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IMPROVING FEEDBACK PROCESS FROM FINAL PRODUCT INSPECTIONS FOR CREATING CONTINUOUS IMPROVEMENT

A case study of ABB Motors & Generators Vaasa

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TIIVISTELMÄ:

Laatu maksaa, mutta huono laatu maksaa vielä enemmän. Tämä on yksi niistä syistä, miksi laadun parantaminen kokonaisvaltaisen laatujohtamisen avulla on kehkeytynyt välttämättömäksi osaksi teollisissa organisaatioissa maailmanlaajuisesti. Eräs tärkeä kokonaisvaltaisen laatujohtamisen aihe on jatkuva parantaminen, joka tähtää jatkuvasti korjaamaan toimenpiteitä siten, että sillä luodaan asiakkaalle lisää arvoa vähemmillä resursseilla.

Tämä työ on tapaustutkimus tuotteiden lopputarkastusten palauteprosessin kehittämiseen ja toimeksiantaja on ABB Motors & Generators Vaasa. Työ on rakennettu käyttäen design science -tutkimusmenetelmää. Työn tavoitteena on löytää keinoja parantaa palauteprosessia tuotteiden lopputarkastuksista ja lopulta vähentää reklamaatioiden määrää soveltamalla suositeltuja toimia lopputarkastusten palauteprosessiin. Yhteyksiä jatkuvan parantamisen ja palauteprosessin kehittämisen välillä on tutkittu tässä työssä ja tutkimusongelma on *Miten parantaa tuotteiden lopputarkastusten palauteprosessia ja kuinka hyödyntää parannettua palauteprosessia parhaalla mahdollisella tavalla jatkuvan parantamisen luomiseksi*.

Tutkimuksen tulokset osoittavat, että kohdeorganisaatiossa palautetta pidetään erittäin tärkeänä. Tutkimuksen aikana tunnistettiin viisi melko helposti jalkautettavaa kehitysideaa palauteprosessiin. On haasteellista sanoa, onko kehitysideoilla vaikutusta reklamaatioiden määrään, mutta ne tunnistettiin sellaisiksi toimintatavoiksi, joiden pitäisi tehdä palauteluuppi tehokkaampi tulevaisuudessa.

AVAINSANAT: Total Quality Management, Feedback process, Continuous improvement

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ABSTRACT:

Quality has costs, but bad quality is even more expensive. This is one of the reasons why improving quality via total quality management has become an essential part for manufacturing organizations globally. One of the most important subareas of total quality management is continuous improvement, which aims to continually correcting operations in a way, that it would create more value to the customer with smaller resources.

This thesis is a case study to improve the feedback process from final product inspections commissioned by ABB Motors & Generators Vaasa. The thesis has been constructed with design science research -methodology. The aim of the thesis is to discover methods to improve the feedback process from the final product inspections and ultimately decrease the reclamation rates by applying recommended actions to the final inspection feedback process. Connections between improvements in feedback process and continuous improvement are investigated in this study. The research problem is *How to improve feedback process from final product inspections and how to utilize the improved feedback the best way for creating continuous improvement?*

The results of this thesis indicate, that the feedback from final product inspections is considered highly important in the case organization. During the research, there were five improvement ideas to the feedback process found, which are quite easy to implement. It is challenging to say, whether the improvement ideas have an impact to the reclamation rates, but they were recognized as those practices, which should make the feedback loop more efficient in the future.

KEYWORDS: Total Quality Management, Feedback process, Continuous improvement

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ABBREVIATIONS

DSR Design Science Research.

TQC Total Quality Control.

SAP ERP (Enterprise Resource Planning) system used in ABB.

TQM Total Quality Management.

CoQ Cost of Quality.

CSF Critical Success Factor.

TPS Toyota Production System.

P-A-F Prevention, Appraisal and Failure.

PDCA Plan, Do, Check, Action.

MBNQA Malcolm Baldrige National Quality Award.

EFQM European Foundation for Quality Management.

SMART Specific, Measurable, Agreed, Relevant, Time bound.

Kaizen Japanese word for continuous improvement.

RCA Root cause analysis.

FMEA Failure Mode and Effect Analysis.

RPN Risk Priority Number.

Muda Japanese word for waste.

SPC Statistical Process Control.

Gemba Japanese word for where things happen.

8D report Report on quality failures.

ISO 9000 Quality system.

IT Information Technology.

SIPOC Supplier, input, process, output and customer.

CTQ Critical to quality.

DMAIC Define, measure, analyse, improve, control.

QMS Quality Management System.

CAPA Corrective and preventive action.

AL Assembly Line.

VM Visual Management.

JIT Just in Time.

ETO Engineer to Order.

1 INTRODUCTION

In the introduction part of this thesis the background, research questions and research problem, methodology of the study as well as limitations and structure of this thesis will be introduced. The introduction part will help the reader to understand the focus for this thesis and explain briefly the content discussed in the study. This study was commissioned by ABB Motors & Generations Vaasa.

1.1 Background

Quality has costs, but bad quality has bigger costs (see 3.1). The need for this thesis started as identifying lack for effective feedback loop from final product inspections in the case company. The aim of the case company is to decrease reclamations by continually improving and improving the efficiency of feedback was considered one way to make this happen. The idea for this topic came from the case company and after a brief discussion, this idea came to its current form.

1.2 Research questions and research problem

The purpose of this study is to improve the final product inspection feedback process in ABB Motors & Generators Vaasa business unit. This thesis aims to investigate, study and apply feedback process from final product inspections. The challenge is to develop an efficient feedback loop, which generates value to the customer and creates continuous improvement for the case company. The ultimate aim is to decrease the costs of reclamations, but it will not be in the scope of this study because of the limits set for this thesis. Instead, this study aims on decreasing the flaws found during the final product inspections. Goal is to first understand how the process works now and investigate the development areas in the feedback loop. After this, an operational model for performing the feedback loop will be the outcome of this thesis.

The research question is following:

How to improve feedback process from final product inspections and how to utilize the improved feedback the best way for creating continuous improvement?

The question investigates what feedback loops are utilized, what are the development areas of the feedback process, what kind of feedback is received, how the flow of information is done and does the feedback reach all the relevant stakeholders. The question examines how continuous improvement is created now from the feedback and investigates the methods to make the feedback utilization more efficient for creating continuous improvement. The current process is illustrated in chapter 4.1.1.

1.3 Methodology of case study

This thesis is a case study, which has been structured by design science research (DSR) -methodology and using mixed research methods. Design science research considers the creation of artefacts and their evaluation. DSR provides models and guidelines for creating artefacts and is at least as significant as problem-solving. (Beck, Weber & Gregory 2013: 637-638). In this research, qualitative part of the research was conducted with interviews and observations, and quantitative part was conducted with questionnaires. During the empirical research part, DMAIC-process improvement methodology was used improving the feedback process.

1.4 Limitations

This study is limited to investigate the creation of continuous improvement from feedback process of final product inspection. The study is conducted from quality point of view and the focus of the study is total quality management and continuous improvement. Also, performance management, final product inspections and feedback process are investigated to define all the processes related to the creation of continuous improvement from the data received. This study focuses on internal improvement of the feedback process and for example external stakeholders, such as suppliers or customers, have not been involved in this study.

1.5 Structure of the thesis

This study consists of five chapters, which are introduction, case study background, theoretical framework, empirical study and conclusions.

First chapter is the introduction part, where the background, research questions and research problems of the thesis are presented. After that, the methodology of the case study and the limitations of the thesis are presented. Finally, the contents and structure of the thesis are introduced.

Second chapter presents the case organization and the background for the case study. The case organization is ABB Motors & Generators Vaasa business unit, to which the reader is introduced in this section. The purpose and the aim of the case study will be discussed.

Third chapter discusses theoretical framework of the thesis. The theory consists from quality, total quality management and its components, performance management, final product inspections, feedback process and customer feedback.

Fourth chapter presents the empirical study of the thesis. In this section, the data collection process, data analysis as well as validity and reliability of the study will be presented. The research is made utilizing mixed methods, qualitative part includes interviews and observations, and quantitative research is made with questionnaires performed during assembly line meetings.

Fifth chapter introduces the conclusions of the case study. In this section, key findings and future research areas will be presented. In this chapter, the thesis is summarized.

2 CASE STUDY BACKGROUND

Background for this study is the need for investigating and improving the feedback of final product inspection process in ABB Motors & Generators Vaasa. The idea for making this case study started as a request for working as a thesis worker. In this section the case company and the quality policy in ABB are presented.

2.1 Introduction of ABB

Asea Brown Boveri, known as ABB, is an organization merged in 1988 from the two best known names in European electrical engineering history: Swedish ASEA and Swiss Brown Boveri (ABB 2019a). Today ABB is a global leader in industrial technology operating closely with its customers in roughly 100 countries (ABB 2019b). ABB is divided into four divisions which are Power Grids, Electrification Products, Industrial Automation, and Robotics and Motion (ABB 2019c), and the headquarters of ABB is located in Zurich, Switzerland (ABB 2019a).

ABB has approximately 147 000 employees, with 5 300 located in Finland. ABB is one of the biggest industrial employers in Finland and the biggest in Helsinki area, with its main factory areas operating in Helsinki, Hamina, Porvoo and Vaasa. The turnover of ABB in Finland is 2.3€ billion. (ABB 2019d).

2.2 ABB Motors & Generators Vaasa

ABB Motors & Generators Business Unit is a part Motion business line division. Local Business Unit ABB Motors & Generators in Vaasa has 550 employees and holds the global responsibility for manufacturing and engineering of low-voltage electric motors. (ABB 2019e). In Vaasa, the factory has been divided into two buildings, MM-building and KK-building. In KK-building, low voltage IEC electric motors with smaller frame sizes are manufactured and in MM-building motors with bigger frame sizes are manufactured (ABB 2019i).

ABB Motors & Generators Vaasa is utilizing SAP (Systems, Applications and Products in Data Processing) as its ERP-system. Enterprise Resource Planning (ERP) –system is a system, which integrates all the core processes of a company into one system (SAP 2019). SAP is a tool, which facilitates many internal functions for ABB Motors & Generators Vaasa, including quality. SAP is being used by various employees across ABB Motors & Generators Vaasa. (Kuvaja 2013: 5, 20-21.)

2.3 Quality policy in ABB

There are many dimensions in which ABB can compete, but none of these are meaningful for our customers without a foundation of quality. The responsibility for quality is something that must be owned by every person, every business, and every location that ABB calls home. –Ulrich Spiesshofer, CEO ABB. (ABB 2017).

ABB is competitive in many industries, but customers value ABB only, if the job is done with quality. ABB's quality policy states, that together all business units and employees are responsible for the quality. ABB is committed to following quality goals for ensuring the fulfilment of the responsibilities to stakeholders. (ABB 2019i.):

1. To deliver of high quality products, systems or services, which will correspond or surpass our customers' demands.

2. To recognize and understand the expectations of our customers, measure their satisfaction and develop our business to increase customer satisfaction.

3. To create requirements and involve the whole personnel to improve our performance with relentless drive throughout the whole value chain from suppliers to the customers.

4. To increase the motivation and skills of our personnel with continuous training and development programs for producing value to our customers and businesses.

5. To utilize the strengths of our suppliers and partners while developing our products and business through all our functions.

6. We carry out our social responsibility and operate according to ABB’s ethical values.

7. We improve continuously our performance in environment-, health- and safety-issues considering all our products, functions, systems and services.

3 THEORETICAL FRAMEWORK

In theoretical framework part, the academic literature of this research will be thoroughly studied. In this section, quality, Total Quality Management with its subareas, final product inspection, feedback process, performance management and customer feedback will be presented and examined. Each of these areas will help to understand the causalities between the empirical study (see chapter 4.) and the recommended improvement ideas (see chapter 4.4). In the end, all these subjects will be summed and the causalities between these will be explained.

***Figure 1**. Areas of theoretical framework.*

3.1 Quality

The definition of quality has varied through the years, but today it covers subjective quality such as attributes or features that correspond to customers' requirements, and objective quality such as ability of an organization to deliver products or services. (Aquilani, Gatti, Ruggieri & Silvestri 2017: 184). One useful description for modern quality thinking is, that quality is the products' or services' ability to fulfil the expectations and needs of the customer. According to this description, quality is based on whether it fulfils customer's requirements or not. Same description covers the flawlessness of the product, since no customer wants a flawed product. (Haverila, Kouri, Miettinen & Uusi-Rauva 2009: 372; Feigenbaum 1991: 7.) Quality factors of a product are for example performance, additional features, image and reliability. Examples of quality factors for services are environment, empathy and customer responsiveness. (Haverila et al. 2009: 373.)

In addition to the customer-based quality definition, organizations require internal quality description. Customer-based quality description is difficult to apply to the monitoring and development of the organization's activities, so from organizations point of view quality can be described as products' correspondence to the specifications and standards. With this definition, criteria and limits for quality can be set, which help to determine the products that are accepted from those that have flaws. (Haverila et al.2009: 372.)

Cost of quality (CoQ) is a functional tool focusing on trade-off between improving quality and keeping the cost factor cautious. CoQ can be described as a cost, which would have not occurred, if the quality would have been perfect. According to a study investigating a wood product manufacturing company, biggest sector of quality cost was internal failure cost (51 %), the second biggest was preventive cost (19 %), and external failure cost (15 %) and appraisal cost (15 %) had almost equal total CoQ. In this study, CoQ was 11 % of sales, but according to experts, CoQ should be 2-4% of the sales. (Malik et al. 2016: 2, 5, 8-9.) Quality has cost, but bad quality is more expensive. Non-quality is 20-35% of the final cost of the product, caused by mistakes during the production. (Stanciu & Pascu: 2014: 39.) The better the quality of operations is, the smaller the quality costs will be. (Haverila et al. 2009: 374-376.)

Development of quality raises cost-effectiveness, and high quality along with low costs brings remarkable competitive advantage. Development of quality creates a positive circle, which leads to improvement of quality and ultimately to increasing profit of an organization. The outcome of bad quality, respectively, is quality costs, which can be divided into two categories: costs of control and costs of failure of control. Respectively, these can be divided into two subcategories. Costs of control include costs of preventive actions and appraisal costs. Costs of failure of control include external failure costs, and internal failure costs. (Haverila et al. 2009: 374-376; Feigenbaum 1991: 111.) Feigenbaum's model can be also described as the P-A-F model, referring to the preventive, appraisal and failure costs. (Malik, Khalid, Zulqarnain & Syed 2016: 4.)

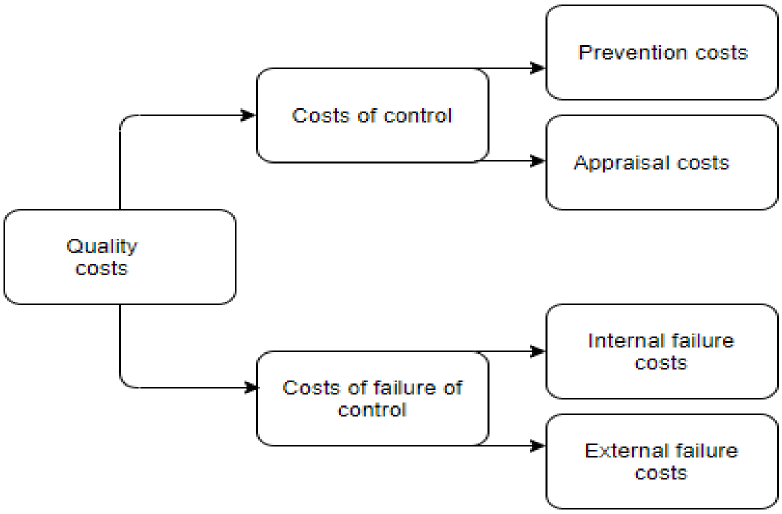


Figure 2. *Categories of quality costs. (Feigenbaum 1991: 111.)*

Quality management principles globally include process improvement, consisting from actions for correcting and preventing problems. Corrective or preventive actions usually initiate in response to a specific event or a collection of events that trigger the need to change. A process is a series of actions under certain circumstances, where inputs are produced into outputs via resources. Corrective action is an action to eliminate non-conformity, defect or other unwanted situations. Preventive actions, respectively, aim to eliminate potential causes of nonconformity, defect or other unwanted situations. Once a problem has been identified, there are several options to be done: do nothing, implement remedial action or investigate the problem to determine the root cause. Remedial action means an action, which alleviates the symptoms of already existing nonconformities or other unwanted situations. The course of action is affected by the processes and the systems involved, knowledge of the problem, risk and benefits, probability that such a problem reoccurs, available resources and organizational goals. The more obvious the negative impact to individual or the organization, the more probable the single event is investigated. Typically, when the negative impact is not so obvious, only the remedial action is implemented, or nothing is done. Investigation of root cause and implementation of corrective action normally wait until the events reoccur or a set of different events result in serious outcome. (Motschman & Moore 1999: 163-164, 171.)

J.M Juran (1986) created a trilogy for quality to find a universal way of thinking about quality, covering all functions, levels and production lines. The trilogy includes quality planning, quality control and quality improvement. Each of these have basic quality processes involved, presented in table 1 below. (Juran 1986: 20-21.)

Quality planning	Control	Improvement
Identify the customers, both external and internal.	Choose control subjects – what to control.	Prove the need for improvement.
Determine customer needs.	Choose units of measurement.	Identify specific projects for improvement.
Develop product features that respond to customer needs. (Products include both goods and services.)	Establish measurement.	Organize to guide the projects.
Establish quality goals that meet the needs of customer and suppliers alike and do so at a minimum combined cost.	Establish standards of performance.	Organize for diagnosis – for discovery of causes.
Develop a process that can produce the needed product features.	Measure actual performance.	Diagnose to find the causes.
Prove process capability – prove that the process can meet the quality goals under operating conditions.	Interpret the difference (actual versus standard).	Provide remedies.
	Take action on the difference.	Prove that the remedies are effective under operating conditions.
		Provide control to hold the gains.

Table 1. *Framework for Juran's quality trilogy. (Juran 1986: 21.)*

The starting point for Juran’s quality trilogy is quality planning, which means that a process, that can achieve its goals under operating conditions should be established. After planning of the process, it should be turned to the operating forces, which responsibilities include running the process at optimal level. Waste is inherent in the process and operating forces cannot get rid of it, so they initiate quality control to prevent the waste from getting worse. If the waste gets worse, a team is brought to determine the cause of it, and corrective actions will be taken. After this, the process goes back to quality control stage. As seen from Juran's quality trilogy table, quality planning, control and improvement are connected in a way presented in figure 3. (Juran 1986: 20-21.)

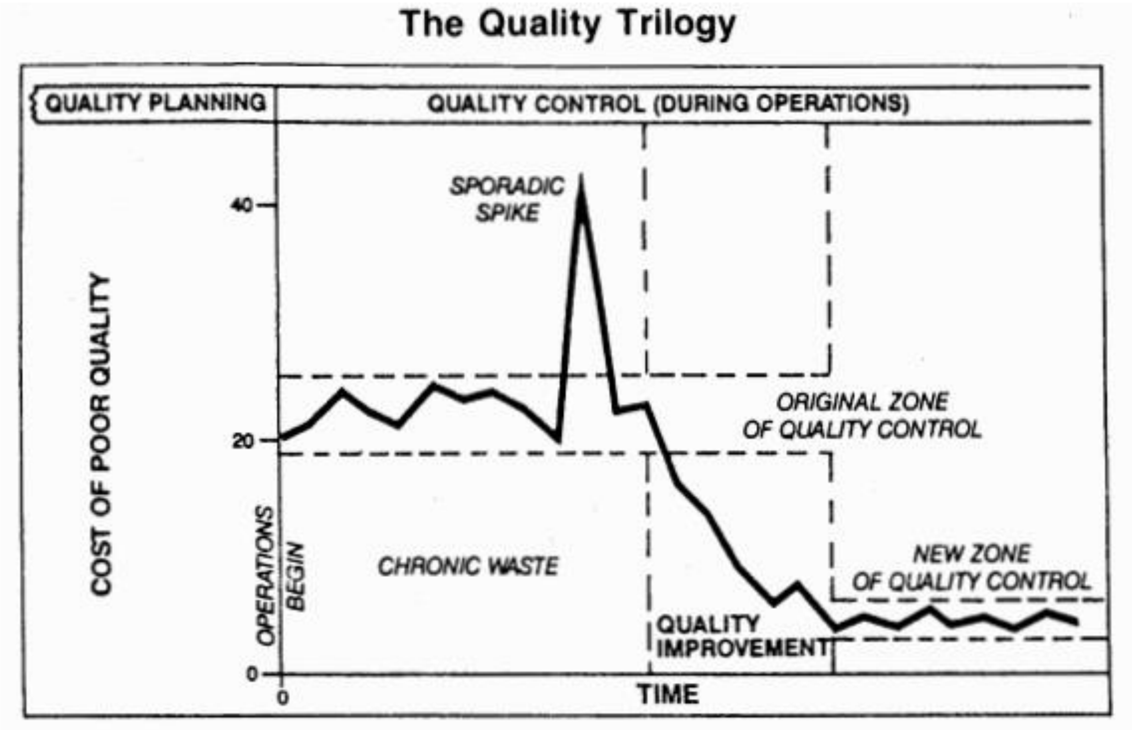


Figure 3. *Juran's quality trilogy. (Retrieved from Juran 1986: 20.)*

Juran's quality trilogy is summarized in table 2 below.

Process	End results
Quality planning	A process able to meet quality goals under operating conditions.
Quality control	Manner of operations accordingly to the quality plan.
Quality improvement	Operations at levels of quality superior to planned performance.

Table 2. *Juran's quality trilogy summary. (Juran 1986: 21.)*

There are seven main quality tools, which are histogram, check sheet, pareto-diagram, cause-and-effect -diagram (fishbone-diagram), scatter diagram, control chart and graph. Kaoru Ishikawa (1994) states, that manufacturing procedure will be most effective if proper evaluation is made by using on-the-job data. Data and evaluation form the basis for decisions and actions, so data should be classified for various purposes (Ishikawa

1994: 1-2, 5, 18, 30, 42, 50, 61, 89.) Different purposes for data evaluation are presented in table 3 below.

Purpose	Description
Data to assist in understanding the actual situation	Data to check for example defective parts contained in lots received
Data for analysis	Data to examine relationship between defect and its cause
Data for process control	Data to determine if the manufacturing process is normal
Regulating data	Data used for taking actions accordingly, for example adjusting an electric furnace.
Acceptance or rejection data	Data for approving or rejecting parts or products after an inspection.

Table 3. *Data classification. (Ishikawa 1994: 1-2.)*

According to Karuppusami and Gandhinathan (2006: 376), the seven quality tools are mainly quantitative and help to answer following questions related to them:

1. Process flowcharting – what is done?
2. Pareto analysis – which are the big problems?
3. Cause and effect analysis – what causes the problem?
4. Histograms – what does the variation look like?
5. Check sheets/tally sheets – how often does it occur?
6. Scatter diagrams – what are the relationships between factors?
7. Control charts – which variations are to be controlled and how?

In this study, the cause and effect analysis is utilized in chapter 4.1. Fishbone diagram is used to represent problems in a process. Fishbone diagram helps to visualize the relationships between elements. (Jayswal, Li, Zanwar, Lou & Huang 2011: 2788).

3.2 Total Quality Management

Principle of total quality control (TQC) is to provide effectiveness. Total quality control starts with the identification of customer requirements and ends when the product is in the hands of a satisfied customer. TQC coordinates the actions of machines, people and information to achieve this goal. (Feigenbaum 1991: 11.)

Modern quality thinking, Total Quality Management (TQM), can be described as an operating philosophy, platform and principle of management (Haverila et al. 2009: 371). TQM achieves customer satisfaction in long term by improving products, services and processes efficiently and effectively (Kutlu & Kadaifci 2014: 561). TQM has spread wide throughout the world as many institutes have concluded that TQM provides strategic advantages and improves competitive abilities in the marketplace (Goel & Gill 2014: 629).

The west got interested in TQM in the early 1980s, when American quality management gurus such as W. Edwards Deming, Joseph M. Juran and Philip B. Crosby started to solve the competitive performance of Japan's success in manufacturing industry. (Oakland 2014: 19). TQM model captures the major features of TQM, linking policies, direction and strategies of the business or organization. The framework brings together quality circles (teams), quality systems such as ISO 9000 (systems) and statistical process control (tools). Communication, culture and commitment play important roles in successful TQM approaches, and in the core of the model there are quality chains, which refers to customer/supplier. (Oakland 2014: 22.)

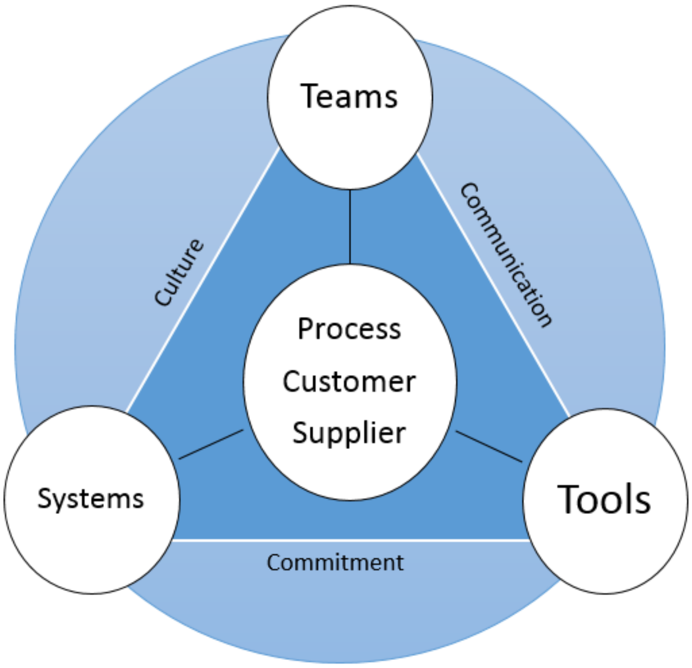


Figure 4. *Major features of TQM. (Oakland 2014: 22.)*

TQM philosophy is associated to quality awards, such as The Malcolm Baldrige Quality award in the USA and the EFQM in Europe, which capture the key elements of TQM (Jimenez-Jimenez, Martinez-Costa, Martinez-Lorente & Rabeh 2015: 330). TQM includes many operating models and techniques, covering all functions of an organization. The elements of TQM are: teamwork; development of personnel; continuous improvement (see 3.2.2); involvement of personnel; customer orientation; quality responsibility; Plan, Do, Check, Action (PDCA) –cycle (see 3.2.3) and Juran's trilogy. (Haverila et al. 2009: 377-382.)

Increasing global competition and more demanding customers require continuous improvement (see 3.2.2) from organizations. Under these circumstances' organizations consider quality and its management as one of the key factors for achieving competitiveness. (Hietschold, Reinhardt & Gurtner 2014: 6254; Van Volsem, Dullaert & Van Landeghem 2007: 621.)

In this study, TQM is defined as a philosophy and principle of management. The TQM dimensions in this study include customer satisfaction, continuous improvement by improving the feedback process, Critical Success Factors, communication, culture and commitment of personnel, and lean six sigma quality tools. In this study, TQM is seen as a key factor for achieving competitiveness.

Next, the critical success factors of TQM, lean six sigma, continuous improvement and gemba walks will be presented. These subtopics are all related to the TQM and will give the reader deeper understanding of the theory behind the study in empirical research part. These subtopics are presented, because they are the most important principles behind the improvement ideas, the artefacts, in chapter 4.4.

3.2.1 Critical Success Factors

Critical Success Factors (CSF) can be viewed as variables, which determine organizations performance through successful implementation of TQM (Aquilani et al.2017: 185; Kumar & Sharma 2017: 1531). To utilize TQM effectively, organizations need certain preconditions and CSFs are the best enablers which drive a company's success. Saraph, Benson & Schroeder (1989) were the first to operationalize critical factors of TQM and after them similar studies were initiated by many authors. (Sila & Ebrahimpour 2003: 237-238.)

Saraph et al. constructed their own CSFs consisting from 8 factors based on critical requirements for quality set by practitioners and academics (Saraph, Benson & Schroeder 1989: 811, 818). Many authors have tried to define the critical success factors using different methods. For example, Black and Porter (1996) used Malcolm Baldrige Award criteria as the basis for their 10 critical success factors, but Tamimi and Gershon (1995) created an instrument to measure quality by using Deming's 14 points as critical factors. (Yusof & Aspinwall 1999: 804.)

Karuppusami & Gandinathan (2006) examined 37 empirical TQM studies to result in 56 CSFs, assembling them into descending order utilizing Pareto analysis according to their frequency of occurrence (306 occurrences). From these 56 CSFs they extracted 14, the "vital few", CSFs to be most critical and covering 80 % of total occurrences. The remaining 42 CSFs they identified were described as the "useful many", covering the remaining 20 % of the occurrences. According to them, industries can select 8-12 most critical CSFs reported in their study and implement them over time. (Karuppusami & Gandinathan 2006: 376-378, 381.)

Sila and Ebrahimpour (2003) made a similar investigation with TQM factors in 23 countries. Their research included 76 empirical studies and most of these could be categorized under the Malcolm Baldrige National Quality Award (MBNQA) 2001 framework. They identified 18 CSFs across countries. (Sila & Ebrahimpour 2003: 244, 258-259.)

A more recent determination for CSFs that ensure the successful implementation of TQM, Kumar and Sharma (2017) introduce 20 CSFs with significant role and importance to the strategy of an organization. CSFs are essential ingredients for accomplishing the aim of systems, so they have a great importance in TQM implementation. The appropriate CSFs are the benchmarks and effective for organizations to get better results. (Kumar & Sharma: 1531, 1533-1538, 1546.)

The different approaches for determining the CSFs for TQM according to different authors are organized in a chronological order in table 4.

Saraph et al. (1989)	**Tamimi & Gershon (1995)**	**Black & Porter (1996)**	**Sila & Ebrahimpour (2003)**	**Karuppusami & Gandinathan (2006) "The vital few"**	**Kumar & Sharma (2017)**
Top Management Leadership	Creating constancy of purpose	Corporate Quality Culture	Top Management commitment and leadership	The role of management leadership and quality policy	Work environment
Quality Data and Reporting	Adopting the new philosophy	Strategic Quality Manageme nt	Customer focus	Supplier management	Top management support
Training	Ceasing reliance on mass inspection	Quality Improvem ent Measurem ent Systems	Information and analysis	Process management	Employ empowerment/i nvolvement
Employee Relations	Ending the practice of awarding business based on price tag alone	People and Customer Manageme nt	Training	Customer focus	Strategic quality management (SQM)

Process Management	Constantly improving the system of production or service	Operational Quality Planning	Supplier management	Training	Interface management
Product/Service Design	Instituting training	External Interface Management	Strategic planning	Employee relations	Quality tools and techniques
Supplier Quality Management	Instituting leadership	Supplier Partnerships	Employee involvement	Product = service design	Cultural change
Role of the Quality Department	Driving out fear	Teamwork Structures	Human resource management	Quality data	Customer satisfaction focus
	Breaking down barriers between departments	Customer Satisfaction Orientation	Process management	Role of quality department	Communication of information
	Eliminating slogans and targets	Communication of Improvement Information	Teamwork	Human resource management and development	Operating procedures
	Eliminating numerical quotas		Product and service design	Design and conformance	Project management skills
	Removing barriers to pride in workmanship		Process control	Cross functional quality teams	Accountability of sponsors
	Instituting education and self-improvement		Benchmarking	Bench marking	Zero defects
	Taking action to accomplish the transformation		Continuous improvement	Information and analysis	Technology utilization
			Employee empowerment		Inventory management
			Quality assurance		Service quality (SERVQUAL)
			Social responsibility		Costs of quality (COQ)
			Employee satisfaction		Competitiveness
					Continuous improvement
					Innovation

Table 4. *CSFs identified by different authors.*

Generally accepted measurement instruments or framework that guides implementation of CSFs does not exist. Organizations can use the recommended measurement instruments for investigating their status of CSFs related to TQM implementation process. For measuring the CSFs, a five or seven-point scale from ‘strongly disagree’ to ‘strongly agree’ is suggested. (Hietschold, Reinhardt & Gurtner 2014: 6256, 6264.)

As seen from the table of various author’s vision regarding CSFs, it can be said, that definition of CSFs vary from the point of view and time. However, some CSFs seem to be identified more frequently, such as support or commitment of management, customer satisfaction or customer focus, communication of information and analysis, role of quality department and involvement or empowerment of employees. For this study, the performance of these more frequently identified CSFs will be investigated in the empirical research part.

3.2.2 Lean Six Sigma

Total quality management in the case company usually shows as utilization of Lean Six Sigma method, and for that reason, it has been moved inside the scope of this study. Recently global business environment has become more complex and turbulent, so organizations must answer to the increasing customer demands by improving their performance related to quality, production, cost, flexibility and lead time. These competitive indicators can be improved simultaneously with lean production systems. (Iwao & Marinov 2018: 1319.)

Lean is a production method initiated in Japan within Toyota in the 1940s. The Toyota Production System (TPS) based on the recognition that producing in a continuous flow with only a little time to process a product added value to the customer. Identification of value for the customer is the starting point, and it may be for example cost, quality or robust process, depending on the customer type. This value is added by reducing waste (*Muda* in Japanese) from the manufacturing process and supply chain. Waste can be described as activities that do not add any value to the customer. There are seven types of waste (figure 5) recognized to be eliminated to improve the processes. Third key concept of lean is flow, which represents the linkage between activities that ultimately delivers value to the customer. Flow is related to value stream, which crosses functional boundaries. This means, that the flow starts from the customer order by defining value and flows through all the functions all the way until the created value will be delivered to the customer. The key tools and techniques of lean are presented in table 5. (Melton 2005: 662, 664-667.)

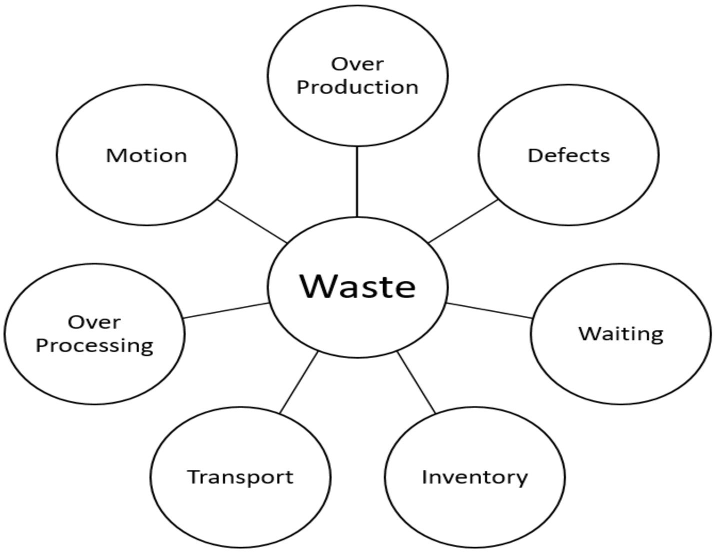


Figure 5. *Seven types of waste. (Melton 2005: 665.)*

Kanban	A visual signal for pulling product through manufacturing process.
5 S	A visual housekeeping technique for control.
Visual Control	A method to measure performance.
Poka yoke	Technique for error-proofing.
SMED (single minute exchange of dies)	Technique to reduce changeover.

Table 5*. Key tools and techniques of lean. (Melton 2005: 662.)*

Providing right information at the right time to the right people is an efficient method to enhance them make the right course of actions and right decisions, which is a remarkable difficulty for many organizations. Visual Management (VM) is a practice, where information is visualized or displayed for setting directions. Cash, information and material are three main flows, that every system experience. In lean environment, the flow of material is regulated by Just-In-Time (JIT) manufacturing, and flow of information can mostly be regulated via visual management. Visual management is simple, but effective tool for simplifying flow and making it available at the point of use at relatively low cost. VM serves its purpose for several reasons, such as simplifying flow of information, empowering employees, facilitating continuous feedback and goal communication, and supporting continuous improvement. (Eaidgah, Maki, Kurczewski & Abdekhodaee 2016: 188, 194-195, 204.)

The six sigma method is an approach to improve organization's products, services and processes by continuously reducing defects. Six sigma is a business strategy aiming for improving the understanding for customer requirements, business systems, financial performance and productivity, dating back to the mid-1980s. The six sigma has two perspectives, statistical viewpoint and business viewpoint. Statistical viewpoint discusses the quantitative view and the principle is, that there should be a success rate of 99.9997% or 3.4 defects per million opportunities, which refers to the term "sigma" for representing the variation of the process average. From the business point of view, six sigma means business strategy to improve business profitability, effectiveness and efficiency of operations. This is done for meeting or exceeding customer expectations and needs. (Kwak & Anbari 2006: 708-709.)

Lloyd S. Kurtz (2012: 17) describes the stakeholder idea as a network of relationships with diverse groups. During the past decades, stakeholder theory has developed solid foundations, and stakeholders are also critical to lean six sigma projects. Lean six sigma literature has recognized the importance of discovering an agreement between stakeholders for the effective management of lean six sigma projects. Researchers have reported, that successful lean six sigma projects increase satisfaction among stakeholders. In real-world situations, managers responsible for lean six sigma projects need to balance between stakeholders, who might have different points of view. This challenging situation could get easier, if managers in lean six sigma projects could use appropriate frameworks for identifying and analysing the stakeholders whom their projects are affecting. (Elias 2016: 394-395.)

3.2.3 Continuous improvement

Customer's expectations of quality are continuously increasing, which means that company's quality performance should increase as well. Companies should implement a program for continuous improvement, such as *kaizen*. Kaizen is Japanese word meaning continuous improvement, and it can be implemented by all levels of an organization. Where Six Sigma (see 3.2.2) projects may require remarkable investments to achieve breakthroughs in improvements, kaizen is able to achieve incremental quality improvements with little costs. Upper management should support kaizen projects for them to be successful. Kaizen activities are related into a concept of five whys for determining the true source of a problem. An example of the usage of these five whys is shown in an example of a machine failed to work in table 6 below. (Barsalou 2016: 107-108.)

Why	Question	Answer
Why 1	Why did the machine fail to work?	There was no control signal.
Why 2	Why was there no control signal?	The control lever was in the wrong position.
Why 3	Why was the control lever in the wrong position?	The control lever was worn.
Why 4	Why was it worn?	The wear check interval was too great
Why 5	Why was the wear check interval too great?	The wear check interval was not in the maintenance plan.

Table 6. *An example of five whys of kaizen. (Barsalou 2016: 108.)*

Kaizen utilizes the Plan-Do-Check-Action (PDCA) –cycle, which's first step is to investigate the problem and determine a plan for the solution. Second, the plan is implemented, and after that the implementation needs to be checked whether it is working as planned or not. Lastly, the actual results should be compared with the expected results. (Barsalou 2016: 108-109.) PDCA-cycle is described in figure 6.

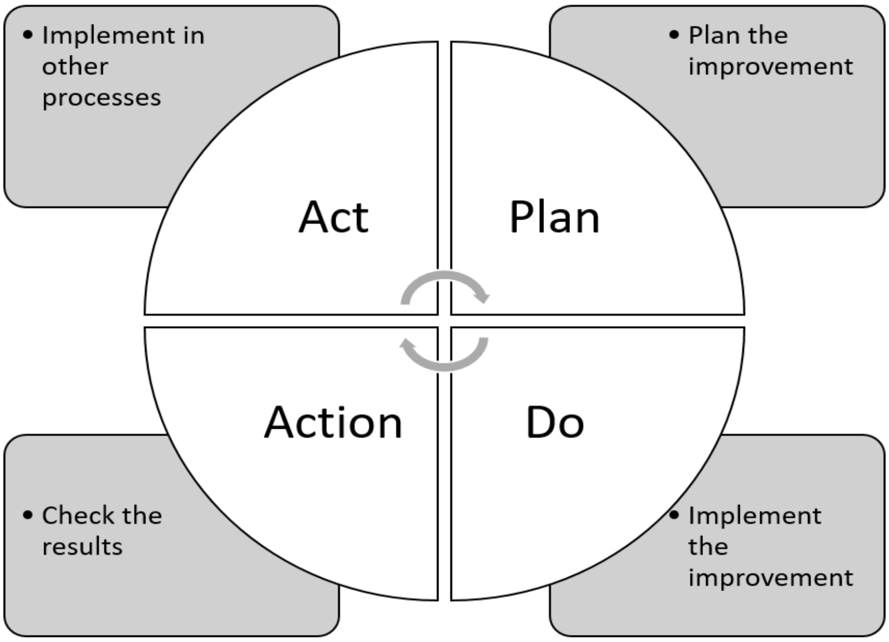


Figure 6. *Plan-Do-Check-Action -cycle. (Retrieved from Barsalou 2016: 109.)*

Another method for continuous improvement is DMAIC (Define, Measure, Analyse, improve, Control). DMAIC is a quality improvement methodology which takes a problem that has been identified by the organizations and utilizes tools and techniques to arrive in a sustainable solution for eliminating or minimizing the problem. Process improvement methodology works within established quality management system (QMS), which's two most necessary actions are corrective and preventive actions (CAPA) (see 3.1), and continuous improvement. DMAIC is the Six Sigma (see 3.2.2) methodology for process improvement. (Shankar 2009: xv, xvii.). **Define** phase involves scoping the project and boundaries for it, customer requirements and expectations, selected goals of projects and defining the team's role. **Measure** phase includes selection of the measurement factors for improvement and provides a structure to asses current performance. **Analyze** phase determined the root cause for problems and helps to understand why defects have occurred. **Improve** phase focuses on the use of experimentation and statistical techniques for generating improvements and reducing quality problems and defects. **Control** phase ensures, that the improvements are sustained, and the process is monitored. (Rahman, Shaju & Sarkar 2018: 812.) DMAIC process is illustrated in figure 7.

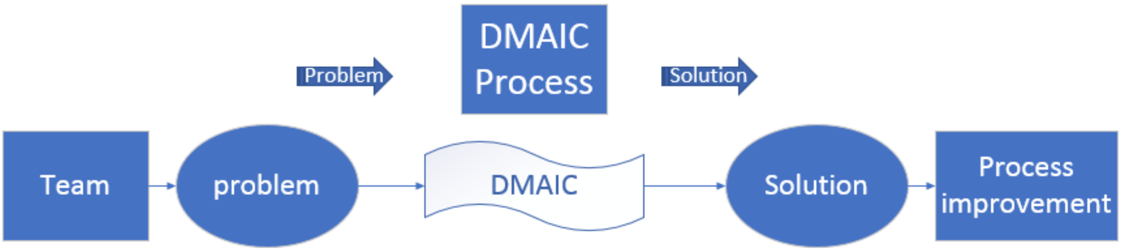


Figure 7. *DMAIC process. (Shankar 2009: xviii.)*

Often organizations want to improve their products and processes after a customer complaint, which should not be the main reason for product quality improvement. Quality should be in products and processes, and Failure Mode and Effect Analysis (FMEA) helps organizations to ensure, that failed products do not end up to the customers. FMEA is used in product development and in the creation of a new process for identifying potential failure modes. There are many types of FMEA used for different purposes, but two main types are design FMEA (DFMEA) and process FMEA (PFMEA). A cross-functional team should be formed with a moderator for updating and writing the FMEA, and after this, information needs to be collected considering comparable products or processes. A way to prioritize the actions that need to be improved, a risk priority number (RPN) should be determined. RPN can be calculated, when severity of risk is multiplied by times of occurrence, which is multiplied by difficulty to detect. After the introduction of improvement actions, the RPN needs to be recalculated. (Barsalou 2016: 71, 74, 77-78.) An example of FMEA table is presented in table 7.

Severity Table		Occurrence Table		Detection Table	
Rating	Severity Description	Rating	Occurrence Description	Rating	Detection Description
10	Safety risk	10	Certain to occur	10	Impossible to detect
8	Property damage	8	Might occur	8	Little chance of detection
6	Complete failure of system	6	Moderate risk of occurrence	6	Might detect
4	Reduced functionality	4	Low risk of occurrence	4	Moderate chance of detection
2	Occasional annoyance	2	Very low risk of occurrence	2	High chance of detection
1	Not noticeable	1	Cannot occur	1	Detection is certain

Table 7. *FMEA table. (Retrieved from Barsalou 2016: 78.)*

Another tool for improving quality is root cause analysis (RCA). RCA can be necessary in case of a quality failure, for example, when a customer sends a complaint, or a failure is detected internally. RCA is useful for reducing scrap rate (Barsalou 2016: 109), which means the percentage of failed products that cannot be repaired but must be discarded (BusinessDictionary 2019). In addition, RCA helps to identify the cause of current performance level in case of quality improvement is desired. The PDCA-cycle can be used as the basis for RCA with cycles for immediate actions, investigations and corrective actions. Quality tools (see 3.2.5) are usually helpful while performing RCA, because they can support brainstorming and list potential causes of failures, for example. Once the root cause is confirmed, the improvement actions should be planned. If possible, the changes should first be tested in a small scale, because the changes may not be effective or can even cause problems. Knowledge gained during the investigation should be saved, and this can be done for example with FMEA or control plan. (Barsalou 2016: 109, 111.) In figure 8, an example of RCA of why lean processes are sustained and improved in Toyota is presented. (Liker & Franz 2011: 14.)

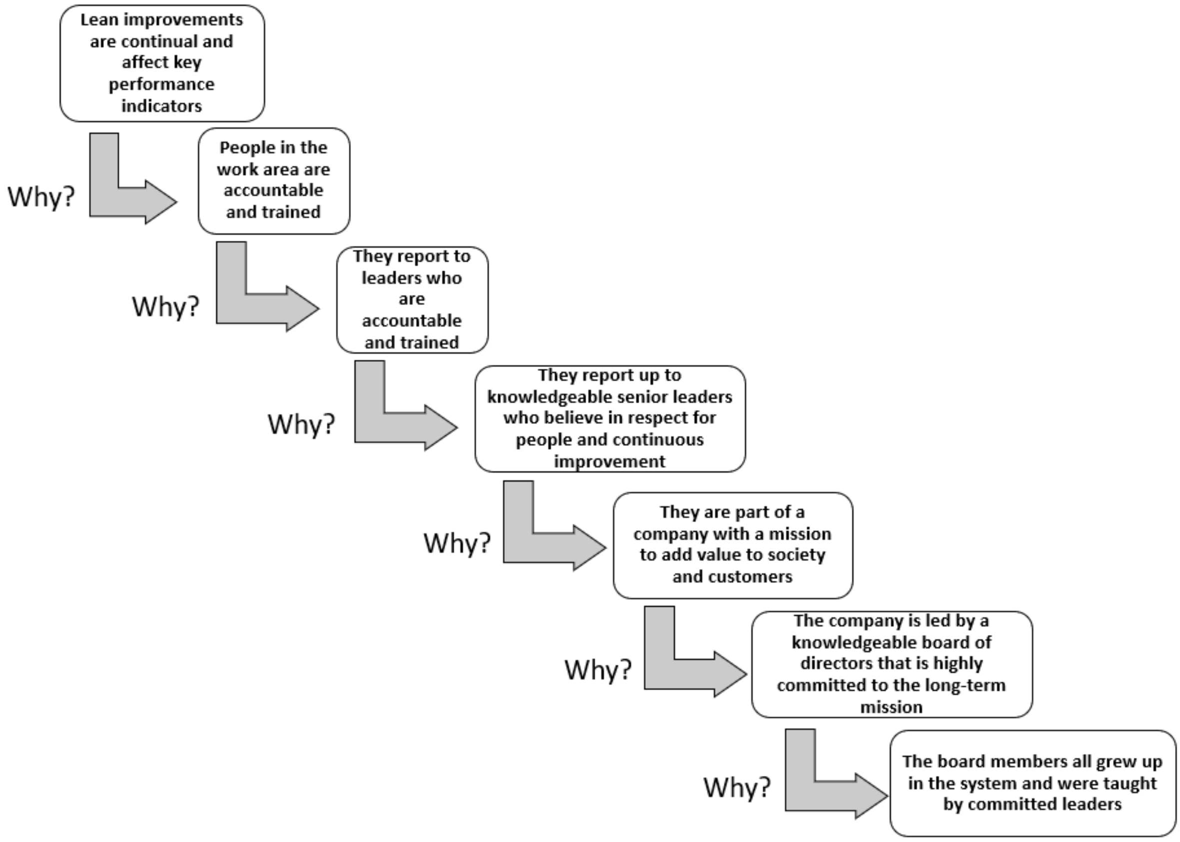


Figure 8. *RCA of why lean processes are sustained and improved at Toyota. (Liker & Franz 2011: 14.)*

In a transformation process, the responsibility for quality lies in the operators of the process. To fulfil this responsibility of quality, employees need to be provided with necessary tools to:

1. Know if the process is capable of meeting requirements.
2. Know if the process meets requirements at any point.
3. Adjust according to the process inputs if it is not meeting the requirements.

Statistical process control (SPC) techniques can assist on these steps, but it is important to first identify which processes are included in the process; what are the inputs and outputs. SPC is not only a tool kit, but a method which helps to bring processes under control and a strategy to reduce variability, which is the cause of most quality problems. SPC is a vital part of TQM and it should act as a focal point of continuous improvement. Presentation of data should be the state of communication regarding the state of control of processes, and it is based on this understanding where improvements initiate. SPC system answers for example the following questions:

1. Can we do the job correctly?

2. Can we continue to do the job correctly?

3. Have we done the job right?

4. Is it possible to do the job more consistently and on target?

These answers provide knowledge on the process capability and where the sources of unwanted outputs are. (Oakland 2014: 283-285.)

Organizations need to balance their issues in short-term performance with the concerns of performing well in the long-term. Short-term performance is usually achieved by utilizing organization’s capabilities, of which continually improving can help to maintain organization’s competitive advantage. Long-term performance comes normally from processes that examine new possibilities, but many organizations have challenges seeking outside from their model for thinking. (Sower & Fair 2012: 11-12.)

Lahidji and Tucker (2016: 164) concluded in their study, that nearly all professionals queried agreed that the compliance of an external quality standard such as ISO (International Organization for Standardization (Cambridge Dictionary 2019b)) is mandatory for their organizations. However, there seems to be differ whether the continuous improvement is implemented and working in most quality standards. According to Lahidji and Tucker (2016: 164), continuous improvement is proactive due to that “improvement” does not only mean “right wrongs” but is also setting new standards for perfection.

3.2.4 Gemba walk

Gemba refers to Japanese word for “where things happen” and can be translated as the shop floor. Gemba is the place where an organization adds value, because that is the place where waste can be cut. For an organization to utilize gemba, it should have a basic idea of kaizen (see 3.2.3), since kaizen activities are implemented via identification and elimination of waste. This brings us to the term gemba-kaizen, which invites an organization's managers to leave their office desks and see what quality issues and waste the blue-collar workers are facing in the work processes. Gemba-kaizen approach is illustrated in figure 9. (Suárez-Barraza, Ramis-Pujol & Estrada-Robles 2012: 29, 46.)

Gemba was selected to theoretical framework of this study, because the feedback gathered during the final product inspections is informed during the daily gemba meetings of the case organization. It is important for this study to understand the meaning of gemba and its concepts for gaining deeper understanding of flow of information in the case organization. The meaning of gemba meetings for information sharing is discussed in empirical research part of this study.

Figure 9. *Gemba-kaizen approach. (Retrieved from Suárez-Barraza, Ramis-Pujol & Estrada-Robles 2012: 46.)*

3.3 Performance management

Performance management consists from many activities, which can holistically lead to efficient management of people. Precise definition of performance management is difficult, because it varies according to the organization and context. Armstrong defined performance management in 2009, that it is a systematic process for improving organizational performance by improving the performance of teams and individuals. This definition links the human resources to the organizational goals, and the alignment of individual's performance and goals of the organization is the key factor in successful management systems. (Ashdown 2014: 2.)

There are many reasons why performance measurement systems have failed, such as lack of defining performance operationally and the boundaries of the processes are not defined (Oakland 2014: 146). To manage performance efficiently, organizations need to be clear of what is expected. There should be suitable measures to analyse whether the expected performance is achieved or not. Setting objectives for teams and individuals is important part of the performance management process, so that everyone understands clearly what is required from them. One example of objective setting is SMART, which refers to:

S	Specific	Clarity in terms of what is to be achieved
M	Measurable	The outcome is possible to measure
A	Agreed	Manager and employee agree the outcome which is to be achieved
R	Relevant	There is a link between business goals and individual goals
T	Time bound	Time frame is clear for the outcome of the achievement

Table 8. *SMART objective setting. (Ashdown 2014: 122).*

If the objectives are not clear or there is a lack of clarity of what needs to be achieved, there is potential to various negative consequences. Firstly, the employee could misunderstand the goals and focus on the wrong things. Second, if the employee is not sure of the objectives, it may cause anxiety and uncertainty on how to progress. Third, a lack of clarity in objectives potentially leads to problems when assessing the performance against those objectives. (Ashdown 2014: 122, 147).

3.4 Final product inspections

Reducing variance is seen as the key for improving quality, and it is acquired via different ways, such as implementing an efficient inspection strategy. Economic inspection strategies optimize the inspection costs and ensure the demanded quality output. (Van Volsem et al. 2007: 622.) For each manufactured product, a visual inspection must be carried out to ensure that they meet the visual characteristics of expectations. (Baudet, Maire & Pillet 2013: 153.)

Product dimensional inspection is one of the vital processes of the production, where product's quality is tested and its interaction with development stages is checked. This enables feedback regarding production and design decisions and provides information from inspection processes. Ideal inspection system should be able to measure the dimensional characteristics of parts and be able to give feedback to the manufacturing processes at real time. To understand the inspection information correctly in design and manufacturing activities, the provided information should be defined. (Barreito, Labarga, Vizán & Ríos 2003: 1621-1622.)

Stages regarding the visual inspection is important and it should include inspection conditions, training techniques, and different ways of controlling or methods to detect defects. Visual inspection is usually described as a method to detect product's functional anomalies, which sometimes includes aesthetic objective. Visual inspection is normally carried out by a single inspector who evaluates the quality of a product about a set of standard products or his own experiences. In case of detecting a flaw, the inspector must scrap the product, if the flaw is critical. The evaluation is subjective, because criticality of the flaw depends on the inspector's knowledge, know-how and view of the criticality of the flaw. A method to reduce variability in the results of visual inspection must be developed if possible. (Baudet et al. 2013: 153.)

3.5 Feedback process

Liker & Franz (2011) point out, that organizations cannot improve without feedback, because when implementing an improvement action or a small change, there should always be some sort of measurement or physical indicator which gives a quick, visible feedback. For example, when they asked in an organization how the employees could know that they have moved closer to their goals or if they have not after completing an action, they first replied that they have no clue. After they implemented a results board (feedback) and a "daily huddle" around the results board (to-do list prioritizing), where the focus based on the change actions and their reasons, the organization managed to achieve their goals within few months. (Liker & Franz 2011: 267.)

Feedback is a powerful tool and it helps people to improve their performances. When team members receive feedback, that they are doing progress, the encouragement leads to greater efforts to be successful. Positive feedback enables recognition for good performance, but good work usually is unacknowledged. According to psychologists, when effective behaviour is recognized, it is usually repeated. Positive feedback makes employees aware of the appreciation that management and others have for them. (Hopen & Rooney 2018: 28-29.)

Stansfield and Longenecker (2006) found out in their study, that goal setting and timely feedback leads to improved performance, greater efficiency, more challenging goals and more effective information systems than traditional supervision systems at improving performance. Performance goal setting and specific performance feedback leads to productivity improvement and in this study, the productivity improvement area is quality. Stansfield and Longenecker's point out, that properly designed and implemented goal setting and feedback interventions offer huge opportunities for improvement. For example, their experiment included 10% increase in average productivity after the intervention. (Stansfield & Longenecker 2006: 346-347, 356-357.)

8D report is a quality tool for quality failures. It can be used either with customers or for internal quality issues. 8D means the 8 disciplines in the report, 1D which are team, 2D problem description, 3D containment actions, 4D root cause, 5D planned improvement actions, 6D implemented improvement actions, 7D preventative measures, and 8D congratulating the team. In the top of the report, there should be information such as date, part number, modification date, when the report was first opened, customer number and supplier number. 8D report can vary according to organization, but all 8D reports should consist the 8 steps mentioned above. 8D report demands a problem-solving approach with a team, which should be cross-functional and have a team leader who can support the team. The problem needs to be described and actions taken accordingly, and the ultimate objective is to prevent sending flawed products to the customers in the future. This can mean for example checking all the new parts, until the root cause of flaws is detected, and corrective actions are taken. The investigation of root cause may require the usage of quality tools (see 3.2.5), and planned improvements need to be initiated after the root cause is detected. After this, the 8D report is done for describing the implemented actions, which include updating of FMEAs (see 3.2.3), control plans and process or work instructions. The objective is to ensure, that the same flaw will not occur again. Finally, the 8D solving team should be congratulated before closing the issue. (Barsalou 2016: 124-127.) An example of an 8D report is illustrated in table 9.

8D report Nr.: **Cust. 8D Nr.:** **Supplier 8D Nr.:**	**Part Nr.:** **Cust Part Nr.:** **Supplier Part Nr.:**	**Opened date:** **Version date:**
Name of issue:	**Customer:**	**Supplier:**
Team leader: **Team member:** **Team member:** **Team member:**	**Problem description:**	
Containment actions:	**Responsible:**	**Implementation date:**
Root cause:		
Planned permanent corrective actions:	**Responsible:**	**Implementation date:**
Implemented permanent corrective actions:	**Responsible:**	**Implementation date:**
Actions to prevent reoccurrence: **Work instructions:** **Control plan:** **DFMEA:** **PFMEA:**	**Responsible:**	**Implementation date:**
Congratulate the team:	**Responsible:**	**Implementation date:**

Table 9. *8D report. (Retrieved from Barsalou 2016: 126.)*

3.6 Customer feedback

Organizations should have a process for handling customer complaints right away, because failing to respond could worsen the situation and potentially result to losing a new or existing business. In case of a complaint, more information should be asked if needed and a briefing to the customer sent. It informs the customer, that they have been heard, but does not automatically mean that their complaint is accepted. Sample of defect part should be asked whenever it is possible, and the root cause investigated, because the defect can also be result of customer’s misuse of the product. After the root cause analysis is done, customers should be assured of making corrective actions. (Barsalou 2016: 127-128.)

4 EMPIRICAL STUDY

The empirical study is performed utilizing a Six Sigma tool DMAIC (Define, Measure, Analyse, Improve, Control) (see 3.2.3). As it is explained in the theoretical framework of this study, organizations need to continuously improve their processes (see 3.2.3). To do this, organizations need to come to consensus on the root cause of the problems in their processes. The DMAIC methodology was selected for this study due to its suitability for process improvement. In this study, the input to the process improvement is the problem and the output is a solution to this problem. The solution for this study is a suggestion of an improved feedback process created from the data gathered during the DMAIC process. DMAIC process is illustrated in figure 7.

The empirical research process begins with mapping the current state of the feedback process and feedback data utilization in the case company. After this, measurements of the process's effectiveness will be gathered utilizing mixed methods, quantitative and qualitative data. The study's data collection process includes questionnaires, interviews and observation of the final product inspection feedback loop. After gathering the data, results will be discussed, and analysis is made. Also, the reliability and validity of the research is evaluated. After the analysis, improvement ideas based on the data on theoretical part are introduced, and lastly the control phase is discussed.

4.1 Defining the feedback process

This research will begin with defining the feedback process. The objective is to answer to the question: what the problems are related to the feedback process. The need for improving the feedback process has been recognized, because the feedback is considered to play a vital role in reducing customer reclamations.

In this study, the definition of final product inspection refers to the additional final product inspection. Regular final product inspections are made for every product, but the additional final product inspection is made occasionally for only some products. The biggest difference is, that the regular final product inspection is done by checking certain points from every product, but additional final product inspection is proceeded to random products, which are then investigated. (ABB 2019g.)

Final product inspection involves all products manufactured in ABB Motors & Generators Vaasa, which means low voltage electric motors. The final product inspections have started in their present form in October 2018. In January 2019, there had been approximately 500 inspections made so far. (ABB 2019f.) The project was first initiated approximately four years ago, but it was shut down after half a year due to lack of resources. Currently, the priority of performing final product inspections has risen along with the resources. (ABB 2019g.) Today, there are two employees making the final product inspections, one for each building operating in the case company (ABB 2019f).

Final product inspection starts with picking a finished product from the production line and inspecting, whether the product has flaws or not. The inspection process includes for example photographing, measurement of paint thickness, checking of rating plate and label sticks, and visual investigation. The product should not have due date on the same day, and if there are some customers, which especially require an inspection, their orders must be taken into consideration while making the inspections. Otherwise, the products are randomly selected. The product should be able to be returned within the same hour, if there are no flaws detected. In case of flaws detected, which cannot be fixed instantly, a quality notification of the product is made. (ABB 2019g.) A quality notification procedure is done as follows:

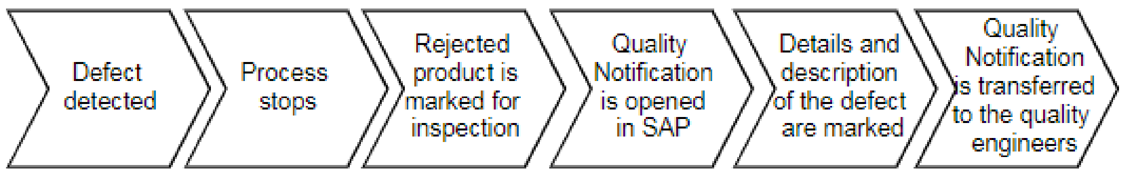


Figure 10. *Quality notification process.*

The measurements investigate the number of inspected products, and the flaws found are categorized weekly (ABB 2019f). The measurement tools used in the final product inspection process include, for example, tape measurement, vernier caliper, general resistance meter, paint thickness gauge and many other calibrated tools. (ABB 2019g.)

Data is created in the final inspection process through documentation. This data gives information regarding, for example, what kind of flaws there has been and in which assembly lines these flaws have occurred, who is the customer of the inspected product and which kind of motor is being inspected. (ABB 2019f.) The reporting includes:

1. Date.
2. Transaction number.
3. Serial number.
4. Line.
5. Basic code description.
6. Acceptation or rejection.
7. Notification number.
8. Paint thickness of frame and cover.
9. If the product is self-fixed.
10. Defect code and description of the defect.
11. Type.
12. Name of the part.
13. Customer.

Supportive functions utilized in final inspection process include for example information technology (IT) and production development. There has been development for an application in SAP, where the work queue is visible for inspectors to pick products for the inspection. (ABB 2019f.)

Other important supportive functions include instructions and material component standards, which can help to find right coloured components mentioned in the production work card acquired from SAP (ABB 2019g). Typical flaw would be for example too thin painting or lack of necessary stickers, and approximately less than half of the inspected products are flawed. Final product inspection process can be expected as a vital process for the supply chain. (ABB 2019f.)

The reason for implementing final product inspections is to correct flaws occurred in manufacturing process, since it is more cost efficient to make corrections while the products are still in the factory. Cost efficiency refers to a way to save money or spending less money (Cambridge dictionary 2019a); or saving money by making a product or performing an activity in a better way (Financial times 2019). Also, the final product inspections create data from manufacturing process and enable orientation of employees to correct flaws occurring during the manufacture. This way, final product inspections can be assumed to create continuous improvement (see 3.2.2). The final goal of final product inspections is basically to reach a situation, where products are flawless and final product inspections are unnecessary to carry out. This means, that the manufacturing processes are fixed via continuous improvement according to the data acquired from the final product inspections constantly. The reason for final product inspections is to create value to the customer by fixing the flaws in the processes. For example, without the inspection, approximately half of the flawed motors would have gone straight to the customer. (ABB 2019f.)

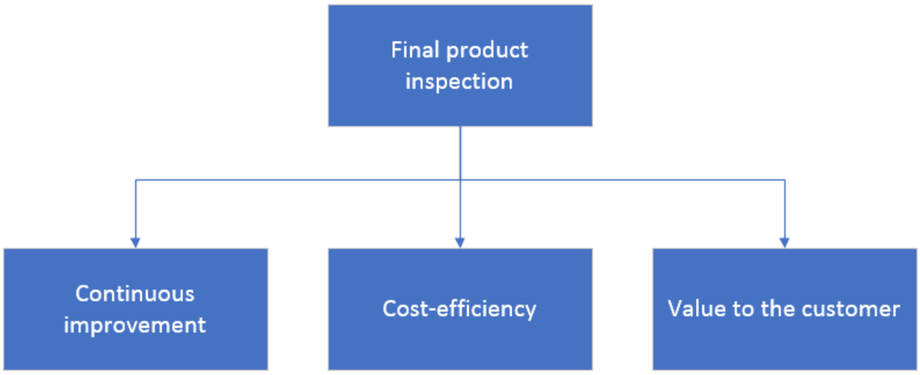


Figure 11. *Final product inspection leads to continuous improvement and cost-efficiency. (ABB 2019f).*

The goal for this study is to produce an efficient operational model for the feedback process so, that it will reach effectively all stakeholders whom the feedback concerns throughout the whole value chain related to the feedback process inside the case company.

The main reason for the development is the need for reducing customer reclamations and create continuous improvement. To conduct an operational model for effective feedback, all the stakeholders and processes related to the feedback process must be understood and measured. This requires a stakeholder analysis and scoping of the process. The stakeholder analysis is illustrated in figure 12 below. The stakeholder analysis for the feedback process was constructed from the data gathered during the interviews of this research and observation during the gemba meetings. Also, the stakeholder analysis was shortly brainstormed with the quality engineer of the case company. The stakeholder analysis is presented below.

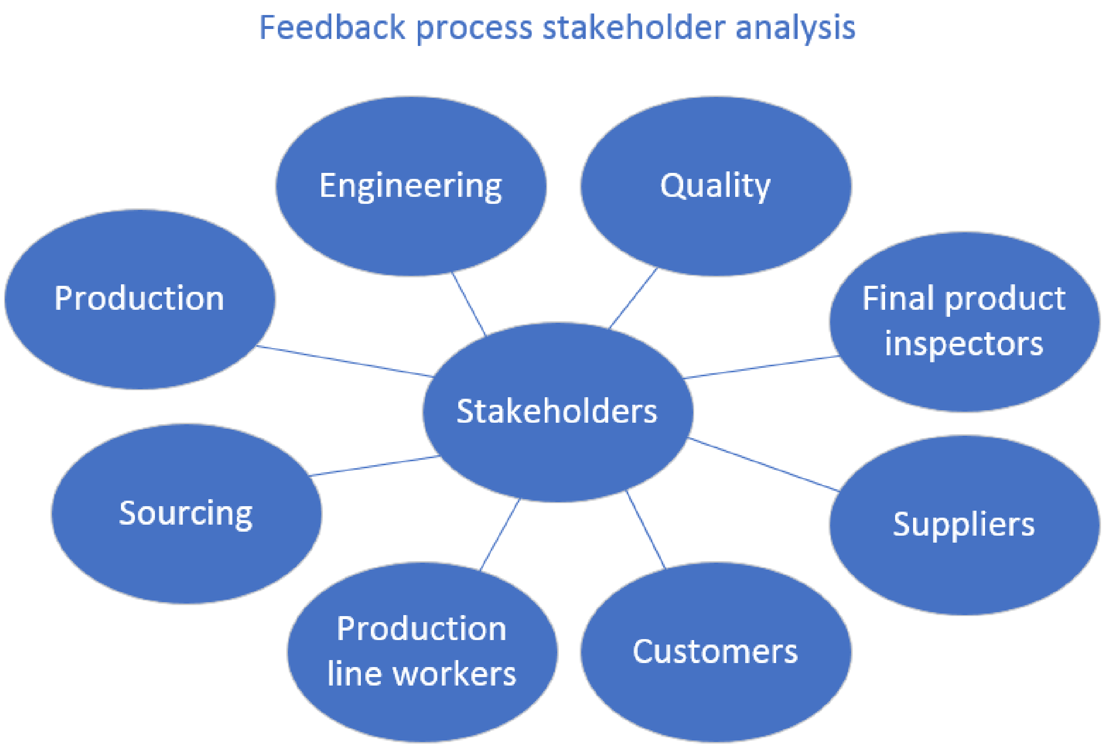


Figure 12. *Stakeholder analysis of the feedback process.*

For scoping the project, a SIPOC (Supplier, Input, Process, Output and Customer) diagram is created. The process identified to improve in this study is the feedback process, which is considered as critical to quality (CTQ). The SIPOC diagram was constructed from the interviews and observations in the initial phases of the empirical study (ABB 2019f, ABB 2019g). Within this scope, the SIPOC diagram for the feedback process starts when an inspector picks a product for inspection and ends when value for customer is created. The SIPOC diagram is illustrated below.

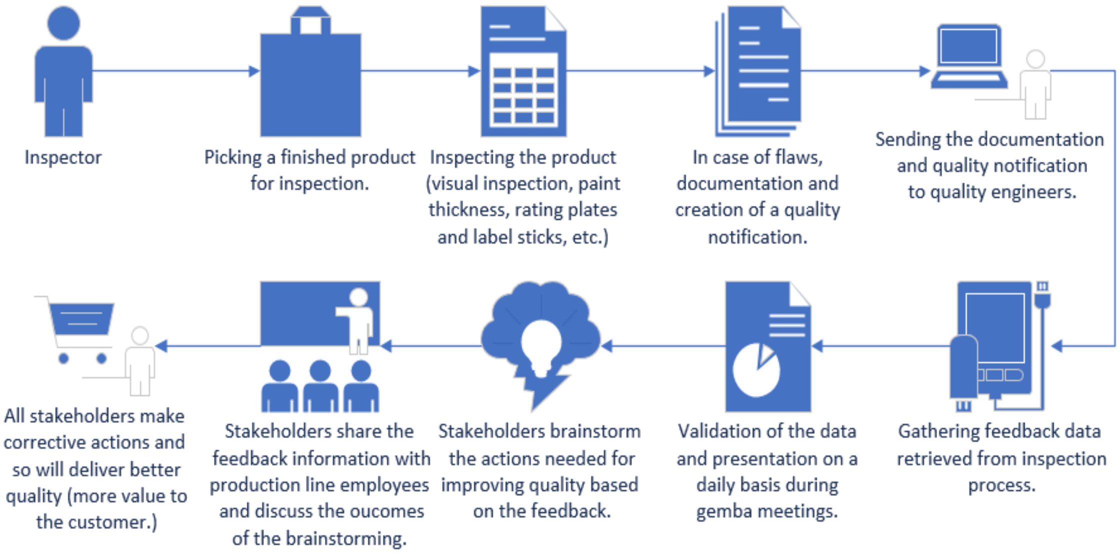


Figure 13. *SIPOC diagram of the feedback process.*

To define the diversity of the research problem, a fish-bone diagram was constructed from data gathered during the define-phase. The most vital problem for the feedback turned out to be communication, since there were several questions related on how the feedback reaches all relevant stakeholders. In addition to the issues related to communication, there were identified development areas in process, documentation and personnel.

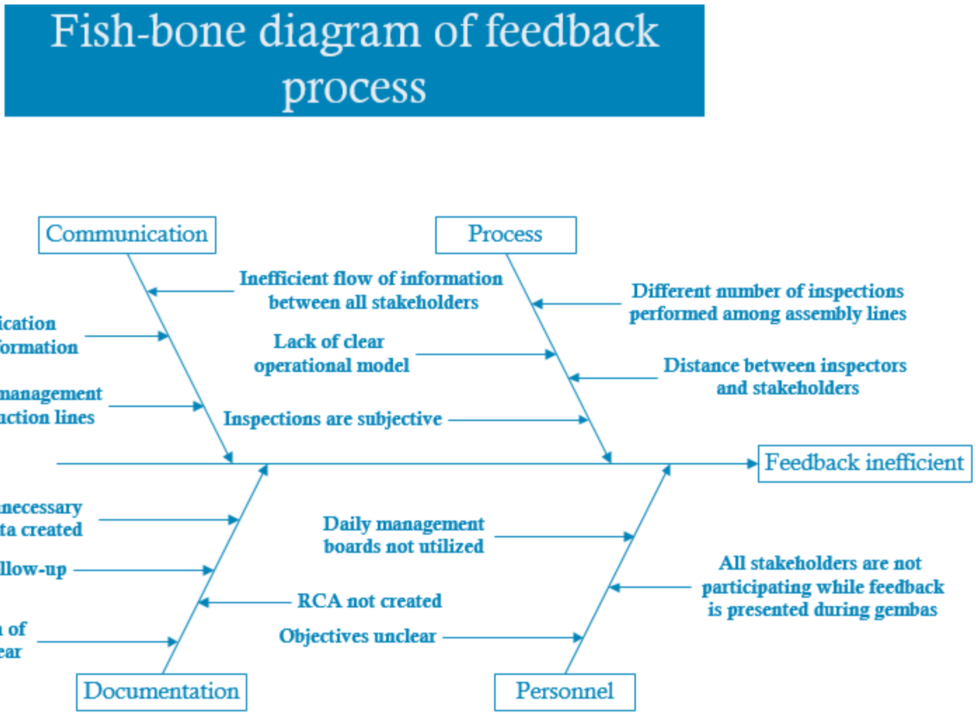


Figure 14. *Fishbone diagram of the feedback process.*

There were several issues related to the feedback process. For example, the communication seemed to have unanswered questions considering, how the information reaches all employees in every shift. In documentation, there were no RCAs created form the documentation and there was no follow-up from the discussion of findings. In the feedback process, there were, for example, different amount of inspections performed in different assembly lines, which basically means unequal chances to receive feedback. Issues with personnel considered, for example, unclear objectives.

4.2 Measuring the feedback process

Data for measuring the feedback process was acquired with three different methods: questionnaires for the production line workers during assembly line meetings, theme interviews with 5 different white-collar employees and observations during gemba-meetings. Next, the different methods are introduced more thoroughly.

Quantitative data of the feedback process was conducted with a survey found from appendix 2. The questionnaire had 7 questions and it measures the effectiveness of the feedback process by asking the employees, for example, if they think the feedback is important, if they are informed enough, if the feedback is understandable, if they check the quality boards on a weekly basis, etc. The purpose of this questionnaire was to acquire relevant data regarding the feedback loop's current efficiency and if it reaches the employees who are adding value to the customer in assembly lines.

Theme interviews included discussion considering the feedback process, communication, documentation and personnel. Base for the interviews is found in appendix 4. During the interviews, the employees were asked, for example, how important they consider the feedback loop, is the process efficient, is there enough communication, is there enough documentation and how they are commitment to the development of the feedback process.

During the observations there was an observation form filled daily for 2 weeks. Observation form can be found from appendix 5. The observations focused on gemba meetings, where the feedback from final product inspections was communicated. The observations consider the number of participants, if final product inspectors were present, if there were feedback presented, if there were other quality issues such as reclamations and if old quality cases' status was rechecked.

4.2.1 Questionnaire results

Questionnaire was conducted for this research to investigate the effectiveness of the feedback and the commitment of the employees to the feedback. There was a total of 7 questions on a scale of 1-5, from fully disagree to fully agree. Questions 2 and 5 were different, having scales of 1-4 with variation in answer options.

Questionnaire for the production line employees covered following number of samples from each assembly line:

- 9 from AL 1 (assembly line 1)
- 19 from AL 2

- 15 from AL 3A
- 21 from AL 3B
- 8 from AL 3C/E
- 13 from AL 3D.

AL 1 and AL 2 are operating in MM factory building and AL 3 is operating in KK factory building. The total amount of samples was 85 (n=85). The overall results of the questionnaire are found in appendix 3.

While examining the results it must be considered, that the amount of inspections varies a lot between the assembly lines. For example, after week 17 of 2019, there were 184 inspected products assembly lines 3C/E and AL 3D, while there were 1482 inspected motors in AL 3A and AL 3B. The same numbers in AL 1A/B were 322 motors and AL 2A/B 41 motors. (ABB 2019j.) These variations in the amount of inspections and available feedback are likely to have an impact to the results of the questionnaires.

The first question of the questionnaire was "Feedback from final product inspections is important", and it had a total of 85 samples. Most employees agreed or slightly agreed to this, indicating, that the feedback is highly valued among the employees. Exception was AL 3A, where 7 % of the respondents disagreed, that the feedback from final product inspections is important.

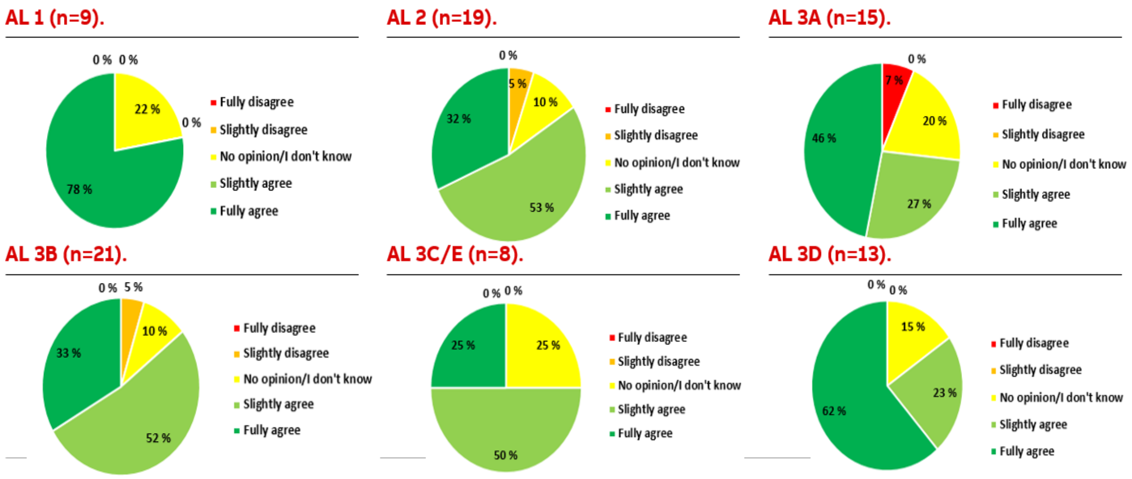


Figure 15. *"Feedback from final product inspections is important." -results.*

The second question was “How many times in a month you hear from findings related to final product inspections?”, which had a total of 76 samples. From the sample it can be said, that it varies between assembly lines how often employees hear from the feedback from final product inspections. For example, in AL 3B, employees hear from the feedback mostly weekly, but in AL 3C/E, employees do not hear a single time in a month from the feedback. However, this might be due to the fact, that in AL 3C/E, there is not so much feedback provided due to the assembly line’s high performance. Overall results indicate, that almost a quarter of employees (24%) hear from the findings less than monthly and only 5% daily. Most respondents hear from the feedback weekly (36%) or monthly (35%).

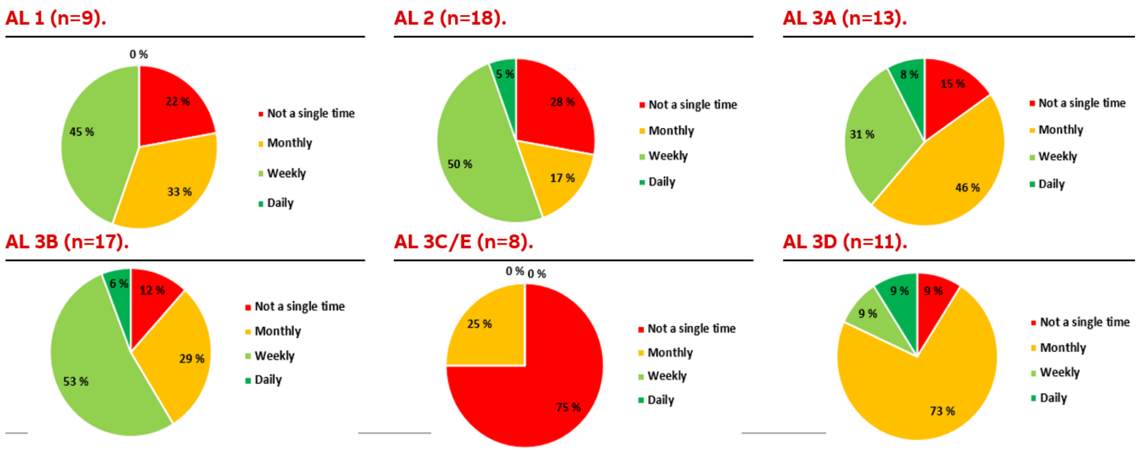


Figure 16. *"How many times in a month you hear from findings related to final product inspections?" -results.*

The third question was “feedback from final product inspections is clear and understandable”, and the sample was 85. Half of the employees fully or slightly agree, that the feedback is clear and understandable, and only 21 % fully or slightly disagree. 28% did not have an opinion, but it can still be said, that feedback is considered mostly understandable among employees. This indicates, that if the feedback is understood, the corrective actions should happen, and the number of flaws should decrease.

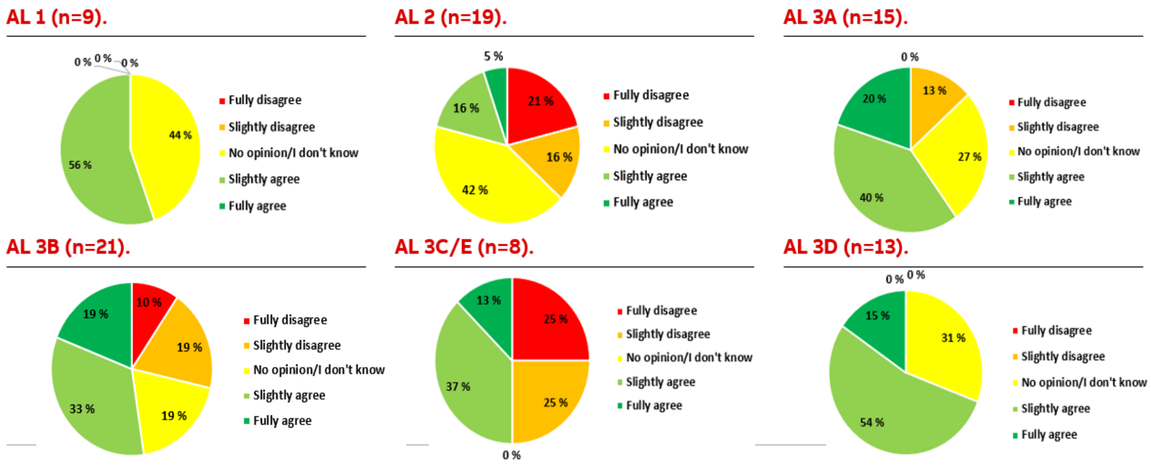


Figure 17. *"Feedback from final product inspections is clear and understandable" -results.*

The sample of the fourth question “I read the quality board information on a weekly basis” was 85 and the results indicate, that most of the respondents either fully (21%) or slightly (24%) disagree to reading the quality board weekly. Major part of the respondents did not have an opinion (29%), which either suggests, that they do not know what the quality board is, or the respondents are unsure whether they read the quality board weekly or not. Since most of the feedback is shown in the quality boards, it is important that all the employees commit to read the information regularly. For example, in AL 1, 45% of the respondents fully disagreed to the questions and 11% slightly disagreed meaning, that only the minority reads the quality board of AL 1 weekly.

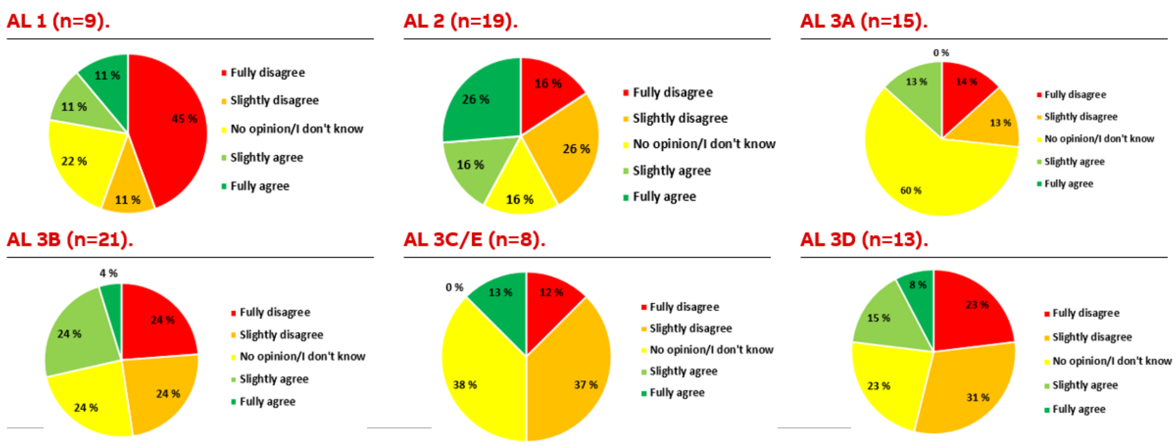


Figure 18. *"I read the quality board on a weekly basis" -results.*

Fifth question “I get informed regarding the findings related to final product inspections” measured how often the employees are informed considering the feedback. The sample to this question was 72, from which most of respondents heard from the feedback less than monthly (37%), or monthly (37%). Only 1% heard from the findings daily and 25% weekly. It is not necessarily the idea to inform all the feedback instantly to all the employees, but the findings should be discussed weekly among all employees and discuss the root causes for those findings. Alarming is, that a whopping 37% get informed considering the feedback less than monthly, indicating that there is not enough information provided or it is not communicated effectively enough. For example, in AL 3C/E, 62% of the respondents get informed regarding the feedback less than monthly and 38 % get informed monthly. However, as stated earlier in this chapter, AL 3C/E do not get as much feedback data provided as, for example, 3A or 3B are receiving.

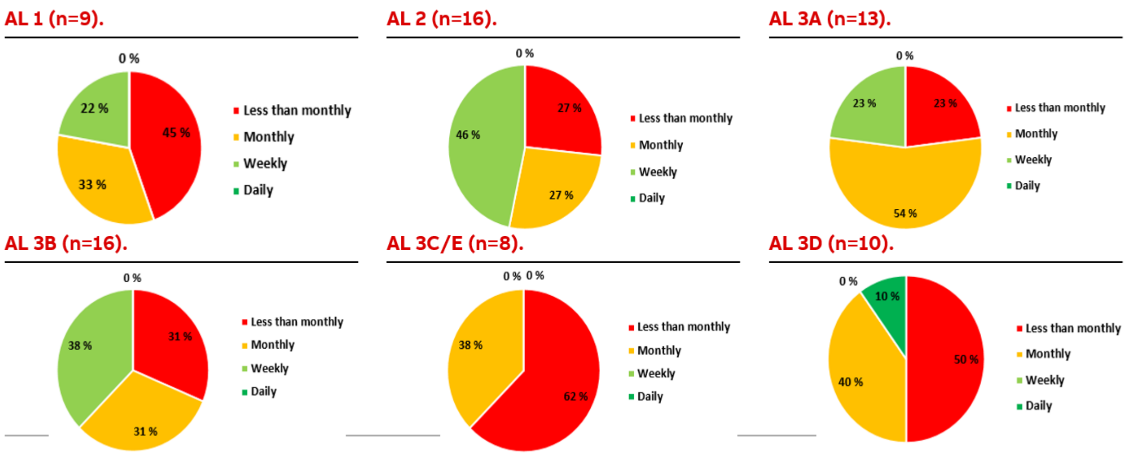


Figure 19. *"I get informed regarding the findings related to final product inspections." -results.*

The sixth question “I am satisfied with the feedback process as it is” indicated how satisfied the employees are with the process currently. The answers varied a lot, most respondents whether fully (10%) or slightly agreeing (31 %). However, 8% fully disagreed and 18% slightly disagreed, while 33% did not have an opinion. Most unsatisfactory outcome was in AL 3C/E, where 12 % fully disagreed and 50 % slightly disagreed. However, the sample size in AL 3C/E was the smallest of all assembly lines (n=8) and it is one of the lines with fewer feedback provided.

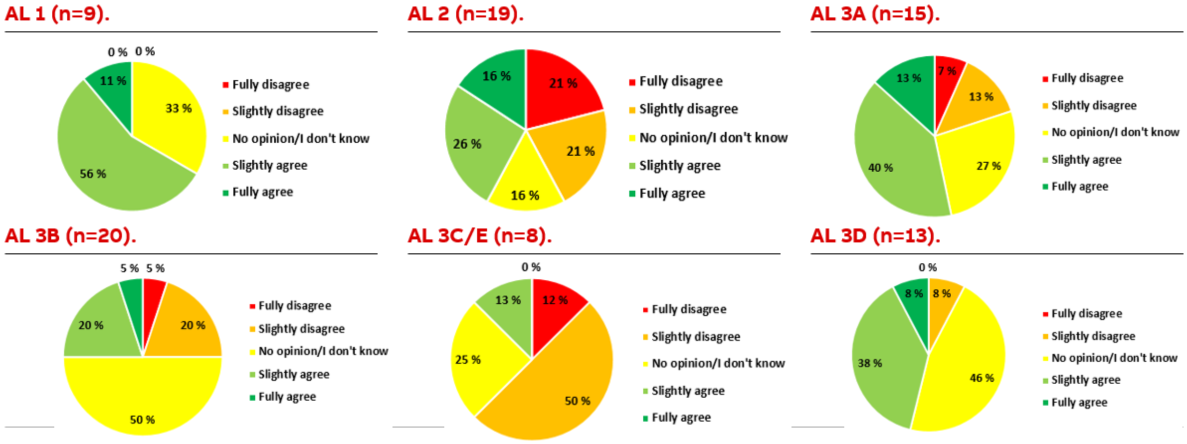


Figure 20. *"I am satisfied with the feedback process as it is." -results.*

The last, seventh question, was "I am ready to change my own working habits according to the feedback received from final product inspections", and the sample size was 85. The results indicate, that almost half (48%) of the employees fully agree and 29% slightly agree on willingness to change their own working habits according to the feedback. Only 1% fully disagrees and 4% slightly disagree, while 18 % do not have an opinion. As 77% fully or slightly disagree, it can be said that employees are committed to the continuous improvement gained through the feedback loop and they have a positive attitude towards the feedback.

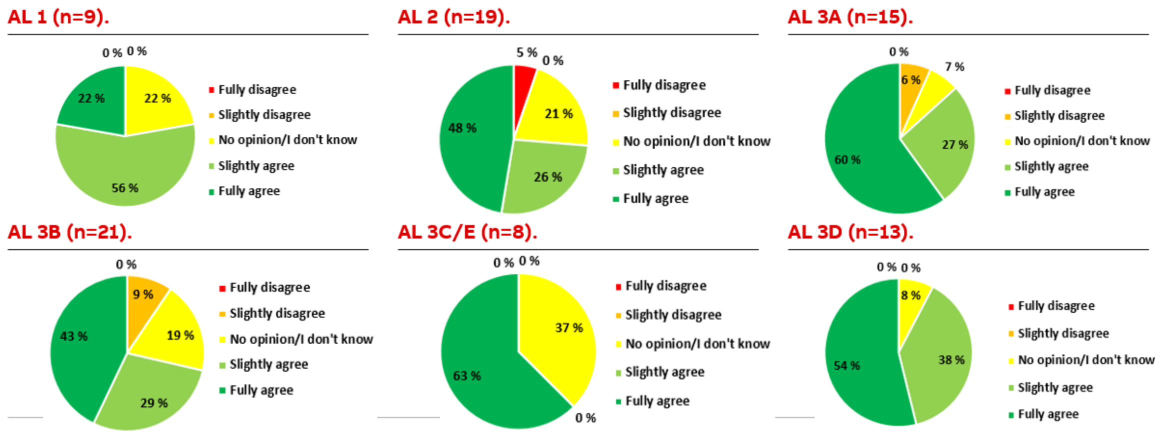


Figure 21. *"I am ready to change my own working habits according to the feedback received from final product inspections" -results.*

Overall the results of the questionnaire indicate, that feedback is considered important and the employees are willing to change their own working habits according to the feedback received. This means, that they are committed to the feedback process and its' goals. However, the employees do not hear or get informed regarding the findings as regularly as would be optimal. Even though there are not so many findings provided for some assembly lines, they should have positive feedback for performing with flawless effort. Employees also do not visit the quality board often enough to seek for the information themselves regarding the feedback for themselves, which could help them to learn and improve in their own performance. Finally, from the questionnaire it can be concluded, that there are clearly some hopes for developing the feedback process, but many are already satisfied as it is.

4.2.2 Theme interviews results

The second research method used in this study were theme interviews. Theme interviews were conducted for mapping the commitment of management to the feedback process and continuous improvement. Theme interviews were performed for 5 white-collar employees, working in:

- 3 in production
- 1 in quality
- 1 in engineering

Themes for the interviews were feedback process, communication, documentation and personnel. These themes were selected for covering the most important issues regarding the development areas of the feedback loop. The interviews were selected according to their importance considering the feedback loop and its development and their position. There were 1 interviewee from KK building and 4 from MM building, which is the main building of the factory performing functions, such as quality and engineering, for both buildings. The key points resulted from the interviews are presented in figure 22.

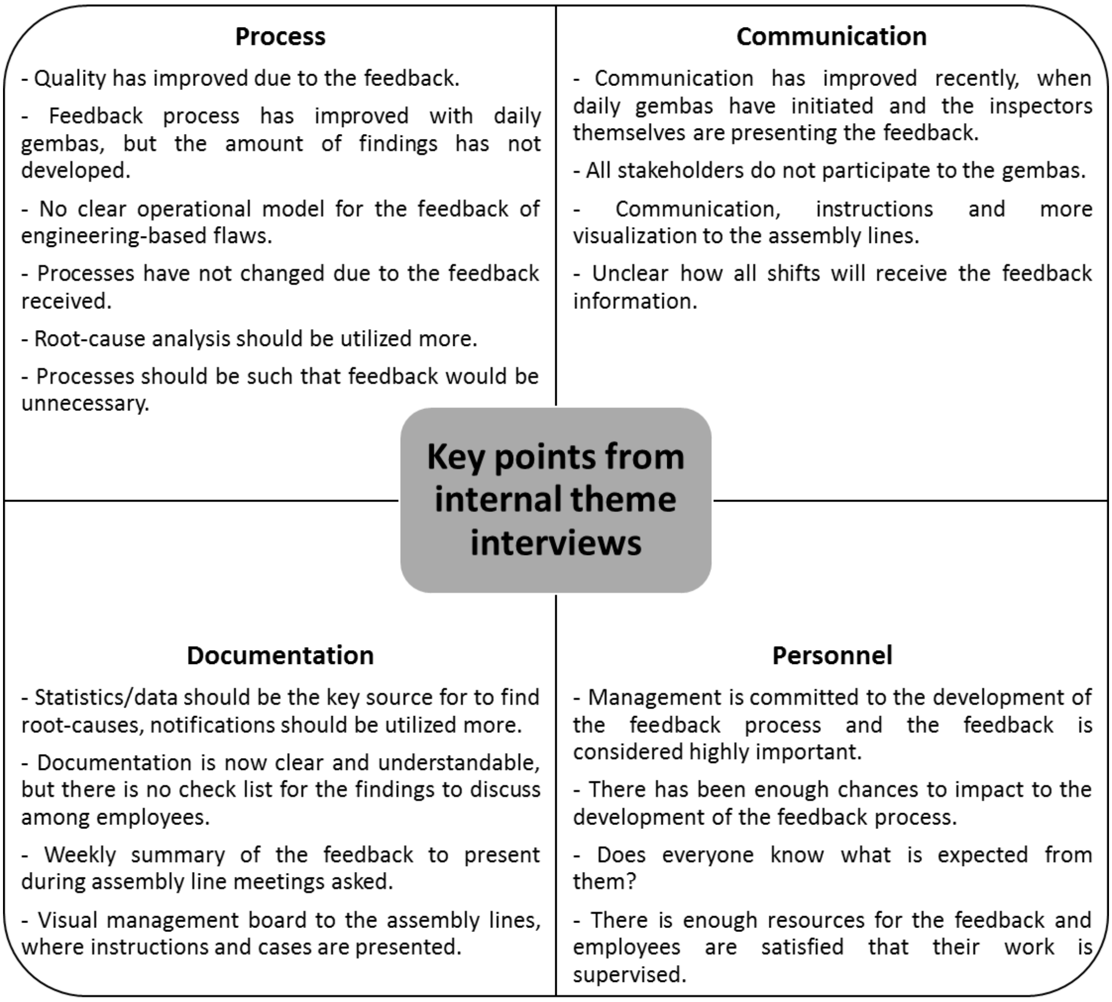


Figure 22. *Key points from internal interviews.*

Many points of views and development ideas arose during the internal interviews. One of the most important points is that the management is highly committed to the development of the feedback process and according to them, quality has improved due to the feedback received from final product inspections. However, feedback process itself has developed, but the amount of feedback has not changed. If the aim is to make the final product inspections unnecessary to perform, it means that the root-causes should be removed with RCAs (see 3.5). According to the internal interviews, RCAs have not been utilized enough, because there has not yet been enough feedback gathered after the initiation of the final product inspections since autumn 2018. For utilizing RCAs, data should be the key source for finding the root-causes, which means that there should be more quality notifications (see 4.1) fulfilled during the inspections. Basically, the volume of the inspections done is less important than making notifications from those, which have been inspected and where flaws have been found. There has now been discussion for initiating engineering-based RCA meetings, where the most frequent engineering-based flaws are prioritized for removal via RCAs performed by engineering department. This function is still developing, so the research for it will be out of scope for this study.

Another development idea from the theme interviews is the surveillance of the discussion regarding the feedback. For example, there is no check list to fulfil after a new flaw has been detected, so now there might not be any discussion of the feedback with assembly line employees. For example, weekly summaries of the feedback could be presented during assembly line meetings. After the biggest issues of the summary have been discussed, there could be a checklist to mark that the flaws have been discussed and everyone is familiarized with the correct course of actions. This would also answer to the questions, whether everyone knows what is expected from them. Employees themselves should have an opportunity to give feedback from the feedback itself and develop the process in a way, that the form of feedback is most efficient for everyone. Management considers the feedback clear and understandable, as do the employees, as shown in chapter 4.2.1, so there should be a short discussion for clearing the objectives for everyone.

Third development idea for improving the effectiveness of feedback are daily visual management boards to assembly lines. There could be, for example, info televisions or a management board in immediate contact with the assembly lines, where feedback and instructions of that assembly line could be displayed. Also, for every stage in production, there should be instructions and, for example, pictures of the correct working methods and wrong working methods. These instructions should be linked to the feedback concentrating to those stages, where there are most flaws found. These visual presentations help to pass information between shifts, and as the pass of the shift is occurring, there should be short discussion involved with the internal cases displayed in the boards or info televisions.

4.2.3 Observation results

As mentioned in the beginning of chapter 4.2, the observation part of the empirical research was conducted with participation during gembas and later filling an observation form daily. There was a total of 14 observations in MM building (AL 1 and AL 2) and 15 observations in KK building (AL 3). Observation form is illustrated in appendix 5.

The observation form included number of participants, whether the final product inspectors were present and had findings to present, whether there were other quality issues and if recent findings statuses were checked or not. In this research, checking the status refers to if the recent findings have been discussed and if necessary, corrective actions have initiated or not. This is because if the issue is only mentioned and it is there is no follow-up, it might be forgotten without a clear procedure to handle the feedback. In this form, green colour means positive results and red colour indicates that there are still some improvements needed. Results of the observation data is presented in appendix 6.

The results of the observation data indicate, that there are more participants present during the AL 3 gembas than AL 1 or AL 2 gemba meetings. In AL 1 and AL 3 gembas, the final product inspector has been present relatively frequently, but in AL 2 the final product inspector has not participated as often. However, this must be in relation to the times there has been feedback to give, which has been more frequent in AL 1 and AL 3 than in AL 2. This might be follow-up of the fact that AL 2 inspections occur relatively infrequently when compared to AL 1 and AL 3. Even though there are no findings to report of, it would give positive impact for the employees to bring up support, since there are zero flaws detected. Because the aim of the feedback process is to improve the processes so, that the final product inspections would become unnecessary to perform, less feedback brings the operations closer to this goal. Therefore, if there is no feedback, it means that the results are good. Respectively, “yes” indicates, that there are some improvements to be done for reducing the amount of negative feedback. The same idea stacks up with other quality issues, such as reclamations or notification reports.

Alarming finding from the observation form is, that only few times were the status of recent quality issues checked. This means, that there is rarely confirmation of whether the latest reclamations or feedbacks have been discussed or corrective actions taken. To achieve continuous improvement and reduce the feedback itself, it is necessary to perform quality assurance such a way, that there would be some confirmation that the issue is taken care of.

4.3 Analysis of the feedback process

Next, the main points that can be retrieved from the results of questionnaires, interviews and observations will be discussed in this chapter. The mixed research method gave an excellent overview of the development areas for the feedback process and brought up those issues, that still need clarification. From the measurement phase it can be assumed, that the feedback process is not very simple. Both employees and management consider feedback process from final product inspections highly important, and almost everyone is committed to the feedback and development of the process. It can be said, that the starting point for creating a sustainable system for continuous improvement via feedback is excellent due to commitment of employees. The interviews are analysed using thematic analysis, where responds have been divided into following themes: quality, risks and commitment.

Quality is very important function for an organization, as discussed in chapter 3.1. Quality has costs, but bad quality has bigger costs (see 3.1). As discussed during internal interviews, quality has improved due to feedback, but the number of findings has not decreased. Communication has improved via daily gembas, but there is no feedback available every time. However, positive feedback from zero-flaws should also be given and if there are no new cases, there can always be follow-up for the old ones. To improve the quality, the follow up should be done in cycles and it should include what has been improved and which flaws are occurring frequently. To help with the frequent flaws, visual boards of correct ways of action should be available in every phase of assembly. In this way, every shift receives the information from the feedback.

Risks are included in the improvement of feedback process. For example, how will the feedback reach all the employees working in different shifts and does everyone know, what is expected from them. Employees were mostly committed to change their working habits according to feedback, but if there is no positive feedback received in occurrence of zero-flaws, only the corrective feedback remains. This may lead to change of attitude, so it is important to maintain the feedback loop in both cases, when the assembly line has performed tremendous and when there is something to correct in the future.

Commitment is important for process improvement, and, as most quality gurus have pointed out, commitment of top management is one of the most critical CSFs for an organization (see table 4). As it turned out during the internal interviews, all interviewees were committed to the feedback process and its development. Also, as came up during the interviews, the employees in the assembly lines are satisfied, that their work is being followed and they receive feedback. However, when compared to the questionnaire results, many of the respondents claim, that they hear from the inspections and they check the quality boards themselves relatively seldom. This raises a question, if there is enough follow up of the discussion of the findings.

Feedback process itself divides opinions among assembly lines, and management thinks that feedback has improved, but the amount of feedback has not changed. Many of the findings are related to engineering-based flaws, but there has not been a clear operational model to eliminate the root-causes of those flaws. There might be causality between volume of feedback and elimination of root-causes, so if RCAs are not performed, these root-causes may remain, and the volume of feedback will not change. An illustration of the development of feedback weekly is presented in figure 23. Grey area marks accepted products and red area rejected products (ABB 2019k).

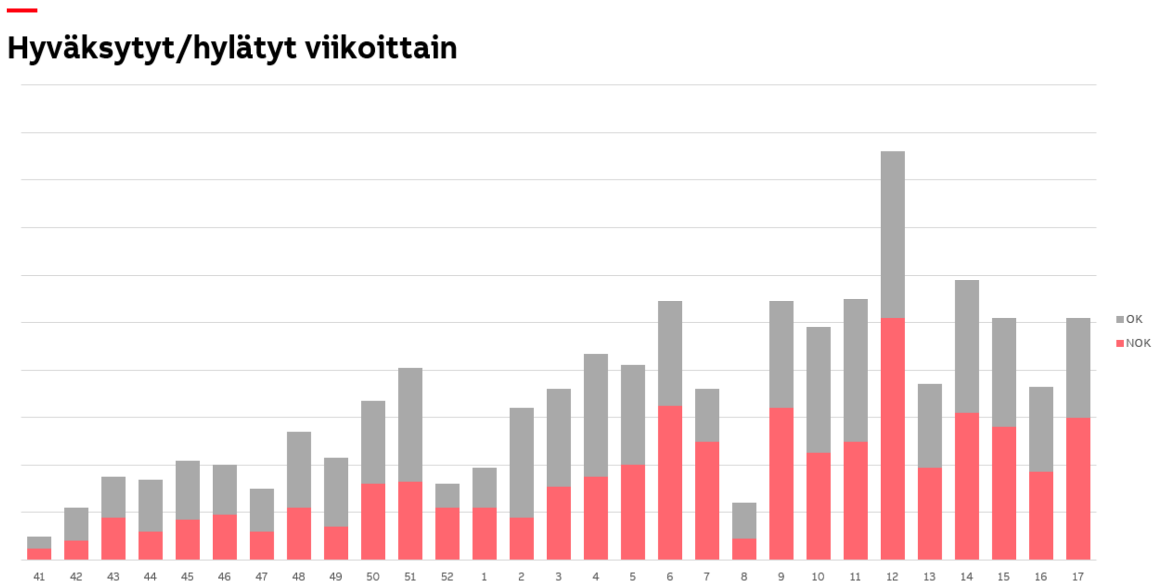


Figure 23. *Volumes of accepted/rejected inspections by weekly 2018-2019. (ABB 2019k).*

This chart confirms what was one of the key points in internal interviews. The amount of feedback and especially the share of rejected inspections has stayed on the same level. However, many of these findings would probably not have led to a reclamation, because the internal level of quality has higher demand than customers. (ABB 2019k.)

When comparing week 13 and week 17 of 2019, the share of rejected inspections has increased from 49% to 50%. By week 17, AL 3C/D/E have had the biggest share of rejected inspections, 68% and AL 1 the smallest, 35% of rejected inspections. However, in AL 3A/B, where there have been most inspections done, 51% were rejected and 49% accepted. It seems, that the bigger the sample size is, the more equal is the division of accepted and rejected inspections. (ABB 2019k.)

Engineering-based flaws is the second biggest cause of rejection after the assembly itself. When pointing out, that the amount of feedback is slightly increasing, but RCA from engineering-based flaws is not done, it seems clear that eliminating the root-causes would also decrease the feedback from engineering-based flaws. According to the interviews, one way to use RCAs better is to utilize notifications more, since statistics/data should be the key source to find root-causes. White-collar employees thought during the interviews, that there is less root-causes than there are issues found, so even though engineering-based flaws is only slightly over quarter of all feedback (ABB 2019k), elimination of root-causes is thought to have an impact to other causes of feedback as well. Statistical process control (see 3.2.3) should be utilized in creation of RCAs, since with SPC organizations can investigate whether they have done the job correctly or if not, could they perform better. This data for analysis helps to find causes between causes and defects (see table 3).

Communication is the key to the feedback process's effectiveness and communication has improved recently, when daily gembas have initiated. According to the questionnaires, there are differentiation on how often employees hear from the findings of final product inspections. In AL 3C/E, employees heard from the findings monthly or less than monthly. In AL 3B, majority of the employees heard from the findings weekly. Similar results occurred on how often the employees get informed regarding the feedback of final product inspections. in chapter 4.2.1 there was discussion, that there is much less feedback provided to some assembly lines than others, which has an impact on how often the information is shared. Still, as mentioned earlier in chapter 4.2.3, if there is no feedback to report, there should be positive recognition for outstanding performance. Of course, this would require at least some inspections in every assembly line. As seen from the observation data, there is not so much feedback to give to AL 2, but every time inspections are performed to AL 2 with zero-flaw detection rate, they should be recognized for performing well. There should be at least some inspections daily performed in every assembly line, so that the possibility of feedback would be equal to everyone.

One big issue with communication is how the feedback information will reach all the employees in every shift. As discussed in chapter 4.2.2, daily visual management boards or info television is one way to solve this problem. For example, if there would be continually updated management boards with the recent feedback cases visible in the assembly lines, the information would reach all the employees or at least the information would be available. As the questionnaire results indicate, employees are committed to the feedback and consider it important, so it would be logical for them to be interested in checking these visual boards for getting information regarding the latest feedback. Small boards could, for example, lie on each stage of assembly line telling the latest feedback of that specific function of the supply chain. There should also be visual instructions of what a correct outcome should look like, so that employees can compare the feedback received to the correct way of action.

Last notice considering the communication is that final product inspectors could visit occasionally assembly line meetings for presenting of findings that are repeating and answering questions of employees. This way, the final product inspectors also can get acquitted with new employees, who might have not heard from all the recent findings. These visits could occur, for example, once every six months or whenever there seems to be a demand for a visit.

Documentation is considered clear and understandable, but there are some thoughts, that some unnecessary data is created during the inspections. During the interviews, a hope of weekly summaries of the feedbacks to present during assembly line meetings came up. Currently, there is a platform to insert the feedback, so assembly line managers could utilize that platform while presenting the findings during assembly line meetings.

There is no checklist for feedback cases to discuss with employees. Documentation considering the follow-up of cases would ensure, that all feedback brought up would reach interested parties. For example, there could be a check-list visible in gemba meetings, where assembly line managers mark those cases, that they have already discussed with employees. This way, it is easy to notify if the same feedback repeats often, and those that seems to repeat themselves should be prioritized for corrective actions. Also, if there has been recent customer reclamations or internal cases, there should be more assurance during gembas, that corrective actions have initiated. If the feedback is not utilized for making corrective actions, continuous improvement (see 3.2) will not occur. The observation results tell, that currently only occasionally is the status check done, but it should be performed more frequently. Assurance could be done every time, when there has been recently internal cases or reclamations, and the responsible manager of gembas should be the one to start discussion of the follow-up. For now, there has not been any changes in processes according to feedback, but it can be assumed, that when the RCAs initiate in June 2019, there might be some upcoming changes. The changes and their impact on the volume of findings should be documented and followed.

This documentation is out of scope for this research, but it could be an interesting research area in the future.

Last theme identified during the questionnaires and interviews is personnel, referring to the commitment and willingness to continuous improvement via feedback. As seen from the results of questionnaires and interviews, employees and management both are highly committed to the feedback process and there has been enough chances for everyone to contribute to the development of the feedback process. There have been enough resources allocated to the feedback and employees are satisfied, that their work is supervised. Only question was, if everyone knows what is expected from them. With utilization of SMART (see 3.3), it is clearer for the employees what is expected from them and how fast it should be done. Visual management board mentioned before, where employees can compare their results of work to a correct outcome of that specific function they are operating at, can help with utilization of SMART. This way, they can learn what the expectation from their function is and performance management takes place.

Key indicators of the quality of measuring tool are the validity and reliability of the measurement. Reliability can be explained with concepts of “true” score, which occurs when measurements were perfectly accurate, and “error”, which happens when measurements are not perfectly accurate. Developing and validating a tool focuses on reducing error in the measurement process. Validity, respectively, means what the tool used to measure is supposed to be measuring. A tool to measure cannot be reliable without validity. For example, incorrectly calibrated scale could result to the same value, even though the weight is changed. (Kimberlin & Winterstein 2008: 2276-2278.) Validity of data collection process is evaluated in table 10.

Data	Type of data	Analysis	Comments
Questionnaire	Quantitative	Descriptive statistics, frequencies	6(7) assembly lines, sample size n was 85, and there are approximately 550 employees overall in the case company
Observations	Qualitative	Statistics, frequencies calculated from observation form (see appendix 6)	There were 14 observations in MM building and 15 observations in KK building
Theme interviews	Qualitative	Thematic analysis of the feedback process, communication, documentation and personnel	There were 3 white-collars from production, 1 from quality and 1 from engineering

Table 10. *Validation of data.*

Detailed theme interview validation data is illustrated in table 11 below.

Date	Role	Analysis	Duration of interview
7.5.2019	Quality engineer	Feedback has improved, but findings have not decreased	00:22:51
7.5.2019	Production manager	Communication has improved, and documentation is clear and understandable	00:27:24
9.5.2019	Production manager	Positive feedback, most optimal scenario is where there is no negative feedback at all	00:18:33
7.5.2019	Assembly line manager	There should be more follow-up, but the process is working good otherwise	00:26:17
13.5.2019	Engineering manager	Data and statistics should be utilized more for creating RCAs	00:29:19

Table 11. *Validation of interview data.*

4.4 Improvement of the feedback process

According to the analysis phase of this research, we can identify at least 5 improvements that can be performed relatively quickly with low investments:

1. Involvement of engineering and utilization of RCA (initiating in June 2019).

2. In case of zero flaws, positive feedback.

3. Equality in receiving feedback

4. Visual management boards to all phases in every assembly line.

5. Improved follow-up.

Next, these improvements will be examined more deeply and at the end of this chapter, an operational model, an artefact, will be visualized as a process map of the improved feedback process.

4.4.1 Involvement of engineering and utilization of RCAs

Engineering needs to be involved in the feedback process and as it turned out during the empirical research, RCA meetings for engineering are initiating in June 2019. It is important to involve statistical process control (see 3.2.3) while creating these RCAs. For example, SPC could be utilized while making the RCAs for that kind of flaws, which occur frequently and are engineering-based. SPC could be utilized, for example, when acquiring data from quality notifications. When creating the RCAs, a risk priority number (see 3.2.3) should be calculated for prioritizing the actions, which need to be corrected first. As we can see in table 4, most quality gurus consider quality data and quality policy as one of the most important CSFs (see 3.2.1). A process map of the involvement of engineering and utilizations of RCAs is illustrated in appendix 7.

4.4.2 Positive feedback

In table 4, almost all quality gurus consider employee empowerment as a critical success factor in one way or another. In cases of zero-flaws, there should be a reckoning to employees for performing in such a high level. Kaizen (see 3.2.3) can be implemented in all levels of an organization and defects are waste in lean thinking (see figure 5), so this encouragement should involve all stakeholders creating value and preventing flaws. As stated in chapter 3.4, encouragement leads to greater efforts to be successful and positive feedback enables recognition. When effective behaviour is recognized, it is usually repeated, so in zero-flaws occasions it is as important to deliver the encouragement of successful performing as it is in case of corrective feedback.

4.4.3 Balanced feedback between assembly lines

During the research it turned out, that there were a lot of variation between assembly lines, how often they hear from the findings regarding the feedback. When inspecting figure 19, we can see, that, for example, AL 3C/E hears more seldom from the feedback than AL 2. One factor is, that AL 3 C/E is performing in a high level, but it should be still ensured some way, that all the assembly lines have similar chances to receive feedback. There should be, for example, at minimum, two inspections done for every assembly line daily so, that statistically there would be a chance for 100%, 50% or 0% performing rate daily. Of course, the volume for inspections need to be adjusted according to the volumes of finished products between assembly lines. In case of 100% performing rate, the positive feedback explained in chapter 4.4.2 should be executed. This way, all assembly lines could hear from the feedback at least weekly during assembly line meetings or even daily, if the feedback is brought straight to the assembly line in a form of visual management board discussed in the next chapter.

Another method to reduce variability in the amount of feedback among assembly lines is to discuss of what factors both inspectors consider important, and then standardize the inspections as much as it is possible in engineer-to-order (ETO) manufacturing. The inspections are mostly subjective and carried out by the final product inspectors based on their know-how (see 3.4). Both inspectors could inspect certain type of products and then it should be discussed, whether they have found the same flaws and then discuss, whether there is any differentiation and how the factors with different point of views could be carried out in the future.

4.4.4 Visual management boards

For improving the awareness, there needs to be clarity of objective setting. SMART (see table 8) is one tool for helping the objective setting and showing, what is expected and how employees are performing. For helping to clarify of what the objectives are and what is expected from employees, there could be visual management boards in every phase of all assembly lines. These visual management boards should include the latest feedback for that specific phase of the assembly, where there are pictures and short description of the findings. Because this alone cannot tell, what the outcome should look like, there should be an example of the correct outcome or precise description of what the outcome of that step of the assembly should be. This way, the employees can compare the received feedback to the correct outcome and learn from the feedback, enhancing the continuous improvement. Setting objectives also helps with follow-up, which is discussed in chapter 4.4.5. Visual management boards could also be implemented in final product inspection phase, where there could be as standardized inspection as possible with minimum subjective view, discussed in chapter 4.4.3. This way, SMART objective setting considers the inspectors themselves also.

Visual management boards have another important task, because they are available in the assembly lines all the time. If the latest feedback is delivered to these boards, the latest information concerning that specific function of the supply chain is available to everyone visiting the board. Because these visual management boards could exist in every step of the assembly, everyone in every shift will receive the latest feedback of their working station. As discussed in chapter 3.2.2, visual management serves its purpose for several reasons, in this case especially facilitating continuous feedback and supporting continuous improvement. A process map of improved visual board is illustrated in appendix 8.

4.4.5 Improved follow-up

Follow-up for the feedback is needed for taking action for accomplishing the transformation and measuring quality. These are also included in critical success factors of quality gurus (see table 4.) If the operations are not followed, quality assurance will not occur. When investigating the observation data, it seems, that even though there is not always feedback to follow, it is very seldom that a follow-up is done for the recent feedback. There should be a check-list for findings to discuss with employees, and it should be assembly line managers who ensure, that the feedback is discussed among employees. If the same kind of feedback seems to occur frequently, it is easy to check whether it has already been discussed with employees or not. If it has, there should be an investigation made of why the same findings seem to repeat. A check-list also helps the managers to keep track on the issues to discuss with employees. Also, there is continually updated list the feedback available internally, which assembly line managers could utilize while summarizing the feedback weekly. Every six months or when there is a recognized need, the final product inspectors could visit the assembly line meetings for presenting their concerns and answering questions. Teamwork is seen as one of the CSFs of some quality gurus, found in table 4, so it can be refreshing for different teams to get acquainted this way. Also, one method for improving the follow-up could be the "daily huddle" discussed in chapter 3.5. If there are corrective actions done, they should be documented. A process map of improved follow-up is illustrated in appendix 9.

Improvement	Description
Involvement of engineering and utilization of RCAs	RCA report is needed for engineering-based flaws. The risk priority numbers need to be calculated for prioritizing the corrective actions.
Positive feedback	Employee empowerment is well recognized critical success factor by quality gurus. Encouragement leads to greater efforts to be successful and recognized effective behaviour is usually repeated. In zero-flaw occasions, this positive feedback should be a standard.
Balanced feedback for assembly lines	Adjusted inspection volumes for assembly lines so, that there is at minimum 2 inspections for each assembly line in a day. This way, there is at least 100%, 50% or 0% performing rate daily. Also, inspection methods should be standardized as far as possible for avoiding variation in findings.

Visual management boards	For improving performance management and SMART-model, it needs to be clarified for employees of what the outcome of their function should look like in case of a constructive feedback. These boards should exist in every function in all assembly and the latest feedback of that function should be delivered to these boards. The employees can compare the feedback to the correct way of action and the feedback reaches every employee visiting the board in every shift. This can also be applied to the final product inspectors.
Improved follow-up	There is rarely follow-up for the feedback, which would improve quality assurance. A check-list to discuss with employees should be created for ensuring, that the feedback is understood, and corrective actions initiated, if needed. Also, continually updated list of the inspections should be utilized for summarizing the feedback weekly in assembly line meetings. If changes are done, they should be documented.

Table 12. *Summary of recognized improvement ideas.*

4.5 Control phase of the improved feedback process

In the control phase of the DMAIC model, such techniques as statistical process control (see 3.2.3), control plan and pre-control are suggested. Most DMAIC guidelines are prescriptive in how process control should be organized. (de Mast & Lokkerbol 2012: 612.) Control models for involvement of engineering and utilization of RCAs, visual management boards, and follow-ups are illustrated in appendices 6-8 for helping to understand, what is the idea behind the improvement ideas and how to control the processes. In the future, it is important to follow the development of the rate of flaws found (see figure 23) for truly concluding, should these improvement ideas be modified somehow. If there are some modifications to be done, PDCA-cycle (see figure 6) is one useful way to create the change. Since the aim for the case organization is to reduce reclamations by half yearly, the control and measurements of the feedback should be carried out for ensuring, that the improvement plan is working. For example, the questionnaire form found in appendix 2 could be conducted every six months or so for keeping track of the development and if the feedback is more efficient.

In the timeframe of this research, it is challenging to evaluate, whether the improvement plan proposed would decrease the detection of flaws or lower reclamation rates. However, as it turned out during the empirical research part, communication has improved recently.

Now it needs to be ensured, that the feedback from final product inspections reaches effectively those stakeholders, who it concerns the most.

5 CONCLUSION

In the final phase of this thesis, the main findings and future research areas, which have arisen during the making of tis research, are discussed. There were many interesting points, which turned out during the empirical research and have a major impact on the efficiency of the feedback. Also, the feedback process involves much larger group of stakeholders presented in figure 12, than how many are inside of this research's scope. Therefore, there are still a lot of research left to be done for improving the feedback process even more, where for example customers and suppliers are involved.

The reliability and validity of this study were evaluated in tables 10 and 11. It can be said, that in this thesis, the results are reliable especially, when assessing the variation in different research methods. For example, the sample sizes in observations and questionnaires were quite large, and the results found from the interviews mostly fell into line with the results of observations and questionnaires. Also, when evaluating the validity of this study, we can see from the tables 10 and 11, that there were correct methods for measurements with enough samples and durations of interviews for conducting reliable results.

5.1 Key findings

During this research it turned out, that the feedback process is not very simple and there are many functions and stakeholders involved in it. However, almost everyone involved in the research considered the feedback form final product inspections important. The feedback process considers the whole organization, because all the functions need to be aligned for creating value to the customer, and the final product inspections and the feedback received from those is one kind of measurement to assess the performance of these functions. The key findings found during this study are, that the feedback process in the case organization is developing continually and all ideas for improvement are welcome.

What comes to the findings of the feedback process itself, there were 5 improvement ideas found in table 12, which should be quite easy to implement to the feedback process: involvement of engineering and utilization of RCAs, positive feedback, balanced feedback for assembly lines, visual management boards and improved follow-up. These were the ideas arisen from the research data, where there were some positive surprises and some factors to improve. One example of a positive finding was, that almost all the personnel in the case organization are committed to the development of the feedback process and are willing to change their own working habits according to the feedback. However, one factor to improve is the follow-up considering the feedback, since there is some lack for efficient tracking of the discussions regarding the feedback or corrective actions it has initiated.

Most employees are satisfied with the process, but as it came clear during the research, there are many ways to make the process even better. It seems, that some employees hear from the findings of the feedback process less than monthly and few employees hear daily. If they are not provided with the findings regularly, it is hard to learn and continually improve one’s performance as stated in chapter 3.5.

5.2 Future research areas

As the discussion in chapter 4.5 points out, when the improvements of this study are implemented, their utility should be measured and in time, the causality to the development of reclamations should be evaluated. Development of flaws in a long-time phase is the true measurement of how the improvement plan is performing. For example, if the same flaws are occurring as frequently as before the implementations of this study, it can be concluded, that the improvement plan needs rechecking. In addition, the feedback process should be discussed regularly for mapping those issues, which need to be prioritized. Changes in processes should be documented and their utility measured.

Feedback loop and continuous improvement are interesting topics and they could be investigated from many points of views. For example, suppliers and customers could be taken into the scope of continually improving the operations by receiving feedback with standardized forms from them. Customer reclamations could be investigated among employees the same way as the final product inspection feedback was investigated in this study. For example, if the employees hear from customer feedback and how are they committed to it. Suppliers, respectively, could be involved while investigating, if there are similar flawed products from same suppliers found frequently in the inspections. If customers and suppliers are involved, external data could be utilized for making the scope even wider and getting a bigger picture on what should be prioritized while making corrective and preventive actions (see 3.1).

Another method to improve continuous improvement is to utilize leaner (see 3.2.2) principles. Visualization is one tool for utilizing lean and for example follow-up could be more visual everywhere. It could be investigated in the future, how the inspectors can keep updated with the recent process improvement projects, so that they can take the development of those projects into consideration while creating the feedback.

Visual inspection has been widely used in quality control and manufacturing but applying accurate 3D inspection is challenging (Zhong, Li, Zhou, Li, Shi & Wang 2014: 1563). To automate part inspection, ABB Robotics has developed robotic inspection system with a 3D scanning sensor for accessing different features from optimal points. The sensor technology records and details surface data and geometrics for comparison with a CAD (computer aided design) model of the inspected part. (Korn 2018: 61.) The possibilities of this technology could be investigated and the possibilities for utilizing it in electric motors evaluated. It would seem logical, since the technology already exists inside the organization.

5.3 Discussion

This thesis was presented in the case organization on 18th of June 2019. The audience varied from several stakeholders of the feedback process and the presentation initiated a lot of discussion among the participants. There were many topics in discussion considering, for example, why are the results such as they are, how the feedback is efficient to all employees, how is the feedback done in other organizations and should the final product inspection and feedback be automated.

From the presentation it can be concluded, that participants agreed and were interested in the research and improvement ideas of this thesis. There are still a lot of research, which can be done for improving the feedback process and this thesis could be one platform for initiating new development ideas. The presentation and discussion it initiated is one example of weak market testing, since it showed if the improvement ideas were agreed or not. In this case, it can be said that the weak market testing was successful as the development areas and improvement ideas were mostly agreed.

REFERENCES

ABB (2017). ABB Quality Policy (ABB) [online]. [11.3.2019] Available from World Wide Web: URL <http://search-ext.abb.com/library /Download.aspx?DocumentID=9AKK107045A7190&LanguageCode=en&DocumentPartId=&Action=Launch>.

ABB (2019a). History (ABB) [online]. [5.1.2019] Available from World Wide Web: URL < https://new.abb.com/about/abb-in-brief/history>.

ABB (2019b). Who we are – ABB in brief (ABB) [online]. [5.1.2019] Available from World Wide Web: URL <https://new.abb.com/about/abb-in-brief>.

ABB (2019c). Who we are – Group structure (ABB) [online]. [5.1.2019] Available from World Wide Web: URL <https://new.abb.com/about/abb-in-brief /group-structure.>

ABB (2019d). ABB Suomessa (ABB) [online]. [5.1.2019] Available from World Wide Web: URL <https://new.abb.com/fi/abb-lyhyesti/suomessa>.

ABB (2019e). ABB Oy, Motors and Generators (ABB) [online]. [5.1.2019] Available from World Wide Web: URL <https://new.abb.com /fi/abb-lyhyesti/suomessa/yksikot/motors-and-generators>.

ABB (2019f). Internal interview, ABB. Interview, Vaasa 11.1.2019.

ABB (2019g). Internal interview, ABB. Interview, Vaasa 11.1.2019.

ABB (2019h). Laatupolitiikka (ABB) [online]. [16.1.2019] Available from World Wide Web: URL <https://new.abb.com/fi/kestava-kehitys/laatupolitiikka>.

ABB (2019i). (ABB intra) [online]. [5.2.2019].

ABB (2019j). (ABB intra) [online]. [23.5.2019].

ABB (2019k). (ABB intra) [online]. [28.5.2019].

ABB (2019l). (ABB internal data) [17.6.2019].

Aquilani, B.; Silvestri, C.; Ruggieri, A. & Gatti, C. (2017). A systematic literature review on total quality management critical success factors and the identification of the new avenues of research. *The TQM journal* [online] 29: 1 [14.2.2019], 184-185. Available from World Wide Web: URL <https://www.emeraldinsight.com/doi/pdfplus/10.1108/TQM-01-2016-0003>.

Ashdown, Linda. (2014). *Performance Management*. Philadelphia, PA: Kogan Page, 2014. ISBN 987-0-7494-6997-9.

Barreiro, J., Labarga, J.E., Vizán, A., Ríos, J. (2003). Functional model for the development of an inspection integration framework. *International Journal of Machine Tools & Manufacture* [Online] 43: 15 [12.3.2019], 1621-1622. Available from World Wide Web: URL <https://ac.els-cdn.com/S0890695503001822/1-s2.0-S0890695503001822-main.pdf?_tid=dc019736-33b7-4a1a-9476-4f5eea2c5bce&acdnat=1552468475_cb56de0d1abe15b25a626612337f5b34>.

Barsalou, M. (2016). The quality improvement field guide: achieving and maintaining value in your organization. Boca Raton, FL: CRC Press, 2016. ISBN 978-1-4987-4574-1.

Baudet, N., Maire, J. & Pillet, M. (2013). The visual inspection of product surfaces. *Food Quality and Preference* [online] 27: 2 [20.3.2019] 153. Available from World Wide Web: URL <https://ac-els-cdn-com.proxy.uwasa.fi/S0950329312001620/1-s2.0-S0950329312001620-main.pdf?_tid=529adb4a-a275-43dd-8a7a-88f60f5a1fa0&acdnat=1553118477_a0a3e78dad2956cd8bee9b71d3cae7dd>.

Beck, R., Weber, S. & Gregory, R. W. (2013). Theory-generating design science research. Information systems Frontier [online] 15: 4 [4.9.2019], 637-638. Available from World Wide Web: URL <https://search-proquest-com.proxy.uwasa.fi/docview/1418096762/?pq-origsite=primo>.

Black, S. & Porter, L. (1996). Identification of the Critical Factors of TQM. *Decision Sciences* [online] 27: 1 [19.3.2019], 13. Available from World Wide Web: URL

<https://search.proquest.com/docview/198123583/fulltextPDF /DA293D40D5F845C5PQ/1?accountid=14797>.

BusinessDictionary. (2019). Scrap rate (BusinessDictionary). [online] [20.3.2019] Available from World Wide Web: URL <http://www.businessdictionary.com/definition/scrap-rate.html>.

Cambridge Dictionary. (2019a). Cost efficiency [online] [1.3.2019]. Available from World Wide Web: URL <https://dictionary.cambridge.org/us/dictionary/english/cost-efficiency>.

Cambridge Dictionary. (2019b). ISO (Cambridge Dictionary). [online] [20.3.2019] Available from World Wide Web: URL <https://dictionary.cambridge.org/dictionary/english/iso>.

De Mast, J. & Lokkerbol, J. (2012). An analysis of the six sigma DMAIC method from the perspective of problem solving. *International journal of production economics* [online] 139: 2 [16.6.2019], 612. Available from World Wide Web: URL <https://www-sciencedirect-com.proxy.uwasa.fi/search/advanced?docId=10.1016 /j.ijpe.2012.05.035>.

Eaidgah, Y., Maki, A., Kurczewski, K. & Abdekhodaee, A. (2016). Visual management, performance management and continuous improvement: a lean manufacturing approach. *International journal of lean six sigma* [online] 7: 2 [16.6.2019], 188, 194-195, 204. Available from World Wide Web: URL <https:/ /www-emeraldinsight-com.proxy.uwasa.fi/doi/pdfplus/10.1108 /IJLSS-09-2014-0028>.

Elias, A. (2016). Stakeholder analysis for Lean Six Sigma project management. *International Journal of Lean Six Sigma* [online] 7: 4 [13.6.2019], 394-395. Available from World Wide Web: URL <https:/ /www-emeraldinsight-com.proxy.uwasa.fi/doi/pdfplus/10.1108 /IJLSS-11-2015-0046>.

Feigenbaum, A. V. (1991). *Total quality control: fortieth anniversary edition.* 3rd edition rev. international ed. New York: McGraw-Hill, 1991. ISBN 0-07-112612-0.

Financial Times. (2019). Definition of cost efficiency [online] [1.3.2019]. Available from World Wide Web: URL <http://markets.ft.com/research/Lexicon/Term?term=cost-efficiency>.

Goel, M. & Gill, A. (2014). Benchmarking the critical success factors of TQM implementation: A review of 21 national quality awards. *Economic Affairs* [online] 59: 4 [5.2.2019], 629. Available from World Wide Web: URL <https://search-proquest-com.proxy.uwasa.fi/docview/1650544304/fulltextPDF/4F887C5BFF024BDAPQ/1?accountid=14797>.

Gurtner, S.; Hietschold, N. & Reinhartd, R. (2014). Measuring critical success factors of TQM implementation successfully – a systematic literature review. *International Journal of Production Research* [online] 52: 21 [24.1.2019], 6254. Available from World Wide Web: URL <https://www.tandfonline.com/doi/abs/10.1080/00207543.2014.918288>.

Haverila, M., Kouri, I., Miettinen, A. & Uusi-Rauva, E. (2009). *Teollisuustalous*. 6. painos. Tampere: Infacs Oy.

Hietschold, N., Reinhardt, R. & Gurtner, S. (2014). Measuring critical success factors of TQM implementation successfully – a systematic literature review. *International Journal of Production Research* [online] 52: 21 [19.3.2019], 6256, 6264. Available from World Wide Web: URL <http://web.a.ebscohost.com/ehost/pdfviewer/pdfviewer?vid=1&sid=713799ad-e137-47b9-847f-c4476498b4e9%40sessionmgr4007>.

Hopen, D. & Rooney, J. (2018). Positive Feedback. *Lean & Sig Sigma Review* [online] 18: 1 [15.6.2019], 28-29. Available from World Wide Web: URL <https://search-proquest-com.proxy.uwasa.fi/docview/2158111966/fulltextPDF/5D5B8C21B9E5443FPQ/1?accountid=14797>.

Ishikawa, K. (1994). Guide to Quality Control. 12th edition. Tokyo: Asian Productivity Organization, 1994. ISBN 92-833-1035-7.

Jiménez-Jiménez, D.; Martinez-Costa, M.; Martínez-Lorente, A. R. & Rabeh, H. A. D. Total quality management performance in multinational companies. *The TQM Journal* [online] 27: 3 [7.1.2019], 330. Available from World Wide Web: URL <https://www-emeraldinsight-com.proxy.uwasa.fi/doi/pdfplus/10.1108 /TQM-01-2014-0002>.

Juran, J. (1986). The quality trilogy. *Quality progress* [online] 19: 8 [20.3.2019] 19-21. Available from World Wide Web: URL <http://info.juran.com/hubfs/documents/App%20Files /TheQualityTrilogy%20by%20JM%20Juran.pdf>.

Karuppusami, G. & Gandhinathan, R. (2006). Pareto analysis of critical success factors of total quality management. *The TQM Magazine* [online] 18: 4 [25.1.2019], 376-378, 381. Available from World Wide Web: URL <https:/ /www-emeraldinsight-com.proxy.uwasa.fi/doi/pdfplus/10.1108 /09544780610671048>.

Kimberlin, C. & Winterstein, A. (2008). Validity and reliability of measurement instruments used in research. *American journal of health-system pharmacy* [online] 65: 23 [7.6.2019], 2276-2278. Available from World Wide Web: URL <http://web.b.ebscohost.com.proxy.uwasa.fi/ehost/pdfviewer /pdfviewer?vid=1&sid=5055e17e-0259-409b-b50a-a24dd695d2ad%40pdc-v-sessmgr02>.

Korn, D. (2018). Inspection automation. *Modern machine shop* [online] 90: 10 [17.6.2019], 61. Available from World Wide Web: URL <https://search-proquest-com.proxy.uwasa.fi/docview/2013219195/fulltextPDF/8715BE05EDDB45FAPQ /1?accountid=14797>.

Kumar, V. & Sharma, R.R.K. (2017). An empirical investigation of critical success factors influencing the successful TQM implementation for firms with different strategic orientation. *International journal of Quality & reliability Management* [online] 34: 9 [9.5.2019], 1531, 1533-1538. 1546. Available from World Wide Web: URL <https://www-emeraldinsight-com.proxy.uwasa.fi /doi/pdfplus/10.1108/IJQRM-09-2016-0157>.

Kurtz, L. (2012). Stakeholder Analysis. In: *Socially Responsible Finance and Investing: Financial Institutions, Corporations, Investors, and Activists* [online], 17-37. Eds. Baker, H. & Nofsinger, J. Hoboken, New Jersey: Wiley [13.6.2019]. ISBN 978-1-118-23071-4. Available from World Wide Web: URL <https:/ /ebookcentral-proquest-com.proxy.uwasa.fi/lib/tritonia-ebooks /reader.action?docID=918159>.

Kutlu, A. & Kadaifci, C. (2014). Analyzing critical success factors of total quality management by using fuzzy cognitive mapping. *Journal of Enterprise Information Management* [online] 27: 5 [4.2.2019], 561. Available from World Wide Web: URL <https://www-emeraldinsight-com.proxy.uwasa.fi /doi/pdfplus/10.1108/JEIM-06-2012-0032>.

Kuvaja, Atte (2013). *SAP-koulutusten suunnittelu*. Vaasan ammattikorkeakoulu. Tietojenkäsittelyn koulutusohjelma. Opinnäytetyö.

Kwak, Y. H. & Anbari, F. T. (2006). Benefits, obstacles, and future of six sigma approach. *Technovation* [online] 15: 1 [13.3.2019], 708-709. Available from World Wide Web: URL <https://ac.els-cdn.com/S0166497204001828 /1-s2.0-S0166497204001828-main.pdf?_tid=583a3703-f259-4b6a-a7b9-2542cec211e3&acdnat=1552482716_ab1134b90312e1932548a3a9c9208456>.

Lahidji, B. & Tucker, W. (2016). Continuous quality improvement as a central tenet of TQM: History and current status. *Quality Innovation Prosperity* [online] 20: 2 [20.3.2019] 164. Available from World Wide Web: URL <https://search.proquest.com/docview/1962334086?pq-origsite=gscholar>.

Liker, J. & Franz, J. (2011). The Toyota way to continuous improvement: linking strategy and operational excellence to achieve superior performance. New York: Mcgraw-Hill, 2011. ISBN 978-0-07-147746-8.

Malik, T.M., Khalid, R., Zulqarnain, A. & Syed, A. I. (2016). Cost of quality: findings of a wood products' manufacturer. *The TQM Journal* [online] 28: 1 [11.3.2019], 2-4. Available from World Wide Web: URL <https://www.emeraldinsight.com/doi/pdfplus/10.1108/TQM-01-2014-0014>.

Marinov, M. & Iwao, Shumpei. (2018). Linking continuous improvement to manufacturing performance. *Benchmarking: An International Journal* [Online] 25: 5 [12.3.2019], 1319. Available from World Wide Web: URL <https://www.emeraldinsight.com/doi/abs/10.1108/BIJ-06-2015-0061>.

Melton, T. (2005). The benefits of lean manufacturing: What lean thinking has to offer the process industries. *Chemical engineering research and design* [online] 83: 6 [13.3.2019], 662, 664-667. Available from World Wide Web: URL <https://ac.els-cdn.com/S0263876205727465/1-s2.0-S0263876205727465-main.pdf?_tid=aab3be20-ceb6-4d6e-b6db-542cdd83154a&acdnat=1552476590_e02017af060976d39ed80fda3cc7bbe8>.

Motschman, T. & Moore, S. (1999). Corrective and preventive action. *Transfusion Science* [online] 21: 2 [5.6.2019], 163-164, 171. Available from World Wide Web: URL <https://www-sciencedirect-com.proxy.uwasa.fi/search/advanced?docId=10.1016/S0955-3886(99)00088-0>.

Oakland, John S. (2014). *Total Quality Management and Operational Excellence.* 4th edition. London: Routledge, 2014. ISBN 978-1-315-81572-5.

Rahman, A., Shaju, S. & Sarkar, S. (2018). Applicaiton of six sigma using define measure analyse improve control (DMAIC) methodology in garment sector. *Independent journal of management & production* [online] 9: 3 [17.6.2019], 812. Available from World Wide Web: URL <https://search-proquest-com.proxy.uwasa.fi/docview/2125641233/fulltextPDF/A70AE6C9FAF1498EPQ/1?accountid=14797>.

SAP (2019). ERP stands for Enterprise Resource Planning [online] [21.1.2019]. Available from World Wide Web: URL <https://www.sap.com/products/what-is-erp.html>.

Saraph, J., Benson, P. & Schroeder, R. (1989). An Instrument for Measuring the Critical Factors of Quality Management. *Decision Sciences* [online] 20: 4 [19.3.2019], 811, 818. Available from World Wide Web: URL <https://search.proquest.com /docview/198049626?accountid=14797>.

Shankar, R. (2009). Process improvement using six sigma – A dmaic guide [online]. Milwaukee: American society for quality, quality press [6.6.2019]. Available from World Wide Web: URL <https://ebookcentral-proquest-com.proxy.uwasa.fi /lib/tritonia-ebooks/reader.action?docID=3002635>.

Sila, I. & Ebrahimpour, M. (2003). Examination and comparison of the critical factors of total quality management (TQM) across countries. *International journal of Production Research* [online] 41: 2 [19.3.2019], 237-238, 244, 258-259. Available from World Wide Web: URL <http://web.b.ebscohost.com.proxy.uwasa.fi/ehost /pdfviewer/pdfviewer?vid=1&sid=589aaec8-077a-427e-a36c-6fb1beb29538%40sessionmgr101>.

Sower, V. & Fair, F. (2012). Insightful Quality: Beyond Continuous Improvement [online]. Business Expert Press, 2012 [18.2.2019]. Available from World Wide Web: URL <https://ebookcentral-proquest-com.proxy.uwasa.fi/lib /tritonia-ebooks/reader.action?docID=922364>.

Stanciu, I. & Pascu, E. (2014). Quality Costs. *Knowledge Horizons. Economics* [online] 6: 4 [28.2.2019], 39. Available from World Wide Web: URL <https://search.proquest.com/docview/1669895942/fulltextPDF /BC8322EB189243F9PQ/1?accountid=14797>.

Stansfield, T. & Longenecker, C. (2006). The effects of goal setting and feedback on manufacturing productivity: a field experiment. *International journal of productivity and performance management* [online] 55: ¾ [29.5.2019], 346-347, 356-357. Available from World Wide Web: URL <https:/ /www-emeraldinsight-com.proxy.uwasa.fi/doi/pdfplus/10.1108 /17410400610653273>.

Suárez-Barraza, M., Ramis-Pujol, J. & Estrada-Robles, M. (2012). Applying Gemba-Kaizen in a multinational food company: a process innovation framework. *International Journal of Quality and Service Sciences* [online] 4: 1 [20.3.2019] 29, 46. Available from World Wide Web: URL <https://www-emeraldinsight-com.proxy.uwasa.fi/doi/pdfplus/10.1108/17566691211219715>.

Tamimi, N. & Gershon, M. (1995). Tool for assessing industry TQM practice versus the deming philosophy. *Production and Inventory Management Journal* [online] 36: 1 [19.3.2019], 28-29. Available from World Wide Web: URL <https://search.proquest.com/docview/199916676 /fulltextPDF/446330E6DDB540B2PQ/2?accountid=14797>.

Van Volsem, S.; Dullaert, W. & Van Landeghem, H. (2007). An evolutionary algorithm and discrete event simulation for optimizing inspection strategies for multi-stage processes. *European journal of operational research* [online] 179: 3 [14.2.2019], 621-622. Available from World Wide Web: URL <https:/ /www-sciencedirect-com.proxy.uwasa.fi/science/article/pii /S0377221705007265>.

Zhong, K., Li, Z., Zhou, X., Li, Y., Shi, Y. & Wang, C. (2014). Enhanced phase measurement profilometry for industrial 3D inspection automation. *The international journal of advanced manufacturing technology* [online] 76: 9-12 [17.6.2019], 1563. Available from World Wide Web: URL <http://web.b.ebscohost.com.proxy.uwasa.fi/ehost/pdfviewer /pdfviewer?vid=1&sid=d00db260-e0ea-4154-ab87-ef87bcd18ece%40sessionmgr102>.

Appendix 1. Internal interview for defining the feedback process.

Role and quality policy and quality team
Työnkuva ja laatupolitiikka sekä tiimi

1. Shortly describe your background in ABB and current role in the company?
   Kerro lyhyesti taustastasi ABB:llä ja tämän hetkisestä roolistasi?
2. What roles are involved in the quality team?
   Millaisista rooleista laatutiimi koostuu?
3. What kind of quality policy is being followed and with what kind of tools? (Shortly)
   Millaista laatupolitiikkaa noudatetaan ja millä menetelmillä? (Lyhyesti)

Final inspection process
Lopputarkastusprosessi

4. What products are inspected?
   Mitä tuotteita lopputarkastetaan?
5. When has the final product inspection process initiated?
   Koska lopputarkastusprosessit on otettu käyttöön?
6. Why they are done?
   Miksi lopputarkastuksia alettiin tekemään?
7. What steps does the process include?
   Mitä vaiheita lopputarkastusprosessi pitää sisällään?
8. How many inspectors are executing these steps?
   Montako tarkastajaa suorittaa nämä vaiheet?
9. What measurements are used in the final product inspections?
   Mitä mittaristoja lopputarkastusprosessissa käytetään?
10. What supportive functions are utilized in the final product inspections? (IT, communication, etc.?)
    Mitä tukifunktioita lopputarkastusprosessiin liittyy? (IT, viestintä, yms.?)

Utilization of information and communication
Tiedon hyödyntäminen ja kommunikointi

11. What kind of feedback is received from the final product inspections?
    Millaista palautetta lopputarkastuksista saadaan?
12. What are the most important goals in the final product inspections and how their fulfillment is being followed?
    Mitkä ovat palauteprosessin tärkeimmät tavoitteet ja miten niiden saavuttamista mitataan?
13. Has the feedback been effective? (Is there continuous improvement in the quality)
    Onko palaute ollut toimivaa? (Onko jatkuvaa parantumista laadussa)
14. What kind of documentation is done from this data?
    Millaista dokumentaatioita näistä tiedoista tehdään?
15. How is the communication of the data executed?
    Miten tiedon kommunikointi toteutetaan?
16. How is the information received from the final production process utilized in practice? (An example)
    Miten lopputarkastuksista saatavaa tietoa hyödynnetään käytännössä? (Esimerkki)
17. Is there a clear bottleneck step in the feedback process and if there is, what is it?
    Onko palauteprosessissa selkeää pullonkaula-vaihetta ja jos on, niin mikä?

Appendix 2. Questionnaire for the employees regarding the feedback process.

Päivämäärä 24.4.2019
Tuotantolinjasi:

Tehtävänimikkeesi:

Lopputarkastusten palauteprosessin toimivuuden kartoituksen kyselylomake. Kysely toteutetaan osana tuotteiden palauteprosessiin liittyvää opinnäytetyötä. Ympyröi vastauksesi asteikolla 1-5 oman kokemuksesi mukaan. Numerot tarkoittavat seuraavaa: 1=Täysin eri mieltä, 2=Hieman eri mieltä, 3=Ei mielipidettä/En tiedä, 4=Hieman samaa mieltä, 5=Täysin samaa mieltä. Kysymyksiin 2 ja 5, ympyröi vastauksesi asteikolla 1-4.

1. Lopputarkastuksista saatava palaute on mielestäni tärkeää.

1	**2**	**3**	**4**	**5**

2. Kuinka monta kertaa kuukaudessa kuulet lopputarkastusten löydöksistä?

1 = En kertaakaan.	**2 = Kuukausittain**	**3 = viikoittain.**	**4 = Päivittäin.**

3. Lopputarkastuksista saatava palaute on selkeää ja ymmärrettävää.

1	**2**	**3**	**4**	**5**

4. Käyn viikoittain katsomassa laatutauluilta löytyvät palautetiedot.

1	**2**	**3**	**4**	**5**

5. Minua tiedotetaan lopputarkastusten löydöksistä

1 = Harvemmin kuin kuukausittain.	**2 = Kuukausittain.**	**3 = Viikoittain.**	**4 = Päivittäin.**

6. Olen tyytyväinen tämän hetkiseen palauteprosessin toimivuuteen.

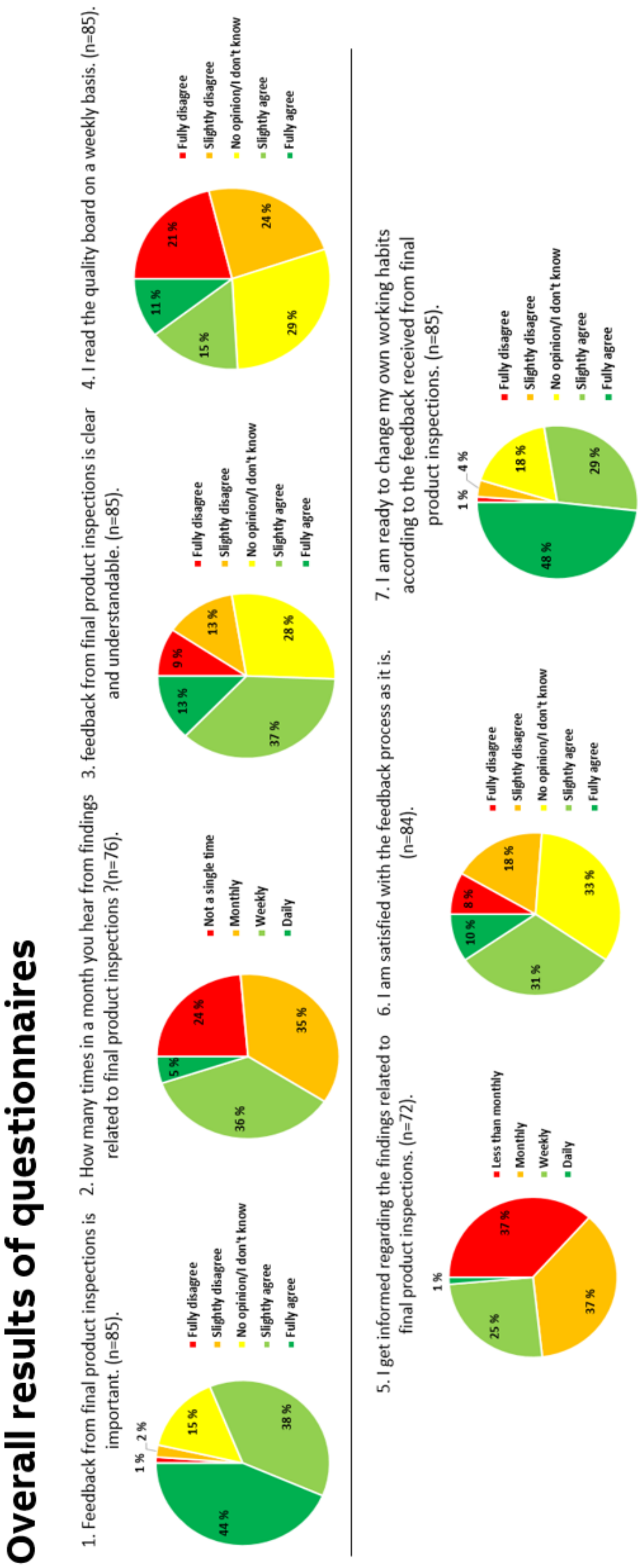
1	**2**	**3**	**4**	**5**

7. Olen valmis muuttamaan omia toimintatapojani lopputarkastusten palautteen perusteella.

1	**2**	**3**	**4**	**5**

Kiitos vastauksistasi!

Appendix 3. Overall Results of questionnaire (n=85).



Appendix 4. Semi-structured theme interview.

Lopputarkastusten palauteprosessin toimivuuden teemahaastattelu. *(Theme interview of effectiveness of feedback process.)*

Vastauksiin toivotaan perusteluja. *(Reasoning is hoped for the answers.)*

Teemat *(Themes)*:

- Kuinka tärkeänä pidät lopputarkastuksista saatavaa palautetta? *(How important do you consider the feedback received from final product inspections?)*

1. Prosessi *(Process)*

- Miten palauteprosessi toimii alusta loppuun? *(How does the feedback loop function from the beginning to the end?)*
- Millainen on oma roolisi palauteprosessissa? *(What is your role in the feedback loop?)*
- Miten tyytyväinen olet palauteprosessiin tällä hetkellä? *(How satisfied are you with the feedback process currently?)*
- Onko palauteprosessi ollut mielestäsi toimiva? *(Has the feedback been effective?)*
- Muutetaanko prosesseja palautteen perusteella? Miten itse edesautat kehitystä palautteen perusteella? *(Have processes been changed because of the feedback data? How do you contribute to the development of feedback?)*
- Miten kehittäisit palauteprosessia? *(How would you develop the feedback process?)*

2. Kommunikaatio *(Communication)*

- Onko kommunikaatiota palauteprosessista tällä hetkellä riittävästi? Onko kommunikaatio menossa parempaan vai huonompaan suuntaan? *(Is there currently enough communication in the feedback process? Is the communication going better or worse?)*
- Saatko omasta mielestäsi riittävästi tietoa lopputarkastuksista saatavasta palautteesta? Voisitko saada enemmän? *(Do you think you receive enough information regarding the feedback from final product inspections? Could you receive more?)*
- Kenelle viet tietoa eteenpäin? Missä muodossa? Miten tiedot otetaan yleensä vastaan? *(To whom do you deliver the information? In what form? How the information is received?)*
- Miten kommunikaatio toimii toiseen suuntaan, eli saatko tietoa, millaista palautetta haluttaisiin saada? Herättääkö saatu palaute keskustelua eri sidosryhmien välillä? Jos, niin millaista? *(How does the communication work in reverse direction, do you get information of what kind of feedback is wanted? Does the feedback initiate discussion among the stakeholders? if so, what kind of?)*

3. Dokumentaatio *(Documentation)*

- Onko dokumentaatio palautteista mielestäsi riittävää? *(Do you consider, that there is enough documentation received from the feedback?)*
- Kuinka ymmärrettävää palautteiden dokumentaatio mielestäsi on? *(How understandable you consider the documentation of the feedback?)*

4. Henkilöstö *(Personnel)*

- Miten olet sitoutunut palauteprosessin kehittämiseen? *(How are you dedicated to the development of the feedback process?)*
- Miten tehtaalla on muutettu toimintatapoja lopputarkastuksesta saadun palautteen perusteella? Koetko, että sinulla on riittävästi mahdollisuuksia sitoutua muutoksen jalkauttamiseen? *(How*

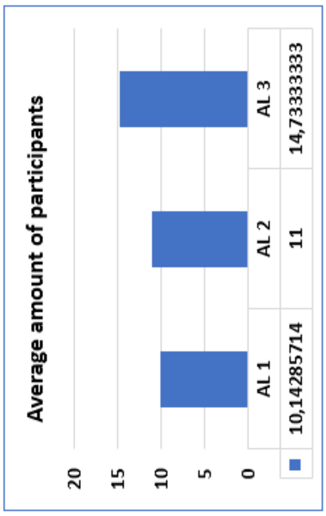
the working habits have been changed in the factory according to the received feedback? Do you consider, that you have enough chances to influence the implementation of the changes?)

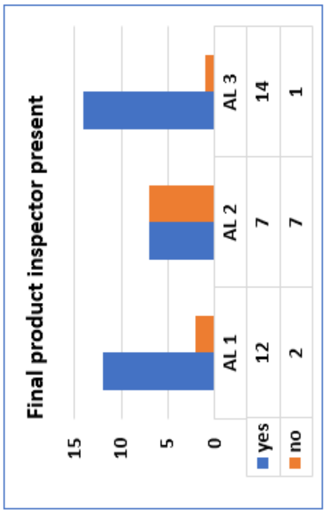
- Koetko, että palauteprosessiin satsataan tarpeeksi resursseja? *(Do you consider, that there are enough resources allocated to the feedback process?)*

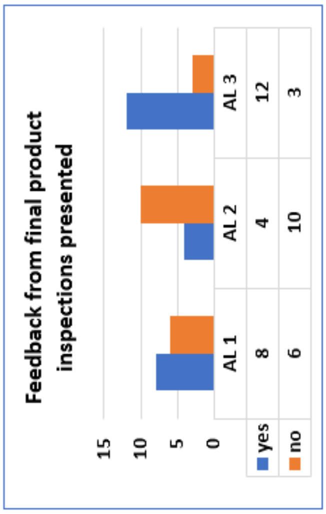
Appendix 5. Observation form.

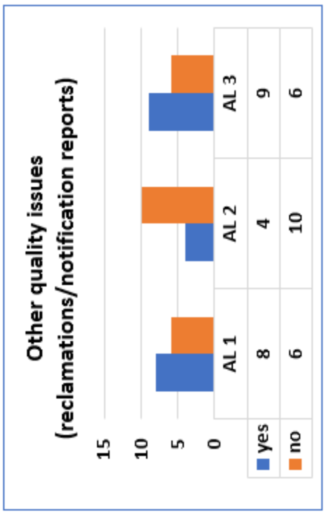
Date	Factory Building	AL	Amount of Participants	Final product inspector present	Feedback from final product inspections presented	Other quality issues such as reclamation(s) or notification reports	Recent quality issues status checked yes/no
8.5.	MM	AL 1	10	yes	yes	no	no
8.5.	MM	AL 2	13	yes	yes	no	no
8.5.	KK	AL 3	13	yes	yes	yes	no
9.5.	MM	AL 1	9	yes	yes	yes	no
9.5.	MM	AL 2	13	no	no	no	no
9.5.	KK	AL 3	14	yes	yes	yes	no
10.5.	MM	AL 1	9	yes	yes	no	no
10.5.	MM	AL 2	11	yes	yes	yes	no
10.5.	KK	AL 3	14	no	no	yes	no
13.5.	MM	AL 1	11	yes	yes	no	no
13.5.	MM	AL 2	12	no	no	no	no
13.5.	KK	AL 3	16	yes	yes	no	no
14.5.	MM	AL 1	10	yes	yes	yes	no
14.5.	MM	AL 2	14	no	no	yes	no
14.5.	KK	AL 3	16	yes	yes	yes	no
15.5.	KK	AL 3	16	yes	yes	no	no
16.5.	MM	AL 1	10	yes	yes	yes	no
16.5.	MM	AL 2	11	yes	yes	yes	no
16.5.	KK	AL 3	15	yes	yes	yes	no
17.5.	MM	AL 1	9	yes	yes	no	no
17.5.	MM	AL 2	11	yes	no	no	no
17.5.	KK	AL 3	18	yes	yes	no	yes
22.5.	MM	AL 1	11	yes	no	yes	no
22.5.	MM	AL 2	11	yes	yes	yes	no
22.5.	KK	Al 3	15	yes	no	yes	no
23.5.	MM	AL 1	10	yes	yes	no	no
23.5.	MM	AL 2	7	no	no	no	no
23.5.	KK	AL 3	13	yes	yes	no	no
24.5.	MM	AL 1	10	yes	no	yes	no
24.5.	MM	AL 2	8	yes	no	no	no
24.5.	KK	AL 3	16	yes	yes	yes	no
27.5.	MM	AL 1	19	no	no	yes	no
27.5.	MM	AL 2	13	no	no	no	no
27.5.	KK	AL 3	14	yes	no	yes	no
28.5.	MM	AL 1	8	no	no	yes	no
28.5.	MM	AL 2	11	no	no	no	no
28.5.	KK	AL 3	17	yes	yes	no	yes
29.5.	MM	AL 1	7	yes	no	no	no
29.5.	MM	AL 2	10	yes	no	no	no
29.5.	KK	AL 3	13	yes	yes	no	no
31.5.	MM	AL 1	9	yes	no	yes	no
31.5.	MM	AL 2	9	no	no	no	no
31.5.	KK	AL 3	11	yes	yes	yes	no

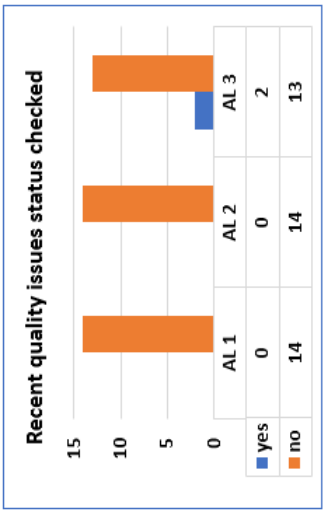
Appendix 6. Results of observation data.



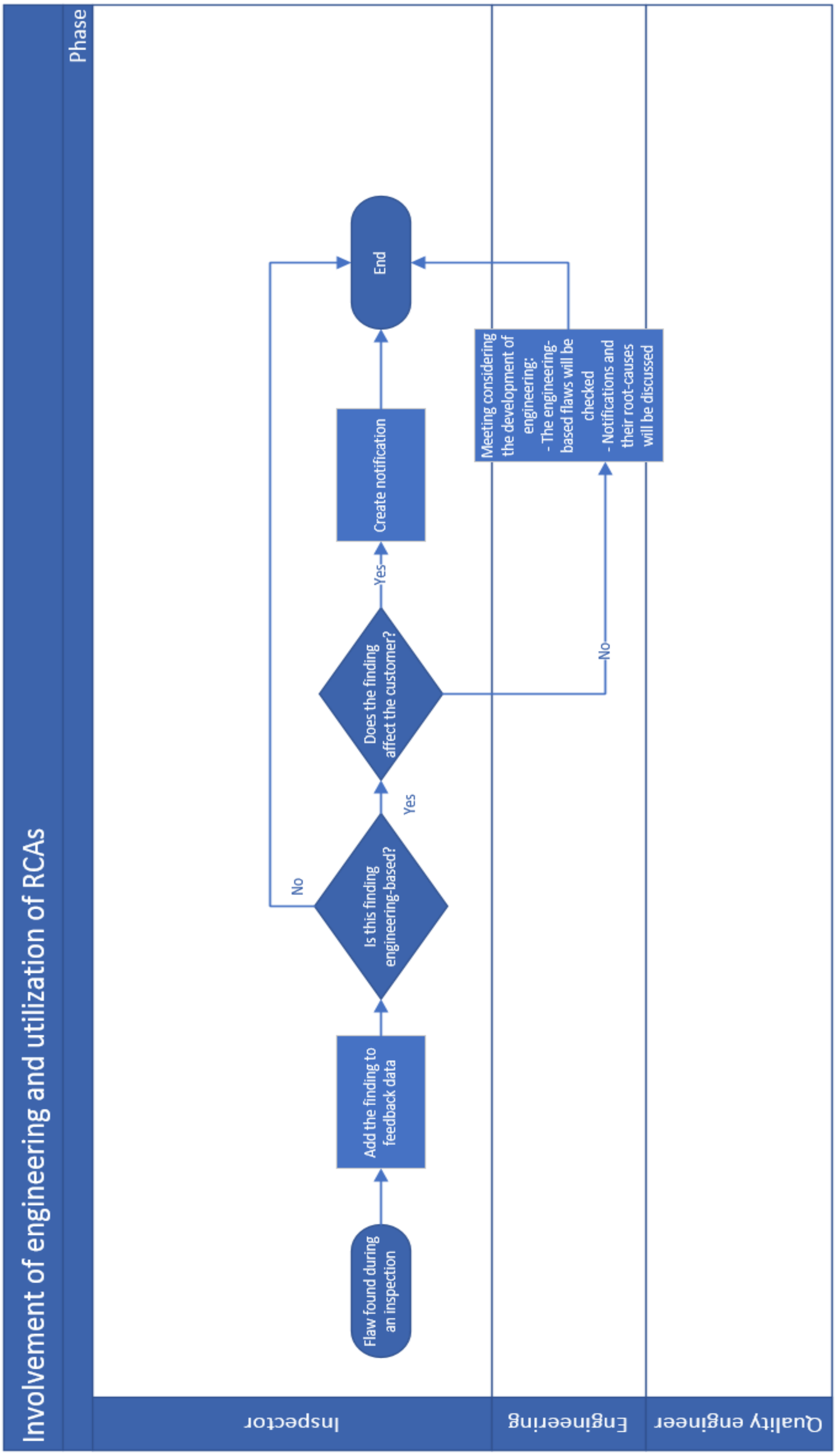




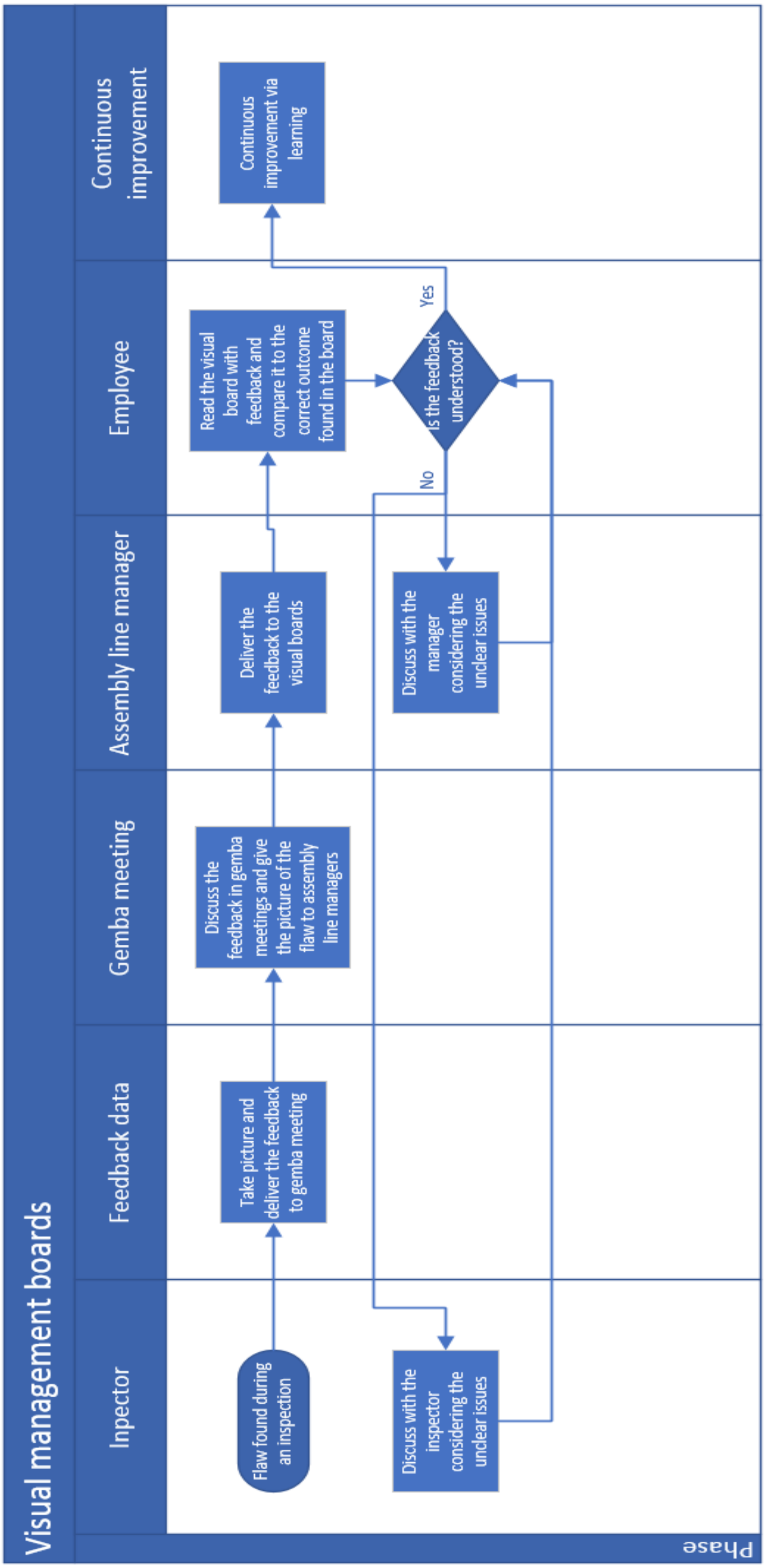




Appendix 7. Process map for involvement of engineering and utilization of RCAs (ABB 2019l).



Appendix 8. A process map for visual management boards.



Appendix 9. A process map for follow-up.