Reduction of scrap and rework on door panels

Karl Abdallah  Raoul Sisodia

International Automotive Components
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Summary

This thesis work has been conducted at International Automotive Components Group in Torslanda, Sweden. The company produces door panels, instrument panels, consoles and cockpits for the automotive industry.

During the production of door panels, defects such as pressure marks and scratches emerge which results in scrap and rework. The objective of the thesis work was to identify the causes of pressure marks and scratches and also to suggest measures to reduce the amount of scrap and rework on door panels.

Through observations, interviews and experiments, several causes leading to pressure marks and scratches on door panels were identified. Small pieces of plastics on fixtures, the operator’s rough handling and specific process steps are the main causes that result in pressure marks and scratches.

Pressure marks and scratches emerge at several places on the door panels during the production. To reduce the amount of pressure marks and scratches both short-term and long-term measures were suggested. Some of the measures are:

- Use vacuum cleaners at some stations
- Add padding on unpadded areas and edges
- Make new instructions that emphasize to keep production stations clean and to avoid rough handling
- Introduce workshops to engage operators
Preface
This report represents the final part of the author’s bachelor degree in Industrial Engineering and Management at the University West. The thesis work has been conducted at IAC, Torslanda. The report has been divided between the authors and thereafter compiled into one report.

We would like to thank everyone who have helped us during this thesis work and made it possible for us to conduct. First we would like to thank Robert Boffey for giving us the opportunity to conduct a thesis work at IAC. We would also like to extend a special thanks to Daniel Skokic and Philip George, our supervisors at IAC, for their expertise and guidance throughout the thesis work. Leif Sandvik also deserves a special thanks for having contributed to the result of this thesis work.

Finally we want to thank Kjell Niklasson, our supervisor at the University West, for his guidance.
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1 Introduction

In order to be viewed as competitive in the manufacturing industry companies must strive towards minimizing waste and thus increase their productivity (Liker, 2009). During the production process of door panels at International Automotive Components Group in Torslanda a large amount of damages on the door panels emerge and lead to scrap and rework. In order to eliminate or minimize the cost of scrap and rework it is important to prevent door panels from being damaged. By minimizing the origin of scrap and rework a win-win situation is achieved where resource utilization is maximized and large costs are avoided.

1.1 Company description

International Automotive Components Group was founded as a joint venture in order to combine a variety of car interiors within one supplier. This action was conducted since the biggest car manufacturers stopped buying their interiors from individual suppliers. In early 2007, Lear Corporation completed the transfer of substantially all of its former North American Interior Systems Division to International Automotive Components, also known as IAC.

With more than 32 000 employees IAC has in the past decade alone grown to become the largest singularly focused supplier of automotive interiors in the world. IAC’s core products consists of Door & Trim systems, Instrument Panels, Consoles & Cockpits, Flooring & Acoustic systems, Headliner & Overhead systems and Interior & Exterior components. IAC has a company-wide “customer satisfaction” vision, meaning that all IAC's customers should be satisfied with the product and its quality.

IAC's door and trim systems provide vehicle safety, comfort, functionality and style, and serve as noise barriers for a quieter interior. Various surface technologies are available to accomplish original equipment manufacturers (OEM) styling requirements.

IAC has 100 facilities in 21 countries with 25 design, technical and commercial centers. IAC has more than 160 years of automotive interiors technology expertise and still remains a leading manufacturer of automotive interiors. In Sweden, IAC has production plants in Torslanda, Färgelanda and Skara. The production plant in Torslanda has approximately 300 employees producing door panels, instrument panels, consoles and cockpits. Figure 1 shows the door panels that the thesis work is based upon.
1.2 Problem description

During the production process of door panels at IAC in Torslanda a large amount of damages on the door panels emerge and lead to scrap and rework. The value of the door panel increases in every step of the process and when the door panel has been delivered from the final assembly line to the final quality control it is as most valuable. In order to eliminate or minimize the cost of scrap and rework it is primarily important to prevent that door panels are damaged. It is also of vital importance to find door panels that have been damaged beyond repair early in the process and scrap them to prevent any further processing.

The door panels produced at IAC are sent Just In Time (JIT) to the customer production line and assembled to the car without any closer inspection. If a door panel deviates from the expected quality at the final inspection, the car is taken aside and a new door panel is ordered. Consequently, the end customer will not receive the car on time. IAC is held responsible for the delay in delivery and have to pay for the added cost of sending a new door panel. These added costs and unsatisfied customers are not within IAC's vision of “customer satisfaction”. This is the key reason to why a project regarding the reduction of scrap and rework needs to be prioritized.

1.3 Objective and limitations

The objective is to identify the causes of scrap and rework due to pressure marks and scratches on door panels. The thesis work should also result in future measures to reduce the amount of scrap and rework.

Following limitations were agreed upon together with supervisors at IAC:

- The thesis work will only focus on pressure marks and scratches on door panels that emerge in IAC’s plant in Torslanda.
- The thesis has a limited time frame and therefore introduction and verification of improvement will not be included. This is why the Control phase of the DMAIC methodology will not be included. DMAIC is a tool consisting of the five stages Define, Measure, Analyze, Improve and Control.
• Improvements will only be based on the existing process at IAC. Thus, replacements of machines will not be considered.
# Methodology

This section presents a description of methods and approaches used by the authors.

## 2.1 Research approach

As a research approach, the thesis work has been conducted using the case study method. A case study is described as a method where an object is investigated in numerous ways. In which way a problem is tackled depends completely on how the situation of the problem looks like. In case studies data is collected from various sources where the information from the sources often complement each other. Some examples that can be mentioned as sources are interviews, observations, documents and experiments (Sharan B Merriam, 1988). According to Søilen and Huber the focus of case studies is emphasized on questions such as *how* and *why* rather than *what* (Søilen and Huber, 2006). The purpose with this report is to identify causes leading to scrap and rework during the production process of door panels. This can instead be rewritten as “Why is a huge amount of door panels scrapped and reworked during the production process?” which motivates the choice of a case study.

Guba and Lincoln mention one disadvantage with the case study. They claim that it can lead to exaggerated factors resulting in misleading conclusions being drawn (Guba & Lincoln, 1981). Collecting data from different sources will prevent this from happening.

## 2.2 Research method

Qualitative data consists of detailed descriptions of situations, quotations from various persons and extracts from different types of documents (Sharan B Merriam, 1988). Briefly a qualitative method focuses on obtaining a deeper understanding of the actual problem through the gathering of information from several sources (Holme & Solvang, 1991).

Quantitative methods are in comparison to the qualitative methods more structured. If the qualitative method is characterized by the proximity to the source of information then the quantitative method, on the contrary, is characterized by a relative distance to the source. This is necessary in order to conduct analysis, comparisons and examine the result obtained (Holme & Solvang, 1991).

The thesis work structure is based upon the use of both the qualitative and quantitative method. A qualitative method has been used in order to identify the causes of scrap and rework during the production process of door panels. Further a quantitative method is used to learn how the identified aspects from the qualitative study affects scrap and rework.
2.3 Data gathering techniques

The data used during the thesis work has been gathered through the following methods.

2.3.1 Interviews

Interviews provide access to information that is directly relevant to the purpose of the study. It also offers an opportunity for a deeper understanding where the person conducting the interview can adapt the questions to each respondent and his previous answers. During an interview it is possible to interpret various signals such as body language (Björklund & Paulsson, 2012).

Interviews were conducted with operators at all stations. Some interviews were semi-structured which requires the preparation of some key questions in advance, such as:

- What do you think is the cause of pressure marks and scratches?
- Where do you believe the pressure marks and scratches emerge?
- What do you think about the current process?

Other interviews were conducted as just conversations where the respondent had the opportunity to express any thoughts he had, whether it was about the production process or the work situation. To make the respondents feel comfortable the interviewers explained the purpose with the interview before asking the respondents to express their thoughts.

2.3.2 Observations

Observations can be implemented in several ways. Observers may participate in the study or observe the event from the outside. According to Björklund and Paulsson the involved staff can either be informed in advance about the observation or it can be carried out “without them knowing” (Björklund & Paulsson, 2012).

Observations were made in order to identify the possible causes of scrap and rework. The observations were made both with and without the awareness of the involved staff in order to see whether the operator’s behavior would differ or not. To be able to identify problems in the process, it is of vital importance to make sure that the operator does his task in the same way that he is used to do it.

2.3.3 Brainstorming

Brainstorming is a type of internal search where team members and creativity are used to generate solution concepts. Ideas that emerge from this step are created from already existing knowledge in the team. Internal search is often thought of as a process of retrieving a potential useful piece of information from the memory of someone. This information can then be used to adapt it to fit the problem at hand. This process can be carried out by individuals working alone or by a group of people working together (Björklund & Paulsson, 2012).
Brainstorming was performed individually and in group together with technicians, operators and managers. The idea was to use their expertise as guidelines to better understand the problem.

2.3.4 Experiment
The main advantages of experiments are that you can have great control over the variables that might influence the object of study and its repeatability. However, experiments can be resource consuming, and it may be difficult to fully reflect the complexity of the reality (Björklund & Paulsson, 2012).

Experiments were conducted with scrapped parts to recreate the pressure marks and scratches that emerge during the production process. The experiments were also conducted to see how easy or difficult it would be to create these types of damages. By testing scrapped parts in different process steps, a clue would be given of where and how a damage emerges. Some of the experiments were conducted with rough handling of the door panels while others were performed with normal handling. This was made to see how much pressure was needed to create a damage and to see whether the damages depends on the manual or automatic process.

2.3.5 Document studies
One strength of literary studies is that it in a relatively short time and with limited financial resources can share much information. Literature is often a help to identify existing knowledge in the field and to build up the theoretical framework. One drawback is that literature is so called secondary data and therefore it is not always clear what methods are used to collect information and for what purpose. It is therefore important to always question the information (Björklund & Paulsson, 2012).

Internal documents from the quality control stations at IAC were studied. The documents describe the type of damage, where the damage emerged and the type of door panel. The data used for gathering information was dated from 16th of February 2015 to 6th of April 2015.

During the thesis work areas such as quality, Lean production and DMAIC has been studied. This was made in order to obtain an understanding for the problem and possible solutions. Section three, Theory, provides a deeper understanding of these areas.


3 Theory

The theories and tools that has been used by the authors during this thesis work is presented in this section.

3.1 Quality

Quality is an important aspect to companies’ success on the market. Companies with an innovative and systematic way of working with quality and quality improvements have often achieved great success on the market, lower internal costs and a shorter design and development phase of new products according to Bergman & Klefsjö (2010).

There are various definitions of quality. For instance, Crosby’s (1979) definition of quality as “conformance to requirements” has a more producer-based perspective while quality is defined by Joseph Juran (Juran, 1951) as “fitness for use” and is rather customer focused. A leading person in quality and quality improvements such as Walter Shewhart reflects on various quality issues and formed a different perspective to quality (Shewhart, 1931). Shewhart mentions that the quality concept should be divided into two separate sides, where one is measurable and the other side is subjective. The measurable side can be viewed as important for the producer since one vital part of quality is to base the decisions on facts and that all decisions should be based on a common base. The subjective side depends fully on how the customers experiences the product. It is the end customer that evaluates the product or service and is considered as a vital aspect for the companies’ success.

Bergman & Klefsjö defines quality as “the quality of a product is its ability to satisfy, and preferably exceed, the needs and expectations of the customers” and discusses that it is not enough to only fulfill the customers expectations. The companies should be aiming to exceed the expectations so that the customer is “surprised, delighted and fascinated”. By doing so the company will attract loyal customers which in turn will attract more customers by speaking in positive terms about their experiences with the company. As David L. Goetsch and Stanley B. Davis mentions in “Quality Management” it is sometimes difficult to define quality. Authors, scientists and business managers have all their own definition to quality which is why Goetsch and Davis suggests that quality is something that lies in the “eye of the beholder”.

3.1.1 Total Quality Management

Total Quality Management often referred to as TQM is interpreted by Bergman & Klefsjö as “a constant endeavor to fulfil, and preferably exceed, customer needs and expectations at the lowest cost, by continuous improvement work, to which all involved are committed, focusing on the processes in the organization”. Long-term company success will be ensured by focusing on continuous process improvement in order to achieve customer satisfaction (Summers, 2009). TQM is on the contrary to inspection and repair instead a matter of proactive work, change and continuous improvement. It
can be viewed as a concept where values, methodologies and tools are combined in such a way that a higher level of customer satisfaction is achieved with the usage of fewer resources (Bergman & Klefsjö, 2010).

For the companies to achieve success for their work with total quality management it is of vital importance that the commitment to solve quality issues and quality improvement starts at the top management. Lennart Sandholm, a Swedish quality expert, expresses his thoughts concerning TQM and mentions that many companies claims to have a programme for TQM which should involve all internal customers. This has proven not to be correct in many cases and at best many companies only have a programme for total quality control (Sandholm, 2000). According to Bergman & Klefsjö, total quality management shall rest on a culture, based on the following values:

- Focus on customers
- Base decisions on facts
- Focus on processes
- Improve continuously
- Let everybody be committed.
- Committed leadership

These six values are often referred to as the cornerstones of TQM. Each of the cornerstones are supported by various methodologies and tools.

### 3.1.2 The cornerstones of TQM

The first cornerstone is to focus on the customers which means finding out the customers expectations and needs and then try to fulfill these during the development and manufacturing stage of a product or a service (Bergman & Klefsjö, 2010). According to Lennart Sandblom, when talking about customers one naturally think of the external customers. But Sandholm claims that a company also has internal customers which “receives inputs from other units within the organization”. From a Total Quality Management point of view, which has a very strong external customer focus, it is important not to forget about the internal customers (Bergman & Klefsjö, 2010). In order for the internal customers to handle their tasks in a good way it is, as for the external customers, of vital importance that the needs and expectations are fulfilled (Sandholm, 2000).

The second cornerstone is to base decisions on facts. To do this requires knowledge about variation and the ability to distinguish between natural variation and variation due to identifiable causes. Also needed is factual data of both a numerical and verbal character (Bergman & Klefsjö, 2010). The seven improvement tools or the 7 QC tools are a set of simple statistical tools that can be used effectively to structure and analyze data of a numerical character. The use of the seven management tools or the 7 QM tools is common when it comes to structure and analyze verbal information.
The third cornerstone focuses on the process. A process is described as linked activities that are repeated and whose objective is to create value. The process uses various inputs, such as data, information and material to transform these into different outputs. The purpose of the process is to satisfy its customers with the end result produced, while using as little resources as possible (Bergman & Klefsjö, 2010).

The fourth cornerstone is to improve continuously which is an effect of the external customers growing demands on quality. Improving continuously is an important element in a successful quality strategy. There is always a way to improve quality using less resources. In many cases very simple steps can lead to dramatic effects in term of improved quality and reduced total costs (Bergman & Klefsjö, 2010).

The fifth cornerstone of TQM is to let everybody be committed. An important means for quality improvements is therefore to facilitate the opportunities for all employees to be committed and participate actively in the decision-making and improvement work (Bergman & Klefsjö, 2010).

The sixth and last cornerstone is committed leadership. It cannot be emphasized too much how important strong and committed leadership is to create a culture for successful and sustainable quality improvements. Committed leadership must be practiced on all levels of the organization (Bergman & Klefsjö, 2010).

### 3.2 Lean Production

The term Lean Production was first mentioned by John Krafcik in his article “Triumph of the Lean Production System” in 1988. By comparing the productivity level between two different production systems, a robust and a fragile, Krafcik managed to prove that production plants that had a low stock level, low bufferts and simple technology had a higher level of productivity and quality than plants with advanced technology. Krafcik decided to name this production system *lean* which would represent an effective production system.

It was not before 1990 when the term Lean Production started to claim a place in companies manufacturing processes much thanks to the book “The Machine that Changed the World” by James P. Womack, Daniel T. Jones and Daniel Roos. The book is based on years of research and to a large extent also studies on Toyotas processes and working methods. The authors of the book describes what Lean Production is and concludes that the core of lean can be identified in the four principles:

1. Teamwork
2. Communication
3. Effective use of resources and eliminating waste
4. Continuous improvement

Womack, Jones and Roos have during several years specialized on the area of Lean Production and continuously published materials on the subject. One book that have
had great success is “Lean Thinking” by Womack and Jones, published in 1996, where the book describes guidelines on how a company should act to become lean.

An interesting book in the subject of lean is “Detta är Lean” by Niklas Modig and Pär Åhlström where lean is described as a business strategy which focuses on the flow efficiency rather than resource efficiency. With a strict focus on the flow efficiency an organization will most likely reduce the amount of unnecessary work, rework and scrap and thus eliminate waste. Modig and Åhlström discusses a process variation as a strong factor that prevents companies from reaching a state not far from the perfect state. To reach a perfect state is not possible due to the fact that there is always something that can be made better. Lean as a business strategy strives consequently to reach a perfect state through continuous improvements of eliminating, reducing and managing variation. Modig and Åhlström also mention that the term lean was created by scientists when observing Toyota and its efficiency and warns that it is not enough for a company to copy Toyotas work methods and call itself lean. Instead the importance of understanding why Toyota focuses on the flow efficiency cannot be emphasized enough. Only then can a company adapt the corresponding ideas and values to its organization.

3.2.1 5S

5S is a Lean tool that stands for sort, systematic arrangement, shine, standardize and sustain. 5S is used in order to enhance the teamwork and involves measures to reduce waste caused by mistakes and errors. It is often the last phase, sustain, that is the most difficult. The rest of the phases can only function if the sustain phase is satisfied. The sustain phase emphasizes the educations, exercises and rewards that is needed to keep the operators motivated to continuously improve the working methods and the workplace. This effort requires an engaged management, suitable educations and a culture making it a habit to support improvements, from the production lines to the management (Liker, 2009).

3.2.2 Genchi Genbutsu

Jeffrey Liker writes in the international best-seller “The Toyota Way” of a certain experience he had with some of the staff during his interviews at Toyota. On the question of what the difference between The Toyota Way and other styles of leadership is, the most common answer was genchi genbutsu, regardless on which division in the company Liker interviewed. Genchi genbutsu meaning going to the source to see what the actual situation looks like. What Toyota realized earlier than other companies was that it is not possible to fully understand an issue if one do not go to the source of the problem and examine it. Another word with a very similar meaning as genchi genbutsu that is even more popular is Gemba, with the meaning that the engineers must go to the manufacturing floor to understand the full impact of the problem, gathering data from all sources. Liker writes that the first step when solving a problem is to understand the actual situation.
3.3 Kaizen

Kaizen describes continuous improvement where both the management and the operators are involved. Kaizen is a compound word where kai means change and Zen means good. The kaizen philosophy assumes that our way of life, whether it is our working life, social life, or our home life, deserves to be constantly improved according to Masaaki Imai (1986).

Kaizen strives to minimize activities that don’t create value for customers and therefore is an unnecessary activity. Kaizen is not only for the company but works with the suppliers, workers, work environment etc. according to Masaaki Imai (1986).

To implement Kaizen, you need only simple, conventional techniques such as the seven tools of quality control together with tools such as Kanban, just-in-time, 5why etc. according to Masaaki Imai (1986).

3.4 DMAIC

DMAIC is a methodology used in six sigma projects. DMAIC stands for Define, Measure, Analyze, Improve and Control, see figure 2.

Figure 2: The different steps in the DMAIC methodology

3.4.1 Define

In the define phase a problem formulation is created and a preliminary calculation is established. The needs of the clients are determined and the underlying process is studied by a flowchart. Thereafter a planning schedule is maintained and a project plan is established in collaboration between the project manager and sponsor. The sponsor is a person financially sponsoring the project. It is important that the problem is well defined and understood by everyone involved. The problem formulation should reflect the customer needs. Tools such as tree diagram and flow diagram are used according to Lars Sörqvist & Folke Höglund (2014).

3.4.2 Measure

In the measure phase the projects critical dimensions are identified and measurement methods are developed and tested after which the data of the problem is collected. Six Sigma uses the mathematical function Y=f(x) where Y stands for the importance of the problems critical factors that should be improved and x stands for the various factors that affect the outcome of Y. In support for the measure phase sometimes failure-mode and risk analysis, shortened as FMEA, is used. This phase contributes to an evidence based improvement according to Lars Sörqvist & Folke Höglund (2014).
3.4.3 Analyze
In the analyze phase the problem is studied carefully. The underlying causes are identified and become a basis for effective problem solving according to Lars Sörqvist & Folke Höglund (2014).

3.4.4 Improve
In the improvement phase the problem is identified and solutions are determined. The solutions are thereafter tested and an implementation plan is developed. Finally the solutions are implemented. Successful implementation of solutions often involves influencing the employees attitudes according to Lars Sörqvist & Folke Höglund (2014).

3.4.5 Control
In the control phase the implemented solutions are made to standards. Necessary follow-ups are made to ensure that standards are maintained. Verification of the results and a final follow-up should be performed according to Lars Sörqvist & Folke Höglund (2014).
4 Process description and flow chart

Both the manufacturing process of the door panels and a flow chart is described in this section.

4.1 Process description

Manufacturing of door panels in IAC starts with a machine molding the frame to the door panels through the process of injection molding. To produce different shapes to various types of door panels, different tools are used in the injection molding machine. The injection molding machine is shortened as IMM in the remaining part of this report.

After the injection molding process it is time for the frame to go through the glue line. This step is needed due to the following process where the leather is glued on to the frame. Glue is sprayed on the surface of the frame by a machine. The glue is of the sort that it has a gluing effect when heated.

When glue has been sprayed on the frame it is time for the leather to be added to the frame. The frame is placed in a vacuum lamination machine where the leather is glued on the frame under the impact of heat. The leather molds to the frame due to the lamination machine pressing the leather against the frame. After the lamination process the frame is called a door panel.

Next step in the process is to cut clean the excess of leather from the door panel. This is a manual process conducted by operators according to the work instructions. It is thereafter placed on racks until needed in the pre-assembly. The door panel is positioned with its A-surface downwards on the fixture at the clean cut station. The A-surface refers to the side of the door panel that is most visible to the customer, while the B-surface suggests the opposite. For a better understanding of the A- and B-surface, see figure 3.

![Figure 3: The A-surface of a door panel is showed to the left, while the door panel to the right shows the B-surface](image-url)
during the pre-assembly and the welding process the A-surface of the door panel is positioned downwards against the fixture.

The last manufacturing step is the final assembly where the last parts are assembled by the operator according to work instructions. When the door panel is positioned in the fixture its A-surface is faced downwards against the fixture. Afterwards the door panel is placed on a line which goes straight to the quality control station. At the quality control station the door panel is examined both manually by the operator and automatically scanned for any defects. After this first control station the door panel moves on to the second and final control station before delivered to customer. Here the door panel is checked carefully by an operator according to work instructions. When the door panels are approved they are placed in racks and delivered to the customer.

In the next part a flow chart gives a detailed overview on the processes needed to manufacture door panels at IAC, see figure 4.
4.2 Flow chart

The numbers in figure 4 indicate the various process steps and an explanation to each step is described below.

1) Door frame storage: The door frames come from IMM delivered in containers.
2) Glue line: The door frames are picked up from the containers and manually put on the glue line.
3) Vacuum lamination machine: Door frames are manually picked up from the glue line and placed in the Vacuum lamination machine. At this station the leather is heated and glued on the door frame. The door frames are later on placed in racks. This step is from here on referred to as kashering. After this process the door frame becomes a door panel.
4) Clean cut: Door panels are picked up from racks and cut clean and placed on racks.
5) Rack: The door panel is stored while waiting for assembly.

6) Pre-assembly line: This is the first quality control station, door panel is picked up from racks, checked for damages and put on a fixture and assembled according to specification.

7) Ultrasonic welding: Door panel and loose parts from pre-assembly is welded and stored. This is an automatic process.

8) Final assembly: Door panel is picked up from racks and assembled according to specification and sent to quality control.

9) Quality control/Rework: Door panel gets a thorough overlook and scanned for defects, if necessary reworks are done. Complete door panels are put into racks.

10) Final quality control: This is an extra step which has been put in to minimize the amount of defective doors being delivered to customer.
5 Define

The following sections will be structured according to the DMAIC methodology, see section two for further information. This specific section defines and determines the information that this thesis work is based on.

5.1 Define the problem

To understand the problem of pressure marks and scratches, observations, interviews and a review of internal documents from the quality controls were conducted. Information about where the different damages emerge were collected through internal documents from the quality control stations, observations, and interviews with operators and experiments.

Figure 5 demonstrates a typical scratch. Scratches can easiest be described as damages that lead to a crack on the leather of the door panel. These types of damages can never be repaired. Scratches emerges primarily during the manual handling and movement of the door panels. It is extremely important that inspectors and operators notice this type of damage as early as possible to avoid adding value to door panels that will ultimately be scrapped.

Figure 6 shows a pressure mark. Pressure marks can to a large extent be repaired by heating the leather. The easiest way of describing a pressure mark is as an indentation on the leather. It is important that the operators understand what damages can be repaired and what types of damages cannot. If the operator is in doubt, further processing should be stopped and a controller with an understanding for rework is called in to assess the damage. It is not always the case that the operator understand what damages can and cannot be repaired and thus continuous to process the door panels.
5.2 Process map

A process map was created in order to get a good overview over the process and get an understanding for the different process steps. A process map can be made by creating a flow chart where a clear image of the process is obtained. The flow chart emphasizes aspects considered affecting a certain process step while the purpose with each process step is clarified. The process maps are found in appendix A.

The data that the process map is based on has been gathered through the use of interviews with operators, observations, experiments in the production line and with document studies such as work instructions.

5.3 Current situation analysis

In order to identify the most frequent aspects causing scrap and rework, data on the ongoing process was compiled. The data was gathered at two locations during the process that also are the quality control stations.

When the operator discover a defect on a door panel at the quality control station, notes are entered into the database. The notes contains information on the type of door panel, type of defect, what part of the door panel that is damaged, during which work shift and who discovered the defect. When a defect is detected it is the operator who decide whether the door panel can be reworked or if it is rejected as scrap. If the operator consider the door panel possible to rework, it is placed on specific racks. This tells the next operator that the door panel needs rework and prevents reporting the same defect twice to the database.

Figure 6: The red arrows indicates the location of a pressure mark
Figure 7 shows how pressure marks and scratches are the largest sources of scrap and rework and as mentioned earlier it is these types of defects that are emphasized in this report.

![Figure 7: Pareto chart on the types of defects](image)

Both figure 7 and 8 are based on data gathered during the period 2015-02-16 to 2015-04-06. In figure 8 an overview of the amount of pressure marks and scratches is shown per week during the studied time period.

![Figure 8: The number of pressure marks and scratches during week 8-14](image)

Although it seems like the amount of pressure marks has decreased slightly in figure 8 it is difficult to say for certain that pressure marks have decreased when they, in fact, increases during some weeks. The same argument applies for scratches with the only difference that the amount of scrap and rework caused by scratches seems to have increased during the time period.
The difference between the shifts has also been studied, but no significant difference concerning the amount of scrapped and reworked door panels caused by pressure marks and scratches were found.
6 Measure

This section presents gathered data that will be the basis for analysis in the next coming section.

6.1 Pressure marks

The define phase revealed that pressure marks emerge when something is pressing against the surface of the door panel. Pressure marks emerging on door panels can be separated into two types. The first type of pressure marks emerges in a specific area on the door panel and has an appearance as shown in figure 6. The second type of pressure marks emerges on various areas and has often a different appearance than the previous one, see figure 9.

![Figure 9: The red sticker indicates several pressure marks](image)

In order to identify aspects causing scrap and rework due to pressure marks, interviews with operators and observations were conducted. During this step experiments with scrapped parts were also conducted.

Observations and experiments showed that pressure marks mainly emerge during some process steps. Pressure marks arise from the handling of door panels in racks, handling of door panels during the clean cut, the pre-assembly and the ultrasonic welding process. Hence the two types of pressure marks can be linked to these process steps. Pressure marks with the appearance according to figure 6 are detected after the handling of door panels in racks. Pressure marks with the appearance like the one in figure 9 mainly arise during the rest of the process steps.
The issue with pressure marks could to a large extent be attributed to the operator’s execution in the case of a lacking supervision. The lacking supervision is primarily due to disregard and negligence with the operator’s execution and also due to the morale of the staff. Interviews with operators revealed that the lacking supervision may partly depend on the sometimes high production rate and the new staff. When the production rate reaches a higher level the operator needs to carry out his or her work during rush. This leads to the operators begin to handle the door panels in a careless manner which will make it more likely for a defect to emerge.

Lately the staff has grown which might be a contributing factor for the occurrence of pressure marks. The new staff is not as experienced as the original staff and will need time to learn the work process. This learning period will most likely lead to an increased frequency of pressure marks. In order to reduce the learning period, the training of new employees must be emphasized. Staff training on how pressure marks emerge and which stations are considered as risk zones, should lead to a fewer amount of pressure marks.

### 6.2 Scratches

To identify aspects contributing to scratches, brainstorming, observations and experiments were conducted, according to section 2.3. Five main causes were found as key contributors to scratches:

- Materials
- Method
- Equipment
- Operators
- Machine
These causes were broken down into even smaller factors. The causes presented in the fishbone diagram is described below, see figure 10.

**Materials:** Leather rolls are purchased from suppliers. The rolls might sometimes be defective. When this leather roll is applied to the door frame it will result in a scrapped door panel. The operators do sometimes take samples of the roll in order to check for defects, but they cannot investigate the entire roll in advance.

**Method:** How the operators comprehends work instructions and follow work instructions have a strong correlation on the amount of damages to the door panel. In some process steps operators do not follow the standard and scratches emerges. For instance, the operator should always make sure that no dirt comes between the door panel and the fixture. If the operator skips this step scratches will emerge. Following work instructions are also linked to production rate. High production rate will lead to operators being careless with the door panel and start differ from the work instructions. This will cause scratches.

**Equipment:** The problem is considered to be poor equipment in the form of fixtures which are difficult to clean at the clean cut station. The fixture has black foam inside to protect the door. Although the black foam is great for protection it tends to collect a lot of dirt. When pressure then is applied by the operator a scratch is inevitable. Both the foam and dirt have the same color making it hard for the operators to detect and separate dirt from the foam.

**Figure 10:** Identified causes that can lead to scratches
The fixtures at the pre-assembly are made out of gray plastic with rough edges. The edges sticking out scrape against the door panel and causes scratches. The fixtures are not product specific. This results in several different models of door panels needs to fit on one type of fixture. The non-product specific fixture and the A-surface of the door panel facing downwards, posts difficulty when parts are assembled. To assemble the speaker grill the operator needs to lift the door panel and place the grill. Often the operator applies pressure during this step which causes scratches, see figure 11.

![Image](image_url)

**Figure 11:** The red ring shows a speaker grill being assembled to the door panel

The racks used today have almost no padding which results in a bad protection of the door panels against the environment. This causes the door panels to press against each other both when placed inside and taken out of the racks which causes scratches.

**Operators:** The operator’s rough handling and understanding of the process are the main causes to scratches. The production rate contributes to the operator’s rough handling. When the production rate increases the operator starts to differ from the work instructions. As a high production rate causes more stress and carelessness the probability for a scratch to emerge increases.

**Machine:** The ultrasonic welding process applies pressure against the door panel, when placed in the fixture, which causes scratches. If the fixture contains any dirt a scratch will emerge due to the welding machine rods applying pressure against the door panel.

### 6.3 Gathered data

In order to understand where the various damages emerges each step of the process were checked. These observations were conducted over a period of two days. Each day
30 door panels of each type were checked. Appendix B shows the occurrence of damages on a specific type of door at each process step.
7 Analyze

In this section the data gathered in the Measure phase is analyzed. The purpose of the analyze phase is to answer the following questions:

- Where in the production does scratches and pressure marks emerge?
- Why does scratches and pressure marks emerge?

Pressure marks and scratches could be traced to the following five process steps: the clean cut, racks, pre-assembly, ultrasonic welding and the final assembly.

7.1 Clean cut

To the clean cut department the door panels come warm from kasher.ing. Warm door panels are easy to damage because the leather is soft and easily formed. Depending on the production rate there is a large number of door panels in the racks, see figure 12. If the production rate is high the operators are stressed and pulls often out the hot door panels from the racks quickly and carelessly which can lead to pressure marks.

Figure 12: Door panels placed in racks after the kashering
The operator puts the door panel on a fixture, according to figure 13. The fixture can be filled with small particles of dirt from previous door panels and plastic clips as shown in figure 13. The dirt combined with black foam makes it difficult for the operator to see the dirt which leads to pressure marks and scratches. When the operator begins to cut off excess leather with his knife he presses the door panel with the A-surface down. After the operator has removed the excess leather he needs to lift the door panel in and out of the fixture to assemble clips and glue the edges of the leather with the edge of the door panel. Lifting the door panel in and out can lead to pressure marks. As the operator uses his hands to move the door panels it can sometimes happen that he puts too much pressure or presses his nails into the door panel, which leads to pressure marks. This is primarily a problem when the door panel is hot.

7.2 Racks
After the clean cut the operator puts the door in racks, see figure 14. The racks have no or little padding on the inside. No padding makes the door panels easier to damage.
Reduction of scrap and rework on door panels

The racks can carry 14 door panels in total, seven on the upper section and seven on the lower section. The problem that arises is that the racks are designed in such a way that the operator must bend down to put the door panels in the lower section of the racks. As there is no or very little padding, the door panel is scraped from the door panel above and pressure marks are created. The front door panel has a plastic clip sticking out which can create a pressure mark on the door panel next to it, see figure 15.

![Figure 15: A plastic clip sticking out of the front door panel](image)

The constant use of the racks leads to dirt. As the door panels are pushed and pulled out from racks pressure marks and scratches are created, see figure 16.

![Figure 16: Dirt inside the racks](image)

### 7.3 Pre-assembly

Door panels are pulled out of racks and quality checked for any pressure marks or scratches. After the door panel has passed the quality control it is placed on a fixture with the A-surface down. The fixtures are not product adapted. All the door panels share a universal fixture. The universal fixture has protrusions that are sticking out, as
shown in figure 17. If the door panel is leaning against these protrusions and the operator apply pressure to it, pressure marks will emerge.

![Figure 17: The protrusions on the fixture](image)

In the pre-assembly parts are assembled according to customer specification. The assembly of some parts such as the armrests requires the operator to apply pressure against the door panel, or in some cases hammering in the part. If during this process the fixture is dirty or the door panel is incorrectly positioned, pressure marks and scratches will appear, see figure 18.

![Figure 18: An incorrectly positioned door panel](image)

### 7.4 Ultrasonic welding process

This process step begins with the operator picking up the door panel from the production line at the pre-assembly. The door panel is then placed in the welding machine fixture with the A-surface downwards and the welding process starts. Multiple rods from the welding machine apply pressure against the door panel to make sure that it does not move during the process. Thereafter it is time for the machine to weld together certain details on the door panel. When the welding process is finished the door panel is automatically moved to a table where it becomes available for the operator at the final assembly.

From the welding process, three causes that leads to pressure marks and scratches has been identified. Some of these causes emerge due to the operator’s execution while
other depend on the automated process. The first identified cause during this process step emerge when the door panel is placed in the welding machine fixtures. It is the sharp metal edge, shown in figure 19, which can cause problems.

If the operator chooses to follow the work instructions the sharp metal edge should not be a problem and no scratch is going to appear. The fixture in the welding machine is also shaped in a certain way, making it possible for the door panel to be placed in one way only. However, it is the step when the door panel is placed into the fixture that can result in a scratch. If the operator’s execution differs from the standardized working methods and he instead conducts work according to his own preferences the possibility for the operator to scratch a door panel increases. The occurrence of a scratch on the door panel can also be caused by negligence from the operator or stress when the production rate is high.

The second identified cause that can lead to a defect emerges if there is small pieces of plastics or other particles on the fixture that the door panel is placed on, see figure 20.

If the operator is not aware of this it will lead to the appearance of pressure marks. A pressure mark will appear when the welding machine rods apply pressure against the door panel and push it against the pieces of plastics in the fixtures. Experiments in the...
fixtures were carried out with a scrapped door panel. Small pieces of plastics were spread out over the fixture after which the door panel was positioned. Pressure was then applied to the door panel in order to simulate the pressure from the welding machine rods against the door panel. Although the manually applied pressure against the door panel presumably was of a lower magnitude than the automated pressure it still generated pressure marks on the door panel.

At the welding station there is an air gun that is supposed to be used by the operator for cleaning the fixtures from small pieces of plastics and other dirt. Conducted observations showed that this tool was used too rarely despite the fact that small pieces of plastics often were found on the fixtures. What this depends on can be discussed, but is basically about the operator lacking knowledge about the process and especially about how easy it is for a pressure mark to emerge.

The third cause that can lead to damages on the door panel is when the door panel is placed on the table after the welding process, according to figure 20. In an attempt to reduce the amount of damages a thick foam layer has been glued on the table. This has been done in order to avoid the door panel from being placed on a hard surface. A hard surface will lead to increasing pressure marks and scratches if pieces of plastics or other dirt appears on the surface. When the door panel is placed on the soft surface, possible pieces of plastics and particles of dirt, sinks down and defects to the panel are avoided.

It is not always small pieces of dirt that are lying on the tables foam layer. In connection with observations, large pieces of plastics were found on the soft foam layer which is shown in figure 21.

![Figure 21: A piece of plastics was found on the soft surface](image)

In order to assess whether pieces of this size could damage the door panel, experiments were conducted using a scrapped door panel. The plastic piece in figure 21 was left lying on the soft surface while a scrapped door panel was placed over it. Earlier observations on how the operator picked up the door panel from the table had shown that instead of lifting the door panel some operators pulled it across the table. Both these approaches were used in the experiment. When the door panel had been lying on a piece of plastic and then lifted away from the table, small pressure marks were created. Respectively, scratches appeared when the door panel was pulled across the table.
7.5 Final assembly

When the door panel has been placed on the table after the welding process it is time for the operator at the final assembly to pick it up. The operator places the door panel with the A-surface downwards on a fixture at his station where the assembly of the last details begins. In order to prevent the door panel from moving during the assembly there is an arm that the operator manually pushes against the door panel and locks in a certain position. The operator can now start the final assembly of the door panel. After this process step the fully assembled door panel is placed on a line that transports it straight to the final quality control.

Several conducted observations at this station showed that fixtures usually are kept clean from small pieces of plastics and other dirt. This means that when the door panel is placed on the fixture there is often no pieces of plastics that gets between the door panel and the fixture and presses against the door panel. This leads to that the number of emerging pressure marks and scratches are lower at the final assembly than other stations.

As it is easy to damage a door panel it was interesting to study the impact the pieces of plastics on a fixture have on a door panel. Experiments were conducted and pieces of plastics were spread out over the fixture. A scrapped door panel was placed on the fixture and the arm at the station was pushed against the door panel to hold it down. In order to simulate the pressure the operator applies when he assembles the various parts, a manual pressure was applied. The result showed that this experiment caused small pressure marks on the door panel. This means that the final assembly is not a completely safe process. In order to reduce emerging damages it is important that the operator continues to keep the fixtures clean.

The experiment also showed that if the door panel is subjected to a higher pressure than normal, pressure marks emerges at areas near the edges of the fixtures. Thus, at higher pressure against the door panel the fixture contour can cause pressure marks. These damages can emerge when the assembly of some parts malfunctions and the operator tries to assemble them in a rough manner. But these damages can also emerge when the door panel is handled in a careless way by the operator.

7.6 Final quality control and extra quality control

Both damaged door panels that already have been noticed, and complete door panels are transported together to the final quality control. At this station operators that specializes in reworking have the task to repair door panels and scrap those that cannot be repaired. This is a matter of an assessment that operators at the rework station are trained for in order to distinguish door panels that can be repaired from those who cannot.
Complete door panels are taken care of by operators who first manually checks them for damages and ensures that all parts are assembled correctly. In the next step there is an automatic process that scans the door panel in order to detect any kind of damage. Once the door panel has passed this step it is placed on racks which in turn is transported to the extra quality control. At the extra quality control the door panel is investigated according to work instructions. This is done in order to avoid that a defective door panel is delivered to the customer. The door panels that have passed the extra quality control are delivered to the customer.

Both the final quality control and the extra quality control have almost identical purposes and very similar work instructions. Conducted observations has therefore resulted in the same causes being identified for the two stations. It should be mentioned that at these stations the operator has few activities that needs to be carried out. This means that the probability for a defect to emerge at these stations is lower than at other stations. It is during the handling of door panels that defects can emerge. Figure 22 shows how several door panels are not correctly placed in the racks. This happens both at the final quality control and at the extra quality control and is the cause of defects at these stations. An interesting observation showed that the racks delivered to customers have the same problems as the ones mentioned in section 7.2.

Interviews with operators were conducted in order to find out why some door panels are not correctly placed in the racks. The answers showed that the door panels were placed in this way so the operator could keep track of which door panels that had and had not been controlled. By placing the door panels like this exposes them. Thus, the probability for a defect to emerge which leads to a damage on the door panel increases.

Figure 22: Not correctly placed door panels
8 Improve

This section presents the suggested improvement measures that the thesis work have resulted in.

In the define phase scratches and pressure marks stands for 59 % of all damages. The previous section showed that pressure marks and scratches mainly emerge at the clean cut station, the racks, the pre-assembly and at the ultrasonic welding process. Short term and long term measures have been recommended at each of these stations. It should be mentioned that IAC should have a vision to strive towards minimizing the manual handling of all process steps.

8.1 Clean cut station

The define phase showed that scratches were estimated to 26 % of the total amount of defects. Through observations and experiments it appeared that this type of defect almost exclusively emerge at the clean cut station. Also pressure marks emerges at this station. Pressure marks emerges at several places during the process of manufacturing of door panels. It is though only a small fraction of the total amount of pressure marks that emerges at the clean cut station. Pressure marks emerging here often have a similar appearance as shown in figure 9.

Previous steps have shown that defects emerging on the door panel at this station depends on the following causes:

- Untidy working station
- The operator does not have an understanding of the process
- Production rate
- Experience

To address these causes and thus avoid scratches and pressure marks from emerging IAC must review the working stations at the clean cut station. Figure 13 shows how the working stations look like at this stage. Clips, tools and other dirt lie on the fixture that the door panel is placed on. At a closer inspection of the working station clips, cutting blades and other dirt have been found in the black foam on the fixture. It is when these details ends up in the black foam that defective door panels emerges. For a deeper understanding of the clean cut station, see section 7.1.

8.1.1 Short-term measure

A short-term measure to solve the problem is to introduce and implement 5S, as described in section 3.2.1, at the working station. In order to avoid scratches and pressure marks from emerging at this station the authors believe that the fixture should only be used as such. It should not be used as a storage for clips, tools and other details. The short-term measure suggests therefore that the fixture should be kept clean from the mentioned details. Clips, tools and other details should be placed in small blue
plastic boxes suspended next to the fixture. If this is implemented IAC has both managed to sort and systematize. This leads to that fixtures are kept clean and tools as well as other details are still easily accessible to the operator. A vacuum cleaner should also be assembled at the clean cut station. The operator should in the beginning or end of the shift use the vacuum cleaner to clean the fixture from pieces of plastic. When these steps have been implemented it is time to standardize and sustain the new improved work approach.

8.1.2 Long-term measure

A long-term measure is to increase the employees awareness concerning the process. TQM suggests it is important to involve the operator in the continuous improvement work, in order to maintain an increased quality level. The operator should therefore be informed of how easy it is to cause a scratch or a pressure mark on the door panel. Further the operator should also be informed of what might cause these damages. When the operator has obtained basic knowledge of the process it is possible to strive to continuously improve the process, also known as kaizen. This can be achieved by the working group at the clean cut station having a workshop at the end of the week. During these workshops the working group goes through positive things happened this week and things that can be improved. Which type of damage that has been most frequent during the week should also be on the agenda of the workshops. The operators are then given the opportunity to get involved in the improvement work as they try to come up with an action that could improve the work process as well as reducing the occurrence of damages. At the end of the next coming week the suggested improvement measure should be evaluated. If the amount of defective door panels has decreased then the suggested measure should be implemented and standardized.

These types of workshops are already held at IAC and involves managers, engineers, etc. The information during these workshops are often not communicated to the rest of the employees which contributes to a gap of information between the employees and the management. A continuous improvement depends according to lean production on the communication, see section 3.2. In case workshops involving the working group at the clean cut station are implemented, the employees will feel more involved in the continuous improvement work. This will lead to the employees making an effort to develop an improvement measure. The authors believe that this will lead to that the employees increasingly get involved in the improvement work and thus start to conduct their work to strive towards a continuous improvement. In this way, the issues that the management are keen to solve will have reduced due to the regular workshops in the working groups.

8.2 Racks

Suggested measures regarding the racks are described below.
8.2.1 Short-term measure
To reduce pressure marks and scratches in the racks operator should only use padded racks for the door panels. The padded racks are less likely to damage the door panels. Operators should be informed through workshops on how to insert and remove the door panels to minimize damages. For instance the operator should lift the door panel in and out of the racks instead of pushing and pulling. Through this two measures the total number of scratches and pressure marks will decrease.

8.2.2 Long-term measure
In the long term the racks needs to be modified. Pressure marks and scratches emerge even in the padded racks. The problem is as discussed before, the upper door panels are pressing against the lower door panels. The new racks should have more space between the upper and lower section. Padding between the upper and lower sections needs to be improved. By having thicker padding between the sections, the door panels will not be damaged during transport. The front door panels are scratched on the underside when pressed against the edge of the racks, see figure 23. Through a thicker padding, this problem will decrease.

Figure 23: The figure shows how the front door panel is scratched on the underside

Dirty racks are a problem that causes pressure marks and scratches. Racks are cleaned when needed. Sometimes the operator has time and sometimes there is no time to clean. The authors believe that an elaborated schedule and standard for cleaning the racks would lead to less damage on door panels. The racks which are used today are gray. The dirt having the same color as the racks makes it difficult for the operator to detect dirt which can cause damages. Dirt can easily be seen on a white surfaces. The recommendation is therefore to modify racks to a brighter color.
8.3 Pre-assembly

Suggested measures regarding the pre-assembly are presented below.

8.3.1 Short-term measure

Operators need to be informed on how to position the door panels through training in order to reduce pressure marks. Since the A-surface is facing downwards pressure marks and scratches easily emerges during this process step. The information should focus on how the operator should place the door panel to ensure that the door panel is correctly positioned.

Black foam is placed on the edges of the fixture to avoid pressure marks, see figure 24. This helps to some extent. Almost none of the fixtures for the studied door panels have foam on the protrusions. The black foam provides a cushioning effect against the door panel and fixture, leading to a reduced number of pressure marks and scratches.

![Figure 24: The red circle shows how foam is placed on the protrusion](image)

8.3.2 Long-term measure

Instead of having one universal fixture to several car models, more product specific fixtures should be purchased. The A-surface is faced downwards which easily leads to pressure marks when the operator assembles the different parts. To reduce damages caused by pressure marks and scratches the A-surface should be faced upwards when new fixtures are ordered. Figure 25 shows how to different models of door panels are manufactured. The ones with the A-surface upwards does not have as much pressure marks as the studied door panels. Lesson learned from the current fixture should be used when new fixtures are ordered. Fixtures should be designed so that parts can be assembled with the A-surface upwards.
A vacuum cleaner has been purchased and the operator should assess if cleaning is needed. Sometimes there is small plastic parts that are easy to miss. If missed, these small plastic parts can lead to pressure marks and scratches. Therefore a schedule and a standard for cleaning should be created. By keeping the fixtures clean the risk of pressure marks and scratches will be reduced.

**8.4 Ultrasonic welding process**

Both observations and gathered data have shown that pressure marks emerges at the welding process. In section 6.1 two different types of pressure marks were described. At this station pressure marks as shown in figure 9 emerges. The appearance of these type of pressure marks emerge when there is dirt on the fixture that the door panel is placed on. When the welding machines rods pushes the door panel against the fixture, dirt and small pieces of plastics are pressed against the door panel which causes pressure marks.

**8.4.1 Short-term measure**

IAC has already put a measure into action in order to reduce the occurrence of pressure marks at this station. Next to the welding machine there is an air gun that the operator is supposed to use to clean the fixture from dirt. As mentioned in the analysis, observations showed that this tool was seldom used by the operator. In order to increase the operator’s awareness regarding the process he needs to be informed in the same way as was described in section 8.1.2. The operator needs to learn how easy pressure marks emerges at this station and also what might cause these damages. Only when the operator fully understands the process, he will frequently start using the tool to clean the fixture.

Regarding the air gun the author believes that it is not the most ideal tool. Although it blows dirt off the fixture, the dirt will not disappear but end up elsewhere. It would
therefore be more convenient with a vacuum cleaner which sucks up the dirt of the fixture. This would lead to eliminating dirt.

8.4.2 Long-term measure

For a long-term measure IAC can investigate the automatic process of the welding machine. It would be of interest to study how large forces the machine rods apply to the door panel and especially how large forces that are needed. The smaller the applied force is the less is the probability for a pressure mark to emerge. Another interesting thought is if the door panel is placed in a fixture and cannot move during the process. Why is it then necessary for the rods to push down the door panel and hold it still? To be able to answer these questions IAC needs to investigate the automatic process of the welding machine.

8.5 Summary of suggested measures

The following short-term measures have been suggested:

- Implement 5S at the clean cut station
- Use padded racks only
- Increase the operators awareness regarding the causes of why damages emerge during the pre-assembly
- Install a vacuum cleaner at the ultrasonic welding process and inform the operator of the importance of using this tool

The following long-term measures have been suggested:

- Increase the awareness of the operators at the clean cut by introducing workshops
- Modify the racks used today
- Replace the universal fixtures with specific fixtures to each type of door panels. The new fixtures should be designed so the A-surface will not come in contact with the fixture
- Investigate the automatic process of the ultrasonic welding machine.
9 Discussion

In this section the chosen method approach and the results are discussed.

9.1 Method approach

In the methodology chapter it is described that the thesis will be conducted as a case study for research strategy. In a case study several different types of studies are done in order to find the root cause. The problem with this kind of approach is that all the data is not reliable. By talking to operators a lot of information can be received quickly, but this information is not always correct.

Data that the company itself have gathered for damaged door panels have been used as a basis for this thesis. The quality controller that has been given a special training follows strict standards. In this training the controller gets an understanding of what is an approved door panel and what should be classified as a defect. The problem is that the controller is human and sometimes might fail to identify a defect. This means that some door panels will not be identified as damaged by controller. The data will in this case show a better result than reality. This can also have a reverse effect. The quality controller might reject a door panel which should be approved. This will also lead to misleading data.

The authors have not been able to study the automatic process of the ultrasonic welding process. Data on what magnitude the rods presses against the door panels have not been accessible. If data were accessible it would be interesting to analyze whether the rods applies unnecessary amount of pressure on the door panels. If this is the case then today’s amount of scrapped door panels due to the welding process could be fewer.

9.2 Validity and reliability

In order to prove validity and reliability through the thesis, primary data has been collected. In most cases authors themselves performed the measurements and have been able to choose the measuring method with regard to reliability and validity. Measurements have been conducted during the same day with the same staff to get an accurate overview as possible.

The current situation analysis is considered to have some deficiencies. The data, as discussed in the previous section, is collected by the company. As mentioned earlier, the controller might fail to detect damages which makes the current situation better than the reality. However the authors have made their own measurements to provide an accurate view of the problem.

Tests which have been conducted gave indications of where pressure marks and scratches emerges. The problem with these tests is to determine how much pressure the door panel is exposed to. The pressure often varies from operator to operator.
10 Conclusions

The causes that have been identified as the reasons to the large amount of scrap and rework on door panels emerge at several places during the production process. They emerge mainly between the clean cut station and the ultrasonic welding process. Small pieces of plastics on fixtures, the operator’s rough handling and specific process steps are the main causes resulting in pressure marks and scratches. To reduce the amount of pressure marks and scratches the authors recommend both short-term and long-term measures. Some of the measures are:

- Use vacuum cleaners at some stations
- Add padding on unpadded areas and edges
- Make new instructions that emphasize to keep production stations clean and to avoid rough handling
- Introduce workshops to engage operators

10.1 Future work

During this thesis work interesting discoveries that causes scrap and rework on door panels have been identified. As time was limited the authors were forced to limit the thesis. Thus, it would be interesting to study other models of door panels and investigate whether pressure marks and scratches are as common as the already studied door panels.

The thesis does not include the Control phase of the DMAIC-cycle. In the Control phase the recommended improvements are implemented. The first step for a future work is to implement the suggested improvements and to follow-up and investigate whether it has resulted in a reduction of scrapped and reworked door panels due to pressure marks and scratches.

The magnitude of pressure that the ultrasonic welding machine rods applies have not been studied due to accessibility. The magnitude of the pressure should be studied and the minimum pressure required should be determined. If the pressure is of a higher magnitude than necessary, pressure marks that could have been avoided will emerge. If the magnitude of the pressure can be decreased the pressure marks and scratches will be reduced.
References


# A. Process maps

## Manufacturing and clean cut of the door panels

<table>
<thead>
<tr>
<th>Information</th>
<th>CTQs (critical to quality)</th>
<th>Instructions</th>
</tr>
</thead>
</table>
| Process: Kashering and clean cut | • The products form  
• The products appearance  
• The products assembled parts | 1. List all CTQs  
2. Divide the process into various steps  
3. Type each steps input to the left  
4. Type each steps output to the right |

### Input variables:  
What has an impact on the output variables in this step?  
- Handling of frame  
- Placement of frame in fixture  
- Assessment of the frames position in fixture  
- Particles of dirt on the frame  
- Machine settings  
- Quality of the leather material

### Output variables:  
What do we expect from this step?  
- Glue is applied to the frame

### Process Map

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Input variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Door frame is placed in fixture and glued</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Door frame is placed in machine and leather is pressed on to the frame</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Door frame is placed on a table and cut clean</td>
<td></td>
</tr>
</tbody>
</table>

## Pre-assembly and welding of door panels

<table>
<thead>
<tr>
<th>Information</th>
<th>CTQs (critical to quality)</th>
<th>Instructions</th>
</tr>
</thead>
</table>
| Process: Pre-assembly and welding | • The products form  
• The products appearance  
• The products assembled parts | 1. List all CTQs  
2. Divide the process into various steps  
3. Type each steps input to the left  
4. Type each steps output to the right |

### Input variables:  
What has an impact on the output variables in this step?  
- Handling of door panel when pulled out from racks  
- Clean fixture  
- The operators’ interpretation of the work instruction  
- The operators’ execution when placing door panel on fixture

### Output variables:  
What do we expect from this step?  
- Placing door panel on a fixture

### Process Map

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Input variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Door panel is taken out from racks and placed on a fixture</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Assembling specified parts on the door panel</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Welding the assembled parts</td>
<td></td>
</tr>
</tbody>
</table>

- Pressure from the axes of the welding machine  
- Cleaned fixture  
- Assessment of the door panels position in fixture

- Parts are assembled to the door panel  
- Door panel and assembled parts are welded together
### Process Map

<table>
<thead>
<tr>
<th>Information</th>
<th>CTQs (critical to quality)</th>
<th>Instructions</th>
</tr>
</thead>
</table>
| **Process:** Final assembly, final- and extra quality control | • The products form  
• The products appearance  
• The products assembled parts | 1. List all CTQs  
2. Divide the process into various steps  
3. Type each steps input to the left  
4. Type each steps output to the right |

<table>
<thead>
<tr>
<th>Input variables: What has an impact on the output variables in this step?</th>
<th>Step</th>
<th>Output variables: What do we expect from this step?</th>
</tr>
</thead>
</table>
| • The operators’ execution of the work instruction  
• The operators’ interpretation of the work instruction  
• Placement of door panel in racks | **Step 7**  
Assembling the last parts to the door panel | • A complete door panel |

| | **Step 8**  
Check the door panel for defects | • Control that the door panel meets the requirements |
|---|---|---|
| • The operators’ interpretation of the work instruction  
• Placement of door panel in racks | **Step 9**  
Check the door panel for defects | • Detect defective door panels before delivered to customer |

---

**Reduction of scrap and rework on door panels**

Appendix A.2
## B. Observations data

<table>
<thead>
<tr>
<th>Process step</th>
<th>Amount of checked door panels</th>
<th>Amount of defects</th>
<th>Type of defect</th>
<th>Type of door</th>
<th>Area of defect</th>
<th>Upper racks compartment</th>
<th>Lower racks compartment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Right front</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Left front</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Right back</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Left back</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kashering</td>
<td>240</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clean cut</td>
<td>240</td>
<td>46+1</td>
<td>Pressure marks/Scratches</td>
<td>8</td>
<td>15</td>
<td>13</td>
<td>11</td>
</tr>
<tr>
<td>Racks (not padded)</td>
<td>240</td>
<td>64</td>
<td>Pressure marks</td>
<td>15</td>
<td>19</td>
<td>13</td>
<td>17</td>
</tr>
<tr>
<td>Racks (padded)</td>
<td>240</td>
<td>22</td>
<td>Pressure marks</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Pre-assembly</td>
<td>240</td>
<td>28+3</td>
<td>Pressure marks/Scratches</td>
<td>12</td>
<td>10</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Welding</td>
<td>240</td>
<td>22+2</td>
<td>Pressure marks/Scratches</td>
<td>8</td>
<td>5</td>
<td>7</td>
<td>4</td>
</tr>
</tbody>
</table>