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Cost of Poor Quality

A Model to Visualize Costs of Poor Quality in a Producing Company

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Abstract

Cost of Poor Quality is the cost of producing poor quality products in a company. When keeping track of Poor Quality costs, where and why they appear, a company can easier reduce them. The company gets information about where and for what products quality needs to be improved and can decide according to that what investments and improvement projects that should be prioritized.

By combining information from the literature study, interviews, and secondary data a model with relevant quality cost parameters was made. The model was then reviewed with employees on every department involved in the data collection for the model. The model was then developed according to their knowledge about the daily work to get information for the model with as little increased workload as possible.

The aim with this thesis was to make a model that visually shows the costs of poor quality, where and why they appear. The information for the model isn't currently easily available, by making suggestions on new ways of reporting quality failures it is possible to get information about poor quality costs directly from the ERP system.

The model has been tested and implemented in some departments in the company. The new ways of working to get the needed data for the model has been implemented but it will still take a couple of months before we have accurate and comparable data. To give easy access of information to everyone within the company the data will be presented as a dashboard in the company's dashboard portal.

Language: English
Key Words: Cost of Poor Quality, Quality cost tool, Quality management

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1 Introduction

Keeping track of the quality costs in a company is an important part of a company's operations. At the market today with high production costs customers expect that the quality is good. With a Cost of Poor quality model it's easier to keep a good quality standard and have better presumption on how to keep the costs down.

Total cost of quality consists of cost of good quality and cost of poor quality. Cost of poor quality is what a company spends on making and shipping out goods of poor quality. Cost of good quality on the other hand is what is spent on actions to prevent that poor quality products are produced and shipped out.

When a company grows bigger it is more feasible to increase the profit by cutting costs than increasing sales. In a sustainability perspective it is also better to make less waste. The costs of poor quality can also be used as a KPI, Key Performance Indicator, that shows how the company is doing regarding the quality costs.

1.1 Background

Currently most of the company's non-quality costs are unknown. They want to have a model to calculate the costs of poor quality. This will make them more aware of where the quality failures and costs appear and gives them a picture of what processes needs improvement and where to start.

The quality issues that the company has needs to be presented in a visual way to the management team and the shareholders. This should create a bigger understanding for the problems and their existence and the gravity of them and what impact they have on the company's results.

1.2 Purpose

The Purpose of this master's thesis is to make a model that shows the costs of poor quality in the company. And to present data visually to make the costs more visible to everyone and increase the awareness of how much money is spent on poor quality products. The model can be used as a KPI for quality, if the costs go down, you can see that the process improvements you are doing are resulting in

something. The model will also provide data that can be used for decision making regarding investments that will improve the quality.

1.3 Method

I will do a literature study where theories needed for the project is presented. The company's process maps will be studied and a model for how to calculate poor quality costs will be made in excel. The data in the model will consist of both primary and secondary data. Primary data is data that is collected for this purpose and secondary data is data collected to be used for another purpose in the first place but can be used for this purpose as well.

1.4 Delimitations

In this thesis I will focus on the costs of poor quality that appears in the production and customer complaints. A major part of poor-quality costs is quantitatively measurable since it mostly consists of rejected products and components. To calculate the cost of good quality, that consists of preventive and appraisal costs, a lot of values for the model would have to be estimated, if the estimations are wrong it will give a wrong picture of the current state.

1.5 Disposition

The second chapter will tell you more about the company where the Thesis assignment is made. In the third chapter the theory relevant for the case is presented. The current state and how things work today is presented in the fourth chapter. The fifth chapter gives proposals of how to change the ways of working to get the needed data for the model. In the sixth chapter the functionality of the model is reviewed.

2 Company presentation

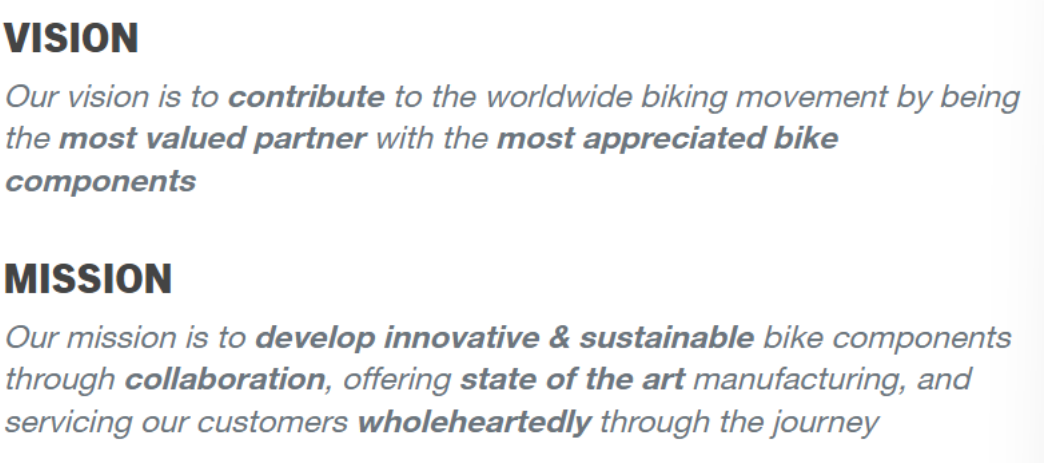
According to Herrmans website they are one of the leading pioneers when it comes to developing solutions for the bicycle industry. The company was founded in **1954** and have over 60 years of experience in plastics technology and design of bicycle components. One of the company's most important values is to support the customers when it comes to improve the comfort, safety, design and experience of their bicycles. The expertise in the company helps them meet the customers needs regarding special solutions and exclusive products, which are appreciated by the end users - cyclists all over the world.

Herrmans Bike Components Ltd is based in Finland, Sandsund, and designs and manufactures grips, lights, chain guards, reflectors and rim tapes mainly for the bicycle industry, several of the products is also used in rehab and industrial applications. They also have an office in Germany and a Branch in Taiwan with a sales team and a warehouse with a small-scale assembly production of lights.

Picture 2.1 Bike with parts produced at Herrmans Bike Components, (Herrmans product catalog 2023)

The goal is to be a one-stop-shop, that the customers can get all the components needed for the bike from one place. All products are developed at their own R&D department in Finland, sometimes as customer projects together with the customer. The production is mainly based in Finland, except for Asian customers who orders

from the Taiwan warehouse where they have a small-scale assembly, adding brackets and adapters to lights.



Picture 2.2 Herrmans Bike Components Ltd's mission and vision (Herrmans, 2023)

When checking Kauppalehti, (Kauppalehti, 2023) Herrmans Bike Components Ltd had a turnover of 31,2 million euro in 2021, 10,2 million euro more than the year before, the operating profit was 5 million euro, 3 million more than the previous year. In 2022 they had 118 employees in 2021 there where 97 employees. The company has experienced a big growth the past years. Most likely due to a cycling boom, more and more people are starting to use bikes instead of cars and public transport. Some reasons to this might be environmental awareness, that many cities are investing in bike lanes to promote biking to get less cars in the cities, corona also had an impact when people avoided crowds and public transport.

3 Theory

The theory that is relevant for the study is presented in this chapter. I will go through what quality is and how it's measured. What a quality cost system is, how to create and implement it and how to improve quality in a company. Management Dashboards, visual presentation of data is also presented.

3.1 What is quality and quality costs

When a customer is about to buy something, they are deciding about what product to buy, supplier, brand, style, price etc. affects the customers decision. It is the decision made by the customers that determines the quality. The ground pillar of quality is the needs, wants and expectations of the customers. (Bob Foley and Joe Johnson, page 3)

Bob Foley and Joe Johnson states that the official definition from ISO 9000:2000 Quality Management Systems: Fundamentals and Vocabulary is:

"Quality is the degree to which a set of characteristics fulfils requirements."

A way to summarize this is to say that:

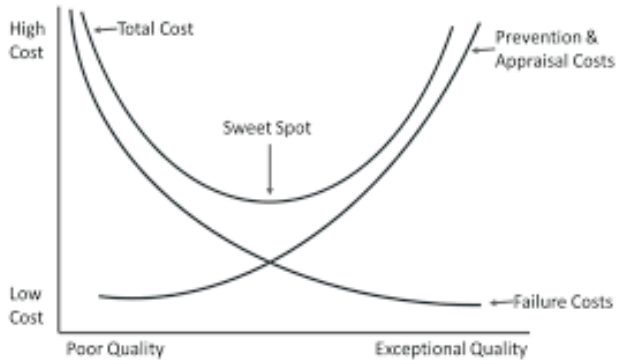
"Quality is fitness for purpose"

The economics of quality, does quality have an economical value? According to Douglas C. Wood there are those who believe that it is never economical to ignore quality and those who believe that it is uneconomical to deliver 100% quality. The optimal level of quality is achieved when both extremes compromises and meet at the middle. (Douglas C. Wood, page 3)

The total quality cost is the cost for delivering good quality products and consists of costs of good quality and costs of poor quality.

Douglas C. Wood states that cost of good quality is the costs for preventing that bad quality products are made and consists of prevention and appraisal costs. Cost of poor quality is the cost of products of bad quality and consists of internal and external failure costs. The optimal level for the total cost is where prevention and appraisal costs and failure costs crosses, there should be a balance between them (picture 3.1). It is okay to increase the prevention and appraisal costs if the total

costs go down. After a certain point the total quality cost will not decrease anymore even if you increase the prevention and appraisal costs. (Douglas C. Wood, page 3)



Picture 3.1 The relationship between different types of costs. (SSDSI)

The cost of quality includes more than just the quality department, it includes all actions in the company that influences the quality. The models and techniques are tools used by management to make decisions regarding improvements, investments and making profit. (Barrie G, Dale, David Bamford & Ton van der Wiele, page 119)

According to Barrie G and others quality costs arise from a large range of activities, such as; sales and marketing, design, research and development, purchasing, storage, handling, production, delivery, all of these contributes to the total quality cost. There is also other players that might have an influence on the quality cost, suppliers, sub-contractors distributors, agents, dealers and especially customers. (Barrie G, Dale, David Bamford & Ton van der Wiele, page 119)

A company's quality costs often range from 5 to 25 % of it's yearly sales turnover. Up to 95 % of this this cost is spent on appraisal and failure costs. When reducing failure costs by eliminating the causes to the failure it may also reduce the appraisal costs, this may reduce the quality costs to one-third of the current costs. This can only be done if using a cost-effective quality management system. (Barrie G, Dale, David Bamford & Ton van der Wiele, page 119)

3.2 Categorizing Quality Costs

Without clear definitions and categorizations of the quality costs it's hard to achieve a common understanding or meaningful communication about the topic. According

to Barrie G, Dale, David Bamford & Ton van der Wiele there are many grey areas in categorizing quality costs, where production and operation procedures overlap in quality related activities, these activities can be hard to categorize. It's important to remember that in order to get consistent data the different cost elements has to stay in the same category, otherwise the data will not be comparable.

Douglas C. Wood states that the most common way of categorizing quality costs is according to the Prevention-Appraisal-Failure (PAF) Model.

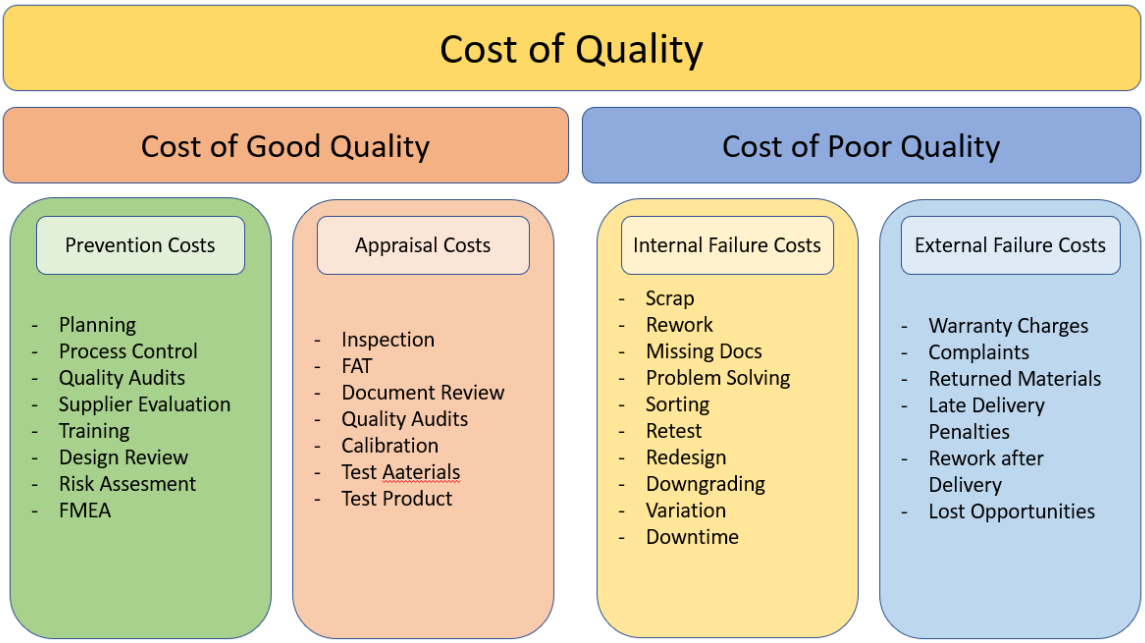
Prevention Costs – Costs of all activities to prevent poor quality in products or services, for example new product review, quality planning, supplier reviews, quality improvement projects, etc.

Appraisal **Costs** – Costs associated with measuring, evaluating and auditing products, services or processes to assure good quality.

Failure Costs – Costs resulting from products or services of non-conformity. Failure costs are divided into two separate categories, Internal and External failure costs.

> **Internal Failure costs** – Consists of failures that are discovered prior to delivery, includes costs of scrap, rework, re-testing, sorting, etc.
>
> **External Failure costs** – Consists of failure costs that are discovered after delivery, includes costs of handling customer complaints, replacement costs, freight costs, etc.

The sum of all the costs above ad up to the Total Quality Cost.



Picture 3.2 Categorization of quality costs (Pinterest)

The prospects for success of a quality cost system will depend on how well the system matches and integrates with other systems in the company, Barrie G and others. It is important to categorize the quality costs, so they relate to other business costs and are easy for people to work with. No matter how you decide to categorize the costs you have to define what costs are quality related and what isn't. (Barrie G, Dale, David Bamford & Ton van der Wiele, page 120)

3.3 Hidden quality costs

Often the real cost of quality is hidden in the total operating cost of the company. According to Douglas C. Wood the main reason for this is that most accounting systems are not designed to identify the quality costs, if you can't get the data automatically from the system it is easier to include the quality costs in the total operating cost. It's easy to collect only a small portion of the costs and think that these represent the total, so isn't the case. A lot of costs can be very well hidden, there are as many ways to hide costs as there are employees with imagination. When inefficiencies are hidden it gives an illusion of effective management. The cost of inefficiencies is mostly hidden in the cost of doing business. It is possible that the hidden costs raises to a level that affects the company's competitive position, therefore it is important to define these costs. Hidden quality costs can be referred to as a "hidden factory" since they represent costs and resources devoted to

production that is invisible to the management and the customer. The “hidden factory” also reduces the company’s capacity and limits it’s ability to respond to customer needs. (Douglas C. Wood, page 5-7)

A teamwork approach is needed when setting up a cost collection procedure that reveals the hidden quality costs. Quality and accounting are the main departments that must work together and analyze existing processes and construct a new user friendly procedure on how to collect accurate and relevant data from both the accounting system and the ERP system. (Mihaela Kelemen, page 87)

Picture 3.3 The true failure costs consist of the following; 90 % of the costs are hidden. (Douglas C. Wood, page 7)

3.4 Quality cost system

A quality cost model is a cost model that is very useful in quality management. The model has a level of detail that most costing models doesn’t have, this can help the organization identify specific areas where costs occur due to poor quality. In many cost systems most of the quality costs are buried within variance and overhead accounts, without a proper quality cost model the costs due to poor quality is often underestimated. (Victor E. Sower & Christopher H. Sower, page 8)

A quality cost system is a system that defines a company’s quality costs. According to Douglas C. Wood a quality cost system can warn against a quality related financial situation so it’s possible to do corrective actions before it’s too late. A quality cost system also enhances a company’s ability to manage quality in all aspects of the company’s operations, this is important to keep ahead of the price and quality competition on the market. (Douglas C. Wood, page 8-10)

Internal cost models are often made to understand the cost structures in the organization. These internal models can have many uses, for example, efficiency improvement, production, and capacity planning or as a part of the quality management system. Internal cost modelling is a way to assure that complete and accurate cost information is available in the organization. (Victor E. Sower & Christopher H. Sower, page 27)

The later in the production chain you find a defect the more expensive it is. If the company finds the defect through inspections and checks the cost will be less than if the customer finds a defect. Defects and their resulting costs can be minimized if the company's quality program is geared towards defect prevention and continuous quality improvements. Process improvements and preventive actions are e subject to cost effectiveness. New technology makes it possible to eliminate the human error in different stages in the production, quality inspections and testing can be done by robots. (Douglas C. Wood, page 8-10)

The main rule is that more spending on prevention and appraisal costs results in decreased spending on failure costs, the usual finding is that the costs correspond on a 8-to-1 ratio, that is a good return on investment. (Douglas C. Wood, page 8-10)

The goal of a quality cost system is to facilitate quality improvements that leads to cost reductions. The strategy is to 1. Attack the failure costs in an attempt to eliminate them 2. Invest in prevention activities to prevent that the same failure happens again 3. Reduce appraisal costs according to the results 4. Continuously evaluate and improve the prevention activities to gain further improvements. (Douglas C. Wood, page 8-10)

Remember that for each failure there is a root cause, causes are preventable and prevention is always cheaper than failure.

The real quality costs can be measured and reduced by a proper analysis of the cause and effect. When failures are revealed through appraisal actions or customer complaints the root causes are defined and eliminated through corrective actions, elimination of a root cause means permanent removal of the failure. It is good to remember that the further in the operating process a failure is found the more expensive it is to correct. (Douglas C. Wood, page 8-10)

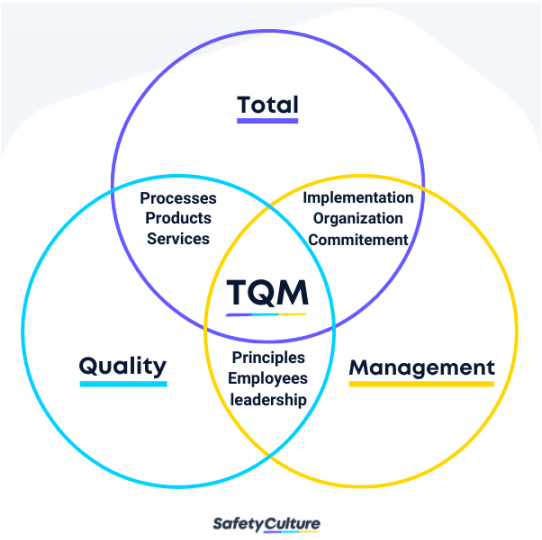
3.7 Quality management

Quality is an integrated part of the whole and all the parts of a product and cannot be added afterwards. This means that quality must be built in through every stage and process and be an essential element within every component. The conclusion is that quality must be total and have to involve every person and activity in the production chain, the main term used for this is Total Quality Management (TQM).'

"Total Quality Management Involves every member of the organization in a process of continuous improvement with the aim of satisfying the customers' wants and expectations"

(Bob Foley and Joe Johnson, page 9)

In today's competitive market the customers demands are increasing, higher quality at a lower cost. For this reason many companies are looking for quality management and process improvements to survive on the market. Quality is often defined as the reliability of products or services and is no longer seen as a benefit on the market, it's considered a given requirement by the customers. Quality management system have evolved rapidly in recent years, simple inspection procedures have been replaced with quality control, quality assurance have been developed further and many companies have a process for continuous improvement. Together inspection, quality control and quality assurance are used towards Total Quality Management. (Barrie G, Dale, David Bamford & Ton van der Wiele, page 23-24)



Picture 3.4 Total Quality Management. (Safety Culture)

According to Barrie G and others there is 4 steps that are needed to be implemented to accomplish Total Quality Management.

Inspection; Earlier inspection was seen as the only way of ensuring quality. In a simple inspection based system a product, service or activity is checked against certain given characteristics to detect and assess non-conformities. In a producing company the system is applied to incoming goods and manufactured products before the goods are passed into the warehouse. (Barrie G, Dale, David Bamford & Ton van der Wiele, page 35-36)

Quality control; Since quality control systems have evolved from simple inspection there are some parts that are common. But in a system of quality control you can find more detailed product and performance specifications, a procedure and process control system and reporting activities. A quality control system leads to greater process control and a lower rate of non-conformance. Quality control is a detection-based system, it has a reactive approach. It is about getting rid of the bad products after they are found. There is no planning for improvements, you are just making sure the products aren't delivered to the customers. This way of working has a big affect on the costs since the defects are found late in the process. (Barrie G, Dale, David Bamford & Ton van der Wiele, page 36-38)

Quality assurance; The third step of management development is Quality assurance. Only if the organizational efforts are directed at planning and preventing problems from occurring a lasting and continuous improvement in quality can be achieved. When progressing from Quality control to quality assurance some features are acquired, a comprehensive quality management system, use of quality control tools, failure mode and effects analysis (FMEA) and use of quality costs. Quality assurance is a prevention-based system, it has a proactive approach. It focuses on improving the quality and increase productivity. Quality is created in the design phase of the product, the majority of quality issues are caused by poor design of products and processes. It strives to not produce any non-conforming products, and if products of poor quality is produced they are found early in the process. The earlier in the process you find the non-conformities the lower the cost. It brings a sense of responsibility for quality and to eliminate root causes of the problems. (Barrie G, Dale, David Bamford & Ton van der Wiele, page 38-40)

Total quality management; The fourth and final level of quality management is TQM – Total Quality Management. At this stage everyone is involved in the management principles, the whole organization, customers and suppliers. The approach involves everyone in the company in the work with continuous improvements. Systems, procedures and requirements may be on the same level as at the quality assurance stage of quality management, but it will involve every person, activity and function at the company. TQM includes more sophistication in the application of tools and techniques, increased focus on the people and process management and greater efforts to eliminate waste and non-value adding activities. The process is extended to also include customers, suppliers and stakeholders. (Barrie G, Dale, David Bamford & Ton van der Wiele, page 41)

Total Quality Management (TQM) is a management approach that focuses on producing products of quality that fulfills the customer needs. TQM involves and encourages employees to keep a high working standard through the whole organization. TQM can help achieve a competitive advantage on the market by increasing customer satisfaction and employee motivation and productivity. (SafetyCulture)

3.8 Implementation of a quality cost tool

To get a functioning quality cost program it needs proper implementation. Douglas C. Wood describes how to successfully implement a quality cost tool in a company. The one who is doing the implementation should have knowledge of quality cost systems, a belief that the program will be of benefit for the company and be willing to advocate for the program and act as a leader.

The first step is to collect facts that a quality cost program is beneficial for the company. Much of the data needed might already be available, for this purpose only the biggest costs are needed, some of the costs may be estimated to get a full picture of what it looks like today. When you have the approximate quality cost levels the opportunity for improvement is also visible. The data collected should be presented to the company management to get their interest in participating in the program and eventually also approves the program. (Douglas C. Wood, page 45-47)

If you can show the purpose and benefits of a quality cost program it might be easier to convince the management to invest in the program. The importance and impact of quality related activities should be presented in meaningful terms, i.e. costs. You can also present possible comparisons of performance and information for motivational purposes to the management team. (Barrie G, Dale, David Bamford & Ton van der Wiele, page 123)

3.8.1. Pilot

When the management is convinced that a quality cost program is needed it's time to do a pilot program, test the program in a smaller scale. This is necessary because it will prove that the program will produce cost-saving results, it's also easier to correct errors at this stage before doing a full implementation. The pilot will be done by the project leader, someone from accounting should also be involved to get a greater understanding of the costs. In the pilot program the following steps should be done:

1. Measuring the quality costs and create estimated values for costs that can't be measured.
2. Making of trend analysis charts.
3. Identify improvement opportunities.
4. Summarize and report the progress.

The whole process should be documented as the pilot program processes. (Douglas C. Wood, page 48-50)

3.8.2 Education

When the management has approved the quality cost program and the pilot is about to start the key members of all departments should be informed about the program. It's important to inform about how the different functions will be involved, the importance of working together and to point out that this will give opportunities for performance and cost improvement. The goal with the education is to make sure that people know the benefits of the program and to remind them about the importance of working together. All department representatives should review the

program and be encouraged to make suggestions of improvements to the program from their point of view, they are the experts about how things work in their departments. (Douglas C. Wood, page 50-52)

It is important that the quality cost-collection guidelines are developed and written so it's easy for employees to understand and use them in the daily work. The guidelines should state what data must be collected in what forms and how to allocate an activity into different cost categories. (Barrie G, Dale, David Bamford & Ton van der Wiele, page 125)

3.8.3. Internal procedure

It has probably already been discovered that many of the needed quality cost data isn't available from the system at this point. Usually most of the appraisal and internal failure costs are included in the cost of normal operations. In other words, the costs we have in the accounting is not the same as the quality costs. For example, rework costs are often included in the total work costs. The internal quality cost procedure describes all different elements of quality costs and defines how and when the cost data is to be estimated and when to use collected data. (Douglas C. Wood, page 52-54)

All new procedures that are introduced when implementing the program should be user-friendly, the information needed should be collected from a relatively small number of sources. The recommendation is that most of the data should be collected automatically with minimum intervention from the employees. (Barrie G, Dale, David Bamford & Ton van der Wiele, page 124)

3.8.4. Collection and analysis of quality costs

Quality cost reporting is not yet very popular when reporting about quality performance. When presenting quality related costs it is important to consider the needs of the recipients, it may be beneficial to present the information in different format depending on who the recipient is. The quality costs could also be included in the company's cost reporting system, this is not always a possibility since the quality cost reporting isn't considered to have the same level of detail and standard as other reporting systems. (Barrie G, Dale, David Bamford & Ton van der Wiele, page 127)

The internal quality cost procedure should include a complete system of cost elements. The elements should be categorized in a way that it is easy to separate them when searching in the system for different costs. You must be able to identify what is prevention, appraisal, and internal and external failure costs. The differentiation can be done by using different codes for different categories, for example all prevention costs have a code beginning with 1 and so on, if a more detailed classification is needed the second digit in the cost element can represent a smaller part of the prevention costs. When using this system, you know that all elements beginning with 1 is prevention costs. (Douglas C. Wood, page 54-56)

To be able to analyze the quality costs a spreadsheet containing all elements of quality costs against the department areas where the costs occur is made. The spreadsheet will be used by accounting for reporting and will show what elements are reported or not by each reporting area, it's also used to make a summary of all quality costs. The summary will be used by the quality department to help make decisions. (Douglas C. Wood, page 54-56)

3.9 Management dashboards and performance management

Performance management describes how to use performance measurement systems to manage the performance of an organization. What is often forgotten is that an organization is a social system built of networks and people and not a machine. Therefore the goal with performance measurement should be learning and not control. (Umit S. Bititci, page 26)

Business dashboards is a tool used to visually present data. Nils Rasmussen, Claire Y. Chen and Manish Bansal states that many managers are using dashboards in their daily job to get visual indications on where the organization is going and how to lead it further. The idea with management dashboards is to give the manager a screen that shows the key information needed to monitor the areas of their responsibilities, where they can quickly check if there are problems and take actions to improve the performance if needed. (Nils Rasmussen, Claire Y. Chen, Manish Bansal, page 3)

Norton and Kaplan advice to use performance measures that shows "results from past efforts and the measures that drive future performance". The measures should cover three major perspectives, customers, internal efficiency and development of

the employees, this provides framework that gives a picture of the company's vision and strategy. (Philip Green and George Gabor, page 82)

The benefit with dashboards is that it improves the decision making and performance. It makes it easier to identify and correct negative trends, and gives you more easily accessed information when decisions have to me made, it also measures the organizations efficiency. It can also help increase productivity by saving time in reducing the need to create many different statistical reports. With dashboards more time can be spent on analyzing the data then on finding, compiling and formatting data for reports. Dashboards provides a mean for sharing strategies, tactics and operational data in an interesting way, this empowers the employees to understand objectives and to make the right decisions. (Nils Rasmussen, Claire Y. Chen, Manish Bansal, page 4-5)

With a business dashboard it's possible to display data that originally came from many sources, display metrics that are a result of calculations, quickly display new information with minimal process time when the data changes, possibility to display the data both as a summary and on a more detailed level. (Nils Rasmussen, Claire Y. Chen, Manish Bansal, page 4-5)

Not all data provides information that is useful, collecting information just for information's sake is inefficient. A few points to consider when collecting relevant data are that the information needs to show a pattern over time, the viewer should be able to understand how the measurements where made and what the data says, it should also be easy to identify items that need immediate attention and provide enough information so the viewer can make an informed decision. (Harold Kerzner, page 260)

Many companies are using a portal for dashboards, enterprise portals, it's a framework for integrating information, processes and people in the organization. This results in several benefits for the organization, all users have a single location to log in to where they can access their dashboards and other information such as reports and presentations. (Nils Rasmussen, Claire Y. Chen, Manish Bansal, page 7)

There is different types of dashboards used for different purposes.

Strategic dashboards supports organizational alignment with strategic goals. With strategic dashboards an organization can monitor their progress towards strategic objectives. Typically strategic dashboards are highly summarized and graphical and isn't updated so often. (Nils Rasmussen, Claire Y. Chen, Manish Bansal, page 9)

Tactical dashboards supports the measuring of progress in key projects or initiatives. Tactical dashboard can be used to monitor progress and related trends of the strategic initiatives. Tactical dashboards can be focused, they are built so it's possible to drill down to detail and zoom in to the data of interest. (Nils Rasmussen, Claire Y. Chen, Manish Bansal, page 9-10)

Operational dashboards supports monitoring of specific business activities. Operational dashboards is used to monitor business processes, activities and special events. The data for the dashboards is updated very often, on a daily or weekly basis, to be able to give a picture of the status of the business or manufacturing process right now. Operational dashboards gives more detailed information with strong analytical functionality so it's possible to perform root-cause analysis on the given data. (Nils Rasmussen, Claire Y. Chen, Manish Bansal, page 10)

People are often using the words metrics and KPI, Key Performance Indicator, interchangeably even if they have completely different meanings, the term metric is generic and KPI is specific. Both KPIs and metrics can be displayed in reports, scorecards, and dashboards, but KPIs indicate and serves as an early warning that something is wrong. (Harold Kerzner, page 121)

A company usually have a lot of metrics but only a few KPI's, the management team should agree on what the Key Performance Indicators should be. If you have a well-designed KPI dashboard it will help the organization to focus on the important activities that drives performance instead of on the activities that aren't as relevant. The KPI metrics is frequently the most valuable content of dashboards therefore more focus should be on them then on other metrics. (Nils Rasmussen, Claire Y. Chen, Manish Bansal, page 10)

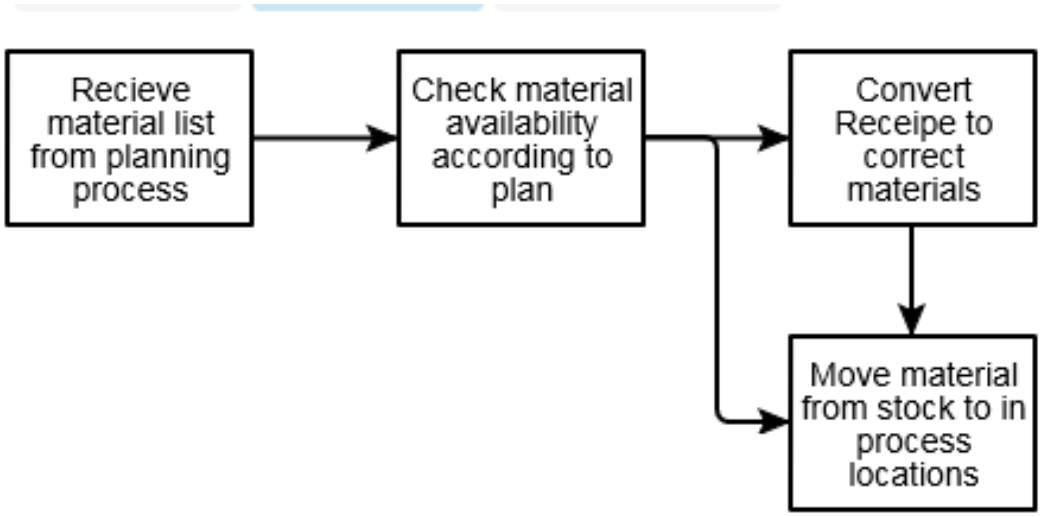
4 Current state

This chapter describes the processes and where the quality costs may occur and how things are handled today. Since this project focuses on poor quality costs that appears in the production and from customer complaints only these areas are included in the description. The information about how things work today has been contained by studying process maps and discussing with the team-leaders on each department.

4.1. Internal quality failures

Internal failure costs are failure costs that are discovered at different stages in the production before the end-product reaches the customer. Herrmans Bike Components have 4 different production areas and a warehouse area. The production and warehouse areas have different ways of working. The processes and the way of working is described separately below.

Common way of working for all production areas is the beginning of the process. When we receive an order from the customer the sales department adds it to the ERP system. When the order is confirmed it creates a production need for the area where the items are produced, it also creates needs for the components and raw materials needed for the end product. For all In-house made or purchased components that are needed for the end product the system also creates production and purchase proposals for. The production is planned according to the production proposals by the area supervisor at the production area. And the purchase department makes purchase orders according to the proposals created in the ERP system. When the production is planned we are also checking that we have all the materials needed before we send the work order to the production.



Picture 4.1 Material checking process in production planning.

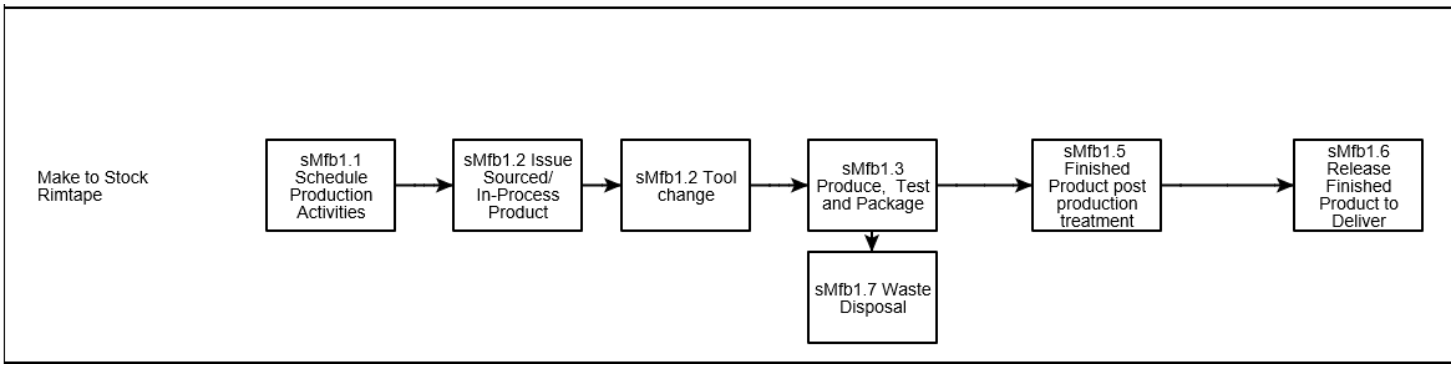
Incoming warehouse

All incoming goods are received at the incoming goods reception where it's checked that the quantities and items are correctly delivered according to the order and packing list, if everything is okay with the delivery it's received to the ERP system and moved to incoming quality check. At the quality check the components are checked according to quality check instructions and against the master sample. If everything is okay at the quality check the components are transferred to stock, if not it's marked as quality locked and a quality failure is made in the ERP system, then the purchase department makes a quality feedback and sends it to the supplier. The faulty components is kept 2 weeks before they are scrapped and the supplier makes a credit invoice for them. Almost all components goes through quality check before it's transferred to the stock, exceptions are stickers and other small and cheap components. When receiving granular raw materials it's only checked that the pallets and packages aren't broken. Faulty raw materials are discovered when they are taken in and used in production.

Extrusion area

Rim-tapes are made at the extrusion area, extruders are used to make rim-tapes from granular raw materials by heating up the material and extruding it through a nozzle and cutting it into the right lengths and weld the strip together to a circular string.

When the planned work is done it is marked complete in the ERP system, when doing this we mark how many rim-tapes we have made of good quality. The rim-tapes of bad quality are re-grinded and used again as raw-material. The rim-tapes are shipped directly to the customer as bulk packed or sent through sub-contracting to be AM packed.

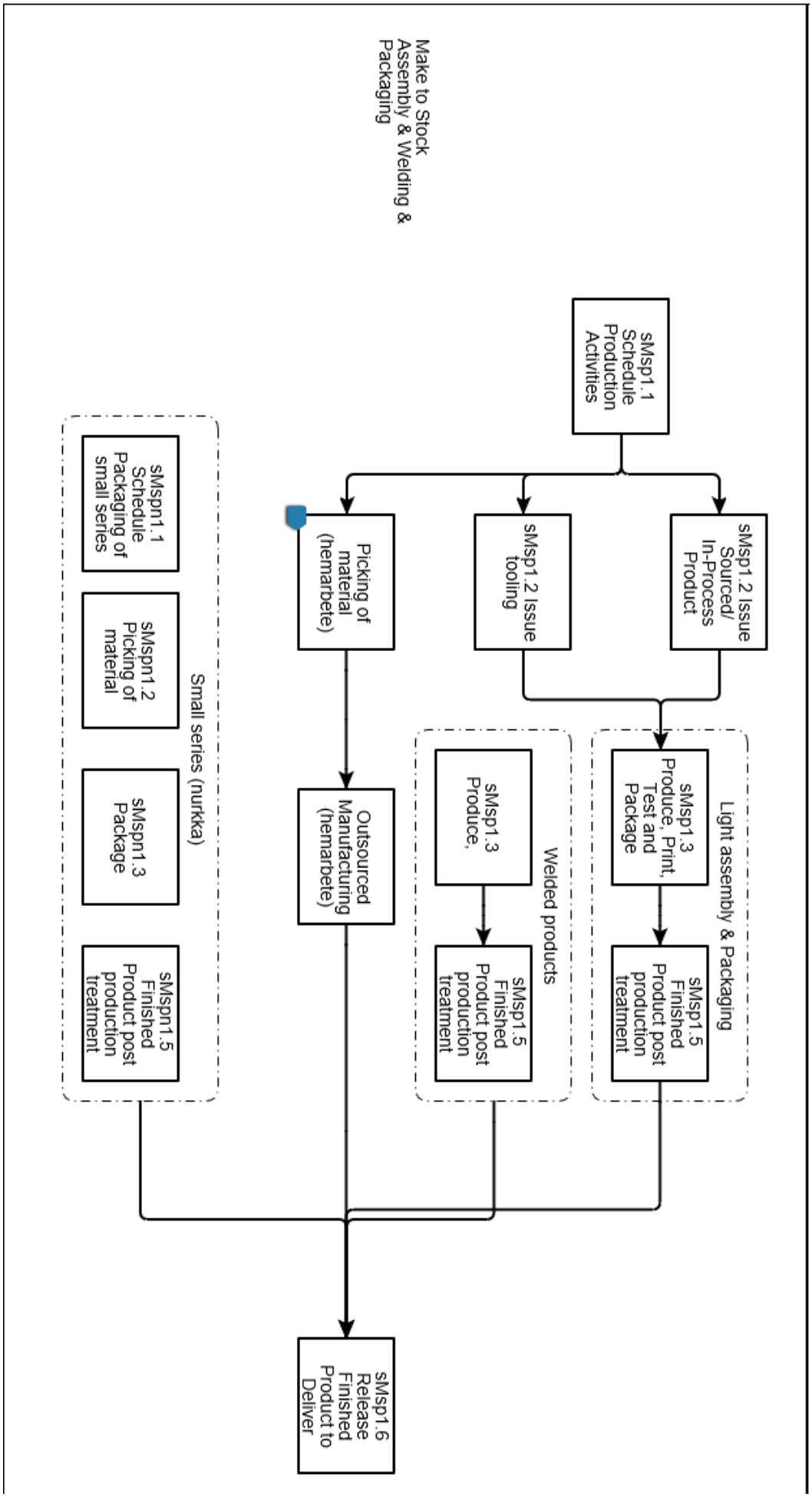


Picture 4.2 Extrusion process map

Assembly area

Lights are assembled and products that needs to be re-packed are packed at the assembly area. There is also an area for ultrasonic welding at the assembly area where reflectors and parts for lights are welded together. Everything that is produced at the assembly area is made from components, both purchased and in-house made. The products made at assembly is sent to customers as bulk or AM packed products.

When the work order is starting the shift-leader collects all the needed components for the order and puts them into the assembly cell. The assembly personnel is producing the order and when finished they return the work card to the shift leader who marks the order completed in the ERP system. The amount of bad quality components and end-products that have been scrapped during production is marked to the work card by the person working in the assembly cell, these amounts are added to the materials needed for the order when completing it in the ERP system. When doing like this the materials used is automatically removed from stock, but we can’t keep track of how many bad quality components or end-products we have scrapped and why.



Picture 4.3 Assembly process map

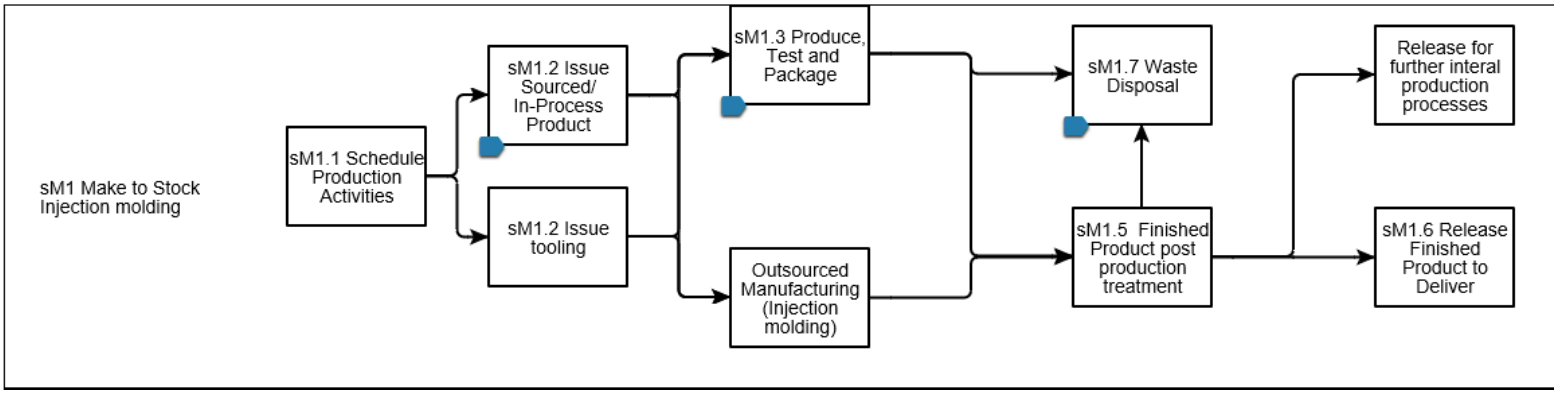
Injection Molding department

Injection molding machines are used to create reflectors, grips, chainguards and components from granular raw materials. The products made at the IM area are shipped to customers as bulk packed, sent through sub-contracting or assembly to be re-packed, welded or to be used at assembly in their production. The raw material is melted and injected into a mold in the machine, when the products have cooled down enough the mold opens and the finished product drops into a box, or if it's a sensitive product it's picked from the tool by a robot onto a conveyor belt or directly to the box. It's possible to have different cavities in the tools, how many products you can make at one shot, the largest tool at Herrmans Bike Components has 8 cavities. The more cavities a tool has the more it costs to make, larger investment, if it is a product that you sell a lot of it's profitable to have a tool with more cavities because you can make a larger amount of products in the same cycle time. It's also possible to have different inserts to a tool if you want to produce the product with small differences, for example different logos or patterns on the outside of a grip. With todays technique it's possible to use multiple raw-materials for the same product, at Herrmans Bike Components the largest amount of different materials for a product is 3. An example is the Primo grips, a robot cuts out a piece of fabric with laser and puts it into the injection molding machine, then the hard inner core is injection molded using one material and after that a softer material is injected outside which attaches the fabric. See the grip in the picture below.

Picture 4.4 Grip made from 3 different materials, 3K Grip Primo, (Herrmans)

When the work order is planned at injection molding we are also ordering a tool change for the machine we are going to produce the product in question in. To make different products we need to have different tools in the machine. The work orders is planned according to the machine availability, different tools only fits in certain

machines. During the production we make partial completions of the work order in the ERP system, when one box is produced it's added to the work order and to the stock. When the whole order has been produced we do a final completion, the total amount of products have been added to stock, then we remove the scrap and the start shots with a manual stock transaction. Start shots is the first products that come out of a tool after material or color change, these can't be used because the color is wrong or made from a mix of different materials. The amounts of good and bad quality products are specified on the work order in the ERP system so we can get data about how much we have scrapped on every order. Most of the bad quality products and the excess material is handled as energy waste.



Picture 4.5 Injection molding process map.

Sub-Contracting

Some items are sent out to be packed or assembled at a sub-contractor. The finished products are shipped out to customers or used in our assembly.

The work orders are planned according to the production proposals, and the components needed are picked at the outgoing warehouse and sent out to the sub-contractor. Normally a sub-contractor has 2 weeks of time before they must return the completed order. When the finished products are returned the work order is marked complete in the system. Only if bigger quantities of faulty components are found it's reported by the sub-contractor and in the system. In other words, we have no track of how many components or end-products has been scrapped and why at the sub-contractor.

The Sub-Contracting process map is the same as for assembly, see picture 4.3 Assembly process map

Rework and sorting

Sometimes poor-quality components that can be used if re-worked is found. Mostly the components are sent back to the supplier for re-work, the supplier pays for the freight and an administration fee for shipping the components back. If there is an urgent need for the components, they will be re-worked locally alternatively sorted in our production. We are invoicing the supplier for the time spent on re-work or sorting if the poor quality is the supplier's fault. There is no follow up for the re-work or sorting costs at this point, they are not registered in the ERP system.

Summary

Since the production areas are so different they have different ways of working. Different types of products are made from different materials and components with different production methods, both granular raw materials, in-house made components and purchased components are used.

When we are completing work orders in the ERP system only the injection molding department is adding information about how many faulty products they have produced. The assembly department is adding faulty components to the total amount of used components. The sub-contractors doesn't report small amounts of faulty components scrapped during the production. When using these system when completing orders we are not able to get almost any data from the ERP system.

To get the cost of poor quality we need data for all components and finished products that are of poor quality in all the departments to be able to collect the data from the same form in the ERP system, sorting and re-work costs should also be added to the ERP system, in some departments it's easier to get the data than others.

4.2. External quality failures

External failure costs are failures that are discovered after the products has been delivered to the customer. These failures are often more costly than internal failures.

When we receive a customer complaint it's added to the system as a quality failure, the failure is then investigated by the quality department, who tries to find a cause for the failure. We are then making a 4 or 8 G report to the customer depending on how big the quality issue is. The complaint can be solved with the customer in 2

ways, we make them a credit invoice for the faulty parts or we send a replacement shipment. Either way we also have to pay for the express freight to the customer. The cost for the express freight is added to the delivery in the ERP system, this data is therefore already available.

5 Method

The focus for this thesis is Cost of Poor Quality, in other words failure costs. If all the quality costs where included we would have to use estimations for many costs, it is a great risk that the estimations would be wrong and would lead to a wrong picture of the situation.

By studying the process maps for the different production areas I have defined where faulty parts are found and where the costs of poor quality appears. I have also discussed with the team-leaders to get a better understanding of how the processes works and how they could be improved to get more data regarding poor quality items from the system. According to the information contained a model for showing the Costs of Poor quality was made, Appendix A. The conclusion was that internal failure costs should include scrapped parts in production and costs for rework and sorting, external failure costs includes the value of faulty parts, administration cost and costs for express freights.

We have decided that the focus should be on poor-quality costs in the production and costs for customer complaints, the focus is on faulty components and products discovered in production or after delivery. There are also other departments that are contributing to the costs of poor-quality, such as purchase, toolshop, maintenance, etc. The poor quality costs from these departments have been excluded from my model since the costs that appears in these areas are more diffuse and would need major changes in the processes or to be estimated in order for us to be able to report the data properly in an easy way. Costs that can appear in these areas are for example; delivery problems, delays and failures in tool changes and maintenance delays and failures.

The model was made with the principle to keep it simple. Measuring doesn't create any direct value therefore adding the data to the system should be easy to do but still give enough information for the model. The implementation of process changes is also easier if the new way of working is simple, not time consuming and easy to understand.

When it's defined where the costs appears and a model has been made a data collection plan is made. The goal is to be able to get the data from the same form in our ERP system, all components of poor quality should be reported as a quality

failure in the system. I discovered early in the process when discussing with my colleagues that a tool for creating quality failures from work order was already available in our ERP system but only used sporadically by the assembly department. The quality failures will be differentiated by using defect location and reason codes, this is information that will be filled in by using a selection menu when reporting the quality failure. The defect location tells where the poor-quality item has been discovered. The reason code tells what kind of quality issue the item has. The implementation of these have been done as a side project by me, I have created the defect locations and the needed reason codes in the ERP system. There is one defect location for all production areas. What reason codes that are needed have been decided together with the team leaders from all production departments. If everything is reported correctly, we can get all data from the quality failure form in the ERP system, we can get statistics of how much faulty parts we have scrapped, where and why, during a specific period of time, from this form it's also possible to create both internal and external reclamations.

To achieve the goal to get the information of faulty parts from the same form in the ERP system all faulty parts has to be reported in the system as quality failures. The best way of doing this is to make it possible to do it at the same time when the work order is marked completed. Below is my suggestions of how we should change our processes to be able to collect the needed data from the ERP system, since the production areas work in different ways there is different suggestions for all departments.

5.1. Internal failure costs

Incoming warehouse

The earlier in the chain a faulty component is found the lower the impact is on the poor quality cost, therefore it's better to put more efforts into finding them already in the incoming quality check. Samples should be collected from the shipment and be checked and measured against the incoming quality check instructions and master samples. It's important that the instructions and master samples are up to date. When a new item is activated or when a change is made to an item it's important to check that these are available and accurate. When samples of poor quality are found the whole shipment should be blocked and it should be investigated and decided if the shipment should be sorted, re-worked, returned to the supplier or

scrapped. A quality failure should be made according to the decision made, if it's decided to do a sorting or re-work the amount of faulty parts and the work costs should be added to the quality failure, if the shipment is returned or scrapped the whole amount of the shipment should be added to the quality failure. When the quality failure is made a quality feedback is created and sent to the supplier where we are demanding a credit invoice for the total costs, faulty parts, administration fee and potential work costs.

Data for the quality cost model can be collected from the quality failure window in the ERP system. There we can get both the value of the faulty parts, sorting and re-work costs.

Extrusion area

The quality failures at the extrusion area are difficult to get data for. Almost all products of non-conformity are re-grinded and used as raw material again. The non-quality costs that appears in this area is the work cost for making poor quality products and re-grinding them. It's hard to estimate how many rimtapes that are of poor quality since they are extruded, they come out of the machine as a long stripe. This means it isn't possible to do a quality failure when completing the order since the amount of faulty rimtapes is unknown.

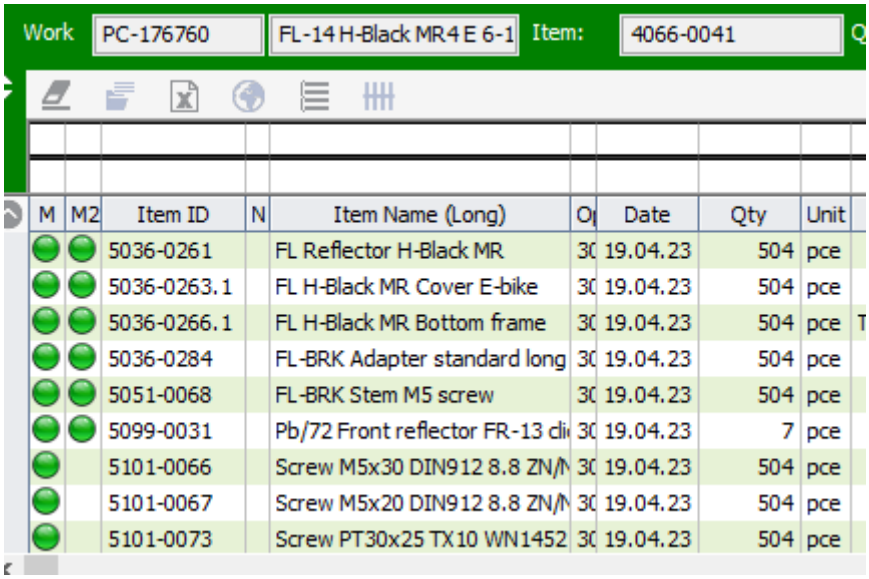
If we have a total weight of the re-grinded material we can calculate the needed work hours for bad quality production since the machine capacity is known, how many kg/hour we can produce. The amounts should be added to the ERP system when the order is marked complete.

Assembly area

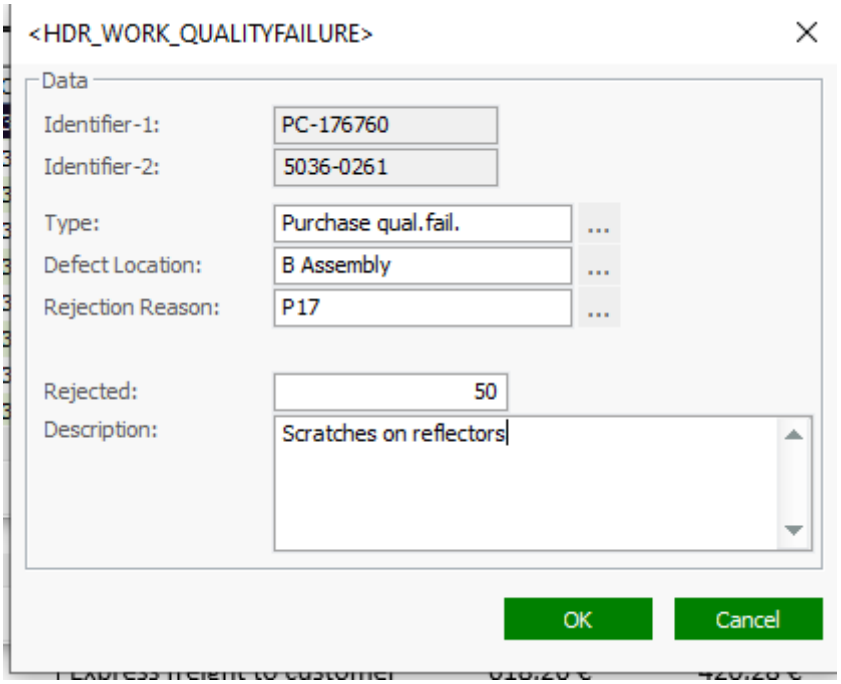
The way of completing work orders should be changed so we get data about faulty components and end products. The information about faulty components found during production should be added as a work quality failure directly on the work order when completing it.

When completing the order, open the material list (picture 5.1) in the material list it's possible to add work quality failure for the selected component (picture 5.2), you have to make different work quality failures for every faulty component. All necessary information should be added in this window such as type, defect location, reason code and rejected amount, a comment can be added if additional information

is needed. When pressing ok the faulty amounts will be added to the material list and will be automatically removed from stock when the order is marked complete, a quality failure will also be made automatically.



Picture 5.1 Material list for a production order.



Picture 5.2 Making a work quality failure

When there is faulty end-products a quality failure is made directly on the work order. Since we can't re-use the components used for the faulty end-products we will have to add these manually to the material list to get the components automatically removed from stock when completing the order.

When doing like this we will get all failures to the quality failure window, when differentiating with reason codes and defect locations it's possible to sort out the reason for faulty end-products and components discovered at the assembly department.

Injection Molding department

At the injection molding area we are already filling in total produced amount and how many of these that are of good quality when completing the work order, picture 5.3. The data needed for poor quality costs is already available, but not in the same window as the data from the other departments.

Work ID	Item ID	Name	Prod.Area	Qty Good Quality	Total Qty
PC-176085	5036-0209	Housing H-Ike	INJECTION MOULDING	4956	5152
PC-176086	5033-0004.1	Backpiece BR-7 mudguards	INJECTION MOULDING	24000	26564
PC-176089	4204-0539	Lens Corona 400 Red	INJECTION MOULDING	1056	1059
PC-176090	4204-0491.1	Lens Scorpius Go WideFlood Blue PA	INJECTION MOULDING	208	514
PC-176091	4204-0323	Housing N520 Grommet 30% GF	INJECTION MOULDING	1980	2000
PC-176092	4204-0253	Lens N25 Indicator Amber ECE	INJECTION MOULDING	3776	3788
PC-176093	4204-0134	Lens N42/N44/44G2/46 LED WideFlood PC Makrolon LQ 2647	INJECTION MOULDING	9048	9088
PC-176103	5050-0011	Cable Holder black single	INJECTION MOULDING	99010	101016
PC-176104	2009-0221.1	Pre-fabric Grip Line DD36BL left 125mm grey-black43 Ø22mm v.1	INJECTION MOULDING	10800	10980
PC-176105	2009-0222.1	Pre-fabric Grip Line DD36BR right 125mm grey-black43 Ø22mm v.1	INJECTION MOULDING	10800	10980
PC-176106	5033-0009	Bakstycke BR-13 skärm (mudguards)	INJECTION MOULDING	52500	53808
PC-176107	2005-0033	Grip Kids Safety 98A 95mm tpe45 black Ø22mm Kids	INJECTION MOULDING	12600	13824

Picture 5.3 Available data from work order

The best way of doing would be to do in a similar way as the assembly area, by adding a quality failure directly from the work order when completing the order.

The problem with this is that the injection molding area only have faulty end-products to report and by adding a quality failure for end-products on the work order the material needed to produce them isn't automatically removed from stock. This means that the material used for production of poor-quality products has to be added manually to the material list, that can be done in 2 different ways.

- By weighing all the faulty products.
- Check the BOM how much material is needed for 1 product and multiplying by the amount of poor-quality products.

Both suggestions goes against our principle of keeping it simple, since there is many persons working in the production and one production order can run for several days it isn't possible to keep track on this.

We should keep the current way of working but also create a quality failure for the poor-quality products when doing the final completion of the order in the ERP system.

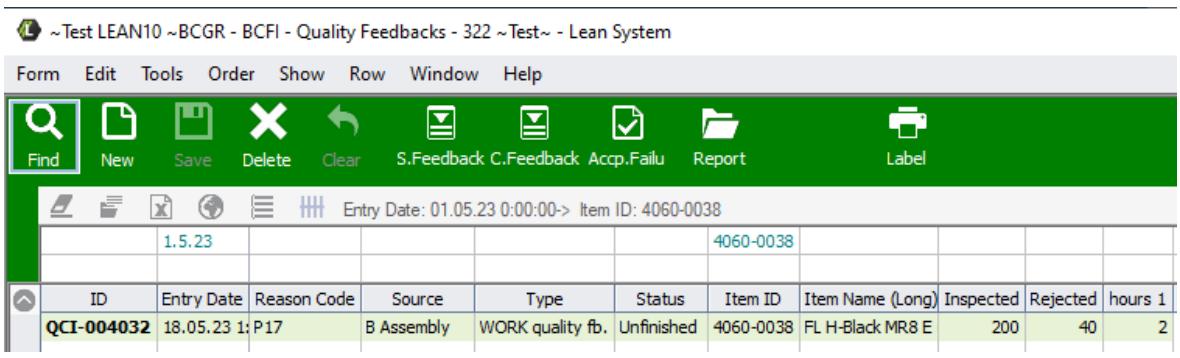
Sub-Contracting

The work orders at subcontracting should be handled the same way as on the assembly area since they have similar ways of working and both use components to make end-products. What needs to be done is to develop how it's communicated about faulty parts between Herrmans and the sub-contractor. The sub-contractor should always report how many faulty components and end-products they have scrapped during their production so we can make work quality failures when the order is returned to us.

Rework and Sorting

It's possible to get information about the costs for outsourced re-work by adding a cost center called re-work that should be added to all invoices for re-work, that way we can separate re-work costs from other costs.

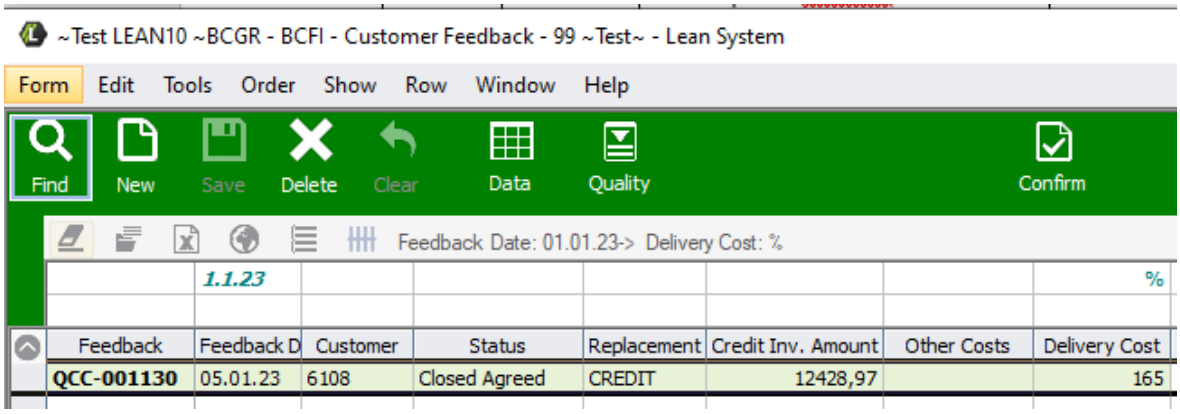
Work hours for internally made re-work and sorting should be registered in the ERP system so we can keep track of the costs. The time spent should be added to the quality feedback that has been made for the items that need rework or sorting, hours 1, picture 5.4. The time spent can then easily be multiplied with the work cost/hour to get the total cost.



Picture 5.4 adding sorting/re-work cost to a quality failure

5.2. External failure costs

The total external failure cost consists of several different parts, such as handling fee, work hours, freights, value of the faulty products. For every customer complaint there will be a standardized administration cost for handling the complaint, total cost is the amount of customer feedbacks * 100€. The cost for the work hours spent on solving the quality issue should be added to the quality failure in the ERP system on other costs, picture 5.5. The cost for sending a replacement order should be added to delivery cost on the customer feedback, picture 5.5.



Picture 5.5 Adding costs to a customer feedback

All the suggestions of how to change our processes have been made with the keep it simple aspect in mind. The next step is to do the implementation of the changes. The team-leaders in all production areas have been involved in the development of the new ways of working, this means that they already have an understanding for the changes, why we are doing them and what is expected from them and their departments.

6 Analysis of the model

The data for the model has to be collected from 2 different forms in the ERP system, internal quality failures from Quality Failures and external quality failures from Customer feedbacks. The search criteria's needed to get the relevant data for the model can be saved as a template to make it easier to collect the data frequently. When the data is displayed in the ERP system we have to export it to an excel file from which we then copies the data to a new page in the Cost of Poor-Quality model excel file. The model in excel is built with formulas to automatically update the costs when adding new data.

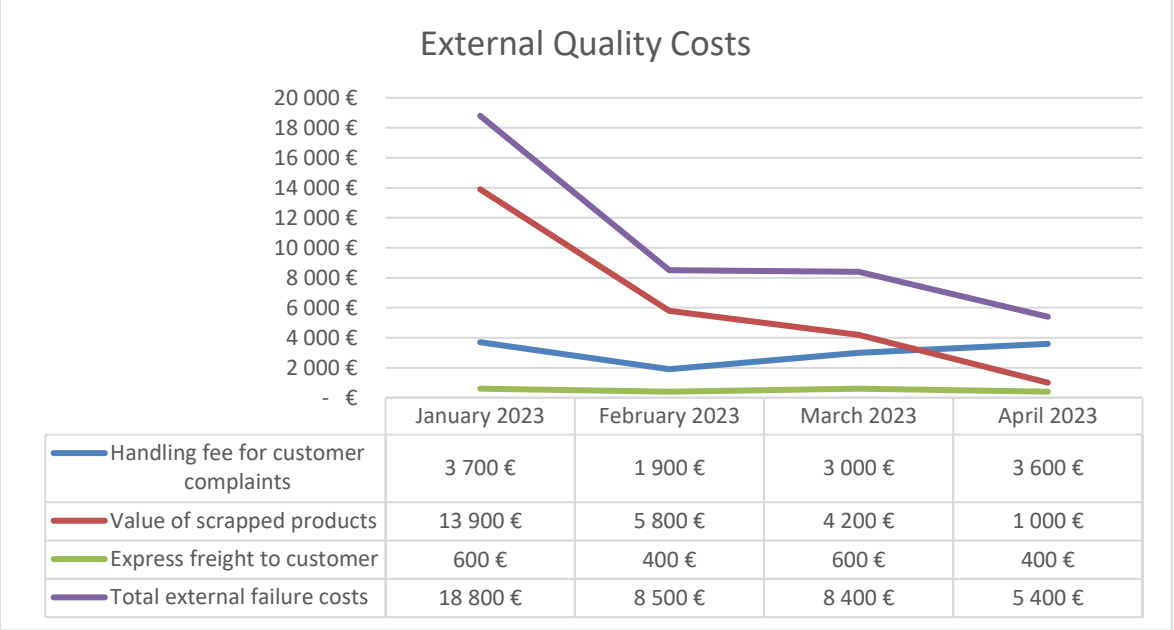
I have added the data currently available to the model I have created to test its functionality. Some manual calculations where needed and the data had to be collected from many different places in the ERP system. The model doesn't show a correct picture with the current data since everything is not reported, we need to get more accurate data to get a more reliable picture. When we start to fill in all quality failures as planned when we complete orders in the ERP system we can also get more accurate data, and most importantly get all data from the same form in the ERP system. When we have the data available in the same place the formulas in the model will work correctly and there will be no excess manual calculations and cut and paste for the data collection.

Internal quality costs	**January 2023**	**February 2023**	**March 2023**	**April 2023**
IM Scrap	23 200 €	20 800€	19 100 €	17 800 €
Assembly scrap	8 300 €	35 500 €	2 400€	500 €
Sub-contractor scrap	-	-	-	-
Extrusion scrap	-	-	-	-
Incoming quality check	-	-	-	-
Total scrap	**31 500€**	**56 300 €**	**21 500 €**	**18 300 €**

Rework and Sorting	-	-	-	-

External quality costs	**January 2023**	**February 2023**	**March 2023**	**April 2023**
Handling fee for customer complaints	3 900 €	1 500 €	2 900 €	3 500 €
Value of scrapped products	13 900 €	5 800 €	1 800 €	1 000 €
Express freight to customer	600 €	400 €	600 €	400 €
Total external failure costs	**18 400 €**	**7 700 €**	**5 300 €**	**4 900 €**

	January 2023	February 2023	March 2023	April 2023
IM Scrap	23 200 €	20 800 €	19 100 €	17 800 €
Assembly scrap	8 300 €	35 500 €	2 400 €	500 €
Total scrap	31 500 €	56 300 €	21 500 €	18 300 €



	January 2023	February 2023	March 2023	April 2023
Handling fee for customer complaints	3 700 €	1 900 €	3 000 €	3 600 €
Value of scrapped products	13 900 €	5 800 €	4 200 €	1 000 €
Express freight to customer	600 €	400 €	600 €	400 €
Total external failure costs	18 800 €	8 500 €	8 400 €	5 400 €

The quality failures from incoming quality check and sub-contracting are included in the data for Assembly in this data set, the quality failures discovered at the quality check and sub-contracting has been put in the ERP system with the wrong Detection area because assembly is the default option for components. Rework and sorting costs are missing because they are not added to the quality failures in the ERP system at the moment.

7 Summary and conclusion

The task was to create a model to visualize the costs of Poor-Quality at Herrmans Bike Components. The model will be used as a KPI to follow up the monthly and yearly poor-quality costs, if the costs goes down the improvements made are working.

I started with a literature study to get the tools needed to be able to create the model and get a better understanding of what quality is and how it is managed in a company.

When creating the model involvement by the colleagues have been an important part of the process. They have given me a greater understanding of how everything works today and what we can do differently to be able to get the data needed to present the poor-quality costs. The model has been tested with the data currently available in the system, it shows that the model works even if the data is not accurate at the moment and has to be collected from many different places.

It has been an interesting project that hopefully will give the managers at Herrmans Bike Components an eye opener of how much money is spent on producing poor-quality products and that preventing these is something we should focus on. There can be a lot of money saved with small efforts.

Going forward more cost categories can be added to the model, there are some departments that also contributes to the costs of poor quality but aren't accounted for in the current model. The purchase department can also in the future take advantage of the data collected for the model, when adding reason codes to all quality failures that are registered it's possible to get data about supplier failures and be able to make supplier feedbacks on a more regular base. At the moment it's not possible to make the supplier feedbacks because supplier data is missing from the quality failure window. This issue should be investigated further and checked if possible to solve. The model should also be visualized in "tableu", our dashboard portal to give a better overview of the poor-quality costs. Tableu can also collect the data directly from the ERP system and automatically create a cost of poor quality dashboard, this needs a little work to get it working but it is possible.

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