Design study of

Designstudie av

**SUBJECT:** Mechanical Engineering
**AUTHOR:** Alfred Smith & Jari Oikarinen
**SUPERVISOR:** Daniel Hegestrand
**JÖNKÖPING** 2018 May
This thesis has been carried out at Jönköping University, School of Engineering, in the subject area of Mechanical Engineering. The authors answer themselves for opinions, conclusions and results.

Examiner: Johnny Tran
Supervisor: Daniel Hegestrand
Scope: 15 credits
Date: 2018-05-28

Mailing address: Box 1026 551 11 Jönköping
Visiting address: Gjuterigatan 5
Phone: 036-10 10 00 (ex)
Abstract

This bachelor thesis in product development and design, done at Jönköping University in collaboration with Husqvarna AB, Jari Oikarinen and Alfred Smith performed the design study.

Lastly, further work is recommended based on this report.
Sammanfattning

Detta examensarbete inom produktutveckling och design, genomförd på Jönköping University i samarbete med Husqvarna AB, Designstudien är utförd av Jari Oikarinen och Alfred Smith.

Slutligen rekommenderas ytterligare arbete utifrån denna rapport
# Table of Contents

1 Introduction ........................................................................................................................................1
  1.1 Background ....................................................................................................................................1
  1.2 Problem description ....................................................................................................................1
  1.3 Purpose & aim .............................................................................................................................4
  1.4 Delimitations .............................................................................................................................4
  1.5 Disposition ....................................................................................................................................4

2 Theoretical framework .......................................................................................................................5
  2.1 Connection between aim and theory .........................................................................................5
  2.2 Product development ................................................................................................................6
    2.2.1 Product development in a construction perspective .........................................................6
    2.2.2 The development process ..................................................................................................6
  2.3 Design process ...........................................................................................................................7
    2.3.1 Bootcamp Bootleg .............................................................................................................7
    2.3.2 Swedish Industrial Design Foundation (SVID) .................................................................7
  2.4 Handle design from an ergonomic perspective .........................................................................8
  2.5 SolidWorks ..................................................................................................................................9

3 Method ..............................................................................................................................................13
  3.1 Connection between aim and method .......................................................................................13
  3.2 Gantt chart ..................................................................................................................................13
  3.3 Design study ................................................................................................................................13
  3.4 Data collection .............................................................................................................................14
  3.5 Market analysis ............................................................................................................................14
  3.6 Function analysis ..........................................................................................................................14
  3.7 Brainstorming ............................................................................................................................14
  3.8 Requirement specification ............................................................................................................14
  3.9 Concept evaluation .......................................................................................................................14
    3.9.1 Gut feel ...............................................................................................................................15
    3.9.2 Pugh matrix .......................................................................................................................15
  3.10 CAD-modelling ........................................................................................................................16
1 Introduction

This report provides a design study for a[deleted]. The following work is a bachelor thesis done in collaboration with Husqvarna AB. This chapter describes the background, problem description, purpose and questions, delimitations and disposition.

1.1 Background

Husqvarna AB is a company with a long history of product development. The company has been in operation since 1689, initially manufacturing guns. Over the years Husqvarna evolved to produce a variety of different products such as sewing machines, bicycles, motorbikes et cetera [1]. Today Husqvarna has shifted towards products for forest, park and garden maintenance, e.g. chainsaws, trimmers, Automowers and more. [2]

[3]

1.2 Problem description
Figure 2: [4]  

- Item 1
- Item 2
- Item 3

Figure 3: [4]
1.3 Purpose & aim

1.4 Delimitations

1.5 Disposition

This study begins with the “Introduction”, describing background and aim. “Theoretical framework” is the following chapter with theoretical basis for the thesis. The next section is “Method” with modes of implementation, approach and data. The Method section leads to a description of “Implementation”. Last of the main chapters are “Results,” forming the analysis, discussion and finally the conclusions. The report ends with the reference list and attachments.
2 Theoretical framework

The following section explains the theoretical basis of the work.

2.1 Connection between aim and theory

To provide a theoretical background for the assigned task, different theories regarding product development and design processes are examined, both from a designer’s and engineer’s point of view. Also, the internal components are reported to further educate the reader about [5].

<table>
<thead>
<tr>
<th>Theory</th>
<th>Question formulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2.2.1 Perspectives of construction</td>
<td>x</td>
</tr>
<tr>
<td>2.2.2 The development process</td>
<td>x</td>
</tr>
<tr>
<td>2.3.1 Bootcamp Bootleg</td>
<td>x</td>
</tr>
<tr>
<td>2.3.2 SVID</td>
<td>x</td>
</tr>
<tr>
<td>2.4 Handle design from an ergonomic perspective</td>
<td>x</td>
</tr>
<tr>
<td>2.5 SolidWorks</td>
<td>x</td>
</tr>
<tr>
<td>2.6</td>
<td>x</td>
</tr>
<tr>
<td>2.7.1</td>
<td>x</td>
</tr>
<tr>
<td>2.7.1.1</td>
<td>x</td>
</tr>
<tr>
<td>2.7.2</td>
<td>x</td>
</tr>
<tr>
<td>2.7.3</td>
<td>x</td>
</tr>
</tbody>
</table>

Figure 4: Chart illustrating the connection between theories and question formulation.

2.2 Product development

Product development is a collective term for the development of different products. By identifying who the user is and what problem to solve, one can identify how a product is appropriately designed. The company’s primary purpose is to develop products that generate money back to the company. [5]

In the creation of any product, at least two professions work closely together, i.e., engineers and designers. The engineers are responsible for technical features of the product, while the designers are responsible for the appearance and design. Considering the need of the user, regarding likeability, function and ease of use. The collaboration between designers and engineers has become increasingly important in recent decades in the development of a new product. [5]
2.2.1 Product development in a construction perspective

In Sweden, the word design refers primarily to aesthetics and some aspects of function. In English-speaking countries, it is associated with the development of products and depending on the context it can be divided into two different meanings; engineering design and industrial design.

Engineering design can translate into construction during development. Measurable technical properties of the product such as material and geometry properties are part of engineering work. The industrial design differs more and focuses on the product’s colour, design and identity. A simple and precise definition of the word design is not easy to find, consequently “design” has different meanings in different contexts. [5]

Construction became an independent activity with the transition from craft work to industrial production during the industrial revolution. The design impacted the function and the production and vice versa. To divide these, one could focus more on each area. The constructor’s task then was to draw up drawings and solve technical challenges that arose, which today can be linked to what is called industrial designs. Previously, the designers used drawing boards. Today, 3D-CAD has replaced paper and pencil. The role of the designer has changed to include a broader perspective such as environment, project management and strategy, et cetera. Contemporary designers are highly educated in mathematics and aspects of mechanics, just to mention a few skills a designer needs to master. [5]

2.2.2 The development process

The process of construction and design arise from a need and ultimately, leads to a user’s acquired product according to H. Johannesson, J-G Persson and D. Pettersson, Figure 5.

Figure 5: The development process according to the book “Produktutveckling - Effektiva metoder för konstruktion och design.” translated to English. [6]

By studying figure 5, one can see an interaction between the different process steps. The boxes represent activities and balloons are the results. Requirement specification, concept model, prototype model and manufacturing basis are all common information carriers that have been placed outside the activities. The specification of requirements begins with the preparation of a solution concept. This is evaluated to find out if it meets the set of requirements. Once approved and fulfilled, one would continue with a handful of ideas that are further developed, until the concept achieves an appropriate level of detail. Subsequently a prototype is made for further and repeated testing and analysis and eventually industrial manufacture if feasible. Product development is divided into two types, new products and further development. Further development accounts for the majority of new projects in industry’s product development processes since it uses existing and known solutions. New development enters unknown territory, e.g. innovative solutions not seen before which is sometimes needed to solve a specific problem or just emerging from true ingenious innovation. [7]
2.3 Design process

Bootcamp Bootleg and SVID (Svensk Industridesign) are two design processes used in product development. These processes suggest how to, in a systematic order, promote design as a competitive feature in product development. [8][9]

2.3.1 Bootcamp Bootleg

Bootcamp Bootleg is a design process in five steps, produced by the Stanford University of Design. These five steps are “Empathize”, “Define”, “Ideate”, “Prototype” and “Test”. The first and introductory step “Empathize” can be described by trying to understand the user placing the user in the centre of the product. Observation and interview are methods that are used in this step.

Furthermore, the data collected from the methods above need to be analysed, which leads us to the second step in the process, “Define”. By collecting data from observations and interviews, one can identify the requirements to meet the purpose of the product.

The third step in Bootcamp Bootleg is “Ideate”. Ideate is working with different techniques of brainstorming. To let many different ideas flow freely, flow of thoughts and ideas not restricted to whether the ideas are realistic and doable for the project in the end. Focus lies in solving the problem that previous data compiled.

Once a screening from the third step is done, one can proceed to the prototype. “Prototyping” is the fourth step in the process and involves making a physical model that gives a feel for the product and provides decision support. Going from sketch to model where one can physically visualize the product facilitates the process.

The process final step, “Test” is to test prototypes to find concepts and prototypes that pass the set requirements. The aim is to find a solution that works as intended. [8]

2.3.2 Swedish Industrial Design Foundation (SVID)

SVID (Sveriges Verkstadsindustri), which is an abbreviation of the Swedish workshop’s industries, is founded on behalf of the Swedish government to strengthen Swedish industry through industrial design. A designer's primary task is to use methods for collecting and understanding the user's needs. Then, the information converts into products.

SVID uses a seven-step process to inform about each area in its design process. "Starting points" cover areas such as technical, economic and human resources and must be defined first to create right conditions for continued work. Then studies considering need and function from a user perspective are performed and analysed.

The evaluation of the collected information goes to step three "Concepts and visualization." In this phase, the data is transformed into one or more concepts. Testing and analysis of the concepts follows to validate that the requirements are within the framework. Further development of concepts is prepared to put the proposals against each other.

The fifth step in the process is “Adjustment and Implementation”, which involves staff with various expertise within the company. Along with the production, the concept must be evaluated to determine if it is ready for manufacture. When all questions have been answered, it is time to consider manufacturing. That is the sixth step in the process.

The seventh and final step in SVID’s design process is “Follow-up and Evaluation”. This step occurs after production has started and has a purpose of evaluating that everything works. User studies and further tests are also conducted within this step. [9]
2.4 Handle design from an ergonomic perspective

A good handle design is an important part when developing a new hand operated product. It should be safe to use, attractive and effective for the user. The design of today’s handles is usually too small, sharp or misplaced to the user. This causes the product to be used incorrectly and the risk of injury. According to M. Patkin’s publication “A Check-List for Handle Design”, a checklist of 13 criteria is described to facilitate the design of all hand products. [11]

This list includes:

1. Size
2. Shape
3. Surface
4. Security
5. Stiffness
6. Sitting
7. Surroundings
8. Signify function
9. Sensing features
10. Storage
11. Special other features
12. Skill needed
13. Validating design

The length of a handle should be at least 100 to 150 millimeters to fit the palm of the hands on the majority of the population [11]. The thickness of the handle where the thumb overlaps the middle finger should be 20 to 38 millimeters in diameter [12].

Figure 6: Swedish Industrial Design Foundation (SVID) seven-step process translated to English. [10]

Figure 7: Different sizes for the handle circumference. [11]
2.5 SolidWorks

SolidWorks is a computer application that helps the user to simulate, create and manage three-dimensional models. The program helps to manage complex geometries and are widely used by designers. SolidWorks can also handle sustainability calculations and simpler renderings. [13]

2.6

2.7

2.7.1

Figure 8: [15]
2.7.1.1 see Appendix 2.

Figure 9, see Appendix 3.

figure 9

Figure 9: [15]
2.7.2 see figure 10.

Figure 10: [15]
Theoretical framework

2.7.3 see figure 11.

Figure 11: [15]
3 Method

The following chapter describes which design methods were the basis for the concept study.

3.1 Connection between aim and method

To facilitate the link between aim and methods, these are illustrated in figure 12.

<table>
<thead>
<tr>
<th>Method</th>
<th>Question formulation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>3.2 Gantt chart</td>
<td>x</td>
</tr>
<tr>
<td>3.3 Design study</td>
<td>x</td>
</tr>
<tr>
<td>3.4 Data collection</td>
<td>x</td>
</tr>
<tr>
<td>3.5 Market analysis</td>
<td></td>
</tr>
<tr>
<td>3.6 Function analysis</td>
<td></td>
</tr>
<tr>
<td>3.7 Brainstorm</td>
<td></td>
</tr>
<tr>
<td>3.8 Requirement specification</td>
<td></td>
</tr>
<tr>
<td>3.9 Concept evaluation</td>
<td></td>
</tr>
<tr>
<td>3.10 CAD-modelling</td>
<td></td>
</tr>
<tr>
<td>3.11 Rapid prototyping</td>
<td></td>
</tr>
<tr>
<td>3.12 Validation</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 12:** Chart illustrating the connection between methods and question formulation.

3.2 Gantt chart

A Gantt chart is made to plan and illustrate work. It is a bar chart that aims to help structure and plan the work. Based on a coordinate system, different objectives and milestones are illustrated as horizontal bars in the vertical axis and the horizontal axis illustrates time. [16]

3.3 Design study

The report follows the workflow defined in Kenneth Österlin’s book “Design i fokus för produktutveckling”.

- **Starting up** briefing, planning, program, offer and decision
- **Analysis** information collection, design specification and decision
- **Sketching** sketch work, sketch discussion and evaluation
- **Processing** development, detailing, presentation and decision
- **Follow-through** manufacturing documentation, follow-up and decision
Method

During the start-up phase, the aim of the design study is defined. The purpose of this step is to understand the aim and the design correctly and to avoid mistakes from the start and achieve the best result from the study. Collection and analysis of information is used to gain as much valuable understanding and knowledge as possible regarding the product. Asking questions about the products functions, ergonomics, appearance, market, manufacturing process, material and more, ends up defining the requirement specification.

Next step is the sketching phase, where ideas and concepts get presented and discussed with constructors, marketers and end users. The sketches get evaluated and became support for decisions. During processing, the concepts that best fulfil the requirement specification gets selected. The decided design is elaborated on a detail level. During the follow-through, a prototype is tested and the concept validated. [17]

3.4 Data collection

Case study, experiment and concept study are three different types of data collection. A case study can be used to gain knowledge of a specific situation. The aim of a case study is to gather as much information as possible about the object and topic, to give an overall understanding. An experiment is a study where a few variables are analysed and other variables are controlled. After an experiment, the data collected need to be analysed. [18]

For the concept study, data is collected during the Analysis stage. Data come from user studies, brainstorming sessions and discussions with designers and end users. [17]

3.5 Market analysis

A market analysis gives a company information on a specific market, especially valuable if the company is new to the market or has a new product on the market. The data collected often comes with some uncertainty but is still of value [5].

3.6 Function analysis

A function analysis specifies the function of a product. It can be broken down into three different categories, primary function, sub function and support function. The further one travels down the tree, from primary function to support function, one travels from “Why” to “How”. [17]

3.7 Brainstorming

Brainstorming was used to develop new and innovative ideas. The purpose was to acquire a flow of ideas, preferably from outside of the box. The technique “Brain writing” was used. This method involves the group members sketching down ideas on paper individually. This technique prevents members from working on the same ideas. After a while ideas are presented and further developed together. [17]

3.8 Requirement specification

During the analysis and collecting-of-information phase, solutions and improvements is presented. The result becomes a specification of design. The primary objective of the specification is to focus on what is to be solved, not how to solve the problem. [17]

3.9 Concept evaluation

Once the evaluation phase is completed and multiple concepts are presented, the different ideas needs to be evaluated and compared against each other. The value of a specific concept is determined when compared to the requirements and features specified in the product specification. Therefore, there is a need to compare the ideas and rank them. The concepts with the highest ranking determine what concepts get developed further.
Some of the known difficulties associated with the ranking process are well known:

- The value of a solution depends on multiple variables
- Different people rank attributes differently
- Some qualities are measured quantitatively and other qualitatively

3.9.1 Gut feel

The designer usually has one of three opinions about a concept.

- It is not feasible
- It might work if something else happens
- It is worth considering

These opinions are not based on fact, but merely the “gut feel” of the designer. It requires experience and knowledge to be reliable when making decisions using gut feelings. [19]

3.9.2 Pugh matrix

Pugh matrix is a relative decision matrix that was used as a method for evaluating the concepts based on the detailed requirement specification. The technique ranked the designs as to whether they met the requirements and promoted further development of the appropriate solution. All concepts were compared to a reference to find out how they relate to further development. All conditions and wishes was include in the matrix during screening.

Each requirement is graded on a scale of one to five. W represented the weighting factor, followed by its score. Five corresponded to a high priority criterion, and one corresponded to a low priority criterion. In the matrix, the score is referenced to the previous handle accordingly, lower = (−), higher = (+) and equal = (0). This score is ultimately summed up for points. [5]

<table>
<thead>
<tr>
<th>Pugh Selection Matrix</th>
<th>Alternative Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria</td>
<td>Rating (w=1-5)</td>
</tr>
<tr>
<td>Requests A (w=3)</td>
<td>3</td>
</tr>
<tr>
<td>Requests B (w=2)</td>
<td>2</td>
</tr>
<tr>
<td>Requests C (w=5)</td>
<td>5</td>
</tr>
<tr>
<td>Requests D (w=4)</td>
<td>4</td>
</tr>
<tr>
<td>Sum of Positives</td>
<td>6</td>
</tr>
<tr>
<td>Sum of Zero</td>
<td>5</td>
</tr>
<tr>
<td>Sum of Negatives</td>
<td>3</td>
</tr>
<tr>
<td>Net value</td>
<td>0</td>
</tr>
<tr>
<td>Ranking</td>
<td>2</td>
</tr>
<tr>
<td>Further development</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Figure 13: Example of Pugh matrix.
3.10 CAD-modelling

Engineers and designers widely use Computer-aided design (CAD) during product development. The program uses a method called solid modelling and uses simple geometries. This method is quick and easy to use to provide 3D-models. However, this at the cost of being limited in design and shape. The use of 3D-CAD is a powerful tool in the visualization of ideas and concepts and provides a simple prototype through 3D-printing. [17]

3.11 Rapid prototyping

Rapid prototyping is a useful technique that allows designers and constructors to present complex prototypes easily, quickly and in a limited edition. The technique uses a model in 3D-CAD that is printed using a 3D-printer. [20]

The 3D-printing techniques FDM (Fused Deposition Modelling) is suitable for early concepts and ideas, and SLS (Selective laser sintering) for higher quality prototype parts.

The FDM technique consists of a plastic filament pulled through a heated extruder. The thread is melted and extruded through the hot end and is applied horizontally or vertically upon a print bed. The print applies layers as small as 0.127 millimetres. [21]

The SLS technique consists of a high-powered laser that melts particles, causing them to fuse. The particles can be from plastics, metals, ceramics or glass. 3D-geometries are divided into horizontal layers and place by the use of software in a powder bed. The laser melts the cross-section area of the 3D-model, which solidifies, and afterwards, the machine lays out a new layer of powder and the process repeats until the 3D-print is complete. [22]

3.12 Validation
4 Implementation

This chapter describes how the design study was conducted and how the workflow was used, to answer the question formulation.

4.1

4.1.1

see Appendix 1.

4.2

4.3

Figure 14:

4.3.1
4.3.1.1

Figure 15:

4.3.1.2

Figure 16:
Figure 17:
4.3.5

- ●
- ●
- ●
- ●
- ●
- ●
- ●
- ●
- ●

4.4

- ●
- ●
- ●
- ●

see figure 18.

Figure 18:
Implementation

see figure 19.

Figure 19:

see figure 20.

Figure 20:
Implementation

Figure 21: see figure 21.

Figure 22: see figure 22.
4.4.1

4.4.2

4.4.3

Figure 23:
Implementation

Figure 24:

Figure 25:
Implementation

4.4.4

4.4.5

4.4.6

Figure 26:
Figure 27:

Figure 28:

4.5

4.5.1

[23]

[24]
4.5.2

1. 
2. 
3. 
4. 

Figure 29:

4.5.3
5 Results

5.1

Figure 30:
Results

5.2

Figure 31:

Figure 32:

Figure 33:
Results

5.3

Figure 36:
Results

Figure 38:

Figure 39:

Figure 40:
6 Discussion and conclusion

The final chapter summarizes the method discussion, implications, theories and proposals for further work of the report.

6.1 Method discussion

This section discusses the methods selected for this study and how they were executed. This thesis has three question formulations who all need specific methods.

6.1.1 Selection of methods

The methods used in this thesis were selected regarding the type of project given. The thesis’ three question formulations affect different areas and have individual methods.

The seventh step of SVID is “Follow-up and Evaluation”. Since we never reach this step we don’t use this process straight off. Bootcamp Bootleg suggest observation and interview as methods of user studies. However, we have limited the work to not include such studies. Therefore, Bootcamp Bootleg were not used straight off. Instead, the design method used is from Kenneth Österlin in the book “Design i fokus för produktutveckling”. It can be described as a combination of the two design processes since they follow a similar pattern and are typically used during product development.

The technique brain writing was selected as brainstorming technique, however, there are several different brainstorming techniques that could have been used. Brain writing was deemed suitable since it provides multiple ideas and prevented us from working on the same idea.

The concepts were 3D-printed instead of modelled in clay since our impressions were that modelling in clay is more suitable for design study rather than construction work and the aim was to produce a working concept. Also, 3D-printing is a faster and easier way of producing prototypes.

Two concept evaluations were selected, Gut feel and Pugh matrix. There is a wide variety of evaluation methods. Our impressions were to that two methods were needed since the method of gut feel revolves heavily on experience rather than measurable facts. The Pugh matrix was selected since it presents a measurable ranking amongst the different ideas.

The experiment used was an observational study to get an overview of the suitability of the This method was considered the most fitting due to the simplicity of its implementation. Observational studies require interpretation of the results and should remove any factors that may affect the outcome.

6.1.2 Implementation of methods
6.2 Theory discussion

6.3 Conclusions
6.4 Further work
7 References


[4] Links to image collage, [Online]. Available: 


[14] 

[15] 


References


[23]

[24]

[25]
8 Appendices

This chapter provides information about the report’s appendices.

Appendix 1 Gantt chart