at the required level. Also, we should clearly define tolerances, so we need to be very clear about our requirements and how to communicate them well to the supplier. (Interview, 25.1.2023)

You should invest in modern manufacturing technologies. With the right equipment, you will get the right quality level and meet requirements. There are technics like 3d printing which you can utilize further in the future. (Interview, 25.1.2023)

To locate and solve the root causes of organizational issues, root cause analysis (RCA) and corrective action analysis (CAA) techniques like 8D and 4Q are utilized. These planned, systematic procedures are employed to stop reoccurring issues and raise the effectiveness of the company as a whole. The questionnaire included in Appendix 1. aimed to gather information about individuals' awareness and experience with these methods and identify areas for improvement in the RCA and CAA process.

The questionnaire consisted of several questions, starting with asking about the level of awareness of the process for conducting RCA or CAA. Eight out of nine respondents said they were at least somewhat aware of the process, while only one respondent did not know about the methods concerned. Although most people have a basic knowledge of RCA and CAA methodologies, additional education and training may be necessary to ensure an even better understanding of the procedure.

The questionnaire also asked if the respondents had ever received a report based on RCA or CAA, to which seven out of nine employees responded positively. This indicates that RCA and CAA methods are commonly known in the organization. However, replies to whether these techniques help locate and treat root problems varied, with some describing them as highly effective. Some, however, thought they were completely ineffective. This highlights the importance of ensuring that RCA and CAA methods are implemented correctly and that the results are considered, and clear actions are determined.

Answers varied in how frequently RCA and CAA were conducted. In some areas, it was consistently conducted, while in other areas, so not so often. This implies that RCA and CAA implementation can be inconsistent and that, in the case company, they may need to examine their procedures to ensure they are carried out regularly and successfully.

The success factors for the RCA and CAA methods were also covered in the questionnaire. Enough resources, clearly defined roles and responsibilities, standardized processes and tools, and strong problem-solving abilities were the most frequently chosen factors. These factors are crucial for ensuring that RCA and CAA methods effectively identify and address root causes and prevent recurring problems.

When asked about the potential changes in the process for conducting RCA and CAA in the future, opinions were mixed. Major of respondents believed it would become more efficient, while others believed it would stay the same.

Several respondents chose 8D analysis as the best quality assurance method. This shows that most respondents believe the 8D report is the best approach to moving ahead. As the 8D method is quite a common problem-solving approach, it is utilized in many industries. All the details regarding an issue and the actions done to address it are contained in the 8D report. The challenge with the 8D lies in the fact that it is updated as a routine action only. Not paying enough attention to the quality of the data.

The questionnaire answers generally imply that the existing RCA and CAA process may be improved. To ensure these strategies' success, organizations should prioritize having enough resources, clearly defined roles and duties, senior leadership support, standard processes and tools, and strong problem-solving abilities. Moreover, initiatives should be taken to solve recurrent issues, including a need for more precise advice and proper data analysis. Finally, to guarantee that the process is as efficient and successful as possible, businesses should review their processes, make sure that RCA and CAA procedures are being conducted regularly and efficiently, and stay up to speed with the most recent methodologies and tools for doing RCA and CAA.

For the electronics industry to produce high-quality, reliable products, mechanical components must be used. These elements support and connect other components,

enabling them to work properly and carry out their intended functions. Thus, defining standards and quality control at a specific level is essential.

Using high-grade mechanical components that can withstand the challenges of daily usage. This contains elements that can impact the functionality and durability of electronic equipment, such as temperature, humidity, and mechanical stress. This is something that must be understood both during the decision-making and quality control implementation processes.

To ensure the quality of mechanical parts, is to select the materials used in their construction carefully. High-strength metals and alloys should be used in this matter as they are known for their durability and resistance in use. The manufacturing process should also be carefully managed to ensure that the parts are always designed to meet exact specifications with strict tolerances.

To guarantee that the mechanical parts meet the requirements of the final product in the electronic field, a quality development plan for these parts should concentrate on several critical areas.

The plan should include precise specifications for the parts, including detailed dimensions and tolerances, materials, and any other relevant information. This will help to ensure that the parts are manufactured consistently and based on the required standards.

In addition to the exact specifications for the parts, the plan should also include an overview of the manufacturing processes that will be used to produce the parts. This might include information about the equipment and technology to be used, as well as the quality control measures that will be put in place. What is considered extremely important in the manufacturing process should be more thoroughly looked at.

The plan should include robust testing and inspection requirements to verify that the parts meet the company's specified needs. This might consist of functional testing, visual inspections, and other methods to ensure that the parts are fit for use.

The testing and inspection process should be carefully documented and tracked to address and resolve any identified issues quickly. This could involve carrying out corrective action plans, like 8D reports, to address any issues found. We can also include routine audits to ensure the quality control procedures are working properly. In addition, visual tolerances should be considered. For example, aluminum is a very sensible metal, and even minor movements can affect the quality of the surface.

Other items in the plan are ideas for continuous improvements, such as regular assessments of the manufacturing processes and implementing any necessary changes to improve the quality of the parts. This could involve updating equipment, implementing new technologies, or making other changes to the manufacturing process. The plan should include using, for example, 4Q and 8D reports to identify trends in the quality of the parts and to facilitate the implementation of corrective actions as a part of continuous improvement. Also, common workshops can be arranged from time to time on the received reports as corrective actions.

To support continuous improvement, the plan should also include a system for tracking and reporting on the quality of the parts. Regular checks based on the manufacturing performance of suppliers and other forms of monitoring, as well as statistical analysis and other data-driven approaches, help to identify trends and patterns in the quality of the parts.

To conclude, the plan should include a clear communication chapter with customers and other stakeholders about the quality of the parts. This might involve regular reports and updates, as well as how to address any concerns or issues.

In general, a comprehensive quality development plan for mechanical parts in the electronics business should focus on precise specifications, robust testing and inspection, continuous improvement, effective tracking and reporting, and transparent communication throughout the whole process with suppliers, customers, and other stakeholders. By implementing such a plan, businesses can better ensure that their mechanical parts meet the necessary standards and are fit for use in the final products which will be delivered from the factory.

5 Conclusions and discussions

5.1 Conclusions

This research aimed to comprehend how the production process is affected by the manufacturing requirements for critical parts and their quality control, how these requirements are established, and how quality control is carried out.

This research questionnaire was based mainly on simple and close-ended questions, so it led to a good discussion in the follow-up interview. After interviews and analysis, we can state the following regarding the research questions that were chosen:

The requirements and quality control measures affect the production process by ensuring the high quality and reliability of the end product. These measures will improve the efficiency and effectiveness of the production process. However, implementing measures takes time and effort, so you must be prepared. Choosing the right metrics supports continuous improvement.

The requirements for the process are typically determined based on the following factors: specifications, existing equipment, proper personnel available, and relevant industry standards or regulations. The manufacturer, the customer, or the collaboration with suppliers may establish these requirements.

Usually, quality control is implemented in the production process through the use of inspection and testing equipment, as well as strict quality control procedures. Effective communication and collaboration among the production team and suppliers manufacturing these parts are also essential in implementing effective quality control. Based on interviews and research, the 8D method could be the right method for quality assurance in the case company.

The performance and reliability of electronic devices depend heavily on the usage of high-quality mechanical components. It is possible to raise the general level of quality and performance by carefully selecting materials and manufacturing procedures and designing these components with consideration for their intended purpose and operating environment.

In addition to using the 8D method, you also need to have a specific quality plan for essential parts. The plan should include, for example, precise specifications for the parts, including detailed dimensions and tolerances, robust testing and inspection requirements, and the quality of materials. This will help to ensure that the parts are manufactured consistently and based on the required standards. The testing and inspection process should be well documented. We can also include routine audits to ensure the quality control procedures are working properly. Other items in the plan are ideas for continuous improvements, such as regular assessments of the manufacturing processes and implementing any necessary changes to improve the quality of the parts. This could involve updating equipment, implementing new technologies, or making other changes to the manufacturing process.

5.2 Discussions

In the industry that the case company operates in, using high-quality tools might sometimes be difficult, especially when it comes to mechanical components. This is because of several reasons, like the small size and delicate nature of electronic components, the rapid rate at which the industry is developing, and the requirement for extremely high levels of accuracy.

New products and technologies are being developed and introduced constantly, meaning quality tools must be continuously updated and calibrated to ensure they remain accurate and relevant. This can be time-consuming and costly, making it difficult for companies to keep up with the latest developments.

Even minor errors can have major consequences for the business, leading to errors or even failures of the finished product. This means that quality tools must be able to measure parts with a high degree of accuracy. It may be challenging to achieve with traditional tools that are open to human error and other sources of measurement factors.

Another issue is that there are a lot of different types of mechanical parts that are used in the industry. A single quality tool may not be able to measure all the different parts a company uses, which can require investments in specialized tools. This can be expensive and difficult to maintain, particularly if budgets and resources are limited.

The increasing complexity of electronic devices means that they are often made up of many different parts that must be carefully assembled and tested. It can be challenging to use quality tools to ensure the overall quality of the finished product because it is often needed to test each item separately.

One way to improve the quality of mechanical parts is to conduct thorough testing and quality checks on all parts before they are used in production. This can help identify potential defects and allow for corrective action before the final products use the parts. In addition, it is also wise to work with reliable and experienced suppliers with a proven track record of producing high-quality mechanical parts. This can help ensure that the parts used in the production meet industry standards and customer expectations.

In addition to these actions, purchasing advanced manufacturing machinery and procedures is advised. This can help improve the accuracy of the mechanical parts and reduce the likelihood of defects. For example, using manufacturing techniques like 3d printing, which was also mentioned in the interview, can help improve the quality and consistency of mechanical parts. The strict regulation based on packing and handling the mechanical parts is also something to be considered. Furthermore, implementing a robust quality management system can help ensure that all aspects of the production process, from

raw material sourcing to the final assembly, are carried out in a consistent and controlled manner. This can help prevent defects and improve the overall quality of the mechanical parts.

If there would be an opportunity for more resources, those should be implemented by creating a supplier quality team. The supplier quality team would continuously monitor and be directly responsible for matters related to quality processes on the supplier side.

In the end, by implementing suggestions like these, companies in the electronics business can improve the quality of their mechanical parts, leading to better customer satisfaction and increased profitability by decreasing the cost of poor quality, which is covered in Figure four. These actions can also assist businesses in keeping a competitive edge in the marketplace and developing a reputation for creating high-quality goods. Likewise, by investing in quality control measures and working with experienced suppliers, companies can ensure that their mechanical parts will be of the highest quality in the future as well. As a result, the total quality of the final products will be on better level.

There is a very strict direct cost control for purchased items. The cost of poor quality is not visible in that follow-up. It is recorded as an overhead cost. In order to improve the total cost, you should focus on investigating overhead costs as well. Nowadays, overhead cost consists of many different items, and it is worth further investigation. Also, the quality costs of sub-suppliers should be considered as they can be significant in the total supply chain and raise the price of the final product.

The results of this study are only partly generalizable because the thesis was done only in one company. However, the trustworthiness of the research was fairly good because we got relevant data from the case company. In addition, we were also able to compare the literature to the data that was acquired from the company. According to this thesis, more research is needed regarding the influence of product design, production

equipment, tolerances, and material quality. Quality tools are commonly known, but understanding how they work in practice must be worked on.

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Appendix

Appendix 1. Questionnaire

How aware are you of the process for conducting a root cause analysis (RCA) or a corrective action analysis (such as 8D or 4Q)?

• Very aware

• Somewhat aware

• Not aware at all

Have you ever received a report based on a root cause analysis (RCA) or a corrective action analysis (such as 8D or 4Q)?

• Yes

• No

In your experience, how effective have root cause analysis (RCA) or corrective action analysis (such as 8D or 4Q) been at identifying and addressing the root cause of issues?

• Very effective

• Somewhat effective

• Not effective

How often are root cause analysis (RCA) or corrective action analysis (such as 8D or 4Q) conducted in your organization?

• Always

• Often

• Rarely

• Never

In your opinion, what factors contribute to the success of a root cause analysis (RCA) or corrective action analysis (such as 8D or 4Q)? (Select all that apply)

• Adequate resources (time, personnel, equipment)

- Clearly defined roles and responsibilities
- Senior leadership support
- Standardized processes and tools
- Good problem-solving skills
- Other (please specify)

How do you think the process for conducting root cause analysis (RCA) or corrective action analysis (such as 8D or 4Q) will change in the future?

- It will become more efficient
- It will become less efficient
- It will stay the same
- Other (please specify)

In your opinion, which method is the best for root cause analysis and corrective action analysis (such as RCA, 8D, or 4Q)?

- Root cause analysis (RCA)
- 8D analysis
- 4Q analysis
- Other (please specify)

Please describe in detail any challenges you have encountered while receiving reports based on root cause analysis (RCA) or corrective action analysis (such as 8D or 4Q). How did you overcome these challenges and what steps did you take to ensure the success of the RCA or corrective action analysis process?

Appendix 2. 8D report

8D REPORT			Reg.no: CCO-A3518/2021
Customer:		Customer Id: 10034	Date: 7.7.2021
Customer reference: NZG-077323			Customer date: 6.7.2021
Article name:	Article no:	Qty:	Rev:
Front Plate Wide, CT/VT Connectors, ~~640HE~~ (2RCA035956P000...	2RCA036376A0001_D	375	
Faulty Article name:	Faulty Article no:	Qty:	Rev:
Front Plate Wide, CT/VT Connectors, ~~640HE~~ (2RCA035956P000...	2RCA036376A0001_D	375	
Batch/serial number:			
Serial number			
Investigator:	Email:		
Handler:	Email:		

D1 - TEAM

Name:	Department:	Email:
	Quality	
	Production	
	Production	

D2 - PROBLEM DESCRIPTION

Customer Description:
Poor quality of threads. Random threads are breaking

Scanfil Description:
Customer's fault description: Poor quality of threads. Random threads are breaking

Picture 1	*Picture 2*

D3 - CONTAINMENT PLAN

	Containment Action:	Responsible:	Due date:	Verified/date:
I				
II				
III				
IV				
V				

Correction

The customer is first asked to provide photographs and then, if necessary, to return the products for examination.

Customer has sent faulty parts and they have been investigated. Fault occurs in 375 parts.
Replacements have been ordered and will be sent for customer after 10th August. We currently have a problem with the availability of aluminum. 100% visual check will be made for them.

D4 - ROOT CAUSE ANALYZE

D4.1 - Root cause for detection - Why was it not discovered: (See separate sheet)	Verified
Serial production, no defined quality control. All parts have not been checked before delivery.	Yes No

Quality Control

D4.2 - Root cause for occurrence - Why did it happened: (See separate sheet)	Verified
These parts are threaded in both ways, at the plate work center in connection with the stroke, or then after the edging.	
The root cause of those cracks in the pulls is that material. In other words, the quality was not such as to withstand that bet.	Yes No

Root cause:

Conclusion from root cause analyze:

Claim accepted

D5 - CORRECTIVE ACTIONS

	Corrective Action (Short term):	Responsible:	Due date:	Verified/date:
1	Find out if a 100% visual inspection could be added to the work card and how increasing the work step affects manufacturing costs.			
2	It remains to be seen whether these eartags could be threaded on a plate machine in the future, so would this problem be reduced by it?			
3	Familiarize the operator to look at the threads already at the construction stage. That weakness of the thread should, of course, be found already in the construction phase when the operator is just careful not to use worn			
4				
5				

	Corrective Action (Long term):	Responsible:	Due date:	Verified/date:
1	We should define some kind of quality control in those must already be in the work phase. the threadmaker must already check a piece by random sampling at that stage.			30.7.2021
2				
3				
4				
5				

D6 - VALIDATE CORRECTIVE ACTIONS

	Evidence of implemented Corrective action (Long term):	Responsible:	Verified/date:
1			
2			
3			
4			
5			

D7 - PREVENTIVE ACTIONS

Preventive Action	Responsible:	Due date:	Verified/date:

D8 - FOLLOW UP			

Appendix 3. Supplier requirements

	RMDR Supplier Requirements for Direct Purchases		Rev 0	
	Create Date 07.02.2018	Security Level	Language code	Pages
Document kind: Manual				
Coverage: Global				

4.8.1 Complaints and Claims

Every non-conformance will result in a claim report from ABB RMDR and it is essential that the supplier acts with a sense of urgency for every received claim. ABB RMDR measures speed of resolution of every claim.

Supplier shall act as follow:

within 24 hours (8D format)

- Initial answer and containment action

within 7 days (8D format)

- Root Cause of Failure
- Corrective Actions
- Preventive Actions

Cost regulation of defective parts can be completed in three ways:

1. For all supplier related defective parts the supplier issues a credit note against ABB RMDR complaint/invoice number.
2. If the defective parts are returned to the supplier, the shipment will be made at Supplier's expense. Supplier must submit RMA / shipping authority notes. The supplier also issues a credit note against ABB RMDR complaint/invoice number.
   a) If the returned parts are reworked or repaired, the supplier must submit a quality rework plan and a First Article Inspection Report (FAIR) for the rework parts.
   b) The shipping label for the rework parts must be identified as rework parts along with the ABB RMDR complaint/invoice number.
3. If the defective parts can be easily inspected, sorted, or repaired, without quality issues on site, at ABB RMDR or it's warehouse, and is advantageous instead of returning the parts, this can be handled by:
   - The supplier
   - ABB RMDR /external company to the supplier's expense.

   Related costs will be invoiced to the supplier.