JÖNKÖPING UNIVERSITY
School of Engineering

Industrial DESIGN

Induction percolator

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Master in Product Development with a specialization
INDUSTRIAL DESIGN

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JÖNKÖPING UNIVERSITY
School of Engineering

Induction powered percolator

Induktionsdriven perkolator

Semir Omerovic

This degree project is performed at the School of Engineering in Jönköping in the subject field of Industrial Design. The project is a result of the master's program Industrial Design. The writers are responsible of the result, conclusions and reflections.

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Abstract

This project was a collaboration with C3 Scandinavian Lifestyle to create an induction percolator. Certain points had to be considered and explored. How can the copper coil be used in the percolator, and how can the new technology be turned off at the specified temperature?

The report will begin with a theoretical foundation. This will include the type of study contained in this report. Every step made during the project will be explained in the procedure. The approach and implementation section will discuss how the work was done, as well as what methods were employed to get the outcomes. Last but not least, it concludes with conclusions and debate.

Keywords

Industrial design, induction percolator, Concept exploration, C3 Scandinavian Lifestyle, product development,

Sammanfattning

Detta projekt var ett samarbete med C3 Scandinavian Lifestyle för att skapa en induktionsperkolator. Vissa punkter övervägdes och utforskades. Hur kan kopparspiralen användas i perkolatorn, och hur kan den nya tekniken stängas av vid den angivna temperaturen?

Rapporten inleds med en teoretisk grund. Detta kommer att inkludera den typ av studie som ingår i denna rapport. Varje steg som görs under projektet kommer att förklaras i proceduren. Avsnittet för tillvägagångssätt och implementering kommer att diskutera hur arbetet utfördes, samt vilka metoder som använts för att få resultaten. Sist men inte minst avslutas den med slutsatser och debatt.

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1 Introduction

This chapter discusses the thesis's background, aim, and limitations.

1.1 Background

C3 is a Swedish firm created in 1997 that is now owned by Empire Sweden AB. C3 specializes in the development of Scandinavian-style household items such as blenders, toasters, and coffee machines. C3 is the market leader in percolators in Sweden.

Coffee percolators, in various forms, have been around since at least 1810. By 1820, the first commercial coffee percolators were on the market, however they were primarily aimed at the more affluent family. Few coffee brewing gadgets are as revered or famous on the market as the percolator. Coffee percolators are a household staple in hundreds of millions of homes worldwide because they are simple to operate, affordable to purchase, and capable of making dependably excellent coffee.[1]

1.2 Purpose and research question

The purpose of this thesis is to design an induction percolator for C3. Certain points need to be considered and researched. The percolator needs to be able to work on an induction hub, and needs to have a smart solution to do so.

There are certain points in this project that needs to be researched to provide a design for the product.

1. How can the copper coil be implemented for the percolator or is it enough with a bottom of stainless steel?

The goal of this point is to investigate if a design with a copper coil can be implemented at the bottom of the percolator and if it can be able to move up and down inside the percolator body.

2. How can the new technology be switched off at the specified temperature?

The goal with this point is to investigate if the percolator can be switched off whit a smart solution with the help of heat

1.3 Delimitations

In this thesis, there are points that will not be considered, the cost of material, the manufacturing process, and a full performed study on the casting process.

This project will only provide a solution that could be implemented in a percolator. Therefore, a fully functional will not be presented.

1.4 Disposition

As for the rest of the report, there will be a theoretical background. This will include what type of research this report contains. The method will contain every step that was taken during the project with an explanation. The next step is the approach and implementation, this section will describe how the work has been done, and a description of what methods were used in order to reach the results. Last, of all it ends with conclusions and discussion.

2 Theoretical Background

2.1 Design

2.1.1 What is design?

The word design comes from the Latin word “designare”, this word means to create something or point it out. The definition of design has changed although the rising of design literature, it’s no longer an agreement on the nature of creation that once existed. The result of the design process may be a product or a service, an object, or a structure, but it is not "Design." Design as a verbal term is explained as a dynamic process. A well-defined field within a design can be found in the Industrial design, graphic design, textile design, and furniture design businesses.

The Industrial Design Foundation in Sweden (SVID). Describes design as: "Design is a work process for developing solutions consciously and innovatively where both functional and aesthetic requirements are included based on the user and the planet's needs. Design is used for the development of goods, services, processes, messages, and environments.” [2]

2.1.2 Design research

According to Medium.com in the 1960s design research was a term used to reflect the study of the design itself, what its purpose is, and the processes used. This term is still used to define design research in academia today. There are various institutes of design research, the most commonly used in large existential or small theoretical questions in academic language. [3]

What differentiates good research from bad is the different techniques used by the user from different ideas, methods, interests, and problems. Well-done research is intuitive, based on the feeling that this idea was correct at the time. Successful research stems from concepts and will lead to theorization and theoretical understanding. Practice is important, but it seems that research that serves practice in the short term often fails to meet the long-term needs of specific groups of people. If important long-term needs cannot be met, research that is only practical and applicable today will not be able to meet the best interests of practitioners. [3]

2.2 Design methods

2.2.1 Design thinking bootleg

A design method that is used a lot by designers is the design thinking bootleg, this is used to provide a creative process. The Bootcamp bootleg is divided into five steps, which are empathizing, defining, ideating, prototyping, and testing. [4] See Figure 1

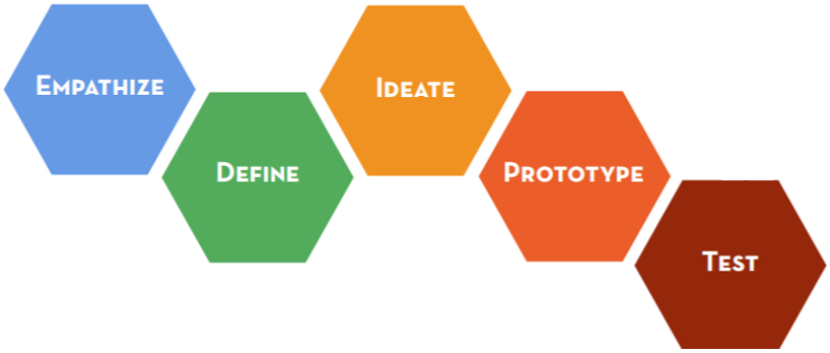

Figure 1: steps in Bootcamp Bootleg

- Empathize – is to gain a knowledge of what users require/want from their product. This can be accomplished with a good brief on the problem or by gathering information from the user. [4]

- Define — This step is used to define an understanding of what to do with the knowledge gathered during the empathizing phase. [4]

- Ideate - is the mode during the design process in which the focus is on idea generation. The goal of ideation is to explore a wide solution space – both a large number of ideas and a diversity among those ideas. [4]

- Prototype - Prototyping is getting ideas into the physical world. A prototype can be anything that takes a physical form, from a physical sample, visualization, storyboard, drawing, or soundtrack. [4]

- Test – in this phase the designer learns more about the user and refines the prototype and if it's necessary to make changes to fulfill the user's requirement. [4]

2.2.2 The product development process

The steps of the product development process used in this project are detailed in Figure 5. The process steps include compilation and analysis, which can be done multiple times to finish the process. This technique is similar to design thinking bootleg, with a more detailed purpose [12].

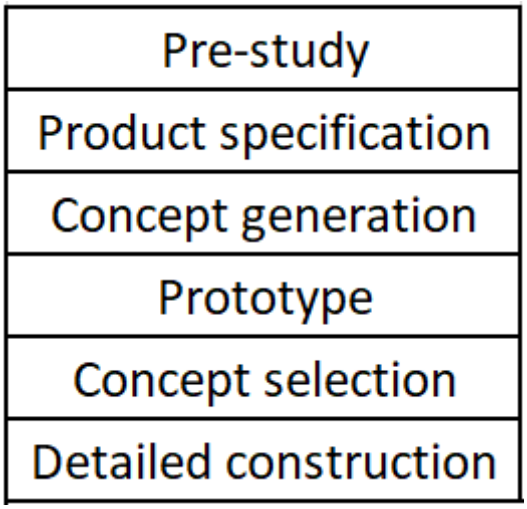

Figure 2 : Phases of the product development process.

2.3 Induction

Induction heating generates heat directly from the induction burner to the cookware with minimum heat loss between the heating element and the cookware. According to Tom Williams of the National Renewable Energy Lab, induction stoves have an efficiency of 85 percent, which is similar to an electric kettle's efficiency of 80 percent. The efficiency of induction cooktops and electric kettles is comparable, however it varies depending on the product quality [5]. The total energy efficiency of boiling water is, however, significantly dependent on the user's boiling behaviors. Overfilling and reboiling waste a tremendous amount of energy.

The theory of magnetic induction supports induction cooktop technology (see Figure 2).

The induction cooktop contains a planar wire coil through which alternating current flows, creating an oscillating magnetic field that connects to ferromagnetic cookware. The fluctuating magnetic field provides a magnetic flux, which produces an alternating current (eddy current) that directly heats the cookware. There is another way to switch off the induction hub. One method is to press the on/off button at the bottom. Another method is to place the magnetic material 30mm above the stove, which causes the current between the copper coil and the material to be too far apart and the magnetic field to turn off automatically. This can also be used if the magnetic field has a closed circuit. [6]

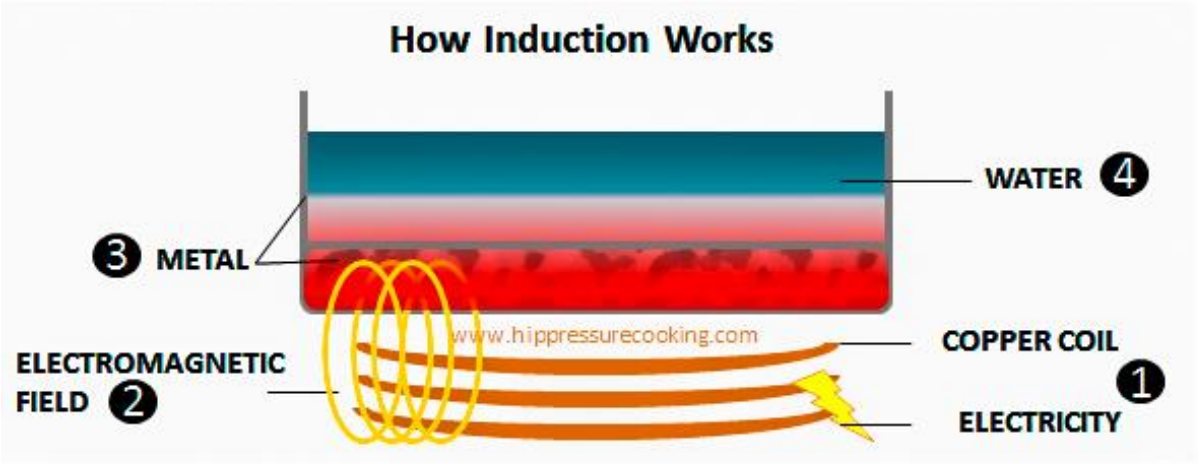

Figure 3: how induction works

2.4 Thermostatic Bimetals

Thermostatic Bimetals are also called a snap disc. Thermostatic bimetal is a permanently bonded composite material made up of at least two layers, each with a different thermal expansion coefficient. A change in curvature occurs when the material is exposed to temperature changes. Spiral coils, cantilever strips, U-forms, and discs are just a few examples of thermostatic bimetal shapes. [7]

A thermostatic bimetal material is made up of two similar metal strips with differing coefficients of thermal expansion at a specific temperature, one high and the other low. The strips' relative lengths change as the temperature rises. The low expansion strip will be stretched, while the high expansion strip will be compressed. These combined pressures produce a moment, causing the material to bend in a uniformed path. This phenomenon can be seen in Figure 3. The temperature fluctuations in the metal strips, as well as the difference in coefficients of expansion, are exactly proportional to the thermodynamic bimetal bending. The overall thickness of the combined strips has an inverse relationship with the bending. [8][9]

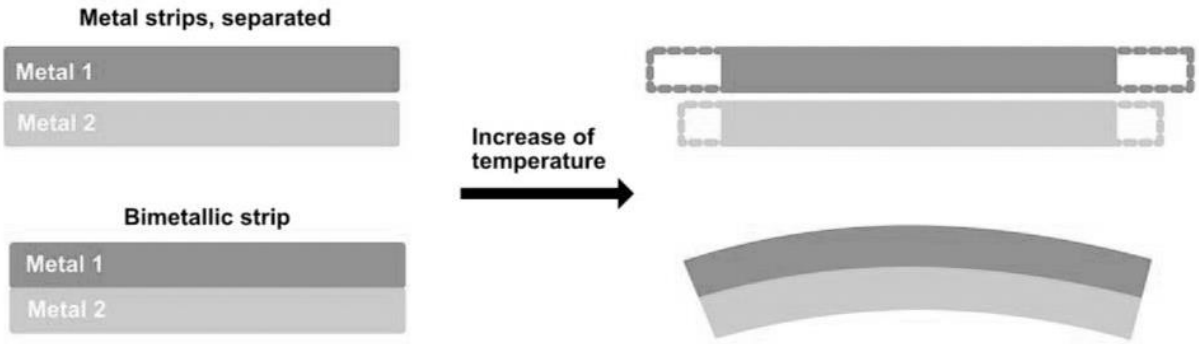

figure 4: bimetal snapdisk funktion

2.5 Percolator

A typical percolator is made up of six separate pieces. The chassis, a basket with a lid in which the ground coffee is placed, a hollow tube through which the boiling water passes, a spring in the tube in which the canister sits, and a boiler, which in this case must be connected to a hub/stove to heat up.

It operates by allowing air bubbles formed by boiling water to rise through the hollow tube. It then falls back into the chamber below, showering down on the ground coffee. This process is done until the coffee is the desired strength. See figure 4 for clarification.

Percolators come in two varieties: stovetop and electric. They function in much the same way, but with different heat sources. An electric coffee percolator contains an electric heating element in its base and must be plugged into a power outlet. A stovetop percolator, on the other hand, requires an external heat source, such as a stove or flame. [10]

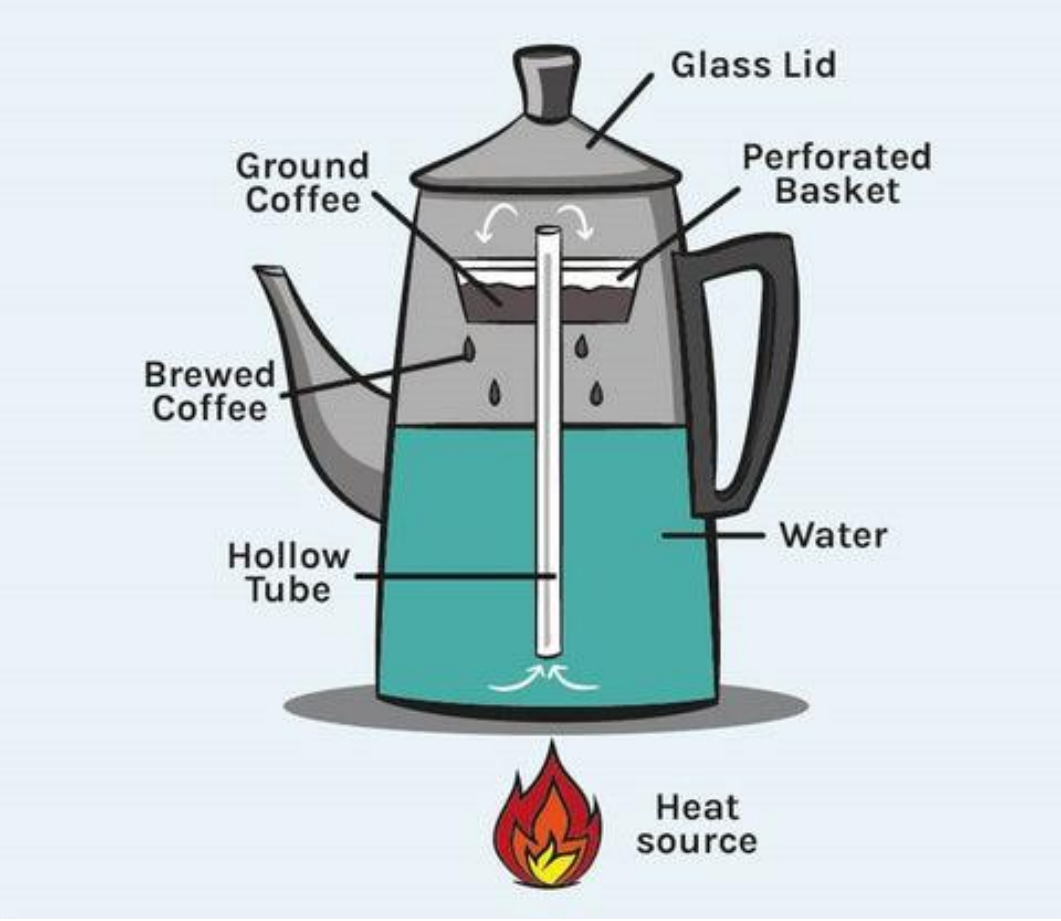

Figure 5: how a percolator works

3 Method

Various research methodologies will be used to address the research questions. The process will include problem identification, problem resolution, and a complete concept. The appropriate information will be required during the problem identification process to obtain a knowledge of the task and how the problem can be solved. The problem solution will be comprised of relevant concepts, which will subsequently be shown with a finished prototype.

3.1 Gantt-chart

A Gantt chart will be referred to during the process to set milestones and to get on track. A Gantt chart is a scheduling method created by Henry Gantt to illustrate the timing of different project parts that occur in the project, see Appendix 1. The Gantt chart is drawn in a coordinate system where the vertical line corresponds to steps to be performed and the horizontal line corresponds to time. The length corresponds to the duration of the activity. The method is used to quickly illustrate the start and endpoint of a project's activity and is usually used in the early phase of the project phase and in the project programs. [11]

3.2 Pre-study

A pre-study is carried out to determine the potential development of a product. Where a market, design, and technology investigation is performed to generate background material about the topic. The pre-study must include a variety of technological options in order to avoid starting a resource-intensive project under insufficient conditions. The feasibility study must produce a requirements specification outlining the functional requirements and "what" the product is to do. The specification is then refined during the development project to discover a solution. To provide a foundation for the task, facts will be gathered through scientific publications, reports, questionnaires, and books. The information gathered will come from trusted sources. [11] [13]

3.3 Product specification

To gain a specification of what is to be accomplished with the work, a product specification must be created. This is done early in the process and must include a clear aim as well as the specifications that the product must achieve. The more information/knowledge you gather during the process, the more the product specification can be revised. A target specification describes relevant product development criteria. The requirements must include: [14]

- *"The assignment and the conditions that are included both explicitly and implicitly."*
- *"Connection between analysis and the task"*
- *"Construction decision during the construction work"*

The criteria mentioned above can be divided into two categories, the first is that criteria set different limits for which solutions are allowed in the product. And the second is criteria related to the product solution. [11] [13]

3.3.1 Functional analysis

Function analysis is used to determine functions in the product and clarify them. The function analysis consists of the main function, sub-function, and support functions. The main function is the purpose of the product, sub-function are necessary functions that contribute to the main function, and support functions are desirable in the product that is usually not necessary. To describe these functions, verbs and nouns are used.

A function analysis can be created through a function tree or function boundaries with a description of the functions in addition to the verbs plus the nouns. With a function tree, you draw lines from the main function to the sub-functions and the support functions with a hierarchical structure so it looks like a tree. [11] [13]

3.3.2 Market research

Market research is the process of establishing the viability of a new service or product through direct customer study. Market research allows you to identify your target audience and measure their interest in your product or service.

The purpose of market research is to look at the market associated with a particular product or service to determine how the audience will receive it. This may include information gathering for market segmentation and product differentiation, which can be used to determine which features are seen as a priority for the consumer. [11]

3.4 Concept generation

In a design scientific context, a product concept is a solution to a design problem. Such a solution contains the points mentioned below. [11]

- *"An approximate preliminary product layout with space estimates."*
- *"Description of the principles of the technical solution in text, sketches, block diagrams, wiring diagrams and any physical models and more."*
- *"Description of the properties of the solution in relation to the product specification (preferably in the form of an evaluation matrix)."*
- *"Reasons for the choice of input sub-solutions."*
- *"Compilation of completed estimates analyzes and experiments with the results obtained."*

3.4.1 Mood board

A mood board is a visual tool that communicates our concepts and visual ideas. It is a well-thought-out and planned arrangement of images, materials, pieces of text, etc. that is intended to evoke or project a particular style or concept. see Appendix 2

3.4.2 Brainstorming

Brainstorming is a technique used to generate as many ideas as possible. Product development (BOK) recommends that you work in a group of 5-15 persons, with one person serving as a leader. The group must generate as many ideas as possible without receiving criticism; in this phase, quantity takes priority over quality. Everyone should be aware of the four guidelines of brainstorming. [11] [15]

- Criticism is not allowed - ideas should not be removed from critical analysis. Preferably give no comments, neither positive nor negative
- Quantity is sought - it is important to develop as many ideas as possible, this increases the chance that some of them are good.
- Go out of the ordinary - think outside the box.
- Combine ideas - combine or complement ideas that have emerged.

You can use a variety of brainstorming techniques. Stop and go, the Gordon Method, and 6-3-5 are all examples. Stop and go is used for time-limited sessions, which normally last 3-10 minutes per idea. The Gordon technique is a version that tries to provide a radical concept rather than a wide number of ideas. The variant 6-3-5 suggests that you sit in a group and rotate ideas, with each person developing the concepts further. The group should have six members, and each participant should give three ideas in five minutes to be sent on. [11] [15]

3.4.3 Sketching

One practice used by data visualization experts is sketching. Most who exercise data visualization have notebooks filled with ideas for symbols, encodings, and shapes. The creation of external representations facilitates the learning process in many ways. There have been studies on the role of learning and others on the application of drawing to reason and learn within education. These studies showed that: [11]

- *"Drawing an idea makes explicit the metaphors and shorthands you're using to think about the idea."*
- *"A shared representation leads to more productive conversation and ideation in group contexts."*
- *"Physical representations allow you to see characteristics and relationships of concepts more easily."*

3.5 Concept selection

The goal of this phase is to develop the best concept that meets all the requirements of the product specification. The selection of concepts is done through different methods. The methods are used to analyze different values of how well the concept meets the requirements assigned in the product specification. The concept that achieves the highest value with the analysis is chosen as the best prototype to be further developed. [12]

Before choosing an alternative, the solution must be analyzed. The analysis can be done through theoretical calculations, experiments on physical prototypes, or technology-based modeling, analysis, and simulation methods. [12]

A strong tool for deciding which concept to choose is an evaluation with decision matrices. The first step in the evaluation process is to remove bad solutions, this can be done through the elimination matrix from Pahl and Beitz with the points mentioned below. [12]

- *"Solves the main problem."*
- *"Meets the requirements of the product specification."*
- *"Fits the company's product range."*

The next step is to reduce through Pugh's matrix once again concepts that do not meet the requirements. The last step in the evaluation process is to compare with the help of the criterion weight matrix (Kesselring) the concepts you have left. [12]

3.5.1 Elimination matrix

An elimination matrix is used to decrease concepts generated during the concept creation process (figure 6). Four characters are assigned to determine criteria within the matrix: (+), (-), (?), and (!). Concept solutions that meet the criterion are marked with a (+), indicating that they forward the concept to the next stage of development. Concepts that do not meet the requirement are marked with a (-), indicating that you do not proceed with the notion. Concepts that you need more information about the solution get a (?), To decide later whether the concept gets a (+) or a (-) after you have studied the concept more. Concepts from the product specification that must be checked get one (!), Which means that you must check the concept more carefully before deciding. [11] [14]

Elimination matrix for sub problem:								Elimination requirements: (+) Yes (-) No (?) More information needed (!) Check the product spec.	
								Decision: (+) Proceed with concept (-) Eliminate the concept (?) More information needed (!) Check the product spec.	
								Comment	**Decision:**
1									
2									
3									
4									
5									
6									
7									
8									
9									

Figure 6: Elimination matrix from Pahl and Beitz [2]

In this work, the elimination matrix was used to sort out concept against concept requirements in order to move forward with a concept that could become a working prototype.

3.5.2 Pughs method

After the elimination matrix, further analysis is required to obtain the most suitable concept. This phase can occur through Pugh's matrix (see Figure 7). Pugh's matrix is a method used to further eliminate concept alternatives, the elimination takes place by evaluating the concept solutions against an existing solution. Each concept is compared with the existing solution by three characters (+), (0), or (-). A (+) means that the concept is better than the existing solution. One (-) means that the concept is worse than the existing solution. And one (0) means that the concept is as good as the existing solution. After the evaluation, all characters are added. Each (+) gives 1 point, (-) gives -1 points and (0) gives 0 points. After the evaluation, everything is summed up in the net value, which is then ranked from highest to lowest. The concept that gets the highest value is considered the best alternative to move forward with. [11] [14]

	Concepts					
Key Criteria	Baseline	Concept 1	Concept 2	Concept 3	Concept 4	Weight
Criterion 1	0					
Criterion 2	0					
Criterion 3	0					
Criterion 4	0					
Criterion 5	0					
Criterion 6	0					
Sum of Positives (+)	0					
Sum of Negatives (-)	0					
Overall Total	0	0	0	0	0	
Weighted Total	0	0	0	0	0	

Figure 7: Elimination matrix from Pahl and Beitz [11]

Pugh's matrix will be used in the work to assess which concept is best to further develop, as the elimination matrix does not provide enough important information to continue.

3.6 Prototype

Making prototypes can be done in a variety of methods, the most frequent being using various types of cardboard, but regardless of the construction, they always serve the same purpose: to demonstrate the product. The difference between creating a CAD model and creating a prototype is that the user gains a better knowledge of the product's shape and scale. [16]

3.6.1 Computer-Aided Design (CAD) & renders

Product rendering and visualization are the digitalization of what a company sells as well as the design that depicts a product in a variety of ways. It can be modeled in software like Solidworks, Alias, or Rhino. The image is then rendered in programs such as Keyshot or Blender. The advantage of 3D modeling is that the program displays the product much more precisely and precisely than a sketch. Making a CAD rendering will provide the user with a better idea of how it will perform and look. [17]

3.6.2 Rapid prototype

Rapid prototyping is the rapid production of a physical item, model, or assembly using 3D computer-aided design (CAD). Additive manufacturing, often known as 3D printing, is commonly used to complete the building of an item, model, or assembly. Rapid prototyping (RP) refers to a variety of manufacturing techniques, the most prevalent of which is layered additive manufacturing. Other technologies used in RP include high-speed machining, casting, molding, and extrusion. [18]

3.7 Detail construction

In this phase, a concept solution will be converted into a prototype based on the idea description. To be tested and analyzed, the prototype must meet all of the product specification criteria. [19]

4 Approach and Implementation

This project was developed in collaboration with C3 lifestyle where a mechanical solution was in focus. The report starts with research on the project and then an explanation of the ideation, mockups, prototyping, and validation. All the steps were followed and referred to with a GANTT- chart that can be seen in the appendices 1.

4.1 Preliminary study

A pre-study was carried out to gather information and gain a knowledge of the percolator's operation. The pre-study comprised several components. Physical and virtual investigations were conducted to determine how the mechanics and construction of the percolator work. A market study was conducted in which various types of percolators were studied to see whether there were any differences in technology. In addition to providing ideas for potential solutions to existing problems.

4.1.1 Mechanics and construction

To answer the questions, a deeper understanding was made on how the product works mechanically. To understand how the percolator is built, physical and virtual examinations were performed. In the physical examination, a percolator was disassembled, see figure 8 for clarification, where all components were examined to get a better understanding of how everything works. The virtual part went by examining CAD files on the C3 percolator model in Solidworks, this showed a deeper simulation of how the mechanism itself works.

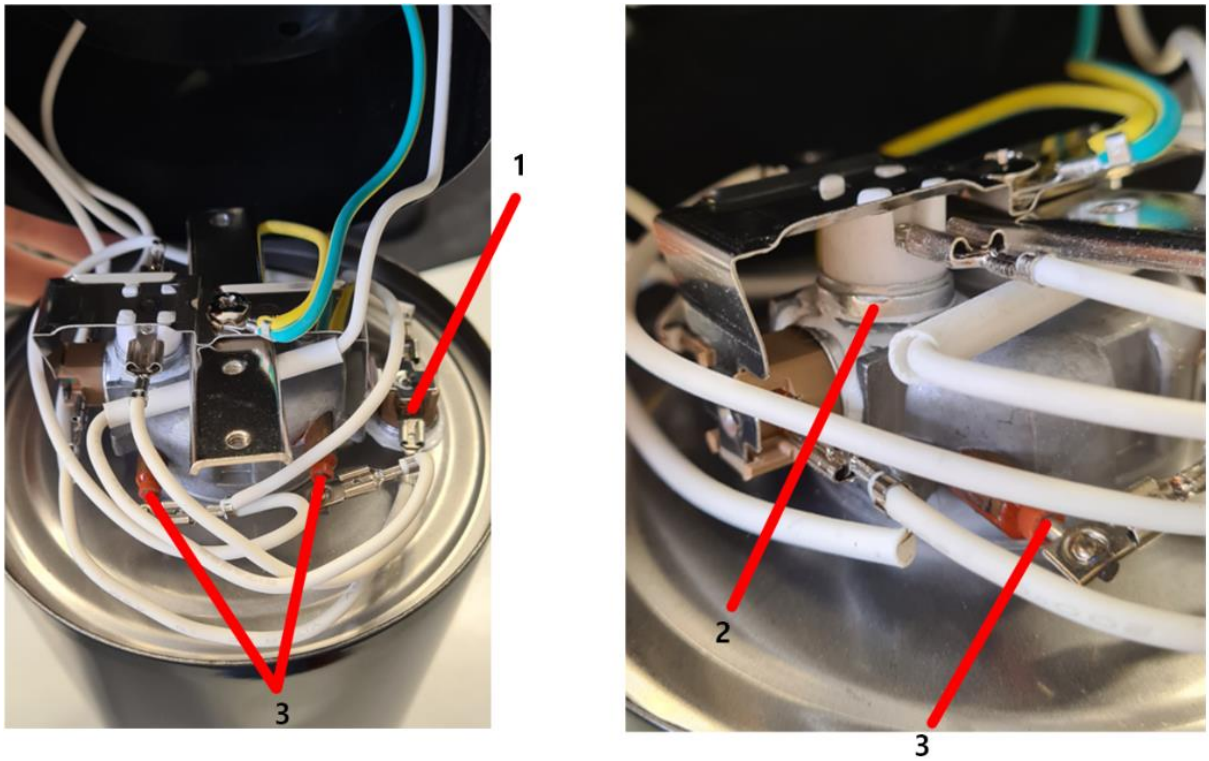

Figure 8: disassembled percolator

List of components with an explanation that occurs.

1. Snapdisk
2. Thermometer
3. Heating element

4.1.2 Market research

The market research was done by examining and comparing different types of percolators, kettles, and coffee machines to see if there is an existing solution to the problem, as they work in the same way. see figure 9. The survey was conducted by analyzing C3's different models of percolators and their competitors in the percolator industry. The function of the products was the same as the existing product, what differed was, among other things, the shape of the handle and the design of the chassis. The study provided new thoughts and ideas for concepts that could be applied in the concept generation part.

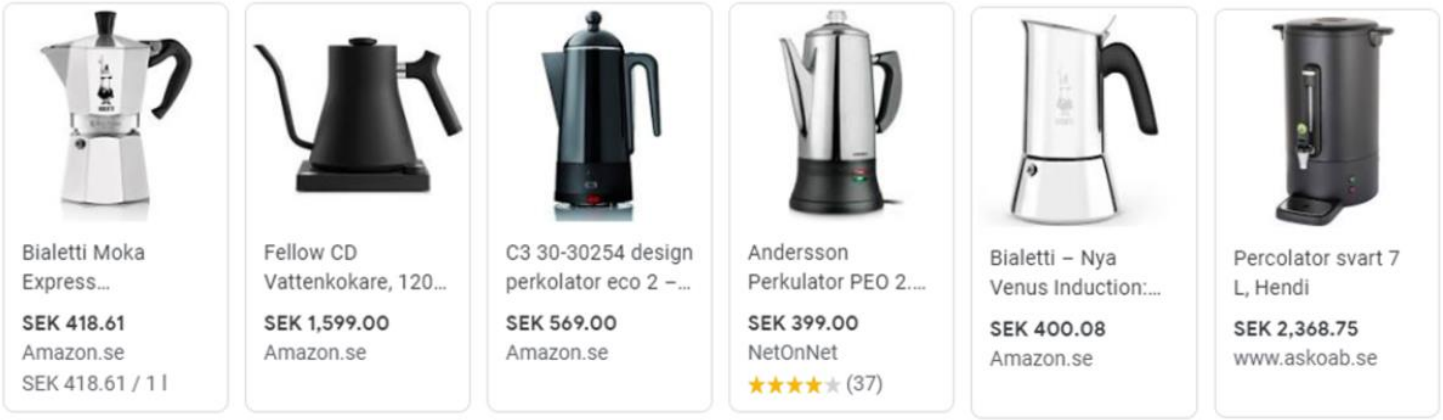

Figure 9: market research

4.2 Product specification

The company C3 lifestyle had requirements in the project description that needed to be met at the start of the project; the requirements specified what was to be done with the task. A function analysis could be created using information from the project description. The requirements were numbered in the functional analysis to provide a study and evaluation of how the product should work. The following is a description of the requirements specification.:

- **Functionality**: The function of the new product must be the same.
- **Manageability**: The percolator must be switched off using a quick disc.
- **Handleability**: The product must work through a copper coil.
- **Useful custom**: The product should work on an induction cooker.
- **Sustainability**: The product's durability must be to the same degree as the existing product.
- **Design and layout**: The product's design must follow the C3 lifestyle design language.

4.3 Concept generation

4.3.1 Brainstorming on the chassis frame

Brainstorming was utilized to generate ideas for how to accomplish the work task. It was critical to generate as many ideas as possible without critiquing the thoughts. There was no requirement for solutions during this period, only a focus on chassis design. The mood board served as inspiration. See figure 10 and appendices 2 for moodboard.

Figure 10: brainstorming design ideas

4.3.2 Brainstorming on functions

In this phase, possible solutions for the percolator were investigated. After the investigations, four different concepts were created that make it possible to apply as solutions, see figure 11.

Figure 11: possible solutions for the percolator

Concept 1

With the help of a lever, the copper coil moves three cm down on the induction stovetop to activate the process. Through an electromagnet, the coil will lock when the copper coil begins to generate current. When the water in the percolator has reached 100 degrees, the snap disk will be activated. The snap disk will change direction and a short circuit will occur. This will cause the coil to stop generating current and the electromagnet will deactivate. Through some springs, the coil goes up to its normal place, see figure 12 for clarification.

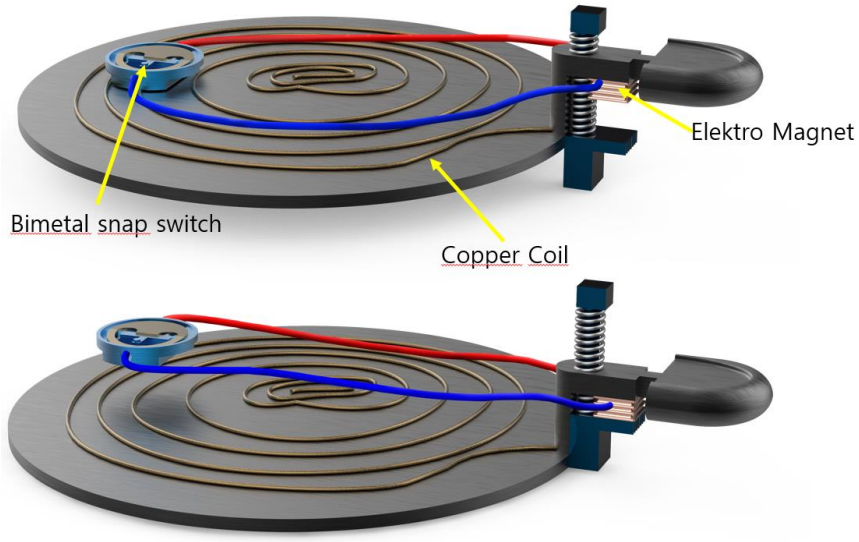

Figure 12: Concept 1 on how it operates.

Concept 2

The second concept works with the function that it is built up of two different materials, one magnetic and one non-magnetic. By pulling down the magnetic material to the induction stovetop the process will activate. See figure 13 for clarification.

figure 13: how concept 2 works.

Through a snap disk, grooves and springs on the side of the percolator. The mechanism works by when the handle pulls down, grooves will lead to a pit where the lever locks, then when the water in the percolator reaches 100 degrees, the snap disk will move back the lever and the handle with the magnetic material will go up. See figure 14 for clarification.

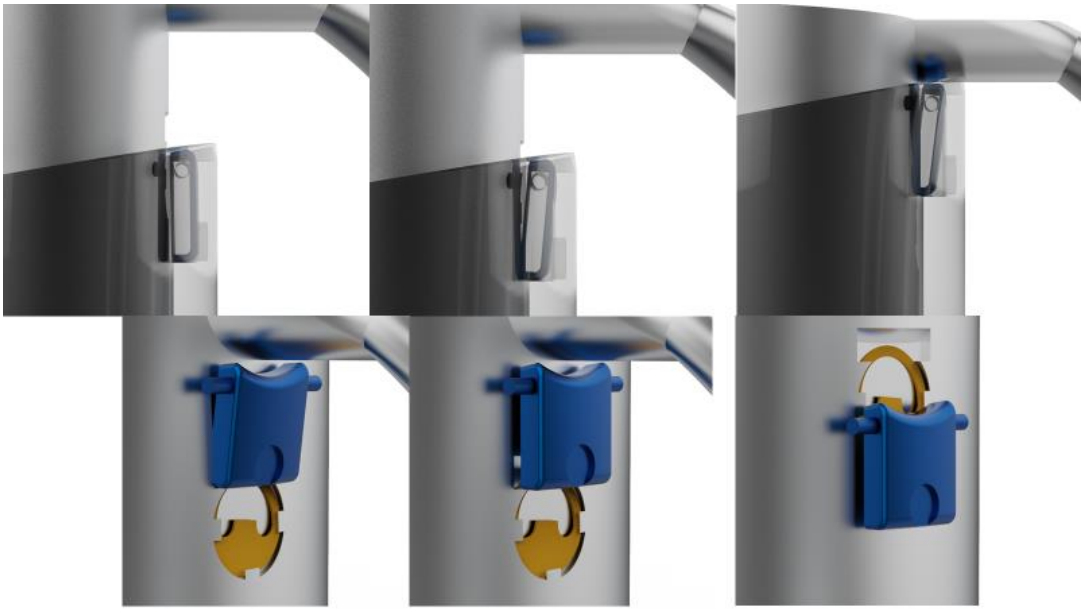

figure 14: the mechanism that locks at.

Concept 3

Concept 3 functions similarly to Concept 1, with the exception that the user must draw down the lid by inserting the copper coil. With this concept, a leaver on the side is avoided, allowing C3 Lifestyle's design language to stand out more. Figure 15 for further information.

figure 15: shows how concept 3 works

Concept 4

Concept 4 is built where the copper coil is located on the bottom of the percolator. It works by when the water reaches 100 degrees and the snap disk will create a short circuit. In previous sections, it was explained how an induction heel works, and when the stove senses that it cannot generate electricity, it switches off automatically after 30 seconds. See figure 16 for clarification.

figure 16: shows how the copper coil is sitting.

4.4 Elimination matrix

In the method during the product development phase, different matrices were described to study concept selection, these matrices were used to study further and to select the best concept solution for the work. The first matrix was used as the elimination matrix according to Pahl and Beitz. The requirements and wishes from the product specification were entered together with the solution alternatives in the matrix. To then eliminate concepts that did not meet the requirements or wishes. The concepts that best met the matrix were chosen to go on with.

Elimination matrix for sub problem:

Elimination requirements:
(+) Yes
(-) No
(?) More information needed
(!) Check the product spec.

Decision:
(+) Proceed with concept
(-) Eliminate the concept
(?) More information needed
(!) Check the product spec.

	1. Maintain the function	2. operate through a copper coil	3. operate through a snapdisk	4.follow C3 design language	5. Easy to understand and use	6. Easy to clean	7. should be safe to use	Comment	Decision:
1	+	+	+	−	+	+	+		6
2	+	−	+	−	+	+	−		4
3	+	+	+	+	−	−	+		5
4	+	+	+	+	+	+	+		7

Figure 17: Elimineringsmatrix from Pahl och Beitz

4.5 Concept development phase

After the elimination matrix concept, 1 and 4 went further on to the next phase. The concepts were selected to be investigated further. The concept works almost equally, the only thing that differs is that concept 1 uses a lever that pushes down while concept 4 uses the copper coil attached to the bottom of the percolator. After choosing the concept, Pugh's matrix was used to continue with the concept choices. When the matrix was created, the requirements and wishes were entered from the previous matrix as well as the concepts that went on, see figure 18. In the matrix, one of C3 lifestyles products (C3 Design Perkolator ECO – 6 Kp) was compared with the concept. with this, one could see if the concepts met the requirements as well or better. Concept 4 became the concept that was considered to best meet the requirements for further development.

	Concepts			
Key Criteria	Baseline	Concept 1	Concept 4	Weight
1. Maintain the function	0	0	0	
2. operate through a copper coil	0	+	+	
3. operate through a snapdisk	0	+	+	
4.follow C3 design language	0	-	+	
5. Easy to understand and use	0	0	+	
6. Easy to clean	0	0	0	
7. should be safe to use	0	0	0	
Sum of Positives (+)	0	2	4	
Sum of Negatives (-)	0	1	0	
Overall Total	0	1	4	
Weighted Total	0	0	0	

Figure 18: Pughs matrix

4.6 Prototype making

4.6.1 CAD Modelling

To get a better understanding of how the final design will look a CAD model in SolidWorks was made. The final design concept was chosen after meetings with the company where the brainstorming concept was presented, in section *4.3.1 Brainstorming on design*. The first step was to have the measurements right, so they could be 3d printed on the right scale. This was achieved by measuring C3 lifestyles existing percolator. C3 didn't want to change up much from their existing C3 Design Percolator ECO. The difference in design was the, see figure 19:

- Handle - made it more ergonomic and fit the hand better.
- The knop – made it fit the fingers better when pulling up the lid
- The water measurement – on the existing percolator the measurement is behind the handle. This made it difficult to see how much water was inside. The new design is on the side of the percolator.
- The spout – only for appearance, the spout was moved 5 mm up so it would align with the frame.

figure 19: shows the difference between the existing and the new design

4.6.2 Prototype making

The final prototype was created in order to present the new design and visualize the new functions. The prototype was created as a model with no functionalities. After finishing the 3D model in Solidworks, it was exported to the printable field with MakerBot Print software. The prototype is created by sanding the finish of the 3D-printed product, then spraying primer on it to achieve the best surface, and then painting the surface, see figure 20 for clarification.

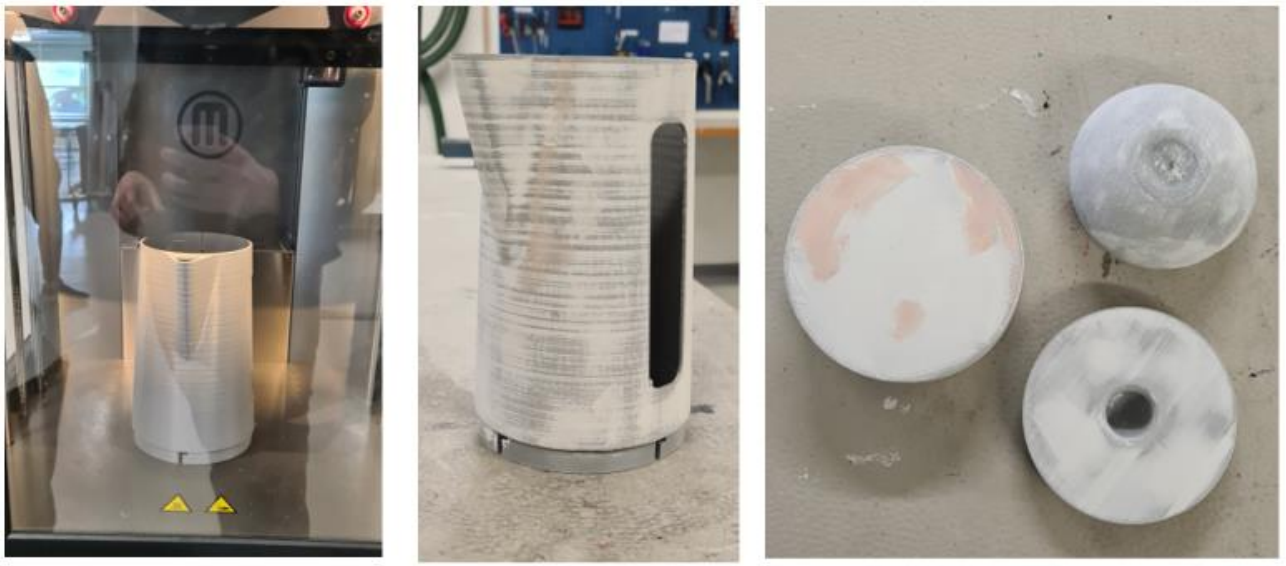

figure 20: prototype making process

4.6.3 Making test prototype

To put the research findings on how the concept will work to the test. One prototype was built using real parts, including a copper coil, a snap disc, and an existing water kettle. The kettle was used because it performs a comparable function to the percolator, as it contains a heating element.

One copper coil was taken from an existing indication hub and connected to a modified short circuit that was joined to the snap disk to create the prototype. Then everything was linked to the water kettle's heating components. For more information, see figure 21. This demonstrated how the percolator will function. Testing may be carried out once all of the components were linked. The experiment will determine whether the copper coil can create the same amount of electricity as an existing C3 lifestyle percolator. The test will be carried out by heating one liter of water on both the old and new designs. This will demonstrate whether or not the copper coil receives sufficient energy.

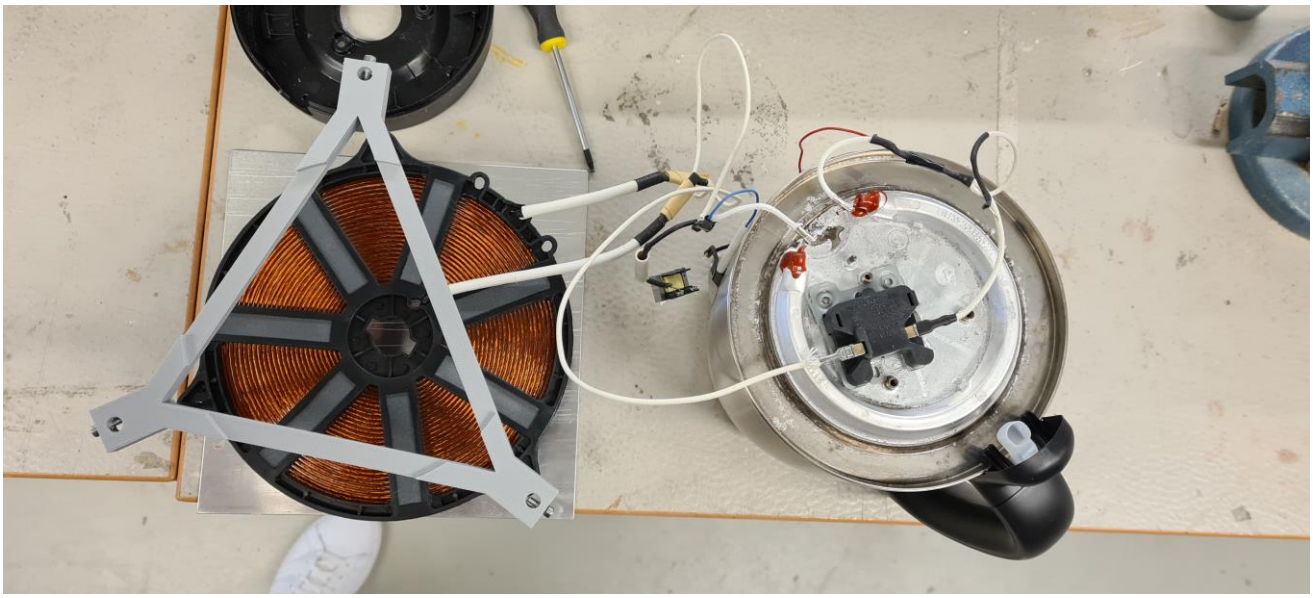

figure 21: the connection from the copper coil to the heating elements.

4.6.3.1 Modified short circuit

The short circuit works by connecting three copper pieces so that the electricity from the copper coil can pass through. One of the copper pieces functions as a leaver, so when the snap disk changes direction, a short circuit occurs and the heating element stops working; for more information, see figures 22 and 23.

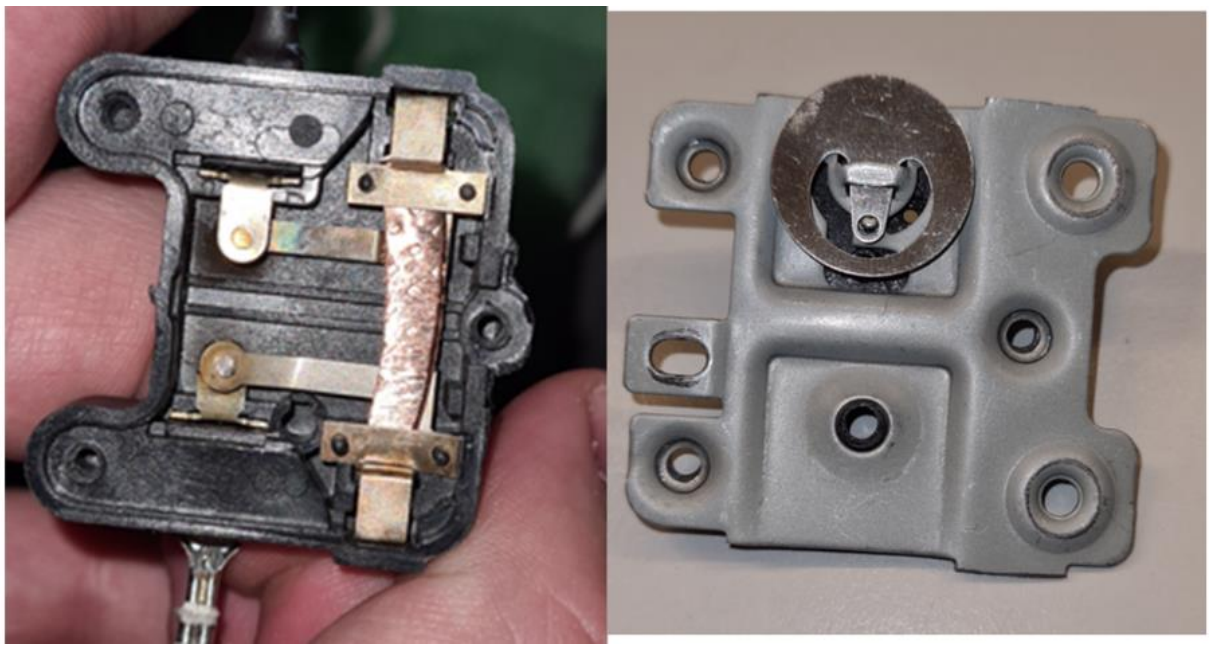

Figure 22: Modified short circuit

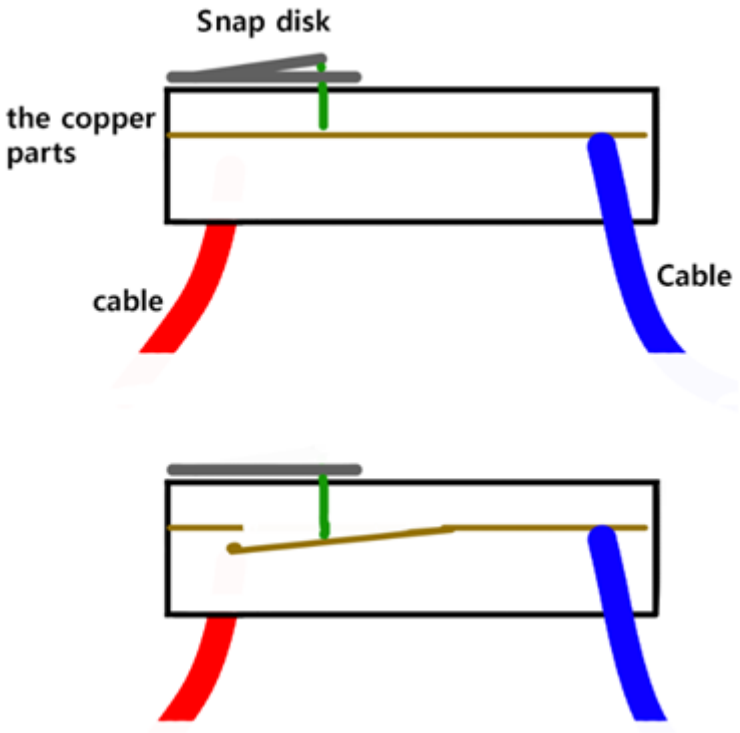

Figure 23: how the Modified short circuit works

4.7 Making the handle

4.7.1 Handle mockups

A handle design research was required prior to producing the handle prototype. This was accomplished through the use of existing percolators and water kettles as inspiration. The next step was to make cardboard mockup models to see which form worked best for the hand. Because the handle was constructed of cardboard, it was simple to establish which ergonomic shape and size was the most comfortable on the hand.

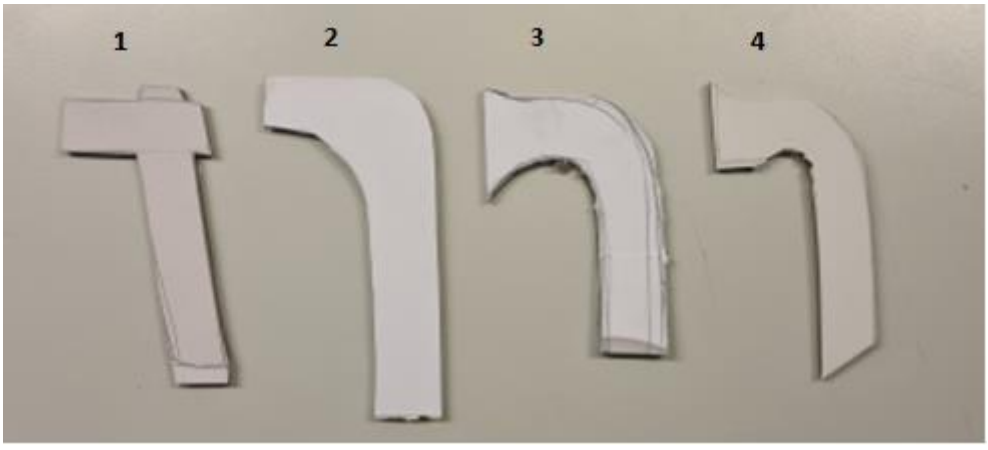

Figure 24: Cardboard mockups

4.7.2 Sketching the handle

The handle was developed after the mockups were completed, and a final design was made. This sketch was inspired by a combination of mockups 3 and 4 because they were the most appropriate for the hand and utilised the C3 design language.

Figure 25: final sketch design

4.7.3 Handle CAD

After creating the final design as a sketch, an Alias design was required for 3D printing, see figure 26.

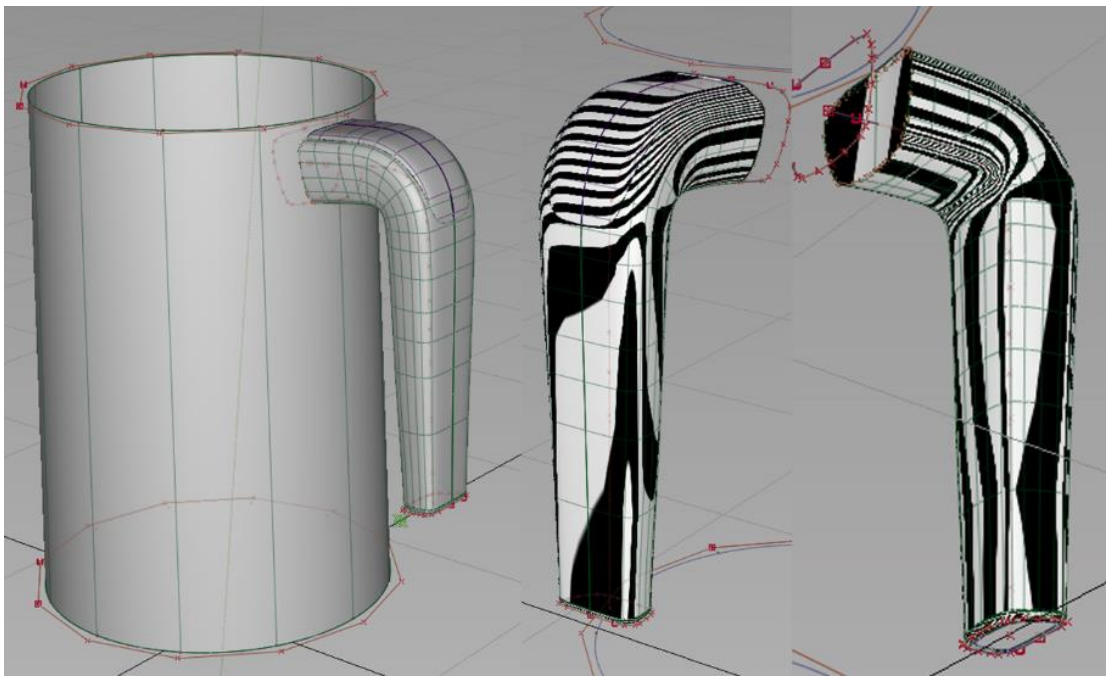

Figure 26: Alias model of the final design

4.7.4 Making the handle.

The prototypes were created using MakerBot printers. The MakerBot Print program is used to export Alias 3D models to printable files. Figure 27 depicts this. The sections will then be painted and shown as the following phase in the process.

Figure 27: 3D- printed handle

Figure 28: Side by side comparison of the new and existing design

5 Result

5.1 Brainstorming Design concept

A dialogue with the company took place during the phase where the brainstorming section was created. The outcome was that they did not want to change much about the design to better fit the brand language; they wanted the design to resemble their existing product, C3 Design Percolator ECO. A list of the changes is provided below.

- Handle - made it more ergonomic and fit the hand better.
- The knop – made it fit the fingers better when pulling up the lid
- The water measurement – on the existing percolator the measurement is behind the handle. This made it difficult to see how much water was inside. On the new design, it is on the side of the percolator.
- The spout – only for appearance, the spout was moved 5 mm up so it would align with the frame

Figure 29: Final design

5.2 Brainstorming Function concept

Creating functional notions for how it will work. The elimination matrix and Phugs matrix results were used to study and build concept 4. The copper coil is situated on the bottom of the percolator in Concept 4. When the water temperature reaches 100 degrees, the snap disk creates a short circuit. In earlier sections, it was explained how an induction heel works, and when the stove detects that it is unable to create electricity, it automatically switches off after 30 seconds. Figure 30 shows how the components is placed an figure 31 shows how it works.

Figure 30: Interior of concept 4

Figure 31: How to use the new percolator with the copper coil

5.3 Final prototype concept

The final prototype was developed to demonstrate the new design and visualize the new functions. The prototype was designed solely as a model with no functionalities. The 3D model was finished in Solidworks and exported to the printable field using MakerBot Print software. The prototype is developed by sanding the 3D-printed product's finish, then spraying primer on it to achieve the best surface, and then painting the surface. Figure 32 shows the process of making the concept and figure 33 shows the final design.

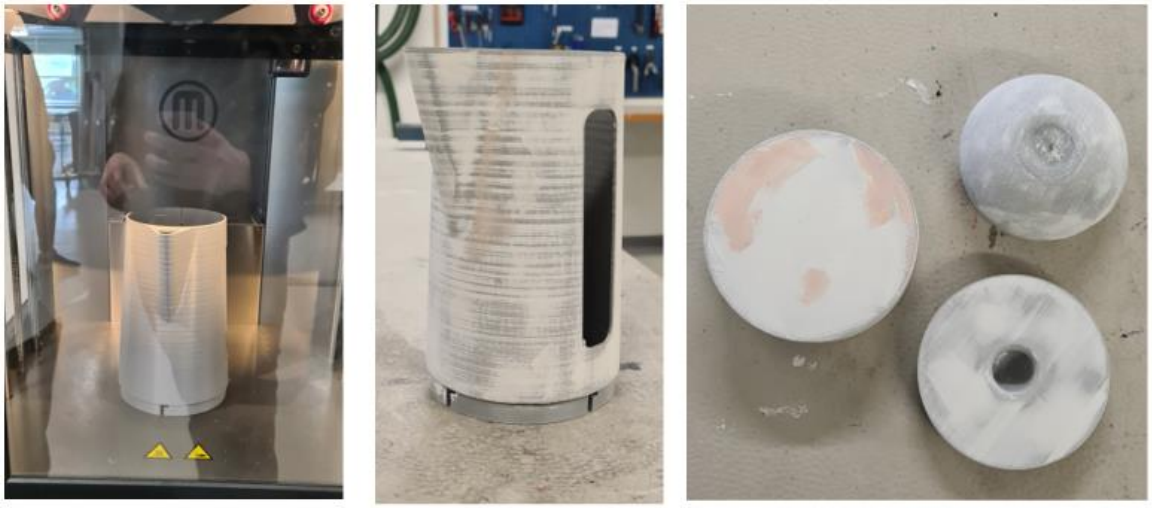

Figure 32: the process of making the new percolator

Figure 33: shows the final design

Figure 34 shows how the percolator is used by a user.

Figure 34: how it is used by a user

5.4 Testing prototype

To test out the theory on how the concept will work real components where used, one copper coil, a snap disc, and an existing water kettle to create one prototype. The kettle has a similar purpose as the percolator and employs a heating element.

The copper coil was removed from an existing indicator hub and linked to a modified short circuit and to the snap disk to make the prototype. Then everything was linked to the water kettle's heating elements.

This demonstrated how the percolator will function. Testing was be done with all of the components connected. The experiment will determine whether the copper coil can create the same amount of electricity as a current C3 lifestyle percolator. The test will involve heating 0,5 liter and 1 liter of water in both the old and new designs, and measuring the time. This will reveal whether the copper coil receives sufficient energy.

	WaterKettle	Concept 4
	Time	Time
0,5 L	1 min 48 sec	2 min 15 sek
1 L	3 min 25 sec	4 min 31 sec

Figure 35: Results from testing

According to the test results, concept 4 took longer to heat up the water. The kettle's timing was 1 minute 48 seconds with 0.5 liters of water. In comparison to concept 4, which yielded a time of 2 minutes and 15 seconds. With 1 liter of water, the kettle took 3 minutes and 35 seconds, while the concept 4 time was 4 minutes and 31 seconds. See figure 35 for chart.

Why it took 27 seconds to heat up 0.5 liters of water and 66 seconds more to heat up 1 liter with concept 4 could be due to a variety of factors such as the wires not connecting properly, the snapdisk not being properly positioned beneath, or the current from the copper coil not producing as much current as the existing product.

6 Conclusion and discussion

Can the copper coil be implemented or if it is enough with a bottom of stainless steel for the percolator?

Using stainless steel for the percolator can be done but it does not solve the switching off at a specified temperature question. The copper coil is located on the bottom of the percolator in Concept 4. When the water reaches 100 degrees, the snap disk creates a short circuit.

To put the research on how the concept will function to the test. One prototype was constructed using real components, including a copper coil, a snap disc, and an existing water kettle. The kettle was picked because it performs a similar function to the percolator in that it uses a heating element.

The copper coil was taken from an existing indication hub and linked to a modified short circuit that was attached to the snap disk to create the prototype. Then everything was linked to the water kettle's heating components. This demonstrated how the percolator will function. The testing was carried out once all of the components were linked. According to the test results, concept 4 took longer to heat up the water. The fact that it took 27 seconds to heat up 0.5 liters of water and 66 seconds to heat up 1 liter more with concept 4 could be due to a number of factors such as the wires not connecting properly, the snapdisk not being properly positioned beneath, or the current from the copper coil not producing as much current as the existing product.

A major factor that played a role during the project was that I could not test out the prototype in school, this prevented me to accomplish a good fully functional prototype, because I didn’t have all of the tools and equipment to modify when I needed to.

How can the new technology be switched off at the specified temperature?

With the modified short circuit, the electricity from the copper coil can travel through the short circuit because it is made up of three copper pieces that are linked to each other. When the snap disk reverses direction, one of the copper pieces acts as a leaver, causing a short circuit and the heating element to stop operating.

A snap disk's material is made up of two comparable metal strips, one high and the other low, having different coefficients of thermal expansion at a certain temperature. As the temperature rises, the relative lengths of the strips vary. The strip with the lowest expansion will be stretched, while the strip with the highest expansion will be compressed. These stresses combine to create a moment, forcing the material to bend uniformly.

This concept was added under the percolator so that when the water reaches 100 degrees it will start to heat the snap disk.

Future work

The purpose of this thesis was to review past work, develop the mechanism further, suggest an exterior design for the percolator, and validate the mechanism with a functional prototype.

The functioning prototype demonstrated that the mechanism functioned and that the concept will automatically turn off when the water temperature reaches 100°C. The concept was given with graphics and a physical model to fit the mechanism of the copper coil, snapdisk, and heating element. The design should now be optimized and ready for a further verification and validation. The most crucial phase is to create a more manufacturing-ready prototype using materials appropriate for the product, such as plastics for the handle and aluminum for the chassis. The following bullet points highlight the product's suggested future progress:

- The componants should be further developed to be designed for assembly.
- Tolerances for bimetal snap disc fastening tests.
- Document the lifespan of the new product.
- Additional user tests should be conducted to provide a better understanding of how the product as a whole is regarded.
- Test out different coppercoils to see if there is any difference of the current flow

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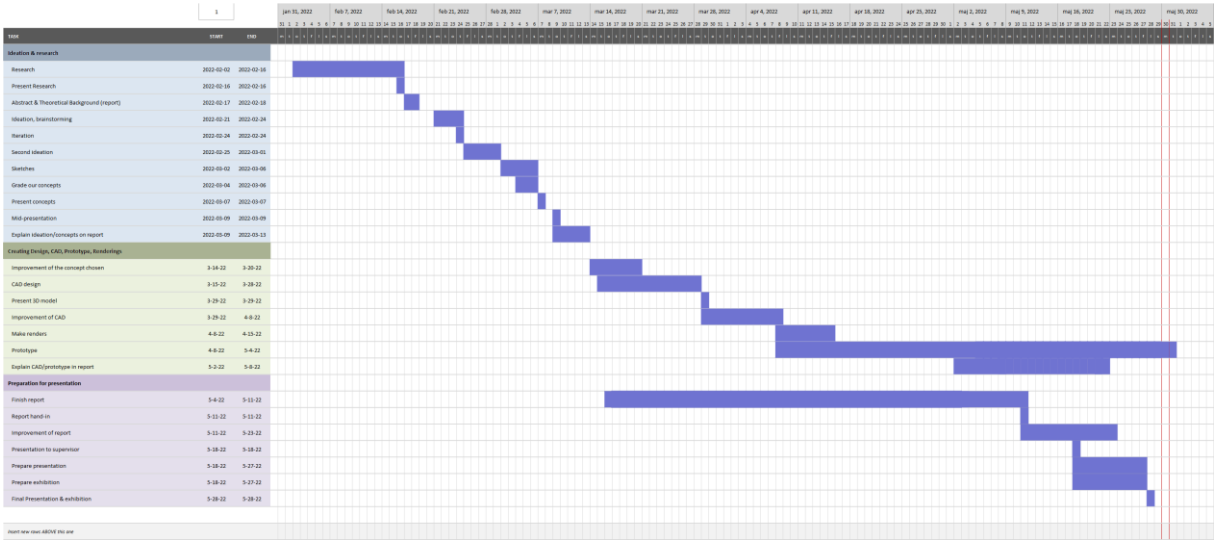
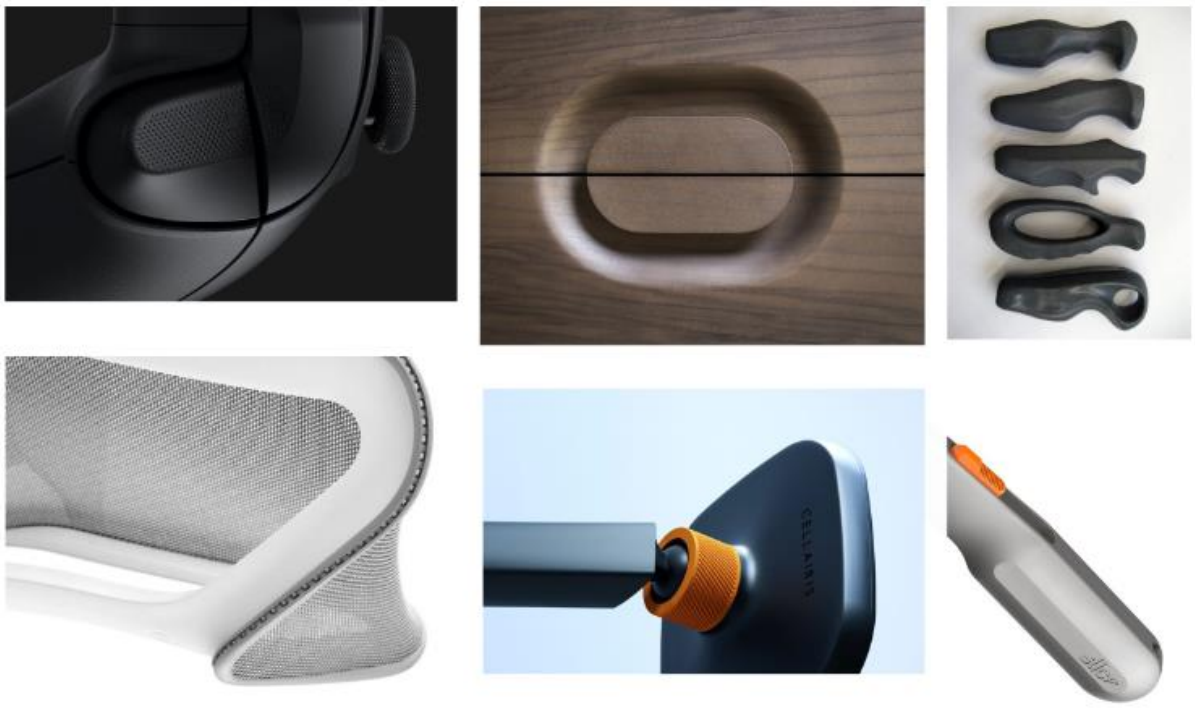
8 Appendices

Appendix 1 Gantt



TASK	START	END
Ideation & research		
Research	2022-02-02	2022-02-16
Present Research	2022-02-16	2022-02-16
Abstract & Theoretical Background (report)	2022-02-17	2022-02-18
Ideation, brainstorming	2022-02-21	2022-02-24
Iteration	2022-02-24	2022-02-24
Second ideation	2022-02-25	2022-03-01
Sketches	2022-03-02	2022-03-06
Grade our concepts	2022-03-04	2022-03-06
Present concepts	2022-03-07	2022-03-07
Mid-presentation	2022-03-09	2022-03-09
Explain ideation/concepts on report	2022-03-09	2022-03-13
Creating Design, CAD, Prototype, Renderings		
Improvement of the concept chosen	3-14-22	3-20-22
CAD design	3-15-22	3-28-22
Present 3D model	3-29-22	3-29-22
Improvement of CAD	3-29-22	4-8-22
Make renders	4-8-22	4-15-22
Prototype	4-8-22	5-4-22
Explain CAD/prototype in report	5-2-22	5-8-22
Preparation for presentation		
Finish report	5-4-22	5-11-22
Report hand-in	5-11-22	5-11-22
Improvement of report	5-11-22	5-23-22
Presentation to supervisor	5-18-22	5-18-22
Prepare presentation	5-18-22	5-27-22
Prepare exhibition	5-18-22	5-27-22
Final Presentation & exhibition	5-28-22	5-28-22

Appendix 2 moodboard