BR ØK 58

a new classic
begins at 58'

Title page

Project title	BRØK 58
Aalborg University	Industrial Design
Project team	MSc04 - ID1
Project period	01.02.2025 - 28.05.2025
Main supervisor	Christian Tollestrup
Technical supervisor	Benny Endelt
Pages	24

Contents

Introduction

BRØK 58 is a semi-automatic espresso machine that focuses on user-centered maintenance and repairability, integrated with timeless design through aesthetics and functionality ensuring a long-lived product. The espresso machine addresses the Right to Repair legislations implemented by the European Union and is a counter to how current design is limiting consumers' ability to fix their own products. BRØK 58 is designed to make maintenance and repair easier for any consumer regardless of expertise.

Problem

Espresso machines are not made to be repaired or manually maintained by the ordinary user. The big killer is limescale accumulation, and nowadays coffee machines only provide software to solve this problem. Attempting to open a machine can cause more harm than good due to the compact and complex design and the requirement of knowledge and skill. Because of the complexity in espresso machines, professional repair takes a lot of man hours making the repair more expensive for the consumer.

Espresso machines are part of the small household appliances that cause a lot of e-waste piling up around the world. To tackle this problem, the EU has introduced new regulations that demand manufacturers and designers to consider how their products are maintained and repaired. Coffee machines are yet to be a part of this change but will soon follow. BRØK 58 remains focused on giving the consumers the possibility to fix their own products through maintenance and repair.

BRØK 58

a new classic starts at 58'

A user-centered repairable
espresso machine

Innovation

BRØK 58 is a user centered repairable and maintainable espresso machine. The backside of the machine is detachable through magnets and gives the user direct access to the components inside. BRØK 58 features a reorganization of the product architecture in a slim design, presenting a clear overview of all the components without compromising on aesthetics. Key components and tubes can be detached and changed by removing the yellow splits connecting everything despite level of expertise. The effects of limescale are often hidden inside compact machines, but BRØK 58 provides a clear overview of limescale buildup in the tubes. BRØK 58 is aimed to build self-repair confidence and emotional attachments prolonging the product lifetime.

Interaction

BRØK 58 is designed for consumers wanting to upgrade their coffee game and looking good while at it. The espresso machine is separated into three sections. First, the front for extracting coffee and steaming milk. The front is where most of the action will happen – here users insert the portafilter and extract the coffee into a cup placed on the drip tray. The steam wand hovers over the drip tray as well, ensuring a straightforward cleaning process afterwards. Second, the top is where users choose what operation they are interested in. Finally, the back is where all the magic happens.

The espresso machine is constructed with a classic 58 mm sized group head and portafilter and a steam knob to open and close the steam valve.

The espresso machine provides a few select programs of coffee extractions without overwhelming with options in a simple yet intuitive user interface. Users can choose a program and press GO to start making coffee, steam milk, or hot water.

ON YOUR MARK . . .

GET SET . . .

COFFEE ! ! !

Maintenance

After having made 175 cups of coffee, the descale button will automatically start to light up. It is important to run the descale program when it is active, as this will cleanse the machine from buildup and make it run smoothly again. If the descale continues to stay on after having run the program, opening the machines backside panel will give access to a more in depth care guide. As limescale is the biggest problem in coffee machines, this guide will be directly available on the backside. Other guides can be reached by scanning the QR codes to reach Maintenance guides.
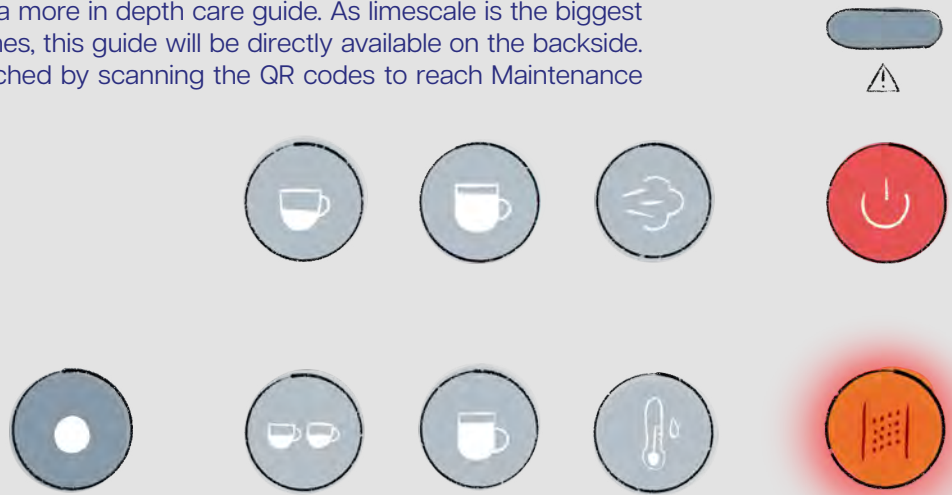
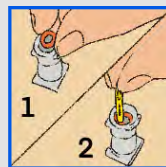**1** To detach the tubes, locate the yellow splits and take them out.

! Use the spare part tray on this backside to avoid loosing them.
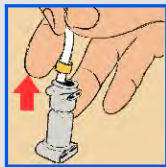
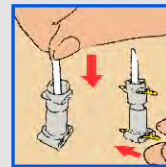**2** Take out the tubes and check for limescale. Clean if needed using a pipe cleaner.

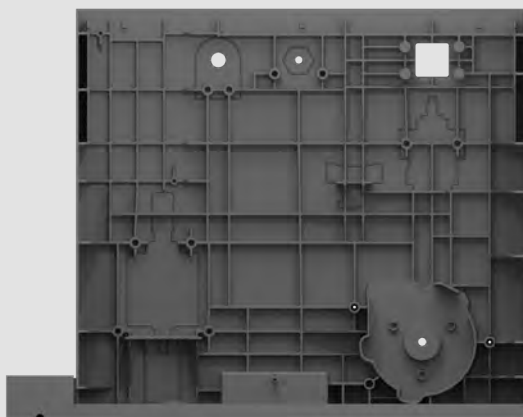**3** Use the yellow split to pry out the o-rings. If they are cracked or damaged replace them.

4 Clean the o-rings and apply the silicone based lubricant.

Insert the o-ring into the connection piece and press it down with the yellow split.

5 Insert the tube into the connection piece. Use some force to drive it into the o-ring where it is tight and secured.

The main shell has outlines of key components to make it easier to locate and place the components correctly again.

If real damage occurs, the emergency symbol will light up and will need immediate attention. Mostly, this status will activate if software becomes compromised or if the descale program has run five times without deactivating again. Other than software, the problem might be due to serious buildup inside the components and will need a more complex clean or replacement, e.g. it could be a failed fuse on the thermoblock.
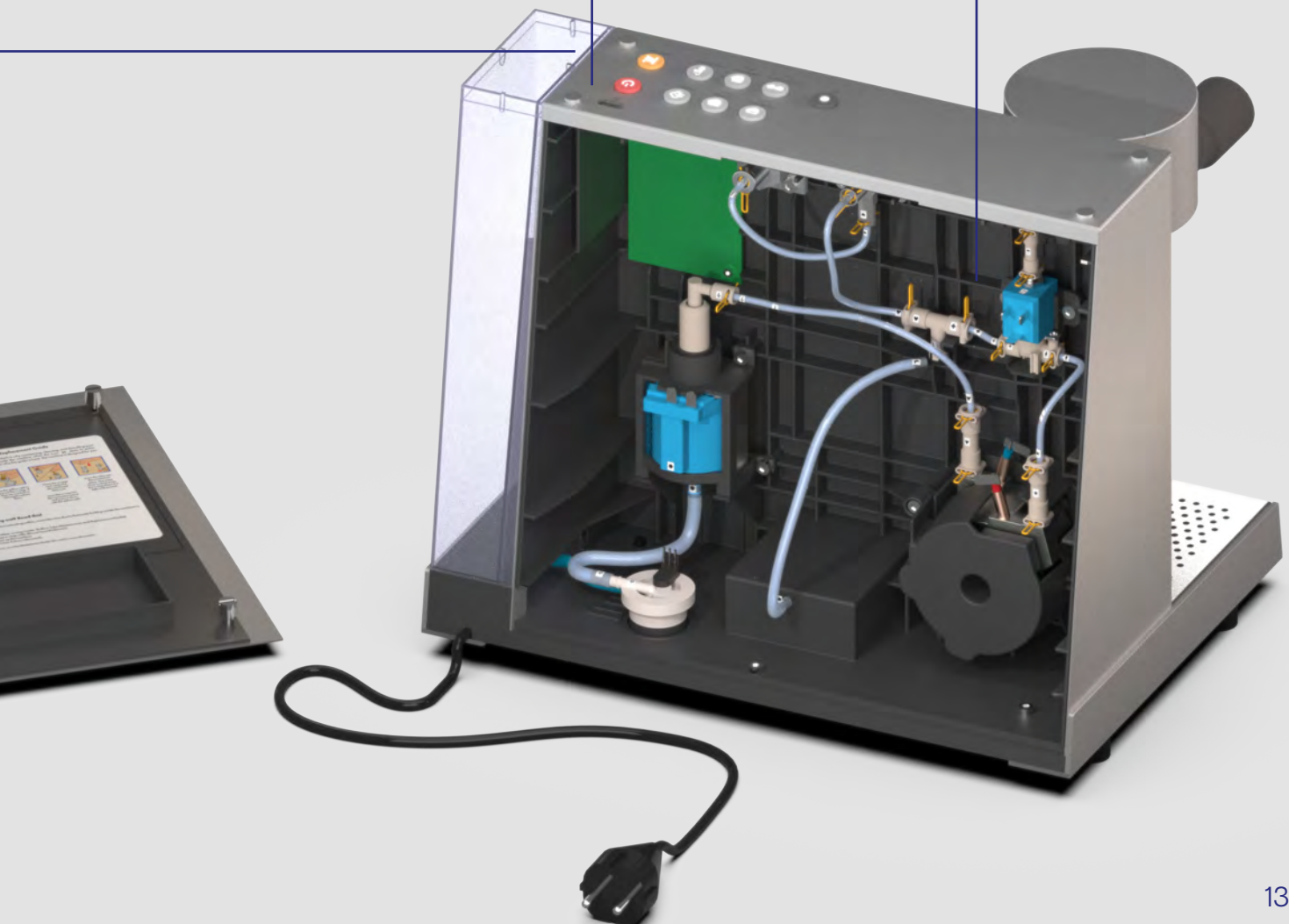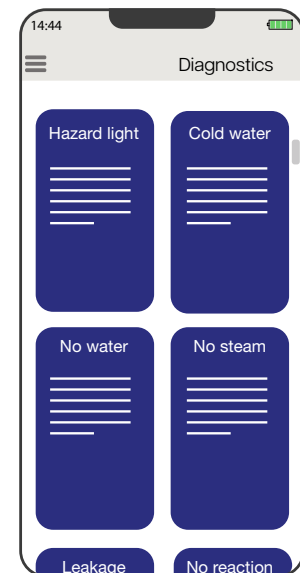
Repair & Spare parts

If any components breaks, BRØK 58 can easily be repaired by the minimal use of tools. Two sizes of umbraco are used throughout the whole machine and is available on the backside of the machine when opened. This makes engaging with repair and maintenance quick and easy for both ordinary users and professional repairmen - the tools are always on hand!
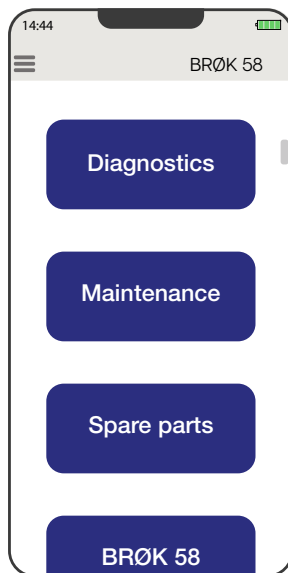
1 When the QR code is scanned the user will land on the BRØK 58 repair page, and can choose between diagnostics, maintenance, spare parts, or general info about the espresso machine.

Diagnostics provides an overview of problems the user can experience. **2**
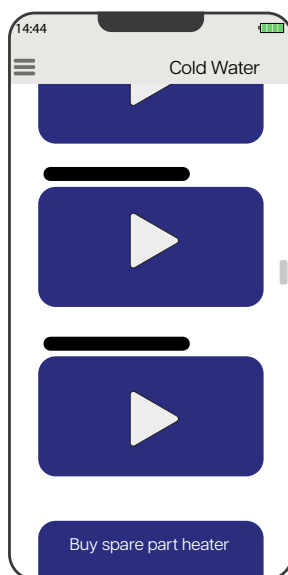
3 Videos and guides are posted on all the different problems users can experience to help maintain or repair their BRØK 58.

The spare part page has all standard and key components available for the espresso machine. **4**
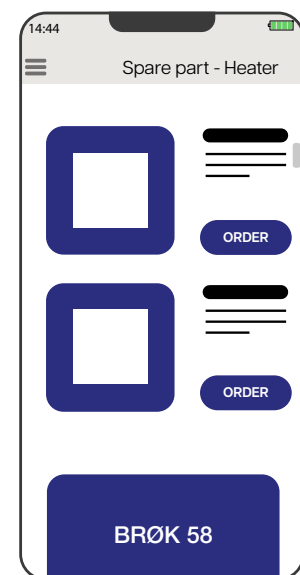
The yellow splits make it easy for users to detach tubes quickly, and the small stickers on the tubes ensures correct placement after cleaned or replaced. The backplate have a compartment for spare parts, which can be used to organize the parts users have taken out of the machine to avoid losing them while engaing with repair and maintenance.

Group head
Stainless steel 316
PA66+25GF
EPDM

Front and side panel
Stainless steel 304

Group head:

Group head shell
Group head plate
Portafilter plastic mount
Portafilter metal mount
Water inlet plate
Diffuser plate
Shower screen

Top shell
PA66+25GF

Steam knob
Stainless steel 304

Steam wand
Stainless steel 316

Grate
Stainless steel 304

Water tank
Tritan

Drip tray
ABS

Top panel
Stainless steel 304

The magic:

Flow meter
Solenoid pump
Thermoblock
Solenoid valve
OPV
Steam valve
PCB

Backplate
Stainless steel 304
PA66+25GF

Buttons
Silicone rubber

Main shell
PA66+25GF

Exploded view

Bottom shell
ABS

The construction of the espresso machine has been designed to make it possible to fully disassemble the machine. The machine is assembled primarily using umbraco screws to avoid using unnecessary glue and almost-permanent click on solutions. Key components are directly available to the user when removing the backplate. Elements such as the button PCB are placed under the top underneath a surface that will need to be screwed off and not immediately accessible for ordinary users but quickly found by professional repairmen if needed.

Feet
Rubber

Rails
Stainless steel 304

Specifications

DIMENSIONS

Width	396 mm
Height	340 mm
Depth	285 mm
Weight	9.2 kg

SPECIAL SPECIFICATIONS

Bar	15
Temperature (celcius)	90 - 96
Water tank	1.4 L
Interface	Semi-Automatic
Limescale indicator	Yes
Cleaning program	Yes
Watt	1350
Repairable	Yes!

BRØK 58
Information guide

SERIAL NO. SDXXXXXXX
MODEL CLASSIC
POWER 120-240V · 55/60Hz 1.5A

Maintenance Guide

Having trouble? Scan the QR code and find our library of maintenance guides and videos. Here you will find information of every component in your BRØK 58 espresso machine and how to maintain or replace them. The guides provides step-by-step videos that ensures you are doing everything correctly!

Scan for more information.

In need of spare parts?

If you are in need of replacing components, tubes, o-rings or more, scan the following QR code to jump right into the store and order new parts.

Scan for more information.

Is the emergency symbol lit up? Scan the **Maintenance Guide** QR and follow the instructions.

When the descale symbol is pulsing, you have brewed 175 cups of coffee and need to clean the system.

Tube and rubber o-rings Maintenance and Replacement Guide

Limescale are the number one reason coffee machines break which is why maintaining, cleaning, and descaling your BRØK 58 espresso machine is essential. Remember to descale the machine when the icon starts to pulse. Sometimes the machine needs a little extra cleaning which is why this guide is here. The machine is designed for you to be able to fix it yourself - just follow the visual guide here.

To detach the tubes, locate the yellow splits and take them out.

Use the spare part tray on the backside to avoid loosing them.

Take out the tubes and check for limescale. Clean if needed using a pipe cleaner.

Use the yellow split to pry out the o-rings. If they are cracked or damaged replace them.

Clean the o-rings and apply the silicone based lubricant.

Insert the o-ring into the connection piece and press it down with the yellow split.

Insert the tube into the connection piece. Use some force to drive it into the o-ring where it is tight and secured.

Low flow or no coffee coming out? Read this!

If you are experiencing low pressure when extracting coffee, most often it is due to limescale buildup inside the machine in the tubes or components.

1. Check tube connections and rubber o-rings inside. (Follow Tube Maintenance and Replacement Guide)
2. Replace or clean and regrease o-rings with silicone based lubricant.
3. Reattach everything and close up the machine.
4. Start descale program and rinse 3 times afterwards.

If you are still experiencing low pressure, scan the **Maintenance Guide** QR code for more information.

BR
ØK
58

Business plan

PEER-TO-PEER LENDERS

3 MONTHS

1

ESTABLISHING SUPPLYCHAIN

SPONSORSHIPS & MARKETING

6 MONTHS

2

1ST LAUNCH

BRØK 58 CLASSIC

PEER-TO-PEER LENDERS

To gain the economic traction to start manufacturing the espresso machine, the P2P method will be used to increase financial capacity. This could potentially introduce people and investors to the company who will be paid back after profits.

MARKETING

BRØK 58 is an espresso machine with a focus on being user-repairable and long lasting. However, BRØK 58 will be marketed as being a user-friendly coffee machine, with a long lasting aesthetic design, that keeps delivering a good cup of coffee every brew. With a note on the system how the user can order if new parts if their machine breaks down, so they don't have to send the machine to repair, thus saving money in the long term. The target group is close to Sage, and with BRØK 58 entering the market, they now has a competitor that is cheaper, makes just as good coffee, and lasts longer.

COST & BREAK-EVEN

Budget

4.352,4 DKK
PER ESPRESSO MACHINE

910.000 DKK
START-UP COST

PRODUCTION COST

The price is estimated through material and tool cost. Included in this price estimation is machine cycles, wages, and hourly rates estimated to assemble the machine. The start-up cost is a one-time payment for tools and molds.

RETAIL PRICE

The retail price of is estimated through market positioning based on popular brands on the market, giving BRØK 58 a selling price of 6.000 DKK.

12
MONTHS

PRODUCT PORTFOLIO
DEVELOPMENT

2
YEARS

3

4

BEAN GRINDER
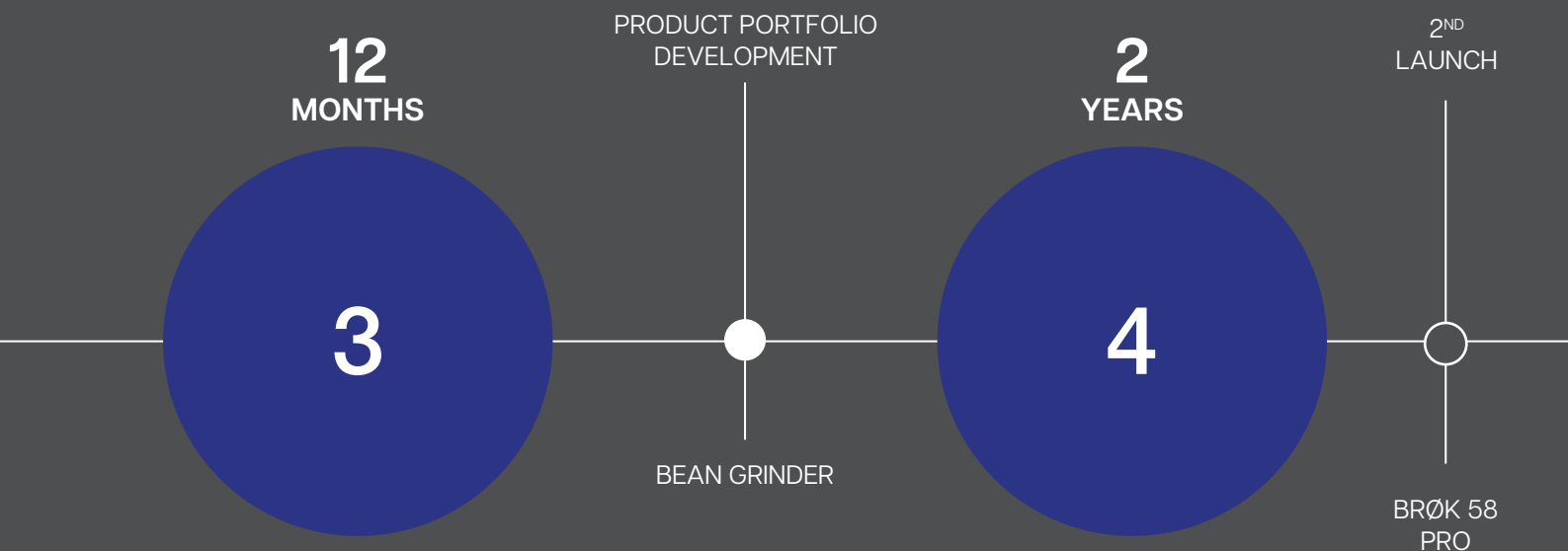
BRØK 58
PRO

MANUFACTURING / 1ST LAUNCH

Business, production and supply chain will take half a year to settle. BRØK 58 will establish partnerships with reviewers and coffee enthusiasts to reach the targeted audience. The reviews and first looks will be on platforms such as YouTube, Instagram and Facebook to gain the attention of ordinary consumers. The goal is to sell an average of 100 coffee machines per month, ending the first year of 500 to 600 units sold and getting close to the break-even point.

MANUFACTURING / 2ND LAUNCH

BRØK 58 will be scaled into variants to expand the target audience. The aim is to design a high-end variant with a heat exchange boiler and a E61 group head for precision brewing. The product portfolio will be expanded into developing a bean grinder to further enhance credibility on the market.

BREAK-EVEN

Break-even is reached after selling 553 units in Q1 of year 2 and is based on manufacturing and assembly in China. If production were to be moved to Europe break-even would be reached at 1220 sold units in Q4 of year 3.
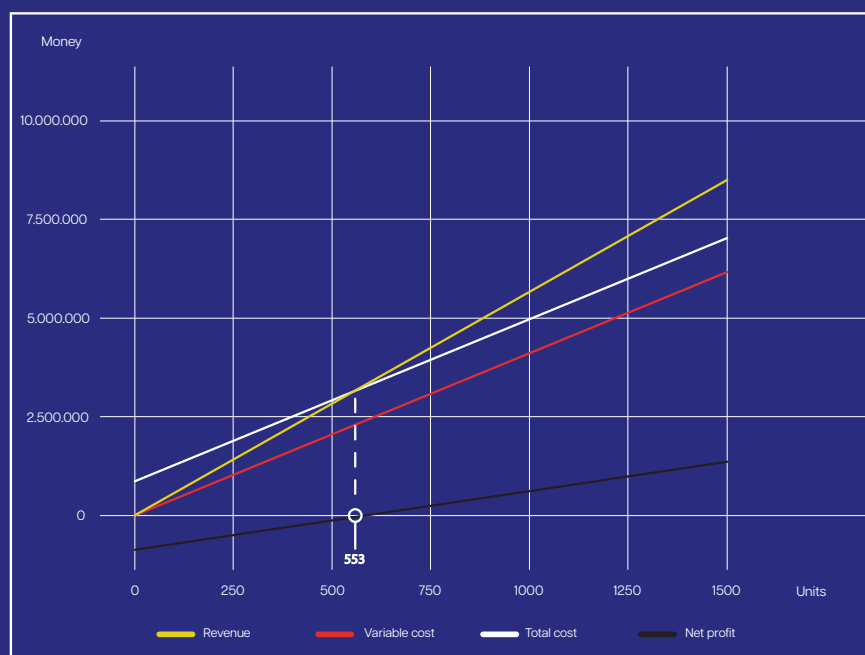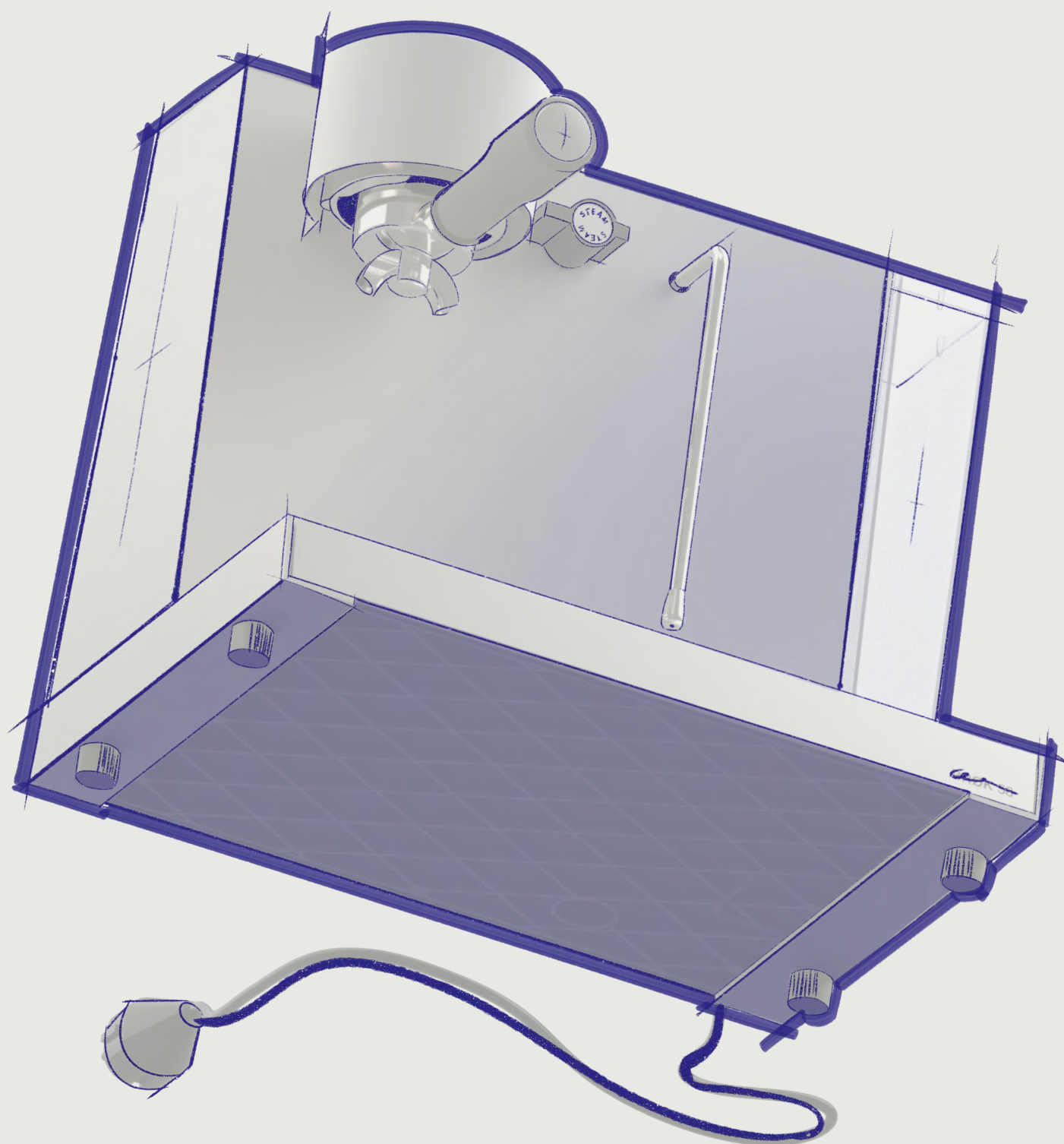
Money

10.000.000

7.500.000

5.000.000

2.500.000

0

553

0   250   500   750   1000   1250   1500   Units

—— Revenue   —— Variable cost   —— Total cost   —— Net profit

BR
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Title page

Project title
BRØK 58

Project team
MSc04 - ID1
Industrial Design
Aalborg University

Project period
03.02.2025 - 28.05.2025

Main supervisor
Christian Tollestrup

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Pages
102

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Abstract

The following master thesis project investigates how repairable design principles can be applied to an espresso machine to improve serviceability, extend product lifespan, and support a more sustainable consumption pattern. While limescale accumulation is known as the primary issue that degrades the machines, most coffee machines remain inaccessible for ordinary users to repair and maintain. Despite growing awareness of environmental concerns, repairability remains a low priority in consumers' purchase decisions, as it is outweighed by convenience, brand intensity, and aesthetic appeal. The high cost of professional repair makes replacement over repair the focus.

The process presents a user-centered design approach through prototyping and user testing, that also addresses the role of visual and tactile aesthetics in fostering emotional attachment. The project presents the product proposal BRØK 58, a timeless and aesthetically pleasing design that makes maintenance and repair more engaging for the ordinary user.

Acknowledgement

Reading guide

This master thesis project is separated into four parts:

- Process report: showcase the process in making BRØK 58

- Product report: presentation of product proposal

- Technical drawings: product specifications

- Appendix: worksheets, methods, and illustrations

The process report presents the development process in nine thematic chapters: Scoping & Framing, Market & Initial Conceptualization, Ideation, User repair & Maintenance, User Interaction, Long lasting Aesthetic Design, Manufacturing, Business & Strategy, and Epilogue. The process report uses symbols for gathered requirements, insights, and design criteria for ease of communication.

Requirement

Design criteria

Insight

Reflection in / on action

References are using the Harvard method.

Lerdahl model for vision-based approach is used to understand what abstraction level the process is currently in and to help navigate the project. This includes the four stages: 1) the spiritual level (intention), 2) The contextual level (expression), 3) the principal level (concept), and 4) the material level (product). The levels are inter-connected and is used to perceive the product on a deeper level and how changing aspects influence across levels. They are not fixed to a certain part of the process, but distributed throughout the whole process (Lerdahl, 2004, p. 100 – 106).

Introduction

Coffee consumption is deeply embedded in daily routines worldwide, driving sustained demand for domestic coffee machines ranging from capsule systems to fully automated espresso makers. While they offer convenience and consistency, their increasingly complex electronic systems are vulnerable to limescale buildup. Over time, limescale compromises the performance and longevity of key components, such as thermoblocks, pumps, and valves.

Despite knowing this, most coffee machines are not designed to be repaired or maintained by end-users. Instead, servicing typically requires specialized tools, technical knowledge, experience, and access to spare parts, making professional repair expensive. Consequently, many consumers opt to replace rather than repair their machines, reinforcing a culture of disposability and contributing to the growing problem of electronic waste. Repair initiatives instated by the EU pushes the world towards other directives, but still coffee machines are yet to be part of this change.

This master thesis investigates how repairable design principles can be applied to an espresso machine to improve serviceability, extend product lifespan, and promote users' confidence in self-repair. By identifying key failure points and differentiating between user-level and professional maintenance tasks, the project aims to bridge the gap between consumer usability, technical repairability, and aesthetics by focusing on the consumer needs and traditions.

Process timeline

Double diamond

The *Double Diamond* (Dubberly, 2004) describes the process as a linear structure, and visualizes how phases converge and diverge. In combination with *The Experimental Learning Cycle* (Kolb, 1984) iterations between *Concrete Experience, Reflective Observation, Active Experimentation,* and *Abstract Conceptualization.* Contrary to the Double Diamond, this learning method is flexible and can be entered in each stage followed in the logical sequence depending on the task at hand.

WHY HAS IT NOT
BEEN DONE
BEFORE?

ASKING
PROFESSIONALS

MOCKUPS

PROBLEM & MARKET

FRAMING

UNDERSTANDING
PRODUCT
ARCHITECTURE

IDEATION

FRAMING

CONCEPTS

CHAPTER
ONE & TWO
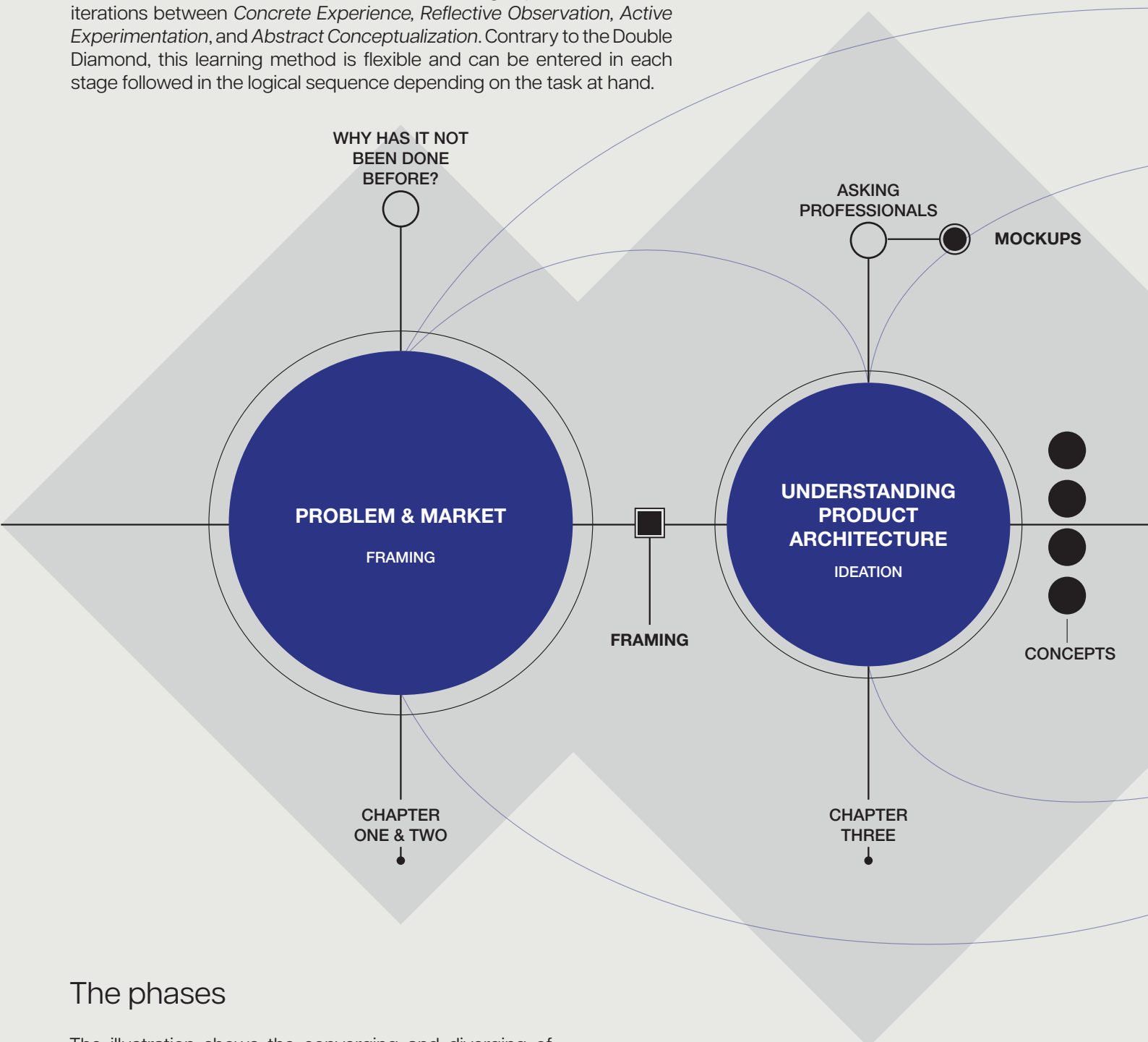
CHAPTER
THREE

The phases

The illustration shows the converging and diverging of each phase and which chapters belong to these phases. Between every chapter is a summary in terms of design briefs and the size of the Double Diamond illustrates the general converging process of the project.

Framing

The project starts out trying to understand the size of the problem and what aspects it affects. Initial ideas unfold during this phase and help the team frame the project.

Ideation

This phase pushes the project to explore the general construction of coffee machines by visiting professional repair technicians. The team begins to understand the extent of the problem on a spiritual and material level and the phase delves into four concept directions which culminate in one chosen direction.

WILLINGNESS TO
REPAIR

USER TEST

CONSTRUCTION
DETAILING

PRODUCT
PROPOSAL

THE
DIRECTION

REPAIR &
MAINTENANCE

CONCEPTUALIZE

BUSINESS
IMPLEMENT

AESTHETICS
DETAILING

PROTOTYPING

CHAPTER
FOUR & FIVE

CHAPTER
SIX & SEVEN

CHAPTER
EIGHT
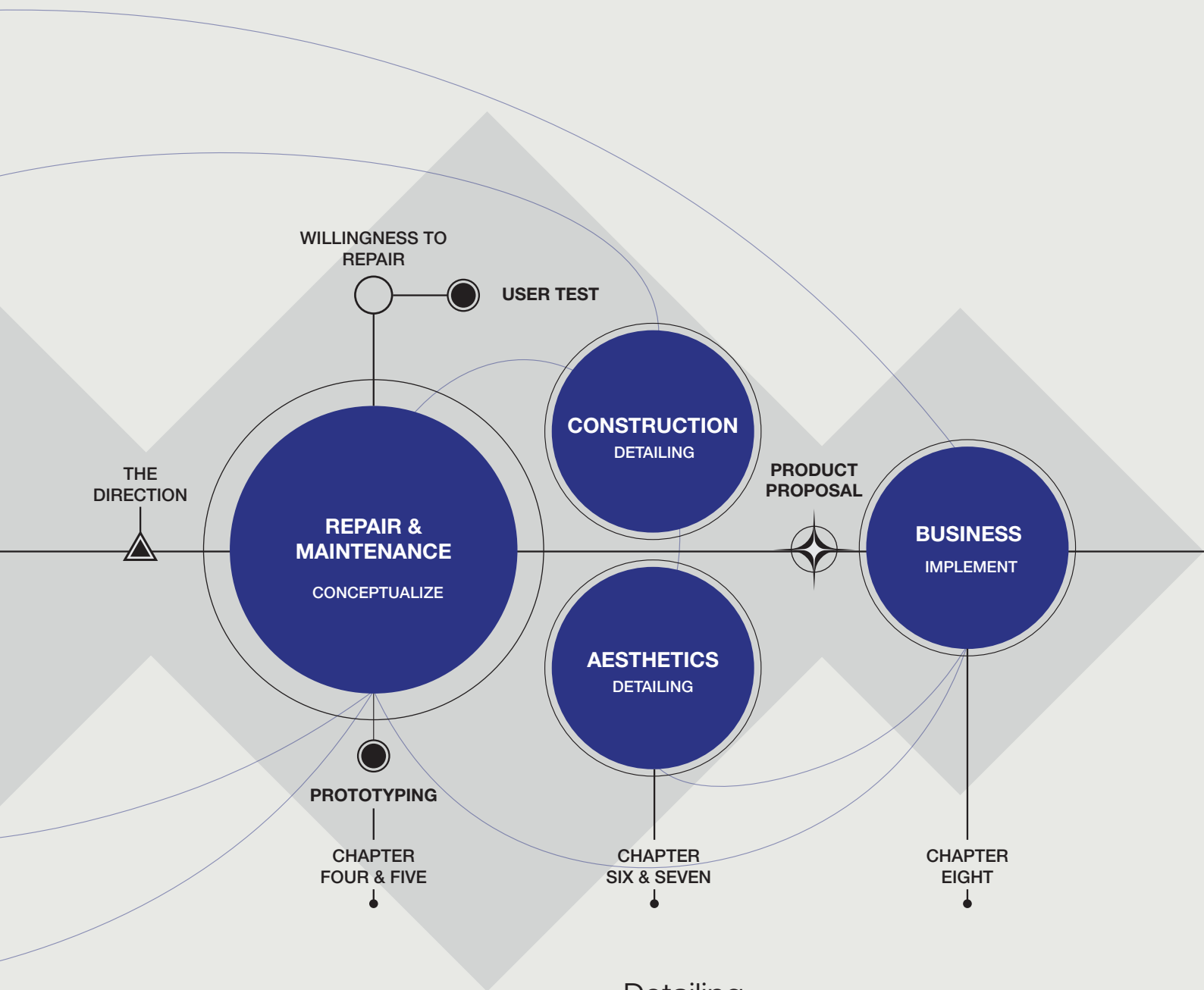
Conceptualize

The concept is examined and tested at a more functional level through methods based on consumers' willingness to repair. During this phase rapid prototyping user testing is executed to further validate ideas and is concluded by presenting a value proposition.

Detailing

The detailing phase is divided into two parts: aesthetics and construction which are processes running parallel. Elements of the product are specified through material selection and production methods to push the current market. The aesthetics are explored through an understanding of timeless and timely design to align with the industry.

Implement

During this phase the team calculates the estimated price to manufacture the product and explores strategies for how BRØK 58 can enter the market.

Table Of Contents

CHAPTER ONE
Scoping & framing

This chapter introduces the research and scoping for the development of the project. The chapter navigates in the principle and material level of the value pyramid (p. 5). It involves strategies that define the entire design project and focuses on uncovering reasoning and opportunities through research and hands on experience. The chapter concludes with the first design brief, highlighting the initial problem statement, insights, design criteria and requirements.

Ill. 1: Electronic waste

E-WASTE

Electronic waste is a global problem, and it continues to rise each year. In 2022 it rose to 59,4 million tonnes (Mt) and is expected to rise to 74,7 Mt by year 2030 (Cornelis et. al., 2025)

The type of E-waste on the market is primarily small from the equipment category, which consists of small home appliances such as vacuums, coffee machines, kitchen equipment, hair dryers and more. Most of these products do not get to be recycled or repaired, as they are cheap and easily replaced. Most of the time it does not make financial sense to fix them, as the cost of the repair is frequently more expensive than buying a new one. The design team saw it as a point of interest to focus on coffee machines and as a way to challenge product architecture experience surrounding repairability and maintenance. (app. 1)

Type of electronics (billion kg)

- Small Equipment: 20,4
- Large Equipment (Excluding Photovoltaic Panels): 15,1
- Temperature Echange Equipment: 13,3
- Screens and Monitors: 5,9
- Small IT and Telecommuncation Equipment: 4,6
- Lamps: 1,9
- Photovoltaic Panels: 0,6
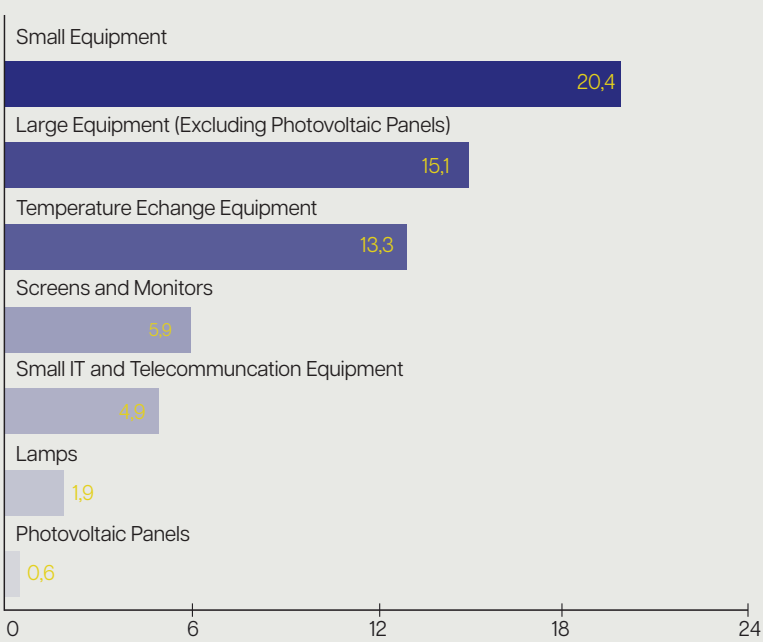
Ill. 3: Type of electronics
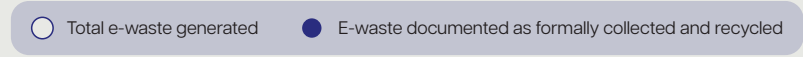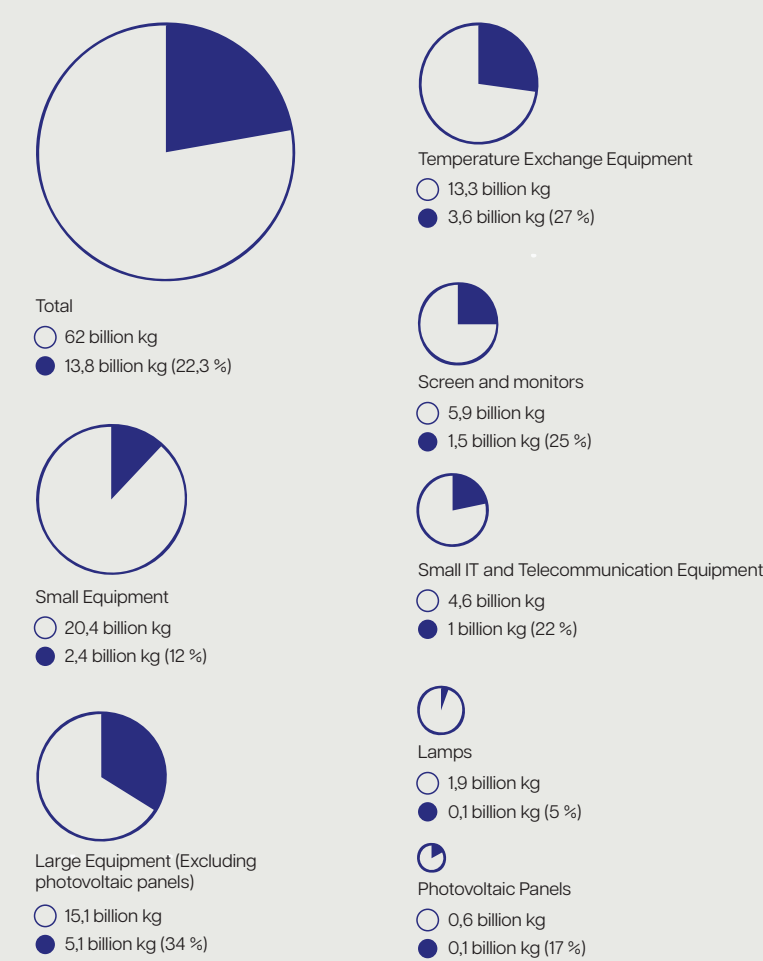
Coffee is a popular and very traditional beverage imbedded in Danish culture, and about 40% of the Danish population has an espresso or capsule machine in their home, while the majority of others own some sort of coffee machine or maker (Statista, 2025). A good portion of these people have more than one coffee machine, that works for different purposes, most likely making the number of coffee machines in each household higher than one on average.

Coffee machines are complex machines and are usually never designed to be repaired by a novice. Coffee machines have an expected lifetime of 3-5 years (Maione, 2023), and this is usually extended by performing maintenance like descaling. The main failure point of coffee machines is primarily lack of descaling which results in leakage and clogged components (Ibid., 2023). As the machines are compact, glued together, and components are stacked upon each other, having to diagnose the point of failure is a difficult task for someone inexperienced. These design decisions impact price heavily, making the products cheap and therefore favoring replacement over repair. (app. 1)

For this reason, it is vital to challenge current design principles used to combat the amount of electronic waste generated, and specifically in this master thesis the throwaway of coffee machines.

Total
- ○ 62 billion kg
- ● 13,8 billion kg (22,3 %)

Small Equipment
- ○ 20,4 billion kg
- ● 2,4 billion kg (12 %)

Large Equipment (Excluding photovoltaic panels)
- ○ 15,1 billion kg
- ● 5,1 billion kg (34 %)

Temperature Exchange Equipment
- ○ 13,3 billion kg
- ● 3,6 billion kg (27 %)

Screen and monitors
- ○ 5,9 billion kg
- ● 1,5 billion kg (25 %)

Small IT and Telecommunication Equipment
- ○ 4,6 billion kg
- ● 1 billion kg (22 %)

Lamps
- ○ 1,9 billion kg
- ● 0,1 billion kg (5 %)

Photovoltaic Panels
- ○ 0,6 billion kg
- ● 0,1 billion kg (17 %)

○ Total e-waste generated   ● E-waste documented as formally collected and recycled

Ill. 2: E-waste generated

- Coffee machines have a lifetime of 3-5 years.
- The main failure point of a coffee machine is limescale build-up.
- Diagnostics of a failure is very difficult.

THE RIGHT TO REPAIR

The Right to Repair is an organization which fights for consumers' right to fair pricing of spare parts and the availability of them, as well as products designed for repairability and easy disassembly. They are demanding access to manuals and diagnostic tools making it possible for consumers to engage with better self-repair and maintenance. (app. 2) (Repair.eu, 2024).

As an answer to this movement, the EU has made the right to repair legislation as a step towards responsible design (Yakimova, 2024). However, far from every product is affected and some small household appliances such as coffee machines are yet to be part of the legislation. The requirements are as such:

Obligation to repair
- Manufacturers must offer timely, affordable repairs and inform consumers of their repair rights. Repairs under warranty get a one-year legal guarantee extension, encouraging repair over replacement.
- After the guarantee expires, manufacturers must still repair common household items (e.g., washing machines, vacuums, smartphones). The product list may expand, and consumers can borrow a device or choose a refurbished unit if repairs are not possible.

Information on repair conditions and services
- Consumers can use a European information form to compare repair services (defect details, price, and duration). A European online platform with national sections will help find local repair shops, refurbished goods sellers, buyers of defective items, and community repair initiatives like repair cafes.

Revitalizing the repair market
- The laws boost the EU repair market and cut costs for consumers. Manufacturers must offer spare parts and tools at fair prices and cannot block repairs with contracts, hardware, or software. They also cannot impede second-hand or 3D-printed parts, refuse repairs for economic reasons, or reject products fixed by others.

Promoting affordable repair
- To lower repair costs, each member state must adopt at least one measure, like repair vouchers, funds, info campaigns, courses, or support for community repair spaces. (app. 2)

According to the Right to Repair movement however, most people will only consider a repair if the total cost of the repair is less than 30–40% of the product value. They estimate a more realistic number of below 15-20% of the product price is more reasonable, but it makes a clear statement that a future push for an even more user-centered direction of consumer electronics. It is vital that solutions should contain considerations of modularity, repairability and easy disassembly (Ganapini, 2024).

These principles create the foundation of this master thesis, which will be actively used throughout the process.

Coffee machines are not a part of the EU repair legislation yet.

Most people will only consider repairing if the total cost is less than 30-40%.

Coffee machines are not designed for the user to open or disassemble it.

Should offer additional guidance to lower repair costs.
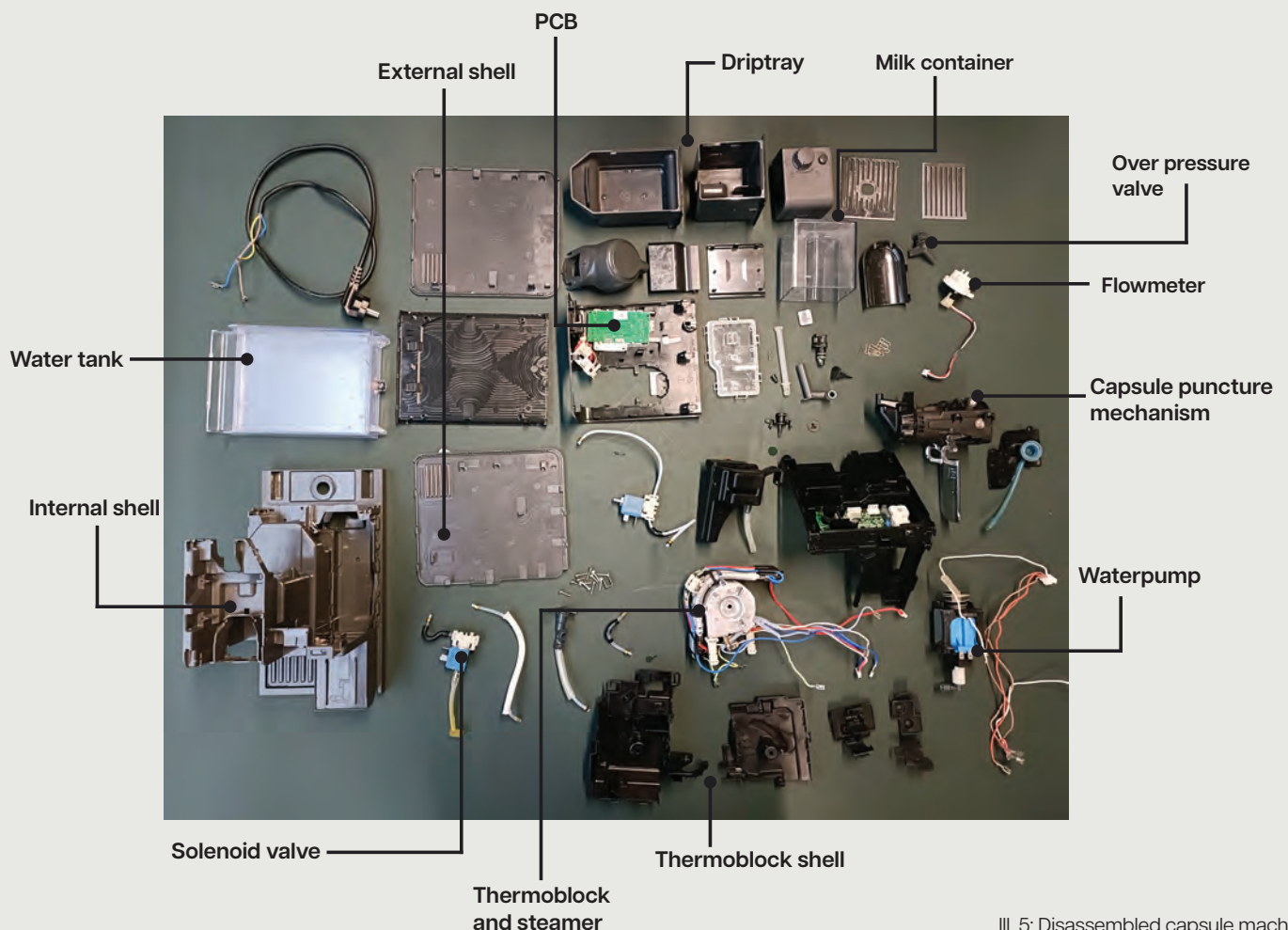
DISASSEMBLY OF COFFEE MACHINES

To understand how a coffee machine works, it was decided to disassemble three different types: a filter-, a capsule- and a manual espresso machine. The machines were second-hand ones bought off Facebook Market place from consumers claiming they work just fine. As these machines are older, they are not produced under the new right to repair directive by EU, nevertheless looking at the market, it seems to be the same machines.

The disassembly gave some insights into how the machines are built and how they work, as it gave a clear overview of how complex they in fact are. The first step was to open up the machine to get a glimpse inside, but that step was just as difficult as separating the rest.

The capsule machine was cramped, and a lot of connections were glued or clasped together with tight snap fittings. Components like the water pump and solenoid valves were encased in rubber and had to be cut out in order to separate them completely.

Ill. 4: Coffee machines

Ill. 5: Disassembled capsule machine

Steam valve · Boiler · Waterpump · Flowmeter

PCB

Pressure gauge

Internal shell

Water tank

Driptray

External shell
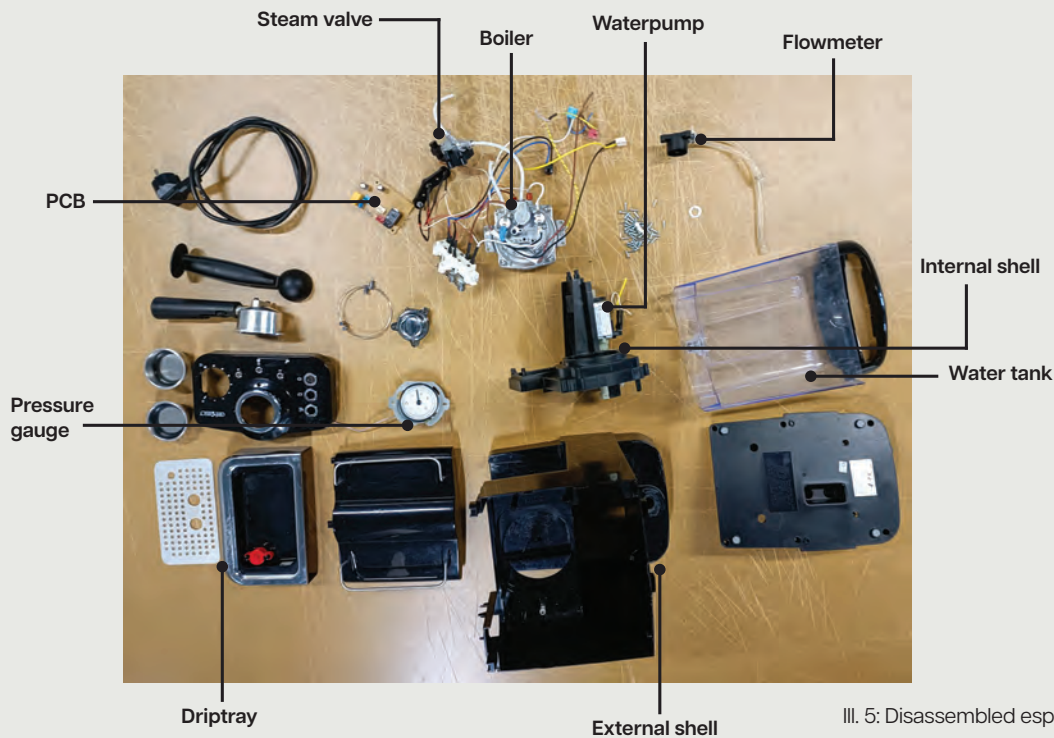
Ill. 5: Disassembled espresso machine

The espresso machine was as difficult as the capsule though succeeding in disassembling the group head, a massive amount of limescale and foul smell was discovered. This would most likely affect the taste of the coffee and effectiveness of the thermoblock. Getting to disassemble the group head came at a great effort and resulted in minor injuries as well.

The filter coffee machine was the simplest to disassemble and provided little problem other than understanding the components' function.

It was obvious that these products were not designed with disassembly in mind, and there was no clear indication that people with little to no knowledge of repair and/or coffee machines are meant to access the core of the machine.

The disassembly also gained insights into the components (size, weight, material) and how everything is connected (app. 3). It should be noted that understanding how everything works was a massive effort. Under multiple rounds the design team had to dissect the connections and functionality to make sense of the "rat's nest". Tubes and wires overlapped, and understanding the direction of the water flow was a tedious task. On the other hand, these principles make it possible to make a small and compact machine that does not take up too much space on the kitchen counter, which could be desirable for the consumer.

Tubes · Top shell

Heating plate

Lid

Thermocoil

Bottom shell

PCB

Coffee filter holder · Water spout
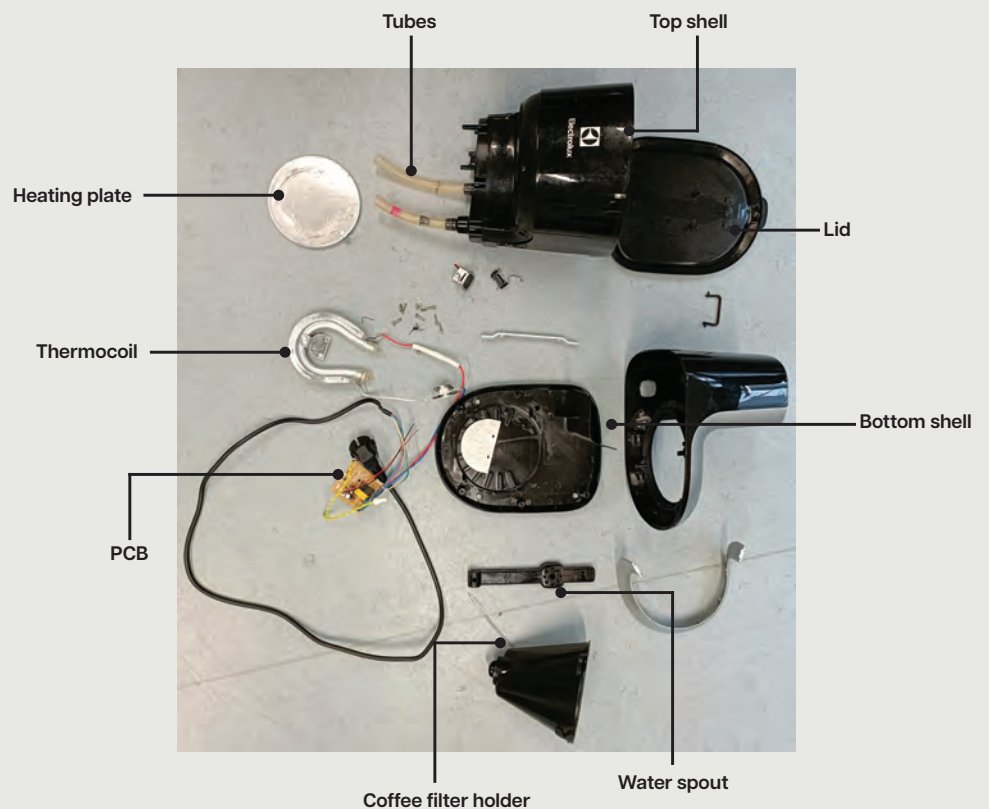
Ill. 6: Disassembled filter machine

Key components must be replaceable.

How does A coffee machine actually work?

Watertank

Heater

Brewing unit

Pump

Coffee filter
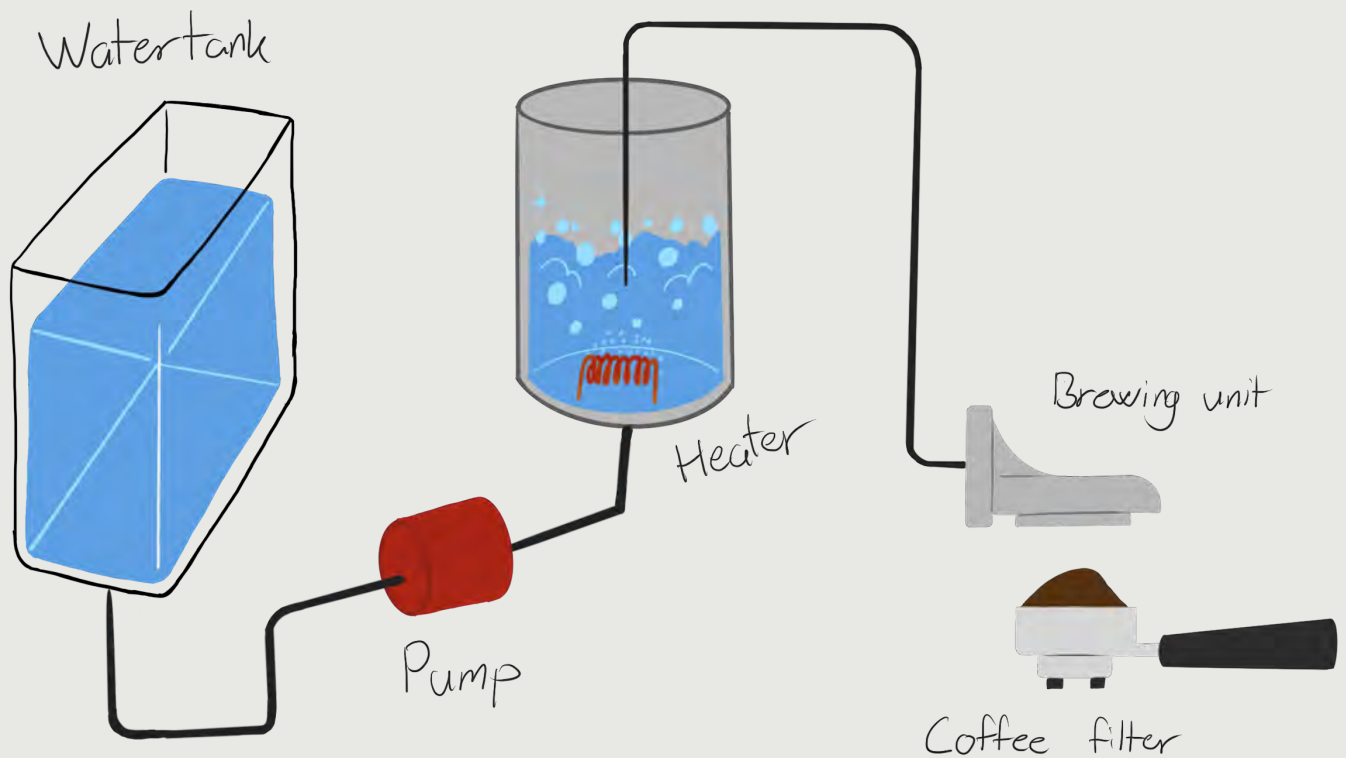
Ill. 7: Brewing process

The fundamentals of how a coffee machine works are quite simple. There is a container with water, that water gets pumped into a heating unit. The heating unit heats the water close to boiling point and transfers the hot water to a brewing unit. The brewing unit brews the cup of coffee from ground coffee. Depending on the type of coffee machine, this is done in different ways. A filter machine through a coffee filter, an espresso machine through a portafilter, an automatic coffee machine through a brewing unit, and a capsule machine through a coffee capsule.

WHY HAS IT NOT BEEN DONE BEFORE?

To understand why there has not been made a user-centered repairable coffee machine before, it is decided to investigate themes such as planned obsolescence and conduct a case study of Fairphone.

Planned obselescence

Planned obsolescence is an act of designing products with a planned expiration date, meaning the product will break or become outdated after a given period (Kenton, 2022). It differs for each product category. Specifically, for coffee machines they are made to last from 2-5 years, depending on the price of the product. They are typically constructed with smooth bodies and barely visible screws or construction lines. Having to disassemble one often creates confusion, frustration, and fear of making things worse. Coffee machines are not made for anyone to disassemble, and often repair technicians use experience to determine how to approach a specific machine. (app. 4)

Even though companies are creating products that are not meant to last, it does not mean they deliberately create bad products. Because of competition and market, many companies opt for cheaper options as a strategy to attract more customers. Some may argue that it is the consumer's fault. When consumers buy the latest, most popular and cheapest product, they are signaling manufacturers and companies that consumers are willing to engage in planned obsolescence (theknowledgeloft, 2017).

Based on Barros & Dimlas' (2021) definitions, the strategy of planned obsolescence consists of three factors:

Functional: When a new product outperforms an existing product. This means when a product is being released a company has already designed or is designing a direct replacement.

Technological: When a product stops functioning as before, due to components lifetime has come to an end reduced by the design.

Aesthetic: *When companies create new variants of an existing product, more specifically changes the aesthetic characteristics to appear new and "special". This happens even if the product works exactly as it should and there is usually no technical changes in the "upgrade".*

Case study: Fairphone

The Fairphone is a smartphone that focuses on repairability to extend smartphones' lifetime. Almost every single component is individually repairable and can be replaced by the consumer. It is only the screen and battery there is inaccessible for self-repair because of the complexity and dangerous materials. Fairphones consist of standard components and screws that are easily accessible. Fairphones consist of 8 different modules, where they clearly indicate what each module is. Making it an easy task for the users to analyze faults and what parts to replace. Fairphone's philosophy is: "repairing your phone should be as easy as assembling an IKEA shelf". (app. 5)

Even though Fairphone gets high scores in repairability, it is not a perfect phone, as the functional value is low compared to direct competitors (Isakeit, 2019). As observed on online forums, users complain: "cracks in the case despite not dropping their device. Components were so easy to pop out that dust was able to work its way into the connections, leading to screen glitches and distracting pixel coloration."

The Fairphone had a hard time gaining any traction, as it was the company who pushed out a product very few demanded. Consumers are no longer interested in tech or specifications; they are interested in prestige and functionality with ease and convenience being the major consumer pull factor. The general smartphone today has a lot of powerful software and hardware and fits the needs of almost every person.

Ill. 8: Fairphone 3

> ⚠ **Make the repairability of the product a secondary or tertiary selling point.**

The why...

Looking into obsolescence and Fairphone, the latter creates a long-lasting product, and obsolescence creates sales and revenue. There has not been designed a flawless product that both generates a lot of revenue, while also lasting a considerably longer time than its competitors and still being at the same level of quality as the competitors. Nor a strategy of how to achieve this coherently over a longer period of time. Fairphone demonstrates a case where repairability and upgradability is not enough alone. It is not the driving factor that creates sales. It is determined that designing products with repair and maintenance in mind should be "self-evident" but not the main feature. So why has no one designed a coffee machine with these features? One argument is timing; the right to repair movement is still ongoing and the legislation is fairly new. Companies might be working on solutions behind the curtain – and coffee machines are, as mentioned earlier, not part of the product group affected by this yet.

Design brief 1.0

Project focus

To design the next generation of modular coffee machines that users of all skill levels can feel comfortable to repair and upgrade.

Aim

To design the next generation of modular coffee machines that users of all skill levels can feel comfortable to repair and upgrade.

Problem statement

How can a coffee machine be designed for user-centered repairability and upgradability?

Insights

Coffee machines have a lifetime of 3-5 years.

The main failure point of a coffee machine is limescale build-up.

Diagnostics of a failure is very difficult.

Coffee machines are not a part of the EU repair legislation yet.

Most people will only consider repairing if the total cost is less than 30-40%.

Coffee machines are not designed for the user to open or disassemble it.

Requirements
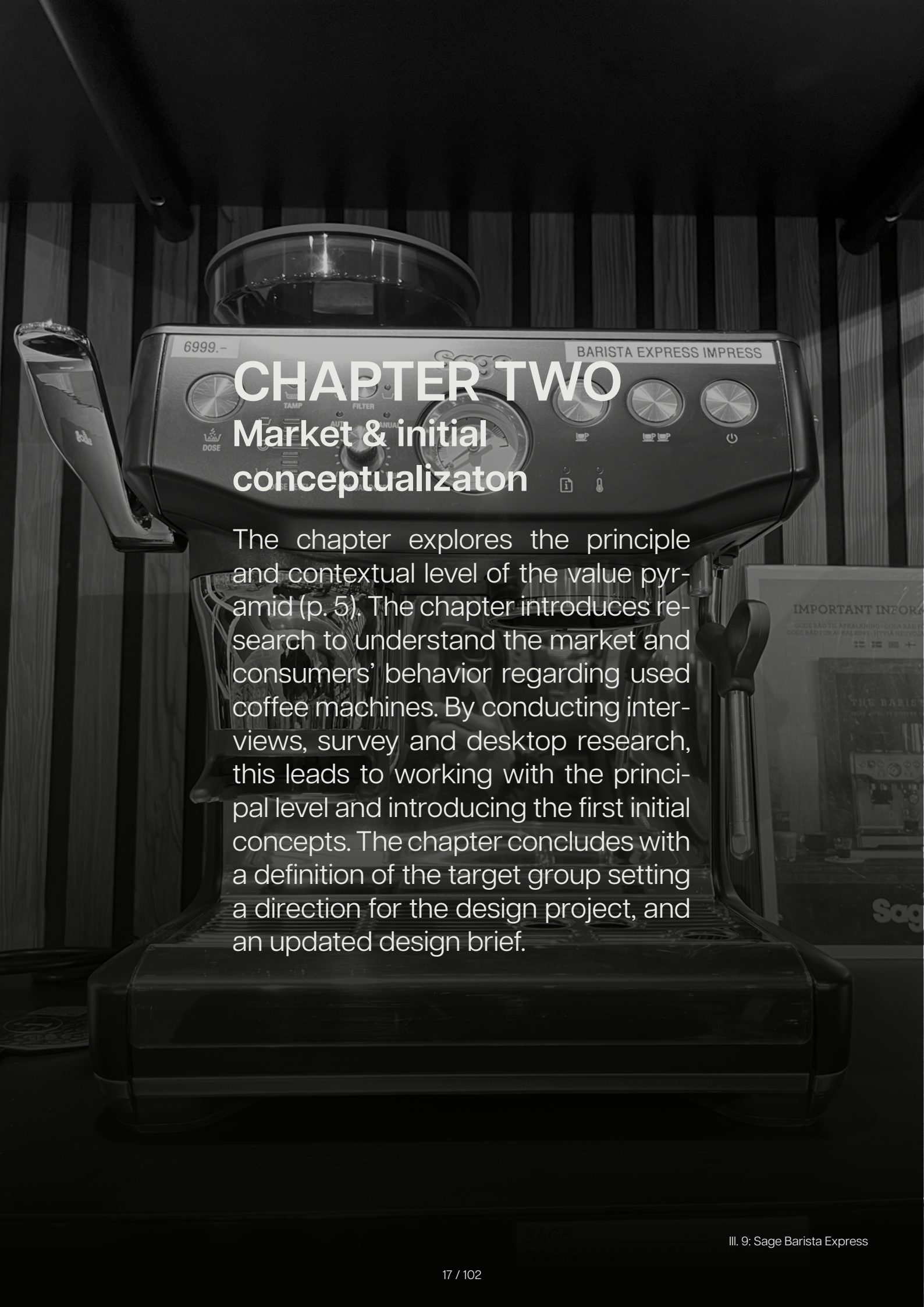
Key components must be replaceable.

Design Criteria

Companies should offer additional guidance to lower repair costs.

Make the repairability of the product a secondary or tertiary selling point.

CHAPTER TWO
Market & initial conceptualizaton

The chapter explores the principle and contextual level of the value pyramid (p. 5). The chapter introduces research to understand the market and consumers' behavior regarding used coffee machines. By conducting interviews, survey and desktop research, this leads to working with the principal level and introducing the first initial concepts. The chapter concludes with a definition of the target group setting a direction for the design project, and an updated design brief.

Ill. 9: Sage Barista Express

SURVEY AND INITIAL INTERVIEWS

Survey

A survey has been distributed to gain an understanding of the perception and behavior regarding coffee machine repair and maintenance. The survey obtained 59 responses. Most notable insights are:

The majority of respondents think it is too expensive to repair a coffee machine in a repair shop.

Are you willing to send your coffee maker to a repair shop in case your coffee maker becomes faulty? (a typical repair shop takes between 170 EUR - 200 EUR an hour (178 - 210 Dollar), but can vary)

- No, it's too expensive
- No, I don't think it's worth the time
- Never thought about it
- I repair it myself
- My warranty covers, otherwise its cheaper to buy a new coffee machine
- Yes
- I have done it before and will do it again
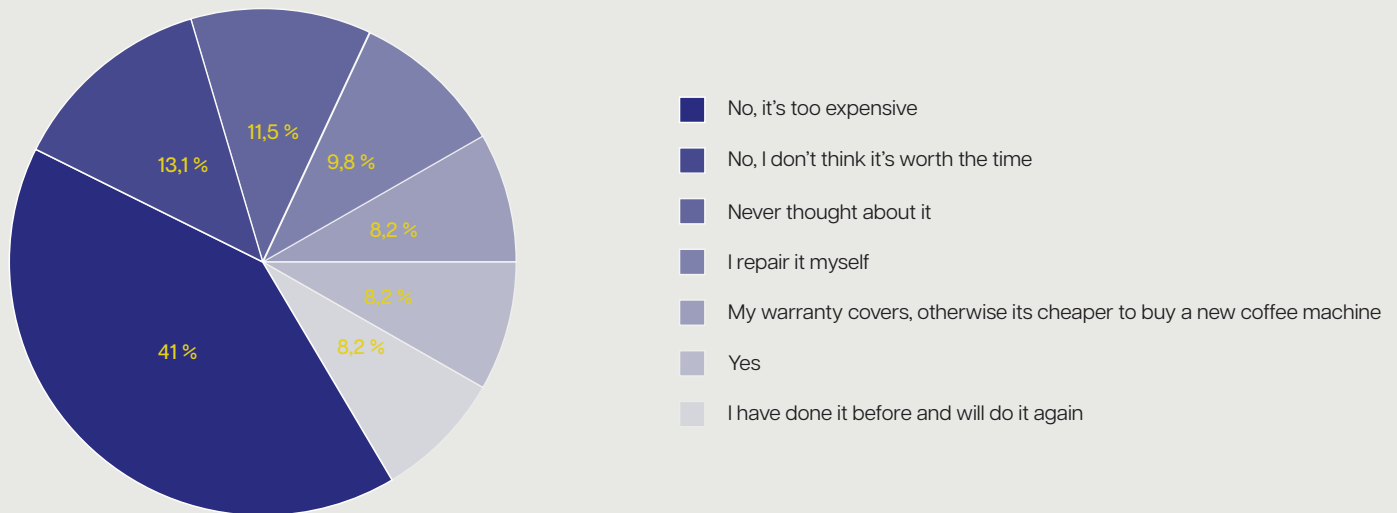
Ill. 9: Willing to pay for repair

Have you ever thrown out a coffee machine and why?

I stopped working, and I did not know why	8 (13,1 %)
Because I wanted a new one	9 (14,8 %)
I tried to repair it, but it did not work	4 (6,6 %)
A part of it went faulty and could not be replaced	11 (18 %)
I have never thrown out a coffee machine before	31 (50,8 %)
Other	6 (9,9 %)
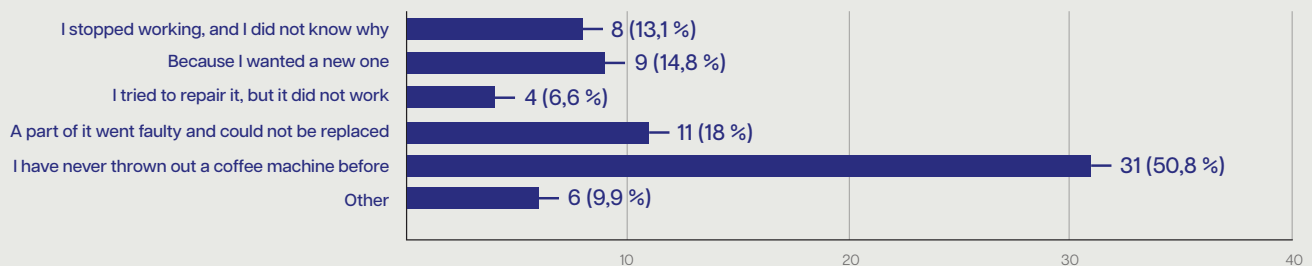
Ill. 10: Have you thrown out a coffee machine?

A little over half of respondents have disposed of a coffee machine before.

The coffee machines were disposed of because the respondents did not know why the coffee machine stopped working or because they wanted a new one.

The coffee machines were disposed of because a component went faulty and could not be replaced.

The coffee machines were thrown out as it was cheaper to buy a new one than to get it repaired professionally.

If you have ever tried to repair a coffee maker, how was your experience? If you have never done it before, how would you go on about it?

"I would never try as I wouldn't know what I'm doing, and I would be risking making it worse."

"I recently replaced my Nespresso machine with the exact same model because they charge 1500 DKK and up for repairs, and a new one was 500 DKK on sale."

"I would never try as I wouldn't know what I'm doing, and I would be risking making it worse."

"If I had an expensive one I might but it would have to be a really good coffee maker or I wouldn't bother"

"See if I can somehow fix it on my own, check pricing for repair, and compare to the price for a new one. Make a decision"

"Would send to a professional", "I would buy a new one"

"Never done it. I would watch videos on the exact same model that I have and then go from there."

These insights display a pattern in opinions and behavior. Half of respondents have never thrown out a coffee machine, though the other half have, and most commonly because the machine did not work and could not be fixed or because they wanted a new machine. The repair cost is often regarded as too costly compared to the alternative of getting a new and well-functioning coffee machine. However, it is important to be wary of what a respondent assumes cannot not be fixed, as this may simply be that they did not know why the machine was faulty. (app. 6)

Initial interviews

An unstructured interview was conducted with two sales employees in Magasin to gain additional insight and initial understanding of the problem-space.

Why do people return their coffee macahines?

"9 out of 10 times it is because users do not maintain their machine."

"Some customers just want to make complaints to receive a new machine for free, so they can avoid paying for a repair."

"Companies like Sage requires certified repair technicians to work on the machine, so it is necessary to send the machine to a repair shop."

"Repair is free if it is within the guarantee period."

What happens after the machines are returned?

"Some brands like Sage take back the machine and use it for spare parts."

"Nespresso just provide a new machine. I don't know what happens to the old one – maybe it is too cheap to care about."

"I have received a kettle before from a customer because it 'stopped working'. I went to the kitchen and descaled it and called the customer the next day."

In addition to these two interviews, an unstructured interview was conducted with a customer and coffee machine owner.

Would you be interested in repairing a coffee machine?

"My hands are 'on backwards', so if I tried to repair my capsule coffee machine, I would be afraid of making it worse."

"I once paid 1200 DKK for my mixer to be tightened – it is a very small fix but it was outside the guarantee."

"Once, I tried to disassemble my capsule coffee machine, but I ended up not being able to assemble it again, it was so difficult."

"I would not try to repair it; it is obviously not made for disassembly."

From a retail perspective, it is usually due to bad maintenance that customers return their coffee machines. Customers want to save money, therefore submit a complaint and avoid sending the machine for repair.

When it comes to repair and technical knowledge, people with no or low skillset would not feel confident opening up a machine. It is also seen as a machine that cannot be disassembled from a consumer perspective. (app. 7)

There is a need to obtain further knowledge of consumers' repair behaviors and why coffee machines become faulty. In chapter three this will be elaborated upon by interviewing and observing professional repair technicians that work repairing coffee machines. Additionally, it should be considered how people of all skill levels can find confidence in repair. (p. 11)

People should feel confident when opening the coffee machine. ⓘ

MARKET & POSITIONING

Market

Market boards of coffee machines, e.g. filter, capsule, and automatic and manual espresso machines (see app. 8), were made to gain knowledge of to what degree competitors have made coffee machines self-repairable.

The most expensive coffee machines have serviceable areas for repair or cleaning, such as super automatic espresso machines' brew groups, while the remaining are mostly encased in their shell.

At the point, the market research was completed, the disassembly of coffee machines had not yet been executed. Therefore, a need to try disassembly and inspect internal components arose.
This is a small section of the market, yet it provides a broad understanding of how the market may be perceived by designers as well as consumers.

Ill. 11: Market

Positioning

To make a coffee machine that stands out compared to competitors, the machine must be easily disassembled and repairable to a high degree by the user. However, these demands come with a price that cannot be determined yet, and therefore the price class remains vague/unclear. The yellow area marks the product positioning. (app. 8)

There is a gap for a user-repairable coffee machine on the market.

PRICE CLASS MATRIX

Based on the initial market research it was evidently essential to understand what differences could be observed across types and low-end, mid, and high-end coffee machines. This was done to ascertain demands in each category, and further to anticipate what potential compromises each price class would have to make (see app. 9).

The price classes have a few minimum requirements across product types – a one liter water tank and a cleaning indicator.

	Low	Mid	High
Filter	• Function first • Drip stop • +1 liter water tank	• Drip stop • Hot plate • Cleaning indicator • +1 liter water tank	• Drip stop • Smart hot plate • Cleaning indicator • +1 liter water tank • Thermo pitcher • Removable coffee filter holder • Detachable water tank
Capsule	• +0,5 liter water tank • Detachable water tank • Cleaning indicator • Buttons • Adjustable drip tray	• + 1 liter water tank • Detachable water tank • Cleaning indicator • Automatic milk function • Adjustable drip tray	• +1,5 liter water tank • Detachable water tank • Cleaning indicator and program • Touch display • Milk steamer • Adjustable nozzle • Adjustable drip tray
Espresso	• +1 liter water tank • Cleaaning indicator • Milk steamer • 15 bar • Buttons	• +1,5 liter water tank • Coffee bean grinder + container • Milk steamer • Cleaning indicator • 15 bar • Touch display • Automatic milk function	• +2 liter water tank • Coffee bean grinder + container • Milk steamer • Cleaning indicator and program • 15 bar • Touch display • Automatic milk function • Detachable water tank
In common	• Buttons • 1 liter water tank • Cleaning indicator	• 1 liter water tank • Cleaning indicator	• 1 liter water tank • Cleaning indicator and program • Detachable water tank

Low-end coffee machines contain the 'bare minimum' of what makes it a coffee machine.

- The assembly is non-intentional, every component just needs to fit into the machine, making it compact.
- It has a smaller water tank and for filter coffee machines they are permanently installed into the machine as part of the main body. This is a compromise not to create more parts and making it cheaper.
- The overall aesthetic of the product is very plasticky and functionality based.
- There is no cleaning indicator or program for low-end filter coffee machines, and it is left up to the user to determine when and how to maintain their machine.
- Generally, low-end capsule and espresso contain cleaning indicators, not directly programs, forcing the user to determine how to clean their product themselves.

The more expensive the coffee machine becomes, the more gadgets and features it gains.

- Some mid filter coffee machines have detachable watertanks and filter holders, but that feature mostly accounts for high-end.
- Milk steam wands and automatic milk programs are parts and features that inceases the price.
- They are generally larger in size and have larger water tanks.
- When going from low-end to high end, the buttons generally change from physical to touch, adding PCB's and additional software.
- High end coffee machines have more intentional design, a lot of stainless steel are used to add a high quality element, as well as more explorative design language. These products feel more 'designer'.

Low-end machines are generally harder to clean as they are more difficult to open. They are not designed to open and for the user to understand the internal layout. Some high-end products have sides/doors that can be detached from the main body, to open op for certain parts to clean or service. Low-end coffee machines transfer the responsibility to the user to clean the product how they see fit, generally risking bad maintenance and user error. Additional components such as double nozzles, milk steamers or different coffee and storage containers add to the cost. Furthermore, software such as milk- and cleaning programs, memory, and touch display increase the price considerably. High-end coffee machines, in general become more gadgety, creative and explorative. As the low-end products are harder to maintain and refurbish, it results in shorter lifetimes as customers will have to buy a whole new coffee machine to make it function properly again. As found in the survey (see p. 18) consumers will most likely replace the coffee machine rather than repair if the repair is too costly. (app. 9)

Repair costs should be researched as they are essential to understand where the consumer draws the line.

Ill. 12: Coffee machines in store

INITIAL CONCEPTS

Building blocks

The building block concept is the idea that the coffee machine is split into 3 different bodies: A main body, a head and a water tank. The reason is to create a body that can act as a main unit or home body, that can brew coffee in three different ways – a filter coffee, espresso coffee machine and capsule machine.

The main body; would consist of all the vital components that would be present in all types of coffee machines. The parts are seen in Illustration 13.

The head; would be the main difference between each coffee machine. The head would build on the parts that brew the coffee in each machine, making it very different from each other. The only thing that would be same, would be the interface of how the head and body would connect and interact.

The water tank; could essentially be the same in each machine, but each machine has different needs for the amount of water needed. Therefore, the tank size would be adapted to the specific machine type.

The vision for this concept is that the users should be able to change between the heads, meaning that you can have three coffee machines in one.

In this concept there were some concerns to keep in mind:

· The different high-pressure pumps normally used.
· The amount of pressure rated solenoid valve needed.
· Whether it should be a thermoblock or a boiler.
· Different brewing temperatures.
· Programming / sensor for the head and type of machine attached to the body.

Instantly, concerns arose whether this would become the next Fairphone, as there was no evidence that there was a pull for an interchangeable coffee machine. There were also concerns whether the concept would be able to brew good enough coffee and not just become a gimmick. (app. 10)
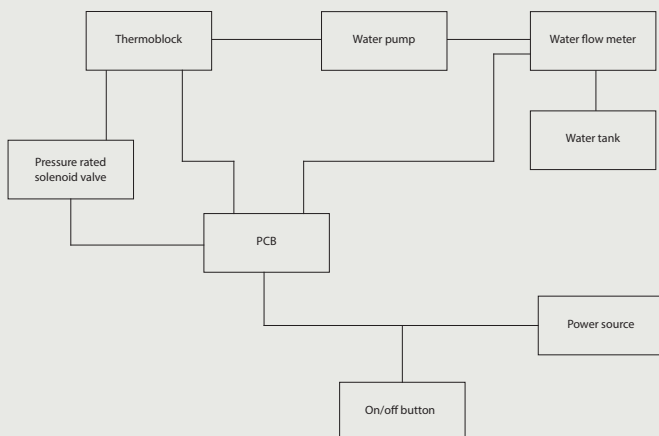
Ill. 13: Architecture
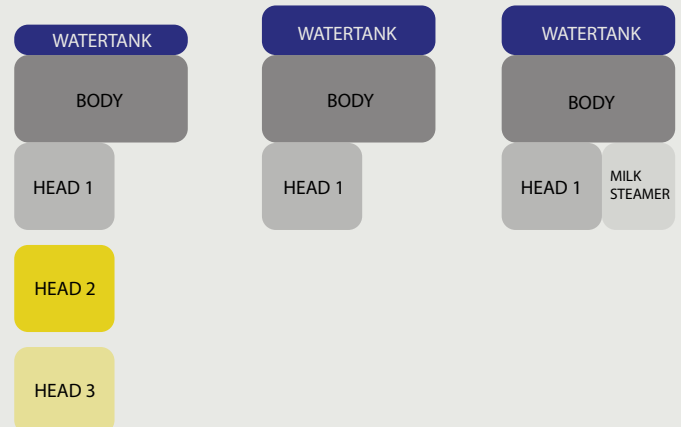
Ill. 14: Bulding blocks
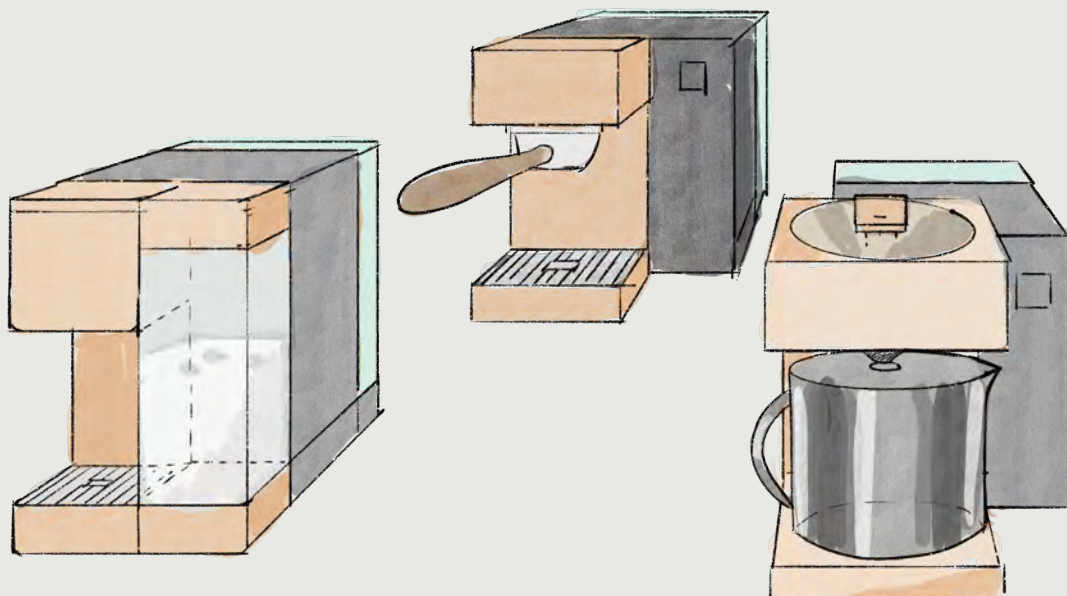
Ill. 15: Initial concept

Desktop

The working core of coffee machines are complex and hard to decipher. To combat this a concept inspired by desktop computers emerged. The idea is to make a side of the coffee machine easily accessible, with no components mounted on this access side. Making it easy to gain access to the inside. The inside should be designed to ensure easy understanding and overview of the coffee machines components and where or how they are connected. Even though the illustration 16 is complex it is much easier to decipher than illustration 17.

Ill. 16: Stationary computer

Ill. 17: Capsule machine inside

From this the idea is to make a layout as shown in illustration 18, with components mounted to one side and excess space for the user to maneuver. To diagnose the coffee machine if something is faulty or needs attention, an idea is that LED lights could light up a color that tells the user where something is wrong.

However, there are still some concerns about this concept. It would most likely be a larger machine than necessary and leave unused space available. The head could also be a difficult part to access in the current layout see illustration 18. (app. 10)

Ill. 18: Sketch 1

There is a need to dive deeper into diagnostics and how machines act when something is wrong. For this concept the focus should be on the interface between components and the layout. The outside will be something that should be focused upon at a later stage.

The inside must be compartmentalized.

UPGRADE & VARIANCE MAPPING

With the concept of building blocks, it would be possible to upgrade and/or change the head to make it possible to have multiple variants of the same coffee machine. The idea is that a user can own multiple heads, thus the user can change between each head. This makes it possible to have multiple variants that have different functions. As seen in illustration 19 there are four different heads that fit upon the body, with various upgrades for each machine and many overlaps. Where the exact position of the upgrades is supposed to be placed is undetermined, as some upgrades make no sense for some heads. (app. 11).
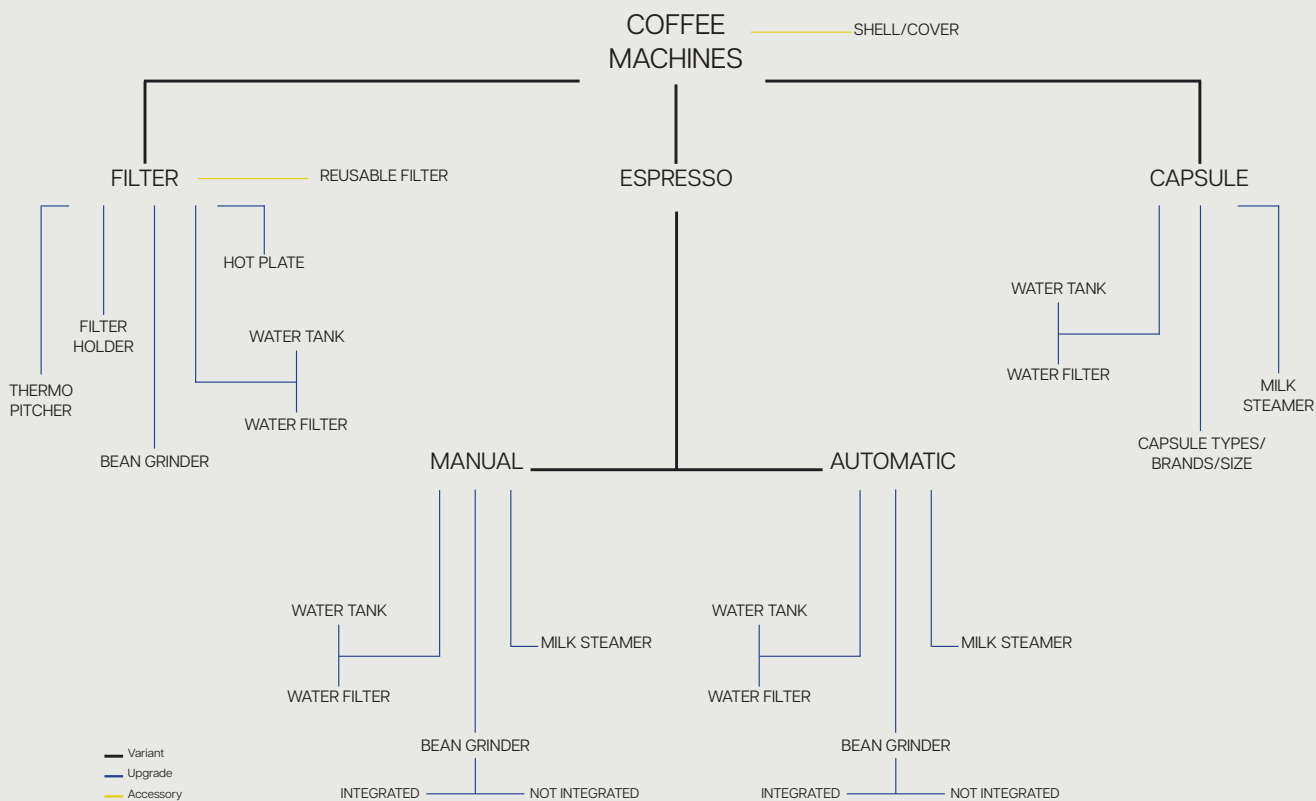
Ill. 19: Variance map

Purchase example

Based upon the variants and upgradeability of the building block concept. An investigation was needed into how users act and purchase products. Illustration 20 provides an example of how this might be.

As a result of this example, it was noted how many different possibilities the user would have and how they would act. It is a complex model and demands the user to understand the entire system, making it very difficult for them to interpret. As the complexity of the system and business model becomes too complex another direction could be needed.

Ill. 20: Purchase example

CONCEPT EVALUATION

With the building block concept, it was evident that the concept consisted of more complexity than first intended. The idea focused upon upgradability rather than repair, and longevity that focused on an all-in-one solution with no indication or knowledge of customers interested in this idea. This concept would encounter the same difficulties as the Fairphone company that consisted of no market pull and therefore slow growth (p. 15). With too much uncertainty in this concept, it is rejected, and the project will refocus on user repairability.

The essential idea of the desktop idea is easy access and overview of the layout for the user. It will not be aimed upon upgrading nor interchangeability of machine types. The foundational idea will be used to discover design attributes to help users with maintenance and repair.

WHICH COFFEE MACHINE?

As this chapter has been investigating the market of both filter-, capsule-, and espresso machines, going forward the project will focus upon semi-automatic espresso machines. The reason for this lies in both price, emotional value, and longevity. Price generally determines how a user cares for their products: spending more money on products usually leads to considerations of how future maintenance will look like – how much do they expect to invest? It is closely related to consumers emotional value as well. Choosing the more expensive option leads to internal review of how long they expect to keep the machine and what "work" goes into it.

An espresso machine is typically the more expensive option on the market. Filter and capsule machines are disregarded going forward. Filter machines are usually not an investment and is seen as "bare minimum". Capsule machines are a time-limited product, and as seen in the survey and interviews (p. 18) is often the beginning point in consumers coffee journey that will eventually be replaced. Choosing the semi-automatic espresso machine is also based on future proofing the product to avoid unintentionally designing a temporary product.

There is a need for a deep dive into repairability and how parts are connected. This brings focus to interface, diagnostics and overview of the coffee machine which are essential elements that make or break the concept. It needs to be focused on the user's repair ability and to figure out what design principles make users willing to engage with repair. In chapter three p. xx the willingness to repair from a user perspective will be elaborated upon.

These products, especially the camera and the speaker, are generally high-end outside and inside. The espresso machine presented in this report will be affected by the components found in the disassembled coffee machines in chapter one and shape the concept development going forward. These are not necessarily high-end components, but due to modern technology they are frequently used in middle to high-end espresso machines such as Sage machines. More on this will be discussed in chapter eight as part of business considerations.

TARGET GROUP

To avoid ending in a Fairphone situation, it has been investigated what type of target group the espresso machine will cater to. As the project focus is maintenance and repairability, this comes from vision to create quality in both functionality and aesthetics ensuring longer product lifetimes – giving consumers the power to fix their own products. Though, this alone will not be the reason why customers buy the espresso machine. Looking at reference products and their design attributes, combining them into a united overview will highlight what principles the design team expects to implement in a product to meet customer needs. (app. 12)

Fujifilm X100VI.
From left to right sourced from: https://www.techradar.com/cameras/mirrorless-cameras/fuji-film-x100vi-review, and: https://www.kevinmullinsphotography.co.uk/blog/fujifilm-x100vi-review

Category: Refined tech - Camera

- High quality everyday camera
- Retro design yet packed with contemporary digital power.
- Interface, controls, and feedback give a feeling of analog mastery. Tactile controls and dials.
- Blends old and new timeless design
- Personal tool
- Leather materials and aluminium frame.
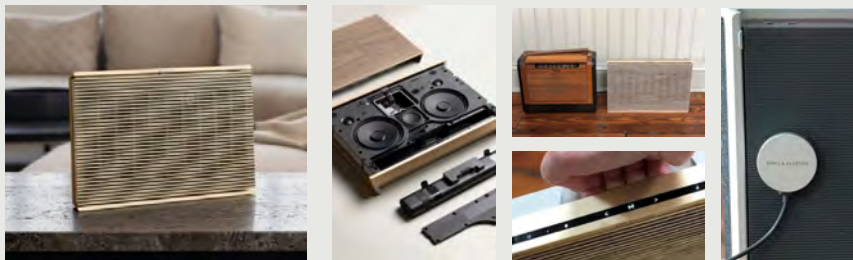
Bang & Olufsen Beosound Level Speaker.
From left to right sourced from: https://www.luxuo.com/homepage-slider/bang-olufsen-beo-sound-level-future-proofed-audio-ecstasy.html, and: https://www.techhive.com/article/579644/beosound-level-review.html

Category: Speaker

- Inspired by minimalist Japanese decór and classic wood radios
- Copper colored metal frame and warm oak on the outside
- Futureproofed inside and out - repairable, software updates, battery replacement
- Articulate presense and descrete apperance
- Magnetic charger
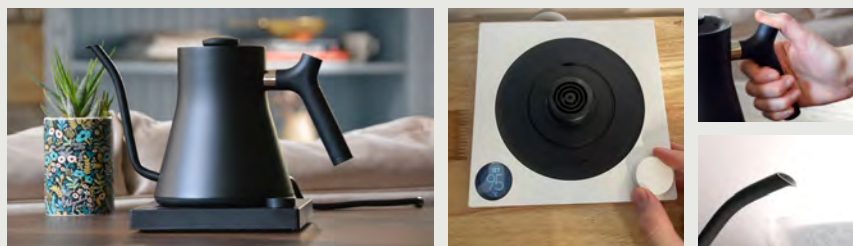
The Fellow Stagg kettle.
From left to right sourced from: https://www.thespruceeats.com/fellow-stagg-electric-kettle-review-5093417, and https://cafefabrique.com/blogs/review/fellow-stagg-ekg-kettle?srsltid=AfmBOopnoZSYtyT-kfJOVaS8TrSpOnt-AMZlulbXu38PM7ubThdYw152S, and https://www.thespruceeats.com/fellow-stagg-elec-tric-kettle-review-5093417 and https://lifestylelab.ca/fellow-stagg-ekg-kettle-review/

Category: Kettle

- Minimal UX - simple dial and single button control
- Great for specific needs: Slow pour which makes pour over coffee a great experience.
- Stainless steel, stylish, heavy duty
- Set temperature and watch the kettle do its work, no need to measure temp. or time.
- Traditional and classic gooseneck design

The overall understanding of these products and their attributes showcases how the target group prioritizes modernized "retro" in timeless design, and how textures and tactile controls initiates satisfying use. The B&O speaker clearly point towards a preference of beautiful exterior and functional interior, comparable to a MacBook on the outside and a windows computer on the inside. Metal finishes and rough textures to promote high quality – these are products made for specific tasks and does the tasks well.

⚠	The machine should have a modernized retro timeless design.
⚠	The machine should have a functional inside and beautiful outside.
✓	The materials and finish must be of high quality.

Design brief 2.0

Problem focus

As concluded in the concept evauation, the direction of the project changes towards a focus of maintenance and repairability rather than upgradability. Knowing the Fairphone situation, the concept of users being able to interchange their coffee machine has no market pull.

Aim

To design the next generation of modular coffee machines that users of all skill levels can feel comfortable repairing, with a timeless design that is easy to understand and decipher.

Problem statement

How can a coffee machine be designed for user-centered repairability and maintenance?

Insights

Coffee machines have a lifetime of 3-5 years.

The main failure point of a coffee machine is limescale build-up.

Diagnostics of a failure is very difficult.

Coffee machines are not a part of the EU repair legislation yet.

Most people will only consider repairing if the total cost is less than 30-40%.

Coffee machines are not designed for the user to open or disassemble it.

Consumers think it is too expensive to send a coffee machine to a repair shop.

There is a gap for a user-repairable coffee machine on the market.

Design Criteria

Companies should offer additional guidance to lower repair costs.

Make the repairability of the product a secondary or tertiary selling point.

People should feel confident when opening the coffee machine.

The machine should have a modernized retro timeless design.

The machine should have a functional inside and beautiful outside.

Requirements

Key components must be replaceable.

The inside must be compartmentalized.

The materials and finish must be of high quality.

CHAPTER THREE
IDEATION

The chapter focuses on the contextual level of the value pyramid (p. 5). This results in exploring the contextual and material level by visiting professional repair technicians at CJ Hvidevarer and doing desktop research to further understand the components needed in a coffee machine. Research into the possible components that can be used in a coffee machine and previous information leads to prototyping to understand the concepts. The chapter concludes with an updated design brief.

Ill. 21: Team members discussing

CJ HVIDEVARESERVICE

A visit to CJ Hvidevarer was conducted to gain further insights into the diagnostics- and repair process of coffee machines. Moreover, which faults do they often face in the different machines. Repair technicians at CJ Hvidevarer believe that there is not much difference between high-end and low-end coffee machines component-wise. Expensive machines are often priced as so due to certain brands becoming status symbols. Another observation made by the repair technicians, is that all kinds of coffee machines are susceptible to limescale accumulation. However, it depends on the customers' geographical location whether limescale accumulation is a big or small problem because of the hardness of local water. (app. 13)

Identified phases of repair

- Test the coffee machine (make a cup of coffee)
- Identify faulty component(s)
- Repair or replace faulty component(s)

Important insights gained

- Capsule machines typically break due to limescale accumulation as a result of poor maintenance. The other most common fault is the puncturing mechanism breaking because the customer uses the wrong capsule.

- When their customers tried to self-repair and failed, they typically made it worse. The machines CJ received were opened, which makes it difficult to obtain overview of the loose components.

- CJ assess the faults by using the coffee machine as the customer would. Their approach of diagnosis comes from experience.
- In automatic espresso machines, the coffee bean grinder often breaks.

- Common problems in coffee machines are leakage and limescale. This is supported by a study (Van der Velden, 2021) which noted that the most common problems for coffee makers are leakage, water will not heat, calcification (limescale), pump.

- The repair technicians at CJ advice customers with coffee machines under 1.000 DKK to buy a new one instead of getting it repaired as CJ charge 500 DKK just to open the machine. They charge between 1.500 – 6.000 DKK depending on the brand, type of machine, complexity of fault and man hours.

The amount of limescale in machines highly depends on the hardness of the water.

Professional repair technicians diagnose the problem the same way the customer would.

In automatic espresso machines the coffee bean grinder commonly breaks.

It is important to place components strategically to avoid damage

A user-centered repairable coffee machine should be as simple as possible.

Going into the visit, a capsule coffee machine was the chosen direction. However, after the visit it became evident that faults with the capsule machine were because of poor maintenance and a user behavior problem. Moreover, capsule machines today can be so cheap that many customers would rather replace them than repair them - even repair technicians advice their customers to do so. It was decided that a change of coffee machine would be necessary for the future arguments made for the project see p. 26 for further explanation.

UNDERSTANDING AN ESPRESSO MACHINE

The following section separates the product into manageable parts - first an understanding of what components a coffee machine consists of and how they work, followed by a deeper dive into what general design language is used to decipher different types of coffee machines.

MANUAL ESPRESSO MACHINE

As mentioned at the end of Chapter Two, the product focus is a semi-automatic espresso machine. Beans are ground in a grinder then placed and stamped into a portafilter where the coffee will be brewed as part of the group head.
The difference whether it is a manual and semi-automatic espresso machine comes down to how much work the user must do in making a cup of coffee:

- For a manual espresso machine, the user must set the temperature and pressure before sending water through the system. When the water and pressure is correct the user manually pulls a handle or a lever to release the water through the portafilter and into the cup. For this it is the user that determines when the right amount of coffee is in their cup. This requires more experience and can become quite "nerdy" and complex.

- A semi-automatic espresso machine has some preset programs like; 1 cup, 2 cups, long black etc. Each program has predetermined temperature settings, and the amount of water running through the system. The user needs to grind the coffee and place the portafilter, press the program to start and the machine will brew the coffee.

The manual version is usually for coffee aficionados – people with a lot of experience. The semi-automatic version enables users of multiple skill levels. Coffee aficionados usually invest in very premium machines and go a long way to maintain them. The semi-automatic espresso machine is the chosen product focus as it contains consumers of many levels, and the amount of discarded coffee machines are higher.

KEY COMPONENTS AND THEIR FUNCTION

The machine is composed of specific components directing the water flow. The components ensure pressure around 9 bar and temperatures between 90-95 degrees when extracting coffee. (app. 14) There are different types in each component category which will be listed and explained below.

Water pump

Pumps water through the system at a pressure higher than 9 bar which is typically around 11-15 bar. There are two viable options: a solenoid pump and a vibration pump: The solenoid pump distribute water with high precision and constant pressure. It is more expensive than the vibration pump and is more silent. They are both easy to replace, but the vibration pump is easier to repair. A vibration pump is typically the more affordable option.

Solenoid valve

The solenoid valve distributes the water to the group head and regulates the pressure to ensure it is 9 bar and removes water from the system when it is done extracting. It is made of an electromagnetic piston that ensures correct pressure or it shuts completely off and is able to switch between steam or water depending on the pressure used.

Ill. 22: Water pump

Ill. 23: Solenoid valve

Flowmeter

Measures the water pumped into the system. Through software it informs when enough water has gone through and when the pump needs to stop. It is made of a propel that uses revolutions as the measuring unit.

Ill. 24: Flow meter   Ill. 25: Over Pressure Valve (OPV)

Overpressure valve

The overpressure valve is small valve that regulates if the pressure is too high inside the machine and is usually combined with the solenoid valve. If the pressure is too high, it redirects water to a spill tray. It is made of a simple spring piston.

Group head

The group head where the portafilter is fastened and where the coffee is extracted. It consists of multiple small parts: the portafilter holder, a shower screen, a water diffuser plate and a water inlet. The group head needs to be stable, as fastening the portafilter usually needs a bit force.

Ill. 26: Group head

Heater

There are a few different options when it comes to heating the water – the heater is often the component that determines the overall price and premium label of an espresso machine. Dual boilers and heat exchange boilers are by far the best heaters due to temperature consistency; however, they are expensive and quite large. The more inexpensive options are thermojets, thermoblocks and single boilers.

Thermojet
A newer technology primarily known for being used by Breville/Sage so far. A thermojet can achieve optimal extraction temperature extremely fast – under 5 seconds. Even though, they are an inexpensive option they tend to break quickly. Many users have experienced a need to replace it in the first year of usage due to fast limescale buildup.

Thermoblocks and thermocoils
Common in entry level coffee machines, thermoblocks reach the optimal extraction temperature in about 30 seconds, making it a decently fast process. Thermoblocks has been on the market for many years and usually works for 3-5 years depending on the amount of usage and maintenance (Libby, 2023). Thermocoils with PID to control and give better temperature consistency is a very viable option. The most common failure point is the buildup of limescale over time, yet it can be extended over 5 years with regular care.
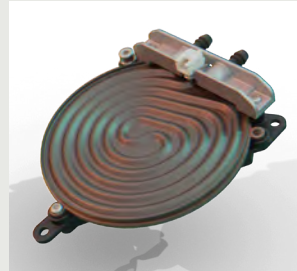
Ill. 27: Thermo jet   Ill. 28: Thermoblock

Single boiler
Comes as a single boiler or dual system as "tanks" containing the water with a coil inside. Single boilers also come as part of the group head sitting directly on top, ensuring perfect temperature every time. A boiler is the slowest to heat up the water, usually taking up to 70 seconds, depending on its size (Ibid., 2023). A boiler is the best heater to maintain temperature within the entirety of the system (tubes and the other components) resulting in longer start up. It is less susceptible to limescale, however a single boiler in the group head is more difficult to repair and replace due to difficult disassembly.

Ill. 29: Single boiler

A thermocoil with a PID system is preferred, as it will deliver a steady temperature over a prolonged period and it is inexpensive. However, it might be worth noting that thermojet technology is an up-and-coming cutting-edge technology that could be the more sustainable solution in the future. It is said to be more energy efficient, as it is much more standby operational (Otter Group, 2024), it is simply too unstable at its current level.

> The extraction pressure must be 9 bar.

> The water temperature must be between 90-96 degrees Celsius

DECIPHERING COFFEE MACHINES - WHERE THE MAGIC HAPPENS

All the components that constitute the coffee machine are not the principles that makes the machine "look" like a coffee machine. Regarding the components, most people would probably never guess they resembled coffee machine components. What are the factors that contribute to this mental model, and how can they be combined with repair-oriented design?

There are four main categories of coffee machines: filter-, manual-, automatic-espresso and capsule coffee machine. In the following section, sketches were created of the overarching architecture that determines the mental models. (app. 15)

Filter coffee machines

Filter coffee machines are well known for their funnel leading into a pitcher, creating the shape of an hourglass. It has an obvious water reservoir that shows the direction of water from the water tank to the funnel into the pitcher.
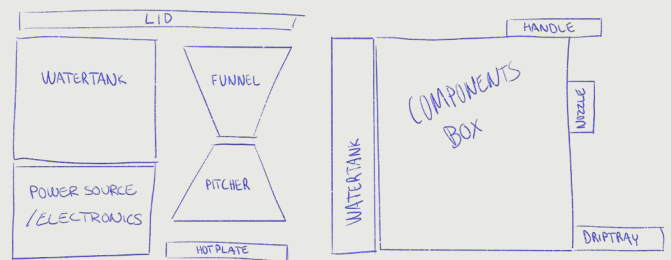
Capsule coffee machines

Capsule coffee machines are known for their very compact and space efficient design. They are usually square with the water reservoir hidden in the back. It has a handle that shows where the capsule needs to go into the puncturing mechanism. The "components box" is anonymous and not much process is clear.
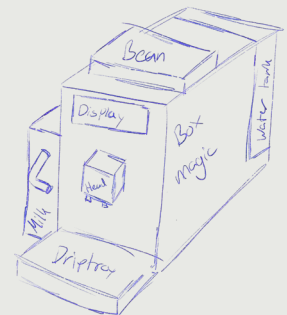
Automatic espresso machines

Automatic coffee machines are larger machines. Everything is programmed into the system, and users merely place a cup and press a button. It somewhat resembles a capsule machine with the overall square design. It has one or two nozzles for the coffee outlet at the front of the machine and is located right above a drip tray, with circles indicating where the cup needs to stand. There is a bean grinder on the top of the machine which also works as a storage container. Everything happens inside the "component box" and is closed off.
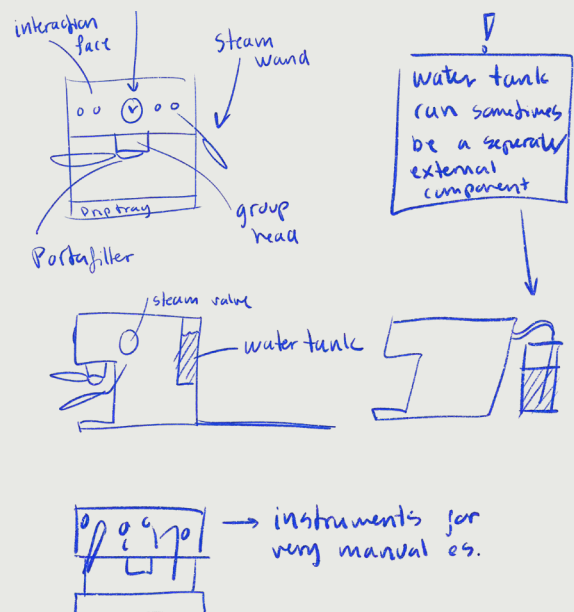
Manual espresso machines

The manual espresso machine consists of a square design as well, though it tends to be wider than oblong. They use portafilters which is a clear indicator of what process is going on. Manual espresso machines usually have an overhanging top that aligns with the drip tray, a lot of levers, dials and pressure or temperature gauges.

There are very different attributes that help create the mental model of a coffee machine based on which type it is. Common among all is the magic box. They are usually a boxy design that incapsulates all the components without any explanation to what it is. The exception is the filter machine that succeeds better at this. Another exception is the water reservoir that remains transparent regardless of type. The manual espresso machine with all the gadgets, as part of the machine tells a better story. It resembles the espresso machines customers see in coffee shops - in a smaller version.

Ill. 30: Deciphering

To summarize, it is important to have clear indication of where the water goes. To simplify on the same level as filter machines might be beneficial to investigate, as the flow of water might help to determine "what is what and how". The conventional look of an espresso machine is noteworthy as well, as the overarching product architecture is easily recognizable and classic.

> ⚠ **There must be a clear direction of the flow of water**

MOCKUPS

Rapid build mockups were made by implementing different design attributes found in previous section. It will be used to find boundaries for the overall architecture and to understand sizes. They all are made with focus on repair and modularity. (app. 16)

Desktop

Ill. 31: Desktop

The desktop design is based on elongating the machines width, making it possible for components to be distributed along the width. This eliminates the need to compress the components and stack them on each other creating a better overview. The workflow follows the reading direction from the front and back. The obvious back side is indented to be easy to open. It resembles an espresso machine with the wider front but has the slim look of a capsule machine.

Pros

- Clean geometrical shapes
- Short depth – can be pushed up against a wall to take less table space.
- Better overview of workflow
- Scaling the architecture to a filter and capsule machine seems plausible

Cons

- Needs to be turned around for access to the inside
- Takes up more space in width.
- Scaling the architecture to an automatic coffee machine seems too difficult
- No clear indication from the front, that the back can be opened.

Airfryer

Ill. 32: Airfryer

The air fryer design is made of three sections; a top, middle and a bottom. In this design, the sections is intended to separate to either gain access to components and for maintenance / repair. The bean grinder and water tank are located at the top, and the process has a downward direction. The middle is the "component box" and where the coffee is brewed in the group head. The bottom section is where the cup is placed. Calling the mockup an air fryer indicates quite a different design attribute which could result in a misunderstanding of the machine.

Pros

- Divided functionality sections
- Direction based downward

Cons

- Bulky
- Tall – takes up too much space on a counter
- Looks like an air fryer…
- Industrial grade design
- -omplex layout
- Scaling architecture to filter, capsule or automatic espresso does not seem intutitive

Stereo

The stereo design is made from the idea of modularity. The simple design has less resemblance to a coffee machine and looks more like an old stereo system. It somewhat looks like the desktop mockup but bulkier, as the backside is intended to open to the components as well. A milk frother and a grinder is incorporated as free modules that can be attached to the "main body". The size mirrors to some extend a capsule machine.

Pros

- Simple layout
- Box design promotes modularity
- Scalable architecture

Cons

- No convenient placement for the frother or grinder
- Bulky
- Retains "magic box" principle
- Compact

Chemistry set
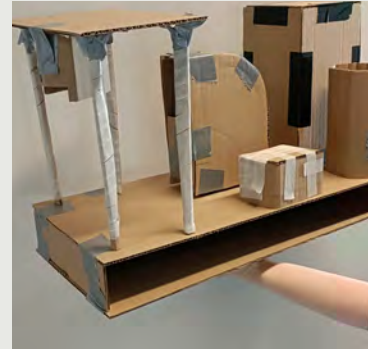
Ill. 34: Chemestry set

The chemistry set is focused on being able to see every single component on the outside. Tubes would be visible between the components and wires will be hidden in the foundation of the design. It will be possible to see the water flow as it runs a program and possibly gain understanding of how it works.

Pros

- Easy access to components
- Clear direction of water
- Easy to spot calcification
- Scalable architecture

Cons

- Gimmicky design
- Tough to clean on the outside (nooks and crannies)
- Every component needs a protective shell – many different molds.
- Potential higher risk of user error
- Unstable

The potential

The mockups give a better understanding of how explorative the product architecture can be, the chemistry set being an extreme example of this. However, having tubes and components on the outside to show the working principles would not necessarily give users a better chance at better maintenance and possible repairs. Overall, the disheveled aesthetics of this construction is very niche and does not corporate with timeless design. From the design team's perspective, the desktop has more potential. The stereo design somewhat resembles the desktop design but is more compact and has moving modular elements (grinder and milk frother) which are still explorable in the desktop design. The desktop design being more aesthetically pleasing and the attribute of having a better overview of the components is intriguing to explore further. These design principles can be investigated on a deeper level while still designing a believable product.

UNDERSTANDING THE DIMENSIONS

Based on the desktop model, it is investigated how components will fit into the machine and what sizes the construction could be. Three different backplates with specific dimensions were made which alters the placement of the components between more spacious or compressed. Due to limitations in cardboard strength, the heavy components were modeled and 3D printed as close to the originals as possible. Tubes and real wires were used to gain a better understanding of potential and limitations. Worthy of note is the original dimensions of the mockup of 31x40 are based on market research and general sizes of other coffee machines. Though, they are usually deeper than wide, and in this test the machine is more wide than deep. (app. 17)

Backplate 1: 26 x 40 cm

Insights gained:
- A lot of space for each component.
- The PCB is places at the top left to ensure no water or heat comes in contact with the PCB.
- Putting wires in sleeves helps combat wire clutter.
- Easy to play around with component placement.
- Maybe too much space?
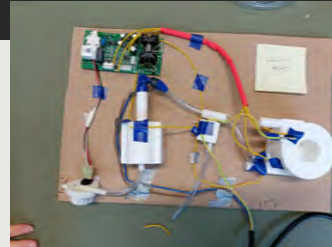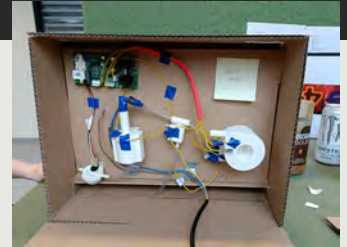
Backplate 2: 24 x 35 cm

Insights gained:
- Enough space for each component but begins to feel a bit cramped.
- Sleeves on wires helps clutter but is more difficult to manage in smaller spaces.
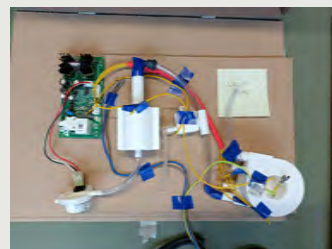
Backplate 3: 20 x 30 cm

Insights gained:
- Difficult to avoid clutter of both wires and tubes.
- As it is more compressed it looks more technical and overwhelming.
- No space for additional components e.g. steamer unit.
- It will be challenging to protect the PCB.

Ill. 35: BP 1

Ill. 36: BP 2

Ill. 37: BP 3

Ill. 38: BP 4

Ill. 39: BP 5

Ill. 40: BP 6

Summary

Smaller dimensions create more compressed architecture and feel more technical to observe.

↻ The number of variables changed, both height and width, should have been avoided. The height of the machine should have been kept the same, as the machine cannot become much lower due to the group head and the need to fit a cup underneath. The height of the machine was also not represented properly, as the mockup was constructed to fit a drip tray underneath, taking away around 5 centimeters of height.
A reflection in action occurred when handling the transparent tubes: they need to be accessible for the user. The tubes do not need to be fastened to the backplate or altered. On the other hand, the wires are prone to create a "rat's nest" and need to be controlled in some way. The width is what influenced complexity the most, and therefore it is determined that the dimensions of 31x40 is considered going forward. It has a lot of leftover space still, but this will be revisited later on in chapter five.

TO GRIND BEANS AND FROTH MILK **OR** <u>NOT</u> TO GRIND BEANS AND FROTH MILK?

As part of considerations when designing the internal architecture is what additional components other than the bare minimum should be integrated. Making coffee usually involves either grinding beans, frothing or steaming milk. Reflecting on market observations, coffee machines usually come with the possibility to steam milk, and automatic machines has integrated bean grinders. Other than that, there are a lot of separate options as well as milk frothers and individual bean grinders – how does these additions influence the product architecture? A lot of energy has been used to investigate what the potentials and challenges would be by integrating these features into the system, whether it be fully integrated, semi or modules outside the system. Integrated bean grinders are usually the largest problem when coming to failure, which makes the whole coffee machine indisposed of. Fully automatic espresso machines with integrated bean grinders consists of a brew group connected to the grinder, which is a full component that received the ground coffee and brews the coffee. This unit is a very difficult component to repair for inexperienced users. It generally has a lot of automated components incorporated into the system not made for repair that would greatly increase the complexity of the project.

In the end it was agreed upon to focus on an integrated steam wand and no bean grinding system. This decision is made partially on behalf of personal preference of process management, if there time to divide the focus. One product risk becoming three; grinder, frother and coffee machine. The decision also comes from the chosen target group – the type of machine does not align with the type of consumer addressed. Therefore, it has been prioritized to focus on the main body i.e. the coffee machine with a steam wand and its architecture to ensure more thorough decision making and design attributes.

> ⊘ **Must have a steamer**

Design brief 3.0

Aim

To design the next generation of modular coffee machines that users of all skill levels can feel comfortable repairing, with a timeless design that is easy to understand and decipher.

Problem statement

How can a coffee machine be designed for user-centered repairability and maintenance?

Insights

Coffee machines have a lifetime of 3-5 years.

The main failure point of a coffee machine is limescale build-up.

Diagnostics of a failure is very difficult.

Coffee machines are not a part of the EU repair legislation yet.

Most people will only consider repairing if the total cost is less than 30-40%.

Coffee machines are not designed for the user to open or disassemble it.

Consumers think it is too expensive to send a coffee machine to a repair shop.

There is a gap for a user-repairable coffee machine on the market.

The amount of limescale in machines highly depends on the hardness of the water.

Professional repair technicians diagnose the problem the same way the customer would.

In automatic espresso machines the coffee bean grinder commonly breaks.

Design Criteria

Companies should offer additional guidance to lower repair costs.

Make the repairability of the product a secondary or tertiary selling point.

People should feel confident when opening the coffee machine.

The machine should have a modernized retro timeless design.

The machine should have a functional inside and beautiful outside.

It is important to place components strategically to avoid damage

A user-centered repairable coffee machine should be as simple as possible.

There must be a clear direction of the flow of water

Requirements

Key components must be replaceable.

The inside must be compartmentalized.

The machine must be upgradeable.

The materials and finish must be of high quality.

The water temperature must be between 90-96 degrees Celsius

The extraction pressure must be 9 bar.

Must have a steamer

CHAPTER FOUR
User repair & maintenance

This chapter focuses on spiritual, contextual, and principal level of the value pyramid (p. 5) to the understand how users identify, replace and locate components, and by understanding the motivators that make users engage with maintenance and repair. Through prototyping and user tests, the chapter concludes upon mental models, symbolism, functional elements as well as an updated design brief.

Ill. 41: User reparing

STORYBOARD: AS IS

Based on evaluated insights from a field study and research a storyboard was set up: As-Is scenario. This is to gain an overview and communicate the process of when users experience failure in coffee machines and how it typically plays out.
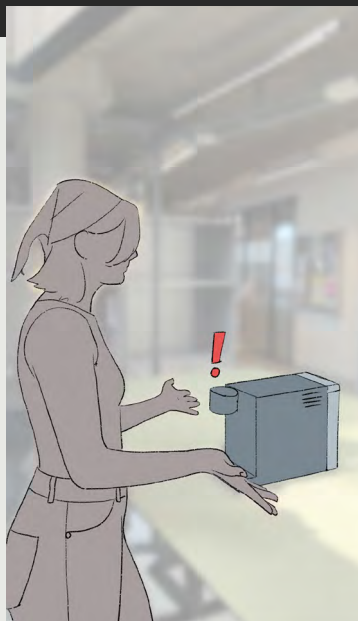
1 There is no coffee coming out and the user does not know why.

2 The user turns the machine to see if she can guess what to do next.

3 The user tries to figure out where to open the machine

4 When the machine is finally open, the user is confused and overwhelmed by what she sees.
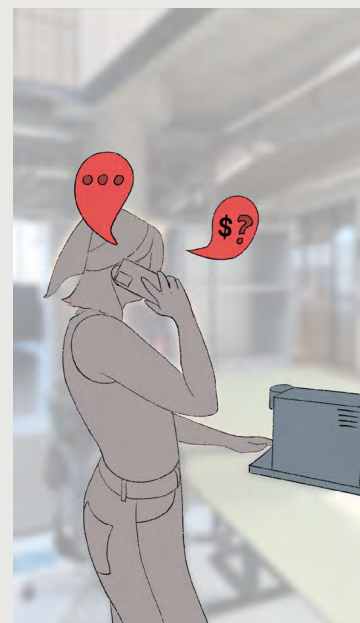
5 Instead of repairing it herself, the user calls a repair service to get an estermite of how much it would cost to repair it or to just buy a new machine

Ill. 42: Storyboard as is.

The use of the as-is storyboard provided further insight into the different directions, it is possible to explore further. This includes getting the machine open, not just barely – but completely without destroying anything, and then somewhat understanding the layout inside.

WILLINGNESS TO REPAIR

To understand what principles, make users more willing to engage with self-repair, research was conducted on which barriers exist and how to potentially overcome them.

Through the study "From "right to repair" to "willingness to repair": Exploring consumer's perspective to product lifetime extension" (Roskladka et. al., 2023) the most notable insights that summarize barriers are:

- Cost of diagnostics and repair
- Time of repair
- Lack of spare parts
- Lack of clear and complete manuals
- Difficulty and complexity of the repair
- Unawareness from the user
- Fear of breaking their machine
- Economic obsolescence

The barrier "fear of breaking their machine" is important, as the product should be designed and communicate clearly what parts that tolerate being handled and what parts does not. What is for professionals and what is for novices. "Difficulty and complexity of the repair" is equally important as users will have to determine whether they feel confident enough to engage with the required maintenance and repair. Design principles that help raise the willingness to repair consists of ((Ipaki & Hosseini, 2025), (Roskladka et al., 2023) (Korsunova et al., 2023), (Van Den Berge et al., 2022)):

- Clear indication of where the failure is.
- Needs to clarify what part is broken.
- The inside needs to be easy to navigate and decipher.
- There should be an interactive guide helping the user through

steps of diagnostics, repair, or replacement for the broken part.
- It should be easy to open op the machine.
- To combat failure, it should be intuitive for the user to maintain the machine.
- Being able to repair, replace and maintain the machine without the use of tools increases willingness.
- The user needs confirmation that the repair and/or replacement have been done correctly.

Both barriers and enabling design principles outline an understanding of what functionalities to include in the design from the beginning. Many principles point towards the "no need for tools" that will dramatically increase the willingness, as having to use tools often leads to uncertainty if they are "allowed" or experienced enough. The attributes used to achieve this are, as mentioned above, design features that; does not necessarily need tools (standard size screws or none at all), the use of magnets, snap-fit-connections, wireless connections etc.. These are all repair-oriented features that according to Ipaki and Hosseini (2025) has relations that introduces both challenges and opportunities. They have created two models that explain the relationship of decisions and the impact these design features have on usability but also the relationship among them (app. 18). Throughout the process and testing the design team will use these design principles to generate ideas.

3. Willingness to repair

This section will work as a foundation for the understanding of what features the product could benefit from and how it might correlate to consumers' willingness to repair as well as their barriers. The goal is to implement principles that will enable the consumer to engage with regular maintenance in simple ways to build confidence and emotional attachment to ensure better product care and a longer lifetime, increasing the feeling of self-efficiency and repair ability (Van Den Berge et al., 2022).

3.6. Unawareness

3.4. Desire for new products

3.7. Lack of emgagement

3.1. Lack of trust to repair

3.2. Fear for further failures

3.5. Lack of clarity | 3.3. Lack of attachment

5,56 (max)

4,11 (avg)

2,88 (min)

2. Convenience to repair

2.3. Costs of diagnostics and repair | 2.5. Unavailability of repairing services

2.4. Consumer's time for repair | 2.2. Economic obsolescence

2.7. Difficulty of repairing | 2.6. Insufficient quality of repair | 2.1. Legislation

The machine must be repairable with 2 tools or less

It should be easy to open the machine.

Users have a high fear of breaking the machine by trying to perform a repair.

1. Technical possibility of repair

1.2. Lack of spare parts | 1.4. Lack of clear and complete manuals | 1.7. Complex and long dis/re-assembly

1.1. Access to diagnostics | 1.10. Product is unopenable | 1.3. Lack of tools | 1.6. Products are nonmodular | 1.11. Planned obsolescense

1.9. Digital locks | 1.8. Fragile materials | 1.13. Impossability of updates / upgrades | 1.5. Posibility of safe repair

Ill. 43: Willingness to repar pyramid.

HOW TO IDENTIFY COMPONENTS

The general assumption is that the normal user has no idea what the components are and how they work. The following section involves a test that provides clues, keywords, or symbols to help identification. Six different boards were made with different instruments to possibly help the user. These boards were made in the dimensions 31x35 cm, the size of the desktop mockup. Five of six had drawn wires on them, to simulate where the wires lead. (app. 19)

1 - Tubes
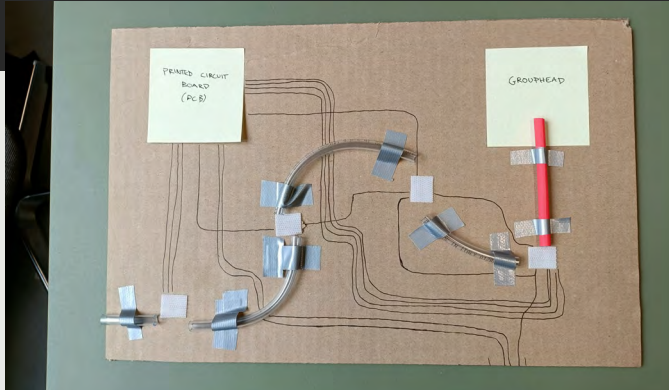
Ill. 44: Surface 1

Tubes are taped into the surface to simulate a set direction. This required the user to compare components to guess which sequence they are placed in. The red tube is implemented to indicate hot water as a clue.

2 - Wires
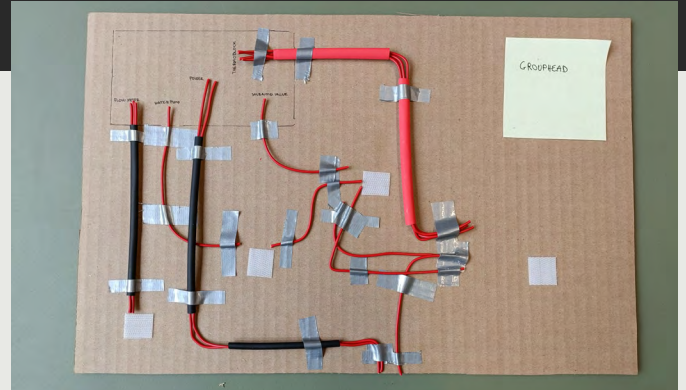
Ill. 45: Surface 2

This shows how the wires would be grouped and where they connect. There was also drawn a small PCB where the name of each component was written as a clue.

3 - Titles
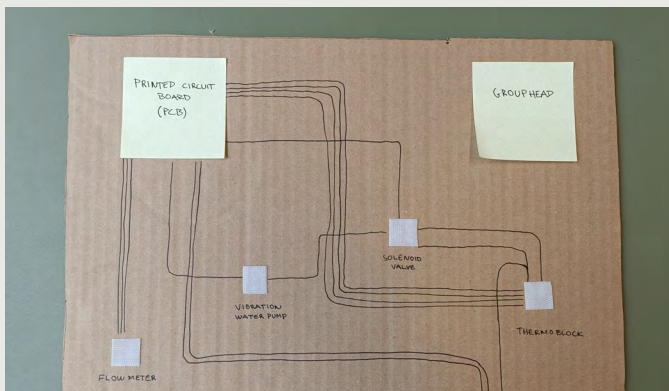
Ill. 46: Surface 3

The name of the components is written directly onto the surface. This requires some knowledge from the user to connect name with component.

4 - Logos
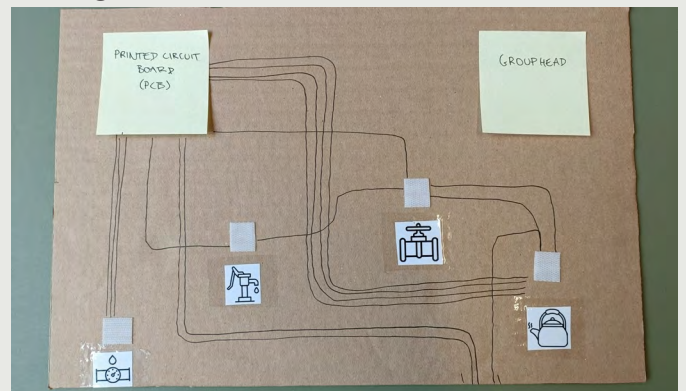
Ill. 47: Surface 4

These logos should indicate what each component does in a more metaphorical way referring to mental models, seeing if it relates to common knowledge e.g. kettle = heating water.

5 - Descriptions
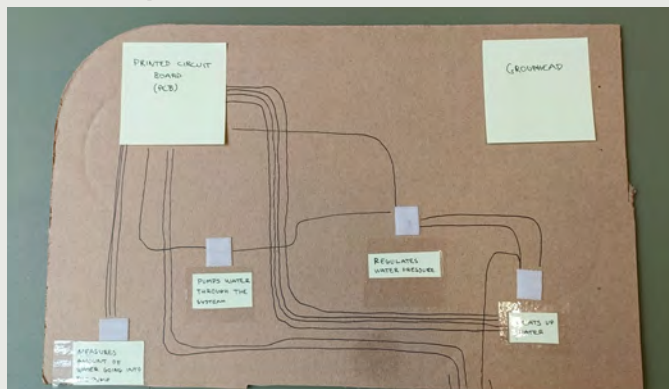
Ill. 48: Surface 5

A short description that tells the user what the component does, to see if that can be compared to the overall shape and look of the component.

6 - Outlines
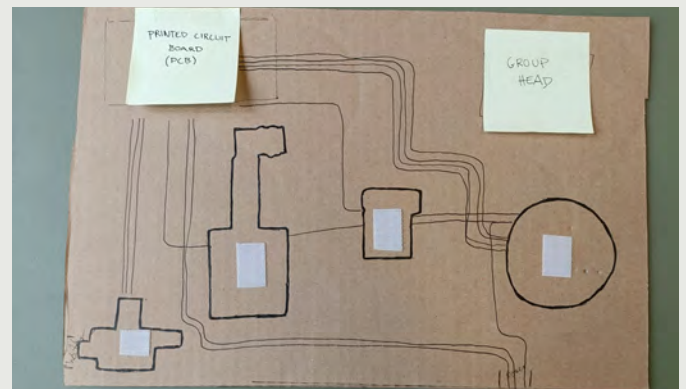
Ill. 49: Surface 6

Shows an outline of the component and how to place it.

To gain an understanding of what principles work best of the six identification methods, user tests were conducted with four people (P1, P2, P3, and P4). Each were given the four 3D printed components: the flowmeter, the heater, the water pump and the solenoid valve. The original components lay beside to allow users to look at their actual shapes, colors, and materials. They were tasked to place the components based on their understanding of each board and its hints. The components had a specific placement but were not told if placed correctly until the end of the test. They were given the boards in the order 1 to 6 from hardest to easiest. This was done like this to understand whether the harder boards were successful. For every answer and note see app. 19.

Test 1: Tubes

Every user got two or more components wrong and generally used a lot of time to understand what each component was. P2 identified the water pump and the thermoblock, and also compared the sequence of the components to reading direction. The coloring of the tubes did not help to identify the heaters placement for any of the participants.

Test 2: Wires

Every user got two or more components wrong again. However, P2 identified the components correctly using the text on the PCB to place the products correctly.

Test 3: Titles

P2, P3, and P4 placed every component correctly. However, it was observed that the participants generally used guesswork – only the pump and heater were somewhat understandable components.

Test 4: Logos

P3 got everything correct: the logo for the pump and heater made sense. P3 and P4 used the logos to place the pump and heater but were clueless of the flowmeter and solenoid valve.

Test 5: Descriptions

P3 and P4 placed all components correctly. P3 generally used a lot of time to understand the descriptions and the components. Yet, it seems to have been primarily guesswork by P4, who also were annoyed having to read and suggested that: "If you don't know anything in this area of expertise, then you don't know what anything means".

Test 6: Outlines

Every participant placed the components correctly, and all liked not having to think of what each component is or does to place it.
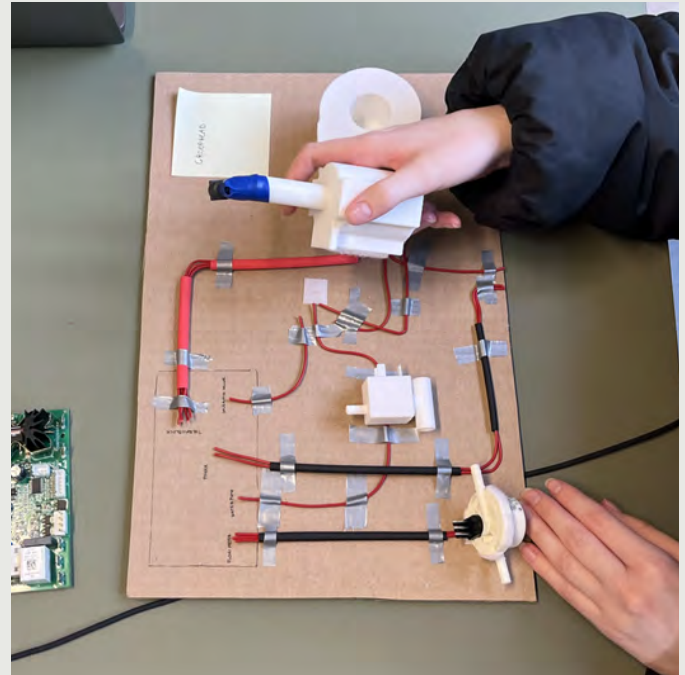
Ill. 50: User testing surface 2

Summary

The design attributes used throughout the test demonstrated that knowing what each component is and does, does not help as the sequence of components is not intuitive. The participants did not know what kinds of components a coffee machine consisted of and primarily used guesswork to place them in a certain sequence. The majority of users did not seem to have interest in figuring out more about the components. The participants responded much better to outlines directly telling them the correct placement, as they would not have to use as much energy.

Going forward the focus lies in diagnostics and repair: how do the user know what areas to maintain or repair, and most importantly how do they perform these steps?

👁 **Knowing what each component is does not help the user.**

COMMON FAULTS AND DIAGNOSIS

The following section focuses on the most common ways a coffee machine becomes faulty and how users will be able to fix it. The outline used consists of symptom, problem, failure point, diagnostics, solution, and finally design principles used to go forward.

Most common fault are ordered from 1 to 5.

1. Weak coffee flow, 2. No coffee is coming out.

Symptom	Problem	Failure point in system	Diagnostics	Solution	Design principles
Weak coffee flow No coffee coming out	Limescale buildup	A tube or component is clogged	Check tube for limescale Descale program	Descale program Manually clean or replace tubes Professional grade or DIY descaling solution Professional repair	Tubes should be easy to detach and attach.

3. Leakage

Symptom	Problem	Failure point in system	Diagnostics	Solution	Design principles
Leakage	Limescale buildup	A tube is clogged or the cause of an old o-ring	Check tube for limescale Check tube connections	Manually clean tubes Replace tubes Replace o-ring	Tubes should be easy to detach and attach. Detach/attach components without affecting other components.

4. Coffee is cold*

Symptom	Problem	Failure point in system	Diagnostics	Solution	Design principles
Coffee is cold	Heating is not working	Thermoblock	Check wires, PCB and connections to the thermoblock for loose connections or damage.	Fasten connections Replace thermoblock Send to professional repair if damaged PCB	Tubes should be easy to detach and attach. Detach/attach components without affecting other components. Wires should be feel safe to touch and easy to navigate.

⚠ **Tubes should be easy to attach and detach**

⚠ **Detach/attach components without affecting other components**

⚠ **Wires should feel safe to touch and easy to navigate.**

* It is not a common fault but it is mentioned as it is a problem, compared to many others, that is easier to diagnose.

5. Unusual coffee taste

Symptom	Problem	Failure point in system	Diagnostics	Solution	Design principles
Unusual coffee taste	Limescale buildup	A tube or components contains noticable limescale.	Check tubes for limescale Descale program	Descale program and rinse system three times Manually clean or replace tubes Professional grade og DIY descaling solution Professional repair	Tubes should be easy to detach and attach.

Summary

The solution section of all common failures is listed in action prioritization starting at more accessible solutions to professional repairs. Limescale buildup is the biggest killer and in almost any case it is caused by user error due to poor maintenance. Design principles such as easy detachable tubes and components from a consumer perspective would make it possible to change out parts as an "easy fix". Designing a solution where wires is perceived as safe to touch while avoiding a rat's nest design could possibly increase confidence in self-repair as well. In case of needing a professional repair, these design attributes can quicken the service times possibly leading to lower service bills. (app. 20)

WHO REPAIRS WHAT?

Designing for repairability and maintenance, it is relevant to distinguish what can be repaired by the ordinary user and what should be done by professional repair technicians due to their respective capabilities.

Users (novices)

Ease of use should be prioritized for everyday maintenance. Novice users can perform the following tasks using included instructions or visual guides which includes:

- Replace easily accessible components with spare parts, such as tubes and wires using plug-in or color-coded connectors.
- Descale the machine using the pre-programmed operation or a guided process.
- Swap group head parts, including the diffuser plate, shower screen, gasket, and middle screw.
- Replace the steam wand tip if clogged or damaged.

As the concept involves around an easily opened backplate, it is important that those components available to the consumer also are intended for the consumer. These user-accessible repairs extend the machine's lifespan and reduce dependency on professional services for routine issues.

Professional Repair Technicians

For more complex or internal faults, trained professionals are equipped to:

- Replace specific components such as the flowmeter, thermoblock, solenoid valve, overpressure valve, and water pump.
- ccess and replace electronic components, including the PCB and buttons.
- Disassemble the internal shell if structural parts require service.
- Perform advanced group head repairs, potentially including the water inlet plate.
- Repair or replace the steam wand joint where high-pressure or thermal sealing is needed.

By distinguishing between user-accessible and professional-only repairs, the design supports long-term serviceability. Some of the points overlap, such as the steam wand joint – this is because user might need to detach the wand to replace an o-ring. Though the level differentiates, as the repair technicians would replace the joint itself if needed.

PREPARING FOR USER TEST

The split

The design attributes and principles are incorporated into the design in multiple ways. Firstly, the split used to attach the tubes to components are considered. When disassembly of three coffee machines was conducted (p. 12), these splits were extremely difficult to detach and tools were needed to do so (ill .51)

As this little component is a mass-produced standard part, the redesign has been carefully considered regarding production and realization. The simple change provides the possibility to grip and pull the split much better. (app. 21)
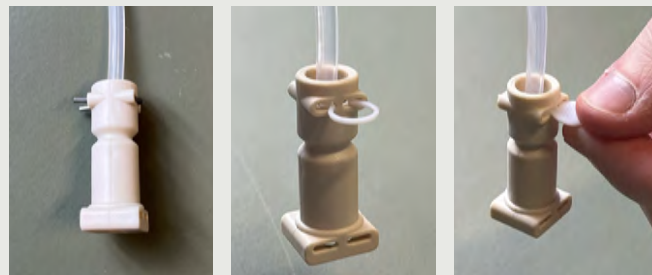
Ill. 51: New splits

👁 **The original splits were very difficult to remove**
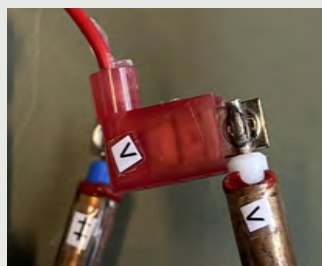
Ill. 52: Therminal flags w. labels

Insulated flag terminals

The non insulated flag terminals and wires are intimidating and often makes people uncertain whether they can be touched or not. An insulated flag terminal would cover the metal parts most people are uncertain about. They allow for easier grip and are visually not as overwhelming. Using this method would remove the need to alter the specific terminal connection methods as flags are a standard connection method. Only one insulated flag terminal was found in the capsule machine (Ill. 52). (app. 22)

Symbols

As tubes and wires are not the same lengths for all connections and components, it is being considered whether symbols will influence correct placements. These symbols would be placed on the wires' insulated flag terminals, on the tubes and the tube connection pieces, see Ill. 53 for reference.

Both heat resistant stickers and stamps are being considered. Stamps would require careful manual working and drying time before final assembly. It will be a more expensive solution. Stickers on the other hand would be attached as the machine is being assembled by the manufacturer. It does require some manual work, though it seems to fit better into the current flow. The components and tube connection pieces as well as the PCB are not made specifically for stickers, though they can be made quite small. The PCB is already made up of a lot of words and numbers to indicate functions and connections, thus it can be easily implemented into the PCB design. The symbols should not be letters or numbers but symbols to avoid confusion on the PCB. (app. 23)
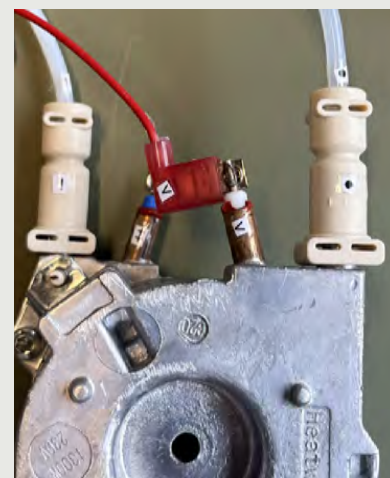
Ill. 53: Labels on the thermoblock

Wires

Wiring is usually what makes repair and overview of a coffee machine tedious. It is being considered how to organize wires within the machine by investigating different types of clamps.

Clamps that does not require the use of tools has the most potential. The majority of the clamps are separate parts that would have to be attached onto the backplate, either using screws or glue. A few such as Edge and Pine caple clips has the potential to be injection molded into the backplate as part of the design. The wires would need to have the counterpart attached with strips. This is possible to do while the machine is being assembled during manufacturing. Additionally, the wires would be put into sleeves in relevant clusters to reduce the chaos.

Ill. 54: Edge clamp

USER TEST: REPAIR AND MAINTENANCE

The design attributes mentioned above is being tested with users to investigate what influence they have on disassembly and assembly of component replacement. The last-mentioned section regarding the wires and their sleeves – this will not be tested in this round. It has been prioritized to leave the wires as is during the test, as it is assumed insights would be missed otherwise regarding the other attributes tested. (app. 24).

The setup consisted of a control test and a modified mockup with the design attributes and was tested by two users (P5 and P6). The tests were separated into four parts:

The test were separated into four parts:

Control test: Replace a component in the control model

1st test: 1) Consists of new tube connection methods (ill. 51). 2) Replace component

2nd test: 1) Consists of new wire connections. 2) Replace component

3rd test: 1) Consists of symbols on tubes, wires, components, and the PCB. 2) Replace component

	Control test	1. test - tubes	2. test - wires	3. test - symbols
P5	Could not identify the components or what they do but identified water flow direction. Needed a tool to remove the splits in the connection pieces. Wires were hard to identify which part was removable. They were hard to remove. It was difficult to know where the wires needed to go. P5 ended up just attaching them and hoping for the best. Tubes were difficult to insert into the connection pieced again, which made inserting the split troublesome. General feedback: Wires were hard to remove and P5 did not know where they should go. She did not know what part of the wire was okay to touch.	The flat surface on the split made her believe she should push it down to remove the tube. Got confused on how to remove the split. However, it had a larger end/head it was easier to get ahold of. With terminal blocks it was hard to identify what part was supposed to be removed. Tube splits were pushed around when working. It was impossible to remember where the wires should go. General feedback: Making splits an "easy to spot color" could accelerate the identification process. Would like to have visual tools as a guide.	Confusing with all the wires in the same color. Insulated flag ends were easier to grip, though tight to remove at first. Insulated flag terminals feel safer to touch compared to the metal ends. Afraid of being electrocuted	Did not see symbols at first due to their size. At first glance she thought the wires would have the same symbol in both ends because she confused three symbols with each other. Knowing it was not the case, placing the wires correctly became easy. General feedback: Some symbols could be associated with water, which was not intended. Symbols should have a very clear distinction from one another. Having different symbols in both ends, and only match with the parts it needs to be mated with is confusing.

Symbols should have a clear distinction from one another	⊘
Some symbols could be associated with water	👁
Having different symbols at both ends can be confusing.	👁

Ill. 55: Redesigned split
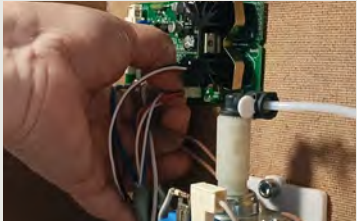
Ill. 56: P5 Interaction zoom
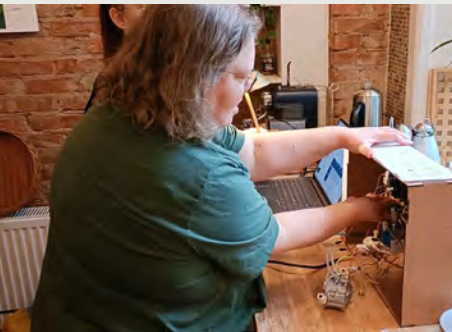
Ill. 57: User test with P5

	Control test	1. test - tubes	2. test - wires	3. test - symbols
P6	Could not identify what the components where or what they do, identifies the water flow direction. Removed the splits with fingers easily but had to figure out what they were at first. Did not look toward the PCB and the solenoid valve to disconnect the thermoblock, and was therefore confused of how to disconnect the component. PCB terminals were difficult to disconnect. When attaching the wires again, it was done without thinking if it was done correct. Tubes were hard to insert and therefore splits were hard to insert as well. General feedback: Wires were hard to remove and did not know where they went. Color coding where you were meant to look would be good	Wires were hard to remove Quickly figured out how to use new tube splits. Tubes were difficult to insert. P6 attached the wires where he thought they went through guesswork. General fedback: Approves of the flat end on the splits, easier to see them. Hard to grip PCB terminal block, and not sure if he is breaking them	Confusing with all the wires in the same color. Insulated flag ends were easier to grip, though tight to remove at first. General feedback: Needs different colors to draw focus to what he is supposed to touch. The wires should be different colors.	Saw the symbols quickly and placed the wires correctly in his first attempt. The symbols are very small.

Ill. 58: Labels and termilans
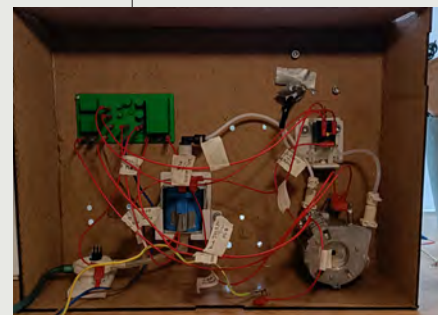
Ill. 59: User test setup
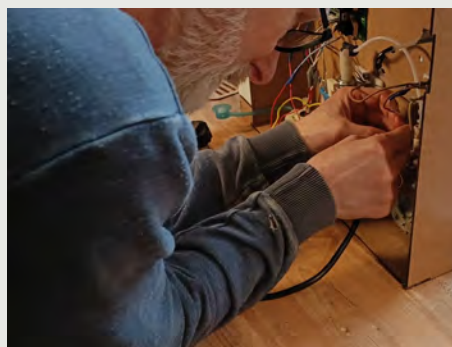
Ill. 60: User test with P6

Summary ↻

☑ **Wires need to be different colors.**

The tests confirmed most of the design attributes such as insulated flag terminals. They felt safer to handle than its "bare" counterpart. Though they were tight in the beginning, as they were completely new, therefore difficult to take on and off, they ended up being a bit looser after use. The wires used in the model were all red, which resulted in unfortunate confusion. The wires would need to be color coded to organize the chaos further. The insulated flag terminals came in red, but they can also be found in a multitude of colors. The symbols worked as hoped when the participants understood how they were implemented. Some of the symbols looked too much alike which caused the complication. The redesigned split worked for P6 but not P5, as she thought they were supposed to be pressed due to the flat surface design.

Removing o-rings were not tested but should have, as they also need to be replaced in case they expire or because of limescale buildup. The split design will be revisited to figure out if they can be used to remove and replace o-rings and how they might be shaped differently. Another unforeseen struggle was the attempt to insert the tubes into the connection pieces. The tubes are a little slippery from the smooth plastic surface and was difficult to press in fully without knowing how much force you can use. This made the splits hard to insert as well, as they need to align properly.

REVISITING THE SPLITS

The split connections make it more intuitive to remove tubes from the components. An unforeseen effect of the current design from the user tests demonstrated that it might be misunderstood. The participant pressed down rather than pulled, which provides an opportunity to reconsider how it might be shaped. When having to change tubes, there is small o-rings inside all the connections to avoid leakage. These o-rings will need to be changed as well at some point, as an old o-ring will become "tender", allowing limescale to build up directly in the connection. This will result in leakage from the tubes but is an easy fix as the o-rings simply needs replacement. (app. 21)

The o-rings can be difficult to get out of the connection pieces and often needs some sort of tool to pry it out. Further ideation has been conducted to see how the split might be redesigned to also remove o-rings, making it possible to take out without the use of tools. As of right now people usually use small screwdrivers.

The split has been redesigned into three different styles (number 1, 2, and 3 from left to right):
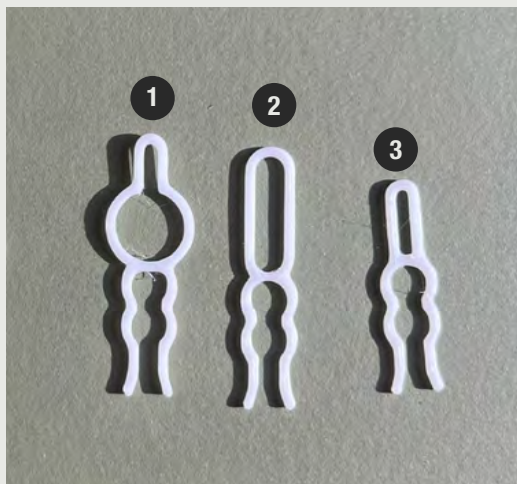
Ill. 61: New redesigned splits

They are based on the original design:

Ill. 62: Original design

Number 1

Based the most on the original pin with the outer circle, it did not fit into the connection pieces and did not reach the o-rings.
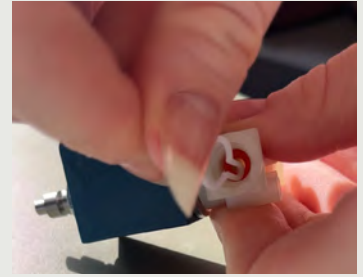
Ill. 63: Split 1

Number 2

With a more elongated design, this version did fit into the connection piece but could not fit into the o-ring and take it out.

Ill. 64: Split 3

Number 3

Based on number 2, the splits end is not much less wide and fits into both connection piece and the o-ring. Due to limitations of the 3D printed material PLA, it is not very strong and bends – making it a bit of an effort to pry out the o-ring though it is possible.
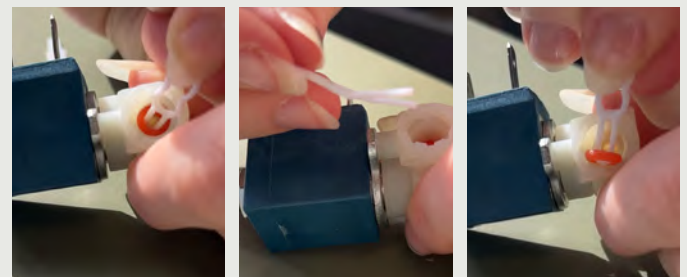
Ill. 65: Split 4

There was made a solid split of the same design to gain better strength and try again. The PLA is still not strong enough and bends, but it does feel a bit easier.

Summary

The split might be a great way to interact with the components without traditional tools as it is a tool incorporated into the design. The split will stick out from the components, possibly risking design barriers in other products if it were to be a commercialized solution. Though it is seen as a great opportunity to incorporate "no tools" methods, and from user testing helps guide intuition.

The actual material the split will be made from is stainless steel and will withhold its shape much better. It is assumed with design number 3 and the expected material, the split will work as intended.

Design brief 4.0

Aim

To design the next generation of modular coffee machines that users of all skill levels can feel comfortable repairing, with a timeless design that is easy to understand and decipher.

Problem statement

How can a coffee machine be designed for user-centered repairability and maintenance?

Insights

Coffee machines have a lifetime of 3-5 years.

The main failure point of a coffee machine is limescale build-up.

Diagnostics of a failure is very difficult.

Coffee machines are not a part of the EU repair legislation yet.

Most people will only consider repairing if the total cost is less than 30-40%.

Coffee machines are not designed for the user to open or disassemble it.

Consumers think it is too expensive to send a coffee machine to a repair shop.

There is a gap for a user-repairable coffee machine on the market.

The amount of limescale in machines highly depends on the hardness of the water.

Professional repair technicians diagnose the problem the same way the customer would.

In automatic espresso machines the coffee bean grinder commonly breaks.

Users have a high fear of breaking the machine by trying to perform a repair.

Knowing what each component is does not help the user.

The original splits were very difficult to remove

Some symbols could be associated with water

Having different symbols at both ends can be confusing.

Design Criteria

Companies should offer additional guidance to lower repair costs.

Make the repairability of the product a secondary or tertiary selling point.

People should feel confident when opening the coffee machine.

The machine should have a modernized retro timeless design.

The machine should have a functional inside and beautiful outside.

It is important to place components strategically to avoid damage

A user-centered repairable coffee machine should be as simple as possible.

There must be a clear direction of the flow of water.

It should be easy to open the machine.

Tubes should be easy to attach and detach

Detach/attach components without affecting other components

Wires should feel safe to touch and easy to navigate.

Requirements

Key components must be replaceable.

The inside must be compartmentalized.

The machine must be upgradeable.

The materials and finish must be of high quality.

The water temperature must be between 90-96 degrees Celsius.

The extraction pressure must be 9 bar.

Must have a steamer.

The machine must be repairable with 2 tools or less.

Symbols should have a clear distinction from one another.

Wires need to be different colors.

CHAPTER FIVE
User interaction

The chapter continues to focus on the contextual and principal level of the value pyramid (p. 5) as prototyping and user test helps analyze user interactions and product size. It explores the dilemma of making a coffee machine small without making the inside a complex compressed cluster of components. The chapter concludes with what initiates attributes for feedforward. The chapter ends by updating the design brief.

Ill. 66: P5 doing tests

DIMENSIONS AND INTERACTION

The next section will contain tests of the overall size of the machine and interactions of both features and displays. Users will participate in some of the tests while others are performed by the design team internally. As seen back in Chapter Three by testing the sizes of the backplates, the dimensions 31 x 40 cm was used from that point and is revisited in this chapter. (app. 25)

A model of MDF is built making it possible to insert the original components. Rapid prototyping of 3D modeled attachment methods was made to make this possible. Two constellations were tried in the 31 x 40 cm model, one that utilize all the space and with a more complex setup. The upper left corner of both setups are left for electronics.

The wider version (1) uses a lot of space and creates a good overview – there is a lot of room for fingers to fiddle with the components. Production wise this setup could risk being a waste of material and space. The pump is horizontal, and a vertical version could be beneficial as it would naturally compress the layout.
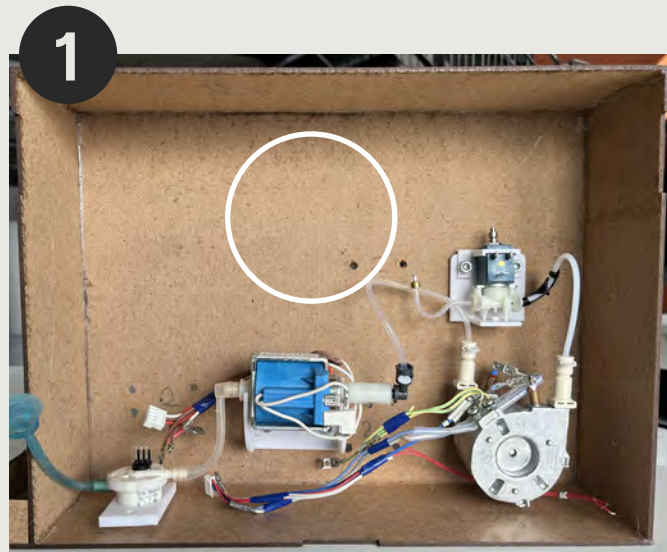
Ill. 67: Wide setup

The tighter version (2) proves that the current dimensions can be altered – there is a lot of blank space. Again, the pump is placed horizontally, which makes a tight gap between the flowmeter to the pump – making it difficult to handle. This layout still allows for proper interaction and is not too cramped. Making the pump stand vertically will lead to better usage of space.
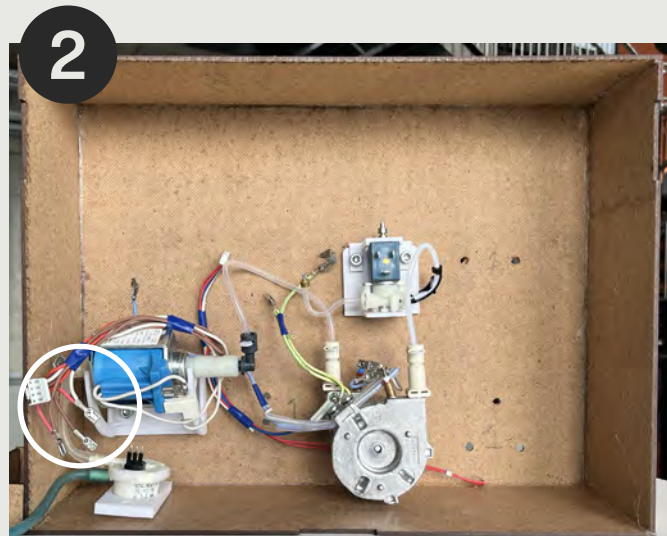
Ill. 68: Tight setup

Using the model as reference, the new dimensions used in the next test of component placement is 31x32 cm.

COMPONENT PLACEMENT

The objective is to investigate different setups to see what layouts alleviate complexity. The flowmeter and thermoblock are in predetermined positions and this test will primarily change the pump and solenoid valve. This test was done using the tubes gained from the disassembled coffee machines, and had incorrect lengths making the tubes overlapping in ways that can be avoided by using correct lengths in the final design. (app. 26)

This setup generated lot of wasted space under the PCB. This could be solved by placing the PCB vertically or on the side. There is room for a drip tray under the pump. The pump and heater are close, which made interaction somewhat cramped.
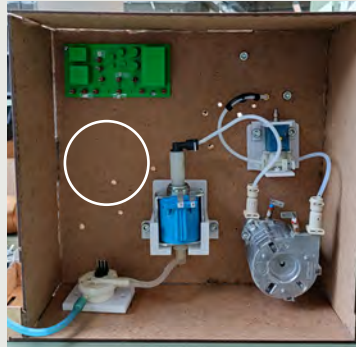
Ill. 69: Setup 1

More room for a drip tray but there is not that much room to experiment with PCB placement. This setup creates more space for drip tray and more space between the pump and heater.

Ill. 72: Setup 4

A lot of wasted space in the middle, however plenty of room for drip tray, OPV and steam valve. The components placement is very separate and generates a lot of empty space.
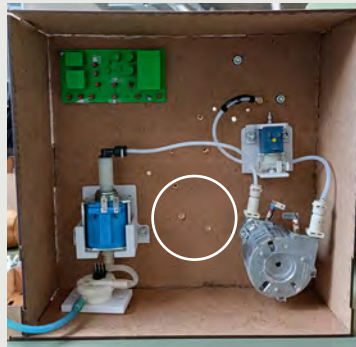
Ill. 70: Setup 2

A lot of wasted space in the middle and no room for OPV and steam valve.
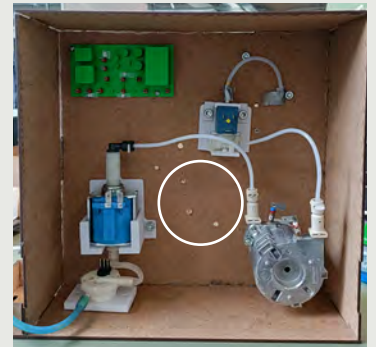
Ill. 73: Setup 5

There is lot of cross over of tubes and does not make enough room for OPV and steam valve. Moving the PCB could possibly solve this problem. It cannot be turned vertical as it would interfere with the pump but placing it on the "ceiling" is a possibility. However, this would make it harder to interact with.
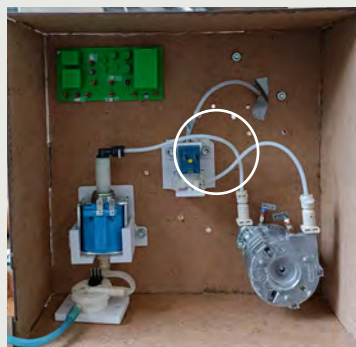
Ill. 71: Setup 3

The empty space is less and makes more room for a drip tray.
The solenoid valve takes up much space considering there should be room for an OPV and steam valve.
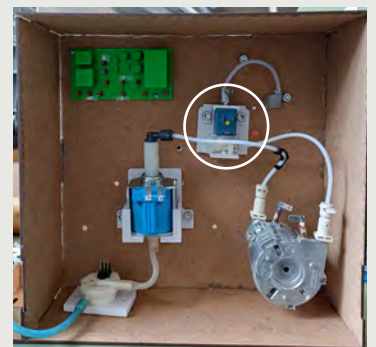
Ill. 78: Setup 6

Summary

To make the machine less compressed without containing too much blank space, the length is extended from 32 cm to 34 cm. It is a small change, but it will provide the exact amount needed to both incorporate OPV and steam valve while keeping it less compressed. Therefore, the final dimension of the machine is 31 x 34 cm.

The materials and finish must be of high quality.

KITCHEN COUNTER TEST

As the design is elongated rather than deep, testing whether the machine fits onto a kitchen counter and the effects is investigated. During this test P5 was invited to try out and act out a use scenario while being observed. (app. 27)

Kitchen counter setup
- Height: 95 cm
- Depth: 71 cm
- P5 height: 166 cm

P5 have never had any prior experience with semi-automatic espresso machines going into this test and provided a few insights accordingly.

The participant placed the machine 55 cm away from the edge but experienced some trouble reaching it properly and had to bring it further forward. Inserting the portafilter into the group head was met with a few difficulties. There were no indications on the head module that provided details of how to correctly place and twist the portafilter. P5 leaned over the counter to get a proper overview of the display at the top before being able to use it.

Ill. 79: Interaction test with P5

The test gave some important insights into how the current design can be interpreted. As the specific decision of elongating the build rather than making it deep like the traditional design gives a bit more awkward use interaction. Usually, machines on the counter will be pushed up against the wall to avoid taking up too much space. As the design is wide and slender, users will have to pull it forward for proper use. On a positive note, this way users will be able to "take space" to use the machine and remove it to get more table surface space. Traditionally designed coffee machines would cause more trouble in regards to this specific situation, where users might need to turn it to the side or remove it completely. The main interaction which consists of placing the portafilter will need to have guidance. Normally group heads have indicators of how it is used, and this will be incorporated into the design, see ill. 80 for reference.

Ill. 80: Group head semantics

👁 The user will move the coffee machine back and forth on the kitchen table.

⊘ The group head needs an indication of where to place the portafilter.

HOW TO OPEN THE MACHINE

As the repair and maintenance steps are user-centered, the method of opening the machine is important to address. Most machines do not have a simple way of getting into the core. Many machines need to be unscrewed from the bottom, and most are clicked and glued into place. Often these screws need special tools. Overall, these machines are not designed to be opened and pushes consumers away from engaging with repair and maintenance.

1. Mailbox principle

This design resembles a handle from a mailbox. The backplate will be hidden up against a wall. When turning the machine, the handle will act as feedforward that the machine can be opened by "anyone". This solution is suggested to be combined with magnets, or some sort of fastening, that does not require tools. Referring to the "willingness to repair" from Chapter Three, the use of tools and special tools makes users less prone to open and repair their products. The mailbox design will create opportunity for seamless assembly.

Ill. 81: Postbox principle

Ill. 82: Postbox

2. Finger tap principle

This design uses small dents or "holes" to communicate how it is opened. This solution is more hidden, though the mockup is made through actual holes – these could potentially be hidden in the side under a smaller dent. The issue with this solution would be the distribution of balance. If a user is going to open the backplate using only the left side, it will create awkward restrictions if combined with magnets. If it is fasteners with small clamps or a snap fit solution, users will have to use both hands at the same time to ensure correct detachment.

Ill. 83: Dent principle

USER INTERFACE

Several different display layouts has been explored based primarily on aesthetics and intuition. Based on the market, a few presets has been incorporated into the system:

- 1 espresso shot (35 ml)
- Double espresso shot (70 ml)
- A cup of coffee (80 ml)
- Americano (120 ml)
- Descale program
- On and off button

All layouts are somewhat separated from system operation to coffee extraction – coffee options are on the left close to the group head. (app. 28) Layout B, where the descale is closer to the GO button, lacks structure with the operational buttons. Layouts where the descale is on the right with the on and off button resembles a clustering of system commands and looks to be the best fit. Having the start button in the middle separates them from the rest, and in layouts like D creates three sections of functionality: System, operational, and action. The layout and attributes from option H will be taken into account when continuing with aesthetics in Chapter Six.
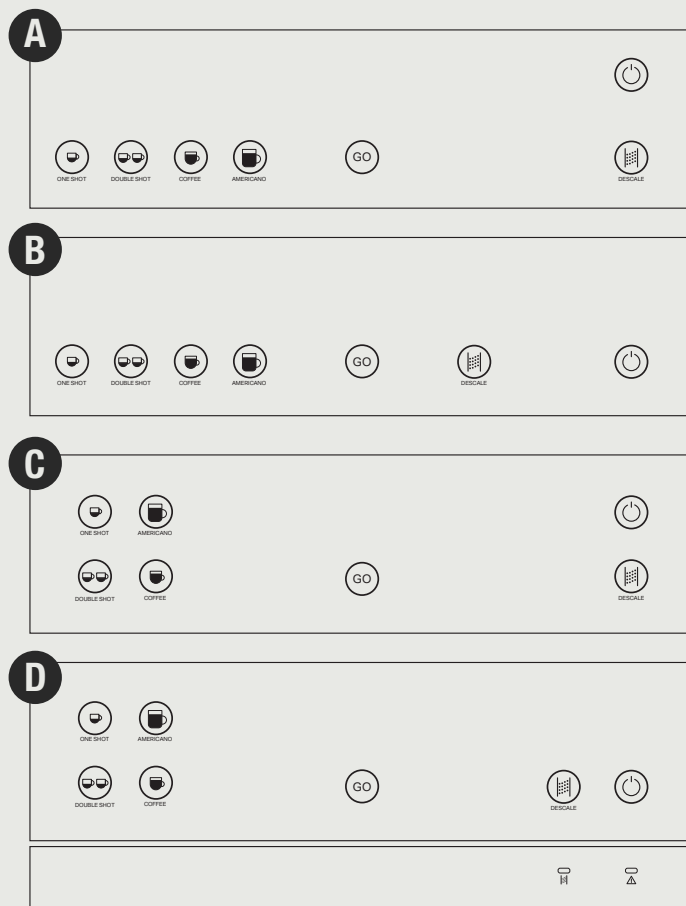
Ill. 84: Initial interface layout

Design brief 5.0

Aim

To design the next generation of modular coffee machines that users of all skill levels can feel comfortable repairing, with a timeless design that is easy to understand and decipher.

Problem statement

How can a coffee machine be designed for user-centered repairability and maintenance?

Insights

Coffee machines have a lifetime of 3-5 years.

The main failure point of a coffee machine is limescale build-up.

Diagnostics of a failure is very difficult.

Coffee machines are not a part of the EU repair legislation yet.

Most people will only consider repairing if the total cost is less than 30-40%.

Coffee machines are not designed for the user to open or disassemble it.

Consumers think it is too expensive to send a coffee machine to a repair shop.

There is a gap for a user-repairable coffee machine on the market.

The amount of limescale in machines highly depends on the hardness of the water.

Professional repair technicians diagnose the problem the same way the customer would.

In automatic espresso machines the coffee bean grinder commonly breaks.

Users have a high fear of breaking the machine by trying to perform a repair.

Knowing what each component is does not help the user.

The original splits were very difficult to remove

Some symbols could be associated with water

Having different symbols at both ends can be confusing.

The user will move the coffee machine back and forth on the kitchen table.

Design Criteria

Companies should offer additional guidance to lower repair costs.

Make the repairability of the product a secondary or tertiary selling point.

People should feel confident when opening the coffee machine.

The machine should have a modernized retro timeless design.

The machine should have a functional inside and beautiful outside.

It is important to place components strategically to avoid damage

A user-centered repairable coffee machine should be as simple as possible.

There must be a clear direction of the flow of water

It should be easy to open the machine.

Tubes should be easy to attach and detach

Detach/attach components without affecting other components

Wires should feel safe to touch and easy to navigate.

The group head needs an indication of where to place the portafilter

Requirements

Key components must be replaceable.

The inside must be compartmentalized.

The machine must be upgradeable.

The materials and finish must be of high quality.

The water temperature must be between 90-96 degrees Celsius

The extraction pressure must be 9 bar.

Must have a steamer

The machine must be repairable with 2 tools or less

Symbols should have a clear distinction from one another

Wires need to be different colors

The coffee machine is 31x34 cm.

CHAPTER SIX
LONG LASTING
AESTHETIC DESIGN

This chapter focuses on the spiritual, contextual, principle, and material level of the value pyramid (p. 5) investigating what makes a product long-lasting, timeless, and Dieter Rams' 10 design principles of good design. The time-line of espresso machines is investigated to help predict the future of coffee machine design while staying true to traditions. Further developments are made through mockups, sketches and bodystorming. The chapter ends in an updated design brief.

VALUE PROPOSITION CANVAS

To further concretize whom the espresso machine is aimed at, the Value Proposition Canvas (Strategyzer, 2025) is used to create reasoning of both aesthetics in this chapter and business in Chapter Eight. The canvas in combined by initial thoughts and knowledge gathered by surveys, interviews, mockup tests, and using the Target Group from Chapter One (p. 27). (app. 29)

Additionally, the design team set out to frame the problem more thoroughly as well, to use the value proposition canvas as an answer:

Espresso machines such as Sage / Breville breaks eventually after a short period of time and ends up costing more money to maintain. Due to the internal component layout in competing espresso machines, professional repair takes a lot of man hours making the repair more expensive for the user.

BRØK 58 saves the target group money in the long run by enabling easy self-repair or quicker professional repair without compromising on aesthetics.

Gain creators

- Preset coffee options.
- Coffee options have preset specifications.
- Aesthetic simplicity by emphasising only essential parts.
- Easily accessible maintenance and repair guide.
- Service portal to find and order spare parts to replace broken components.
- Helps boost confidence in self-repair.

Products and services

- Espresso machine with steam wand.
- Timeless design.
- Multiple preset coffee options.
- Easy access and overview of the internal components.
- Accessible maintenance and repair guidance.
- Extra set of tubes and o-rings.
- Screwdriver included.

Pain relievers

- Preset specifications in the coffee options to ensure the best brew every time.
- The design is inspired by traditional espresso machines and therefore avoids being timely.
- The customer can save money by being able to repair the coffee machine themselves.
- Simple user interface by emphasising essential functions.
- Indicators and guides to assist the user in maintenance and repair.
- Clear overview of everything when opening up the machine.

Knowing that focusing on maintenance and repairability would risk creating the same case Fairphone experienced (p. 15). From investigations and research, it has not been clear whether consumers actively seek a repairable espresso machine. It is mainly the new EU regulations, the Right to Repair, that pushes design in this direction. Thus, the value proposition canvas focuses mainly on aesthetics and user experience. In the following section the aesthetic history of espresso machines will be elaborated further to understand the nature of said machine.

Value proposition

An espresso machine designed for effortless use, simple maintenance, and lasting elegance.

Customer segment

Coffee drinkers who prioritize simplicity in both aestethics and user experience.

Gains

- Easy to navigate.
- Can make a good cup of coffee.
- To serve good coffee for guests.
- To do minimal maintenance.
- A machine that contributes to the home aestethically without being too loud visually.
- Easy to repair.
- Long lasting aestethic design and functionality.

Customer job(s)

- Make a cup of coffee.
- Offer guests a cup of coffee.
- Show off their of coffee machine.
- Maintain their coffee machine.

Pains

- Drinking mediocre/bad coffee (severe).
- Often needs to descale the coffee machine (severe).
- Spending money on a coffee machine that needs to be replaced within a few years (medium).
- The coffee machine does not look good in their home (severe).
- Does not know where to begin when engaging with more complex maintenance (medium).
- Having to learn and decipher a complex user interface (medium).

Ill. 86: Value Propersition Canvas

manual control

traditional g shape

Ideale espresso machine
1910

Faema E61
1961

Gaggia
1980
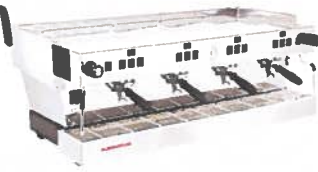
La Marzocco
1993

Ascaso
2006

ascaso Steel Duo Black

Gaggia Classica
1948

La pavoni E61
1961

Gaggia classic
1991

Ascaso dream
2000

Gag
200

industrial machinery

sharp corners

double curves

Complex to use

⭐stainless steel

naked/honest design

ESPRESSO MACHINE TIMELINE

By organizing espresso machines on the timeline, it is evident that some design attributes repeat and might be described as timeless. Espresso machines have gone from being a professional instrument to a product found in most households. Materials such as stainless steel is frequently used throughout time, and colors were largely introduced in the late 90's. The used colors were mostly vibrant primary colors such as red and yellow. Design from the mid 1900's generally looks complex to use as it resembles industrial and manual features such as levers, knobs,
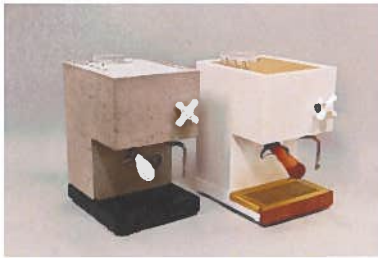
Anza
2017

Smeg
2023

Smeg
2024

Nunc.
2025

gia
9

La pavoni
2016

Sage the barista
express impress
2022

Gaggia classic pro
E24
2024

Breville oracle jet
2024

Soft shapes

digital

Same "model"

new color

and dials. The overall attributes are somewhat naked and honest. The dominating shapes are sharp edges and angles - after the 2000's design becomes more organic and softer. The contemporary designs consist of displays and become more complex to look at. The digital displays, buttons, gauges and settings add to the intricacy. Even though modern espresso machines have become visually softer they still consist of many straight surfaces. Brands such as Gaggia has kept their design first launched in 1980 with a few alterations in 1991 proving its timelessness. Looking into what future espresso machines aesthetics looks like, products such as the soon to be released Nunc. espresso machine is a great indication of the

☆ boxy → modern

Complex to look at

magic box design

potential direction. Mixing geometrical attributes from the mid 90's with soft rounded corners creates a simple display of effortlessness. Stainless steel is the most used visible material and is often combined with timeless design because of its plain and versatile style – it fits into almost any interior.

HOW IS SOMETHING TIMELESS?

A need to understand what "timeless" entails, it has been investigated how it might be defined through timeless and timely design (Laursen & Barros, 2022) and what timeless design styles are (Wallner et al., 2020).

According to Laursen & Barros (2022) timeless design is "not influenced by changing consumer tastes and preferences" and timely design is described as "designs that adapt to consumer trends". They discuss that the anchor point of a design process should be values and frames rather than the working principles. The final design should express timelessness in a timely manner due to the design being relevant in its present time as well as across time. (app. 30)

Value	Timeless
Frame	Timeless/Timely
Working principles	Timely
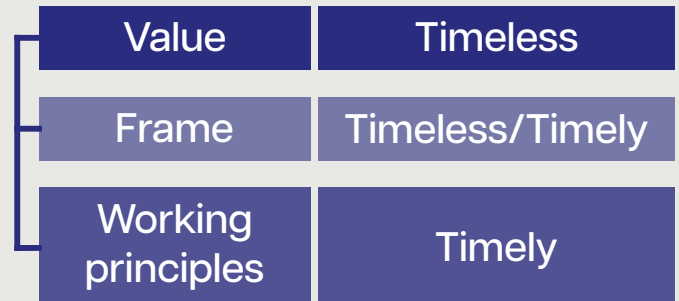
Ill. 87: Value framing

The paper "An Exploration of the Value of Timeless Design Styles for the Consumer Acceptance of Refurbished Products" explores what design styles and attributes makes timeless design and how refurbished products in those categories are perceived by consumers. They have set three strategies to incapsulate different ways of achieving timeless design:

Exceptionally beautiful designs
• Will trigger a dramatically emotional response
• Is highly subjective
Nostalgia evoking designs
• Design with associations to the past and suggest to prolong the emotional durability of a product.
Simplistic designs
• Seek simplicity without loosing correspondence to "the essential nature of the product".
• With as little ornament as possible suggested to be independent of culture and time-related cue.
• Dieter Rams.

The first strategy is based on subjective experiences and in accordance with the paper is not considered further. Nostalgia design, also described as neo-retro, were described as beautiful in the past thus it is beautiful now; therefore, timeless. Neo-retro products are seen as "good old times" and a great design style, though in some instances the perceived quality outweighed some product choices.
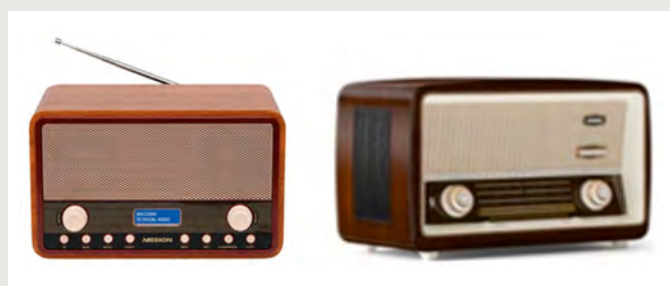
Ill. 90: The Medion Life Radio.

Simplistic designs were seen as timeless as well. In addition, simplistic refurbished products gained more positive traction than neo-retro styled products, as they generally were seen as more durable and worthy of refurbishment while containing high quality.

Ill. 89: Braun T3 Pocket Radio.

Overall, refurbished products were seen as lower quality than buying a whole new product, but simplistic design was still seen as high-quality despite this.

The paper briefly touches upon material selection and how they are compared to timelessness and durability. Materials such as metal, wood, and leather were appreciated more than plastic. They were seen as more repairable and easier to determine the state of a product.

Continuing the aesthetic design reasoning: exploring the simplistic strategy due to its irrelevance to time related cue is being investigated. The paper repeatedly refers to Dieter Rams as a great representation to the simplistic design strategy. Therefore, in the next section Dieter Rams' design principles and products will be analyzed to further determine how to implement them into the espresso machine.

DIETER RAMS - 10 DESIGN PRINCIPLES

Dieter Rams a legendary German industrial designer who is known for his simplistic designs driven by functionality (Carroll, 2019). As Rams' designs is rooted in people, it is fitting to combine this master thesis' user-centered design approach with his line of thinking. He created 10 design principles to explain what good design entails:

GOOD DESIGN IS INNOVATIVE

GOOD DESIGN IS HONEST

GOOD DESIGN MAKES A PRODUCT USEFUL

GOOD DESIGN IS LONG-LASTING

GOOD DESIGN IS AESTHETIC

GOOD DESIGN IS THOROUGH DOWN TO THE LAST DETAIL

GOOD DESIGN MAKES A PRODUCT UNDERSTANDABLE

GOOD DESIGN IS ENVIRONMENTALLY-FRIENDLY

GOOD DESIGN IS UNOBSTRUCTIVE

GOOD DESIGN IS AS LITTLE DESIGN AS POSSIBLE

Dieter rams' designs can be considered timeless as they avoid trends and emphasize the products' aesthetic and functional simplicity, while implementing practical design choices for the design to remain relevant through time. Dieter Rams designs communicate hierarchy and importance of functions through color. Implementing and accentuating Rams' 10 design principles will add guidance to the further development of the product. These principles can help to make sure the product is well cared for and remains in the user's possession for a long time. (app. 31)

Designs can be considered timeless by emphasizing functional and aesthetic simplicity while implementing practical design choices.

An analysis of Dieter Rams' designs has been made to illustrate what attributes results in simplistic and timeless design (ill. 91)

Simplicity by emphasizing only essential parts

Instructive text

Button placement creates hierachy

Color highlighting important functions

The design principles implemented into BRØK 58 is:

· Simplicity by emphasizing only essential parts
· Instructive text
· Button placement that insinuates hierarchy
· Color highlighting important functions

How the design principles are implemented in BRØK 58:

· Bright colored splits, most likely a bright yellow or orange
· To combat having more than one PCB for the user interface, gathering and creating a hierarchy of the buttons will be the solution.
· Bright colored buttons of the most important functions.
· Simplicity by emphasizing only essential parts
· To pare back the aesthetic to only essential parts and avoiding visual clutter

Overall, all the principles will be considered when compiling even the smallest details in the design such as rounded edges and clean lines. The knobs and buttons should be inviting through feedforward and feedback. A product you would like to touch.

ⓘ **Simplicity by emphasizing only essential parts.**

ⓘ **Instructive text.**

ⓘ **Button placement that insinuates hierarchy.**

ⓘ **Color highlighting important functions.**

IMPLEMENTATIONS

Style

The functional styleboard (ill. 92) provides insight into how functions could be implemented in different ways. It contains ideas for different parts of the espresso machines and gives an idea of how the design should look and feel at the same time using reference products.

Magnetic fit
easy

"mail box" backside opener
feedforward

"no tools needed"
accessible

Destinct backside line

Standardization
- house hold tools

snap n click water tank
feedback

Rubber pivot point

squircle shape for timeless
aesthetic

feedforward
steam wand dial

LED indicators
shape difference

Detachable drip tray
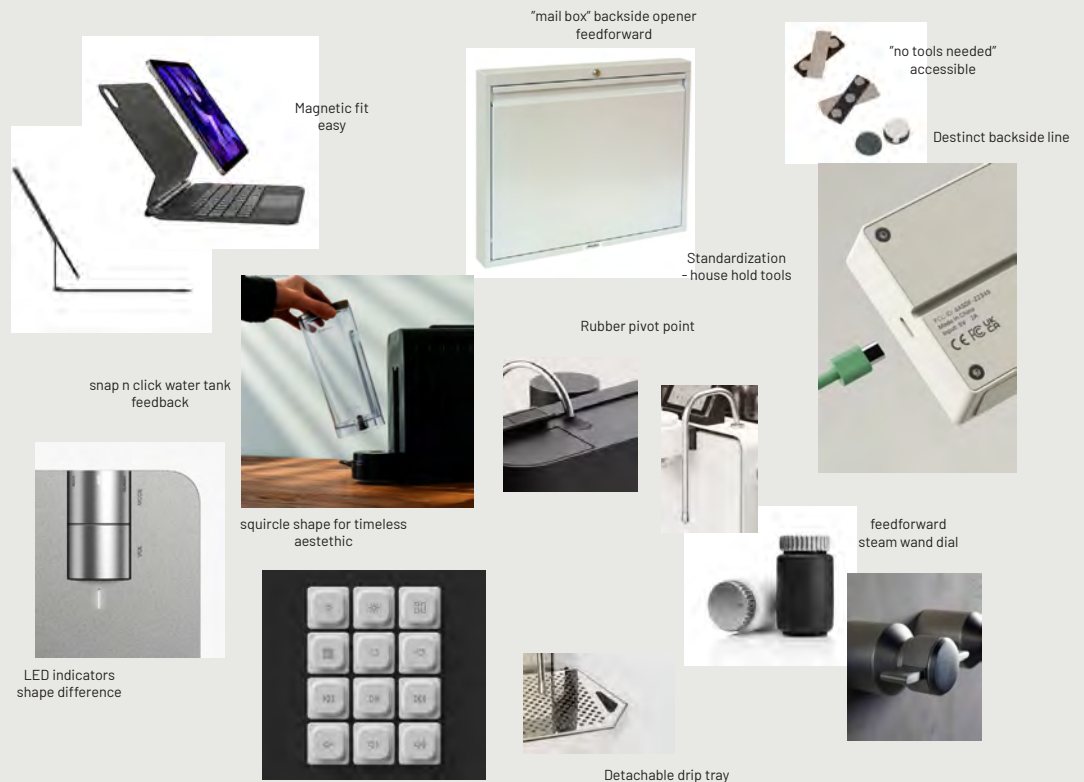
Ill. 92: Functional style implementation

Timeless buttons shape

tansparent water tank

Warm greys and blacks

Mix between sleek and textured surface

classic

mat stainless steel
- traditional

The aesthetic styleboard (ill. 93) elaborates upon the potential look of the espresso machine and what finishes might be used. The use of either brushed or shiny metal with few details such as grooves is considered to create interesting surfaces yet keeping it simple. A transparent water tank breaks up the surface while keeping it intriguing through different materials.

Ill. 93: Aesthetical implementation

The first step toward implementing these design attributes mentioned from this chapter is experimenting with the outer shape of the espresso machine. (app. 32)

Overall shapes were 3D modelled to bodystorm and to give an understanding of what direction to go in. The shapes were inspired by the rounded corners of apple products and B&O speakers.

Ill. 96: 3D bodystorming

Ill. 94: B&O Speaker

Ill. 95: Apple iPhone
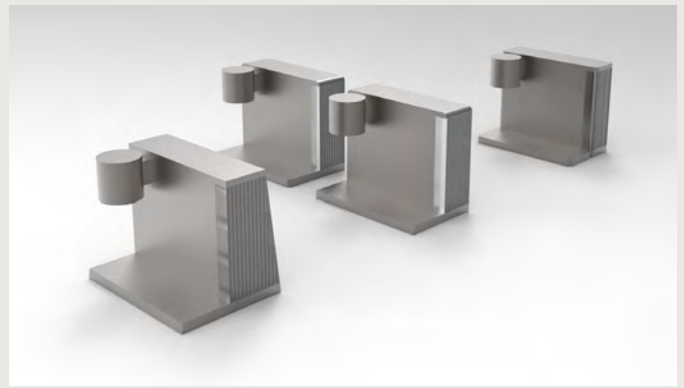
1 Rounding the edges depth-wise gives the machine a neo-retro look which is not the desired look. The corners go the opposite direction of the group head. As the group head attracts a lot attention, the difference in curvature is intruding.
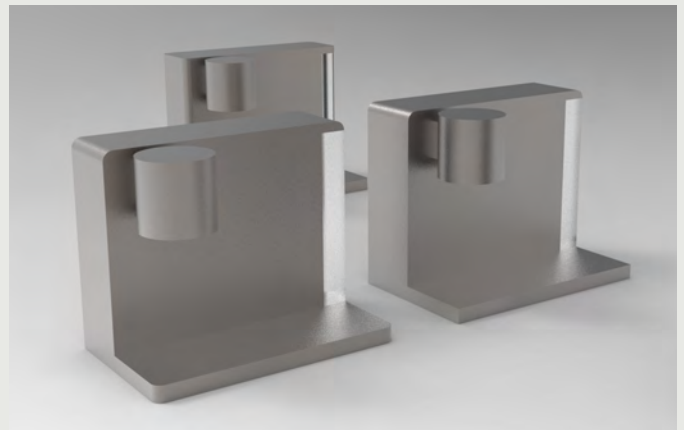
Ill. 98: 3D bodystorming 1

2 Rounding the edges 10 mm height-wise works better and matches the curve of the group head, however it can very easily look like a Nespresso coffee machine. This could be counteracted by rounding the corners less dramatically. A mistake during 3D modelling ended in separating the driptray from the main body, creating an unintended curve in the middle, which is not desired. (app. 32)
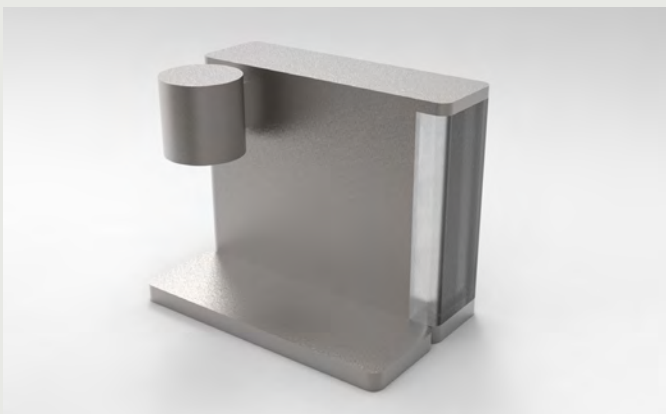
Ill. 97: 3D bodystorming 2

Ill. 99: 3D bodystorming 3

3 Changing the edges to 5 mm helps tighten up the desired look making it less like a Nespresso machine. Though the current "sleek" shape of the espresso machine makes it look more fragile and is against the simplistic design type discussed by Wallner et. al. (2020) back in section "Espresso machine timeline" (p. 60). Simplistic design needs to come off as robust and strong as it assures durability. A simple yet impactful change was investigated:
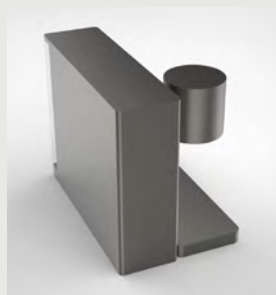
4 This version looks more solid. It references the B&O speaker more clearly with the slight angle, and as the backplate will need ventilation grooves, it will reference it more (fig x: bo speaker). If the machine were to be placed up against a wall the slant would help ventilation, whereas the former version would risk poor airflow. The front edge on the drip tray has the same slant as the back to enhance symmetry from the side. This form language also references already well-known espresso machines such as Sage / Breville, as they have a slanted front (ill. 101).
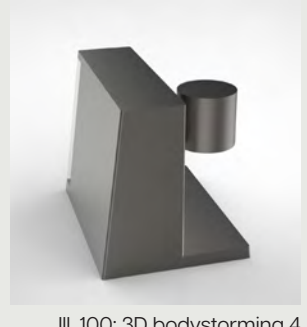
Ill. 100: 3D bodystorming 4

Ill. 101: Dé'longhi Coffee machine

Steam wand: Point of interaction

The rubber handle is attached for the user to more easily lift the wand and to avoid potentially burning their fingers, as some steam wands get hot. Option A has the rubber cover in the middle and ensures more natural movement. Option B would be awkward to use and would demand much more force. In option B it is assumed the user would pull the bottom of the wand as the rubber is placed an inconvenient place.
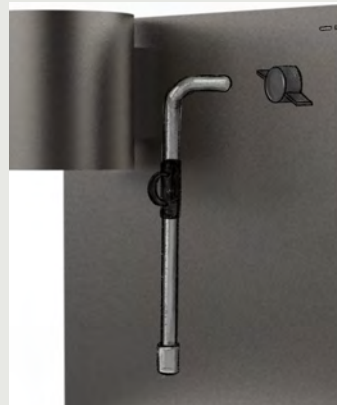
Ill. 102: Option A

Ill. 103: Option B

Steam wand: Angle

It is investigated whether the wand should have a slight angle when in its default position. Option A has a 90 degree angle and is parallel to the front plate. Option B has the same angle as the backside and front of the drip tray to ensure continuity. Since theangle on the drip tray is not that noticeable on the front of the machine, angling the steam wand looks messy and unnecessary. The slight angle could risk misunderstanding, as it looks like it is not all the way in. A consumer might try to push it further and break the wand. Having it at a 90 degree angle follows the general direction of the front and would eliminate miscommunication.

Ill. 105: Option A.1

Ill. 106: Option B.1

BACKPLATE DESIGN

Designing the backplate to include organizing tools, information sticker, vents for airflow, and spare part container to assist the user in repair and maintenance. It has been decided the tool included is an allen key, as it is something IKEA and other companies include in their products and is cheaper to include than a screw driver.

The spare part container is a hollow square and will function as a "bowl" for users when engaging with maintenance and repair. It is the same container where spare parts will be included in a paper bag taped into the area during assembly. It has been investigated how to make it a closed box or make a lid solution to the container but due to production methods and cost (see Chapter Eight) it is evaluated that it would become too complex. (app. 33)
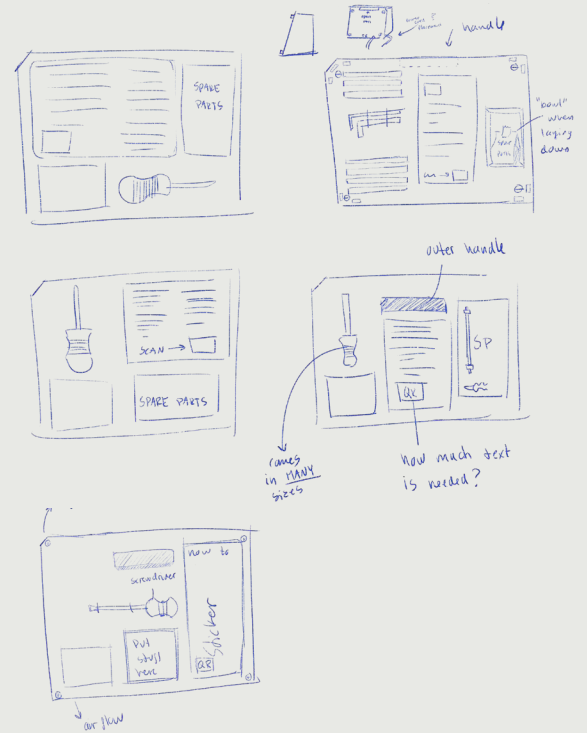
BUTTON HIERARCHY

By using Dieter Rams principles regarding interaction hierarchy and colors several iterations of buttons has been made.

The user interface was divided into three sections: system, operational, and action. These sections gave an understanding of importance but also how the hierarchy might be organized.

The division E on ill. 107 was regarded as the most optional way of organizing the buttons. Colors were implemented as well to further explore what meaning they promoted without the use of icons. Determining the action and system sections as the more important buttons, those went through multiple iterations of color systems.

Eventually the red buttons became the on and off button as it resembles buttons on TV-remotes, calculators and many more products. It is a typical semantic that has been created through time and seems appropriate to implement as well.

Yellow represents e.g. cleaning products, safety, maintenance, road work, and became the color for the descale program. This color is also being considered for the splits inside the machine. They will provide a semantic connection between descale and physical maintenance of the tubes and components.

The darker gray represents the GO button and is used to differentiate between the operational section making sure the hierarchy remains. Green was considered for this section though it became somewhat caricatured. Together with the yellow and red it would represent a stop-light and took away from the aesthetic qualities pursued.
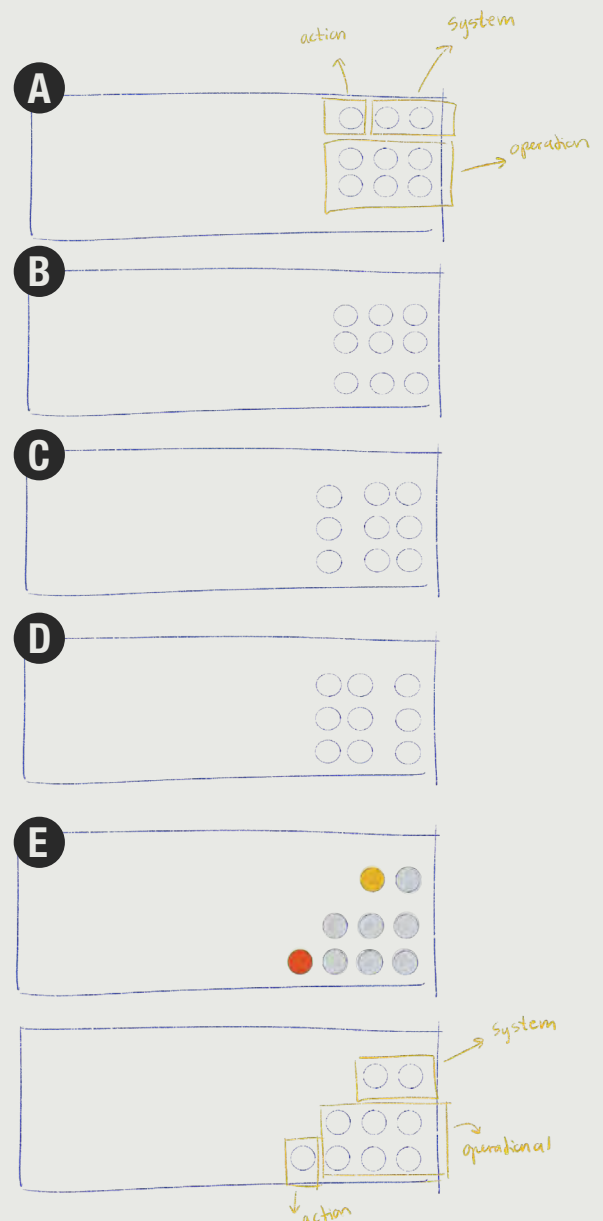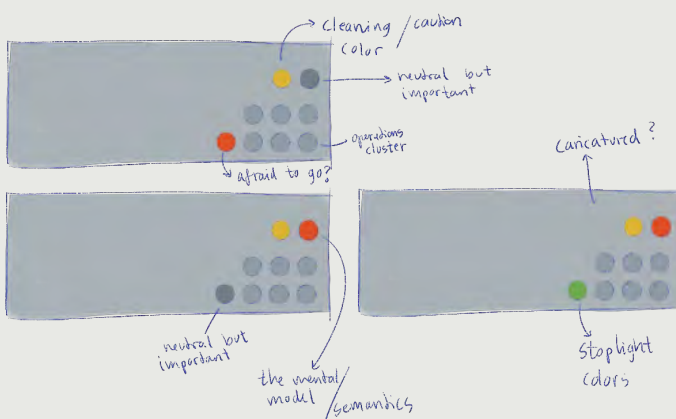
Ill. 107: Button hierarchy sketches

The next step is to test the sizing and spacing between the buttons to further understand the effects of the hierarchy. (app. 34)

Using a computer keyboard button the overall size of 15 mm was chosen.

Ill. 108: Button reference

1 Separation between action, system and operational. Creates a curve between the edge of the buttons, that does not align with the shapes used throughout the design. The hierarchy works great.
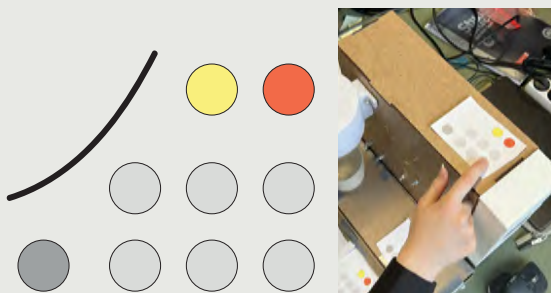
Ill. 109: Hierarchy 1 .1

Separation between system and operational. Action is clustered with operational. Less curve between buttons but does not clearly separate action button from operational. Still functional hierarchy.
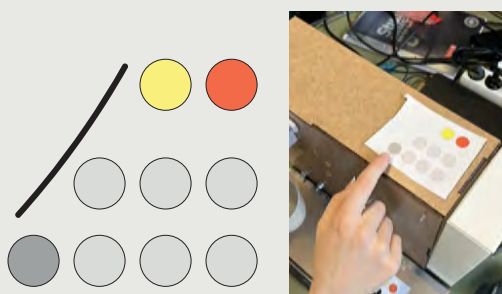
Ill. 110: Hierarchy 1.2

No separation between action, system and operational buttons. No curve between buttons and the hierarchy only relies on color, which does not work as well.
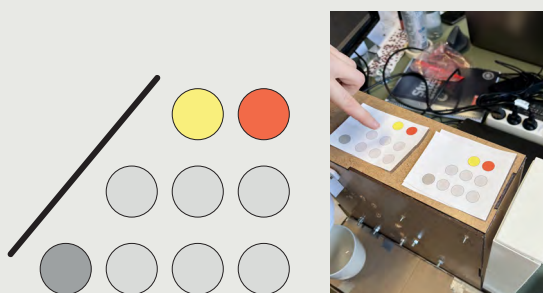
Ill. 111: Hierarchy 1.3

2 Distancing the buttons by 10 mm between operation and action while separating the operation and system by 15 mm. It looks too separated and still creates the slight curve between buttons. This option might work better when naming the buttons.
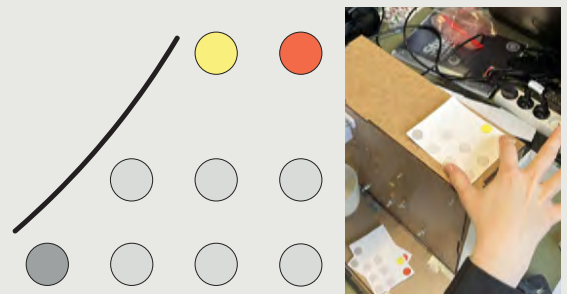
Ill. 112: Hierarchy 1.1

Separation of 10mm between operational buttons. Separation of 20 mm to system and action buttons which looks more balanced. Creates a slight curve again. Making the action button the same distance as between operational makes the curve less, though separating the sections seems to provide better value. The curve will have to be disregarded.
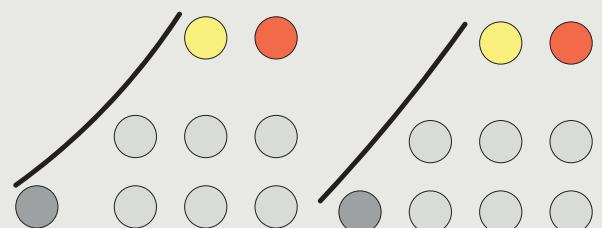
Ill. 113: Hierarchy 2.2

Ill. 114: Hierarchy 2.3

3

The 2nd iterations will be used and tested with names and icons.

They were tested with caps lock text in a size 12, and some had the amount of ml provided as well. Generally, it looks cramped.

Ill. 115: Hierarchy 3.1

Using normal texts in the size 12 gives more room, though it still looks tight.

The ml creates better understanding of how much is expected of an extraction and would enhance quick understanding of the specific operation.

Ill. 116: Hierarchy 3.2

4

The text size has been changed to 10 and balances the overall look making it more relaxed. The on and off button text has been removed while keeping the icon. This is due to the general understanding of the symbol which makes it possible to avoid naming it.

Ill. 117: Hierarchy 4.1
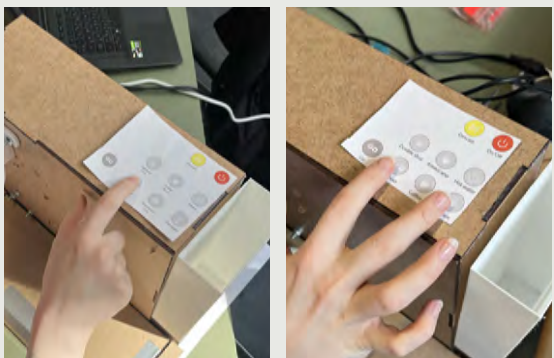
5

The go button has been redone to be simpler as the GO symbol looked redundant. For now, the decision of whether it should be normal letters or caps lock has not been decided. (app. 34)
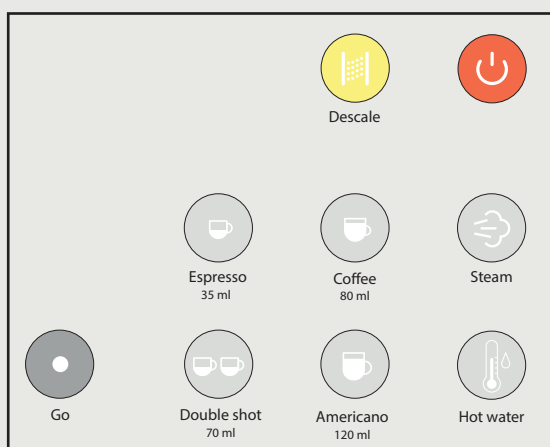
Ill. 118: Final button hierarchy
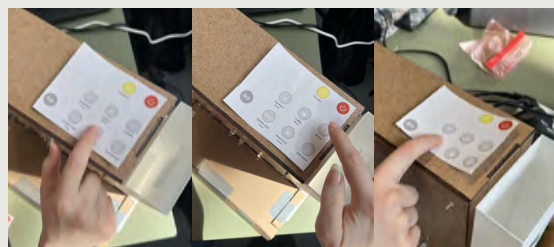
These button options were tested on the design team; however, they should have been tested on users to see if the system is understandable. This was not done because of time pressure.

STEAM WAND KNOB

The knob is on the front face of the espresso machine and a part that will be used to open and close the steam valve. It is important to ensure continuity with the rest of the machines' style, while still remembering ergonomics and feedforward. Different iterations of types and styles of knobs will be investigated. (app. 35)

Using reference products and using the timeline of espresso machines, other knobs are considered and 3D printed for testing to see whether they conform with current design and values.

Ill. 119: Ergonomic knobs

Ill. 120: Lever knobs

Ill. 121: Round knob

Ill. 122: Click buttons

Many classic machines have knobs with indents to create a better ergonomic grip. It also is an iconic look that has transcended time. Wooden knobs are premium versions and usually costs around 300 DKK to buy separately. Some espresso machines have levers for a very industrial feel. Most espresso machines have round knobs and is usually placed on the side.

More and more modern machines have a button that activate the steam as part of the user interface as the digital solutions and complexity increases.

Classic knobs are usually with indents to enhance the ergonomic feeling, and others have levers to give a more industrial experience. Contemporary espresso machines have round knobs mostly on the side as the steam wand is rotated away from the machine. Some machines have the knob on the front, making it possible for BRØK 58 to do the same. A "throwback" to classic design would be beneficial but in a simple design to keep on track with simplistic design. The following section will test out different knob heads. (app. 35)

Five different shapes were designed based on what is seen on the market. They are tested to see how comfortable they are to use, and which knob fits into the desired design.

Ill. 123: All knobs

Some of the knobs were designed to look like regular knobs from other espresso machines, see worksheet 82. The steam valve from the disassembled espresso machine back in Chapter One is used to test the knobs and how they are to turn. Many of the knobs were too far from the desired look and disrupted the aesthetic look too much. The following knob showed the best potential.

Ill. 124: Intuitive grip

The knob has a very intuitive grip and is fun to use. The aesthetic of the knob combined soft shapes with hard edges.

The chosen knob has gone through a few iterations to explore its potential. Before the knob had one "handle" which somewhat resembled a door handle. Either you would use one finger to turn the handle, or you would grip the whole knob which felt a bit awkward.

Ill. 125: Knob design

The new knobs are designed with handles both ways for better feedforward and grip.

The smaller knob is chosen as it is subtle in size while still maintaining the same design language as the rest of the machine. The smaller knob will give better room for both the group head and steam wand without creating a too cramped look on the front of the machine.
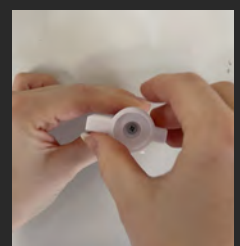
Ill. 126: Final knob design

Design brief 6.0

Aim

To design the next generation of modular coffee machines that users of all skill levels can feel comfortable repairing, with a timeless design that is easy to understand and decipher.

Problem statement

How can a coffee machine be designed for user-centered repairability and maintenance?

Insights

Coffee machines have a lifetime of 3-5 years.

The main failure point of a coffee machine is limescale build-up.

Diagnostics of a failure is very difficult.

Coffee machines are not a part of the EU repair legislation yet.

Most people will only consider repairing if the total cost is less than 30-40%.

Coffee machines are not designed for the user to open or disassemble it.

Consumers think it is too expensive to send a coffee machine to a repair shop.

There is a gap for a user-repairable coffee machine on the market.

The amount of limescale in machines highly depends on the hardness of the water.

Professional repair technicians diagnose the problem the same way the customer would.

In automatic espresso machines the coffee bean grinder commonly breaks.

Users have a high fear of breaking the machine by trying to perform a repair.

Knowing what each component is does not help the user.

The original splits were very difficult to remove

Some symbols could be associated with water

Having different symbols at both ends can be confusing.

The user will move the coffee machine back and forth on the kitchen table.

Designs can be considered timeless by emphasizing functional and aesthetic simplicity while implementing practical design choices.

Design Criteria

Companies should offer additional guidance to lower repair costs.

Make the repairability of the product a secondary or tertiary selling point.

People should feel confident when opening the coffee machine.

The machine should have a modernized retro timeless design.

The machine should have a functional inside and beautiful outside.

It is important to place components strategically to avoid damage

A user-centered repairable coffee machine should be as simple as possible.

There must be a clear direction of the flow of water

It should be easy to open the machine.

Tubes should be easy to attach and detach

Detach/attach components without affecting other components

Wires should feel safe to touch and easy to navigate.

The group head needs an indication of where to place the portafilter

Simplicity by emphasizing only essential parts

Instructive text

Button placement that insinuates hierarchy

Color highlighting important functions.

Requirements

Key components must be replaceable.

The inside must be compartmentalized.

The machine must be upgradeable.

The materials and finish must be of high quality.

The water temperature must be between 90-96 degrees Celsius

The extraction pressure must be 9 bar.

Must have a steamer

The machine must be repairable with 2 tools or less

Symbols should have a clear distinction from one another

Wires need to be different colors

The coffee machine is 31x34 cm.

CHAPTER SEVEN
MANUFACTURING

This chapter focuses on the material level of the value pyramid (p. 5) and develops the technical aspect of the coffee machine. It focuses on detailing the final layout of the product, the expected manufacturing process and an assembly guide for the coffee machine. The chapter ends with an updated design brief.

Ill. 127: Team discussing manufacturing

FINAL PRODUCT ARCHITECTURE

Legend:
- Wire/Signal/Electricity
- Water/tubing
- Coffee/tubing
- Steam
- User movement
- Milk

Espresso · Double shot · Americano · Coffee · Steam · Descale · Go · Hot water

Power on/off → Button → Display PCB

Electricity → Power cord → PCB

Water tank lid → Water tank

Water → Water tank

Flowmeter → PCB

Thermostat/PID

Pressure Sensor → Thermoblock

Solenoid Water pump ← Pressure Sensor

Thermoblock → Solenoid Valve → Group head

Over pressure valve → Steam valve → Steam wand → Pitcher

Portafilter

Coffee spout

Drip tray

Pitcher → Mug

Ill. 128: Final prouct architecture diagram

The product architecture (ill. 128) demonstrates what connects inside the coffee machine with how the signals, water and steam flows through the system. The wire diagram (ill. 129) shows how the wires are connected between components and the PCB.
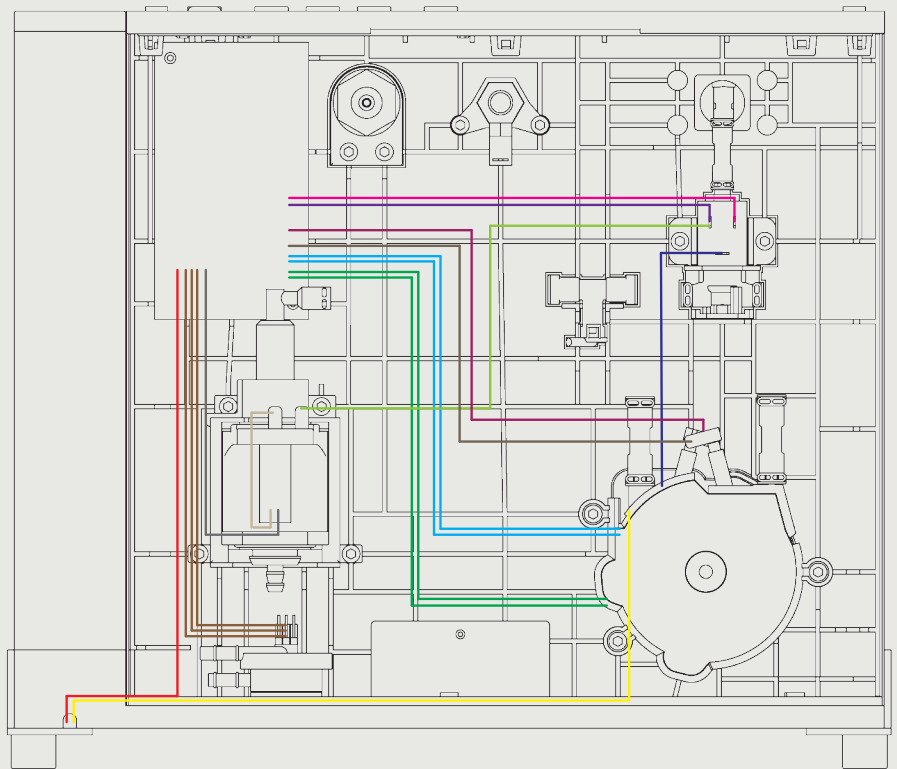
MATERIAL SELECTION

To figure out what kind of materials should be used in the product, it is important to understand what the specific parts are exposed to.

- External panels: Touch, general cleaning.
- Internal shells: High temperatures, heavy weight of internal components.
- Bottom shell: Heavy weight from the coffee machine.
- Drip tray: Hot water.
- Group head plate: Heavy weight from group head parts.
- Group head shell: Touch, weight under the user supporting themselves on it, general cleaning, possibly high temperatures.
- Group head internal assembly: 90+ degrees warm water, high pressure.
- Portafilter holder: High pressure, 90+ degrees temperatures.
- Steam wand assembly: High pressure, 100+ degrees temperatures.
- Water tank: Drinking water, cleaning, regular touch.
- Buttons: Regular touch.

Most significant materals:

Steel
- Stainless steel 304 (SS304)
- Stainless steel 316 (SS316)

Plastic
- Nylon + glass Fiber (PA66+25)

Stainless steel

Using stainless steel is especially important as it is corrosion resistant, which is needed in the presence of moisture. Further, stainless steel is food safe, meaning it does not store bacteria and is easy to clean (Geise, 2021). When brewing coffee and steaming milk, the steam wand and group head is subjected to high pressure and temperatures, which stainless steel can withstand. For aesthetic reasons the material aligns with the materials used throughout time on the espresso machine timeline (p. 60) and is able to give the machine the clean look that is strived for. Lastly, the material can be recycled. In addition, stainless steel is often used on kitchen appliances, therefore leaving no doubt of the possibility of use. When looking at the specific stainless steel variations, the parts directly in contact with water, steam and pressure will be SS316, as well as parts that are metal injection molded (p. 80) . SS304 is a more affordable option that still has great qualities, which is why SS304 is used, when possible, e.g. external panels. (Ibid., 2021). For the external panels there will be used a finish of stainless steel SB and with the drip tray grate, a finish of stainless steel No. 2B. (Ulbrich, 2024)

Nylon 66 + glass fiber

The material was first found in the disassembly of the multiple coffee machines in the beginning of the project. It was found that internal shells were made with PA66+25GF. PA66 or Nylon 66 is a thermoplastic with great stiffness, wear resistance, and thermal dimensional stability (Plastcom, n.d.). Reinforcing the nylon with glass fiber will increase the strength and stiffness, while improving pressure and thermal dimensional stability and increased heat resistance (Fuchen New Material, 2025). These factors are important as the shell will be in contact with hot steel parts e.g. thermoblock. Additionally, it is possible to recycle by being able to re-granulate it.

PANEL PRODUCTION - THE IMPORTANCE OF SIMPLICITY

To establish the aesthetic design as a main value proposition for the user, it is important that the construction of the external panels justify these arguments. Therefore, many iterations were considered, although not many were feasible or elegant enough to keep up with the criteria from Chapter 6.

Certain for all iterations of the panels were the production methods fiber lasercutting and a version of bending. The main concern was the gap that would be left in the top front corners, as the double bending would create a significant hole in the 3D model. Multiple kinds of bending were considered to accommodate for this concern (press braking, hemming, folding), yet the 3D model would not comply to the wishes of the design team. The subsequent iteration built in Autodesk FUSION 360, that also did not work, can be seen on illustration 130. These construction principles were inspired by espresso machines already on the market, observed through videos and physical machines. (app. 36)

Ill. 130: Construction of the external panels 1
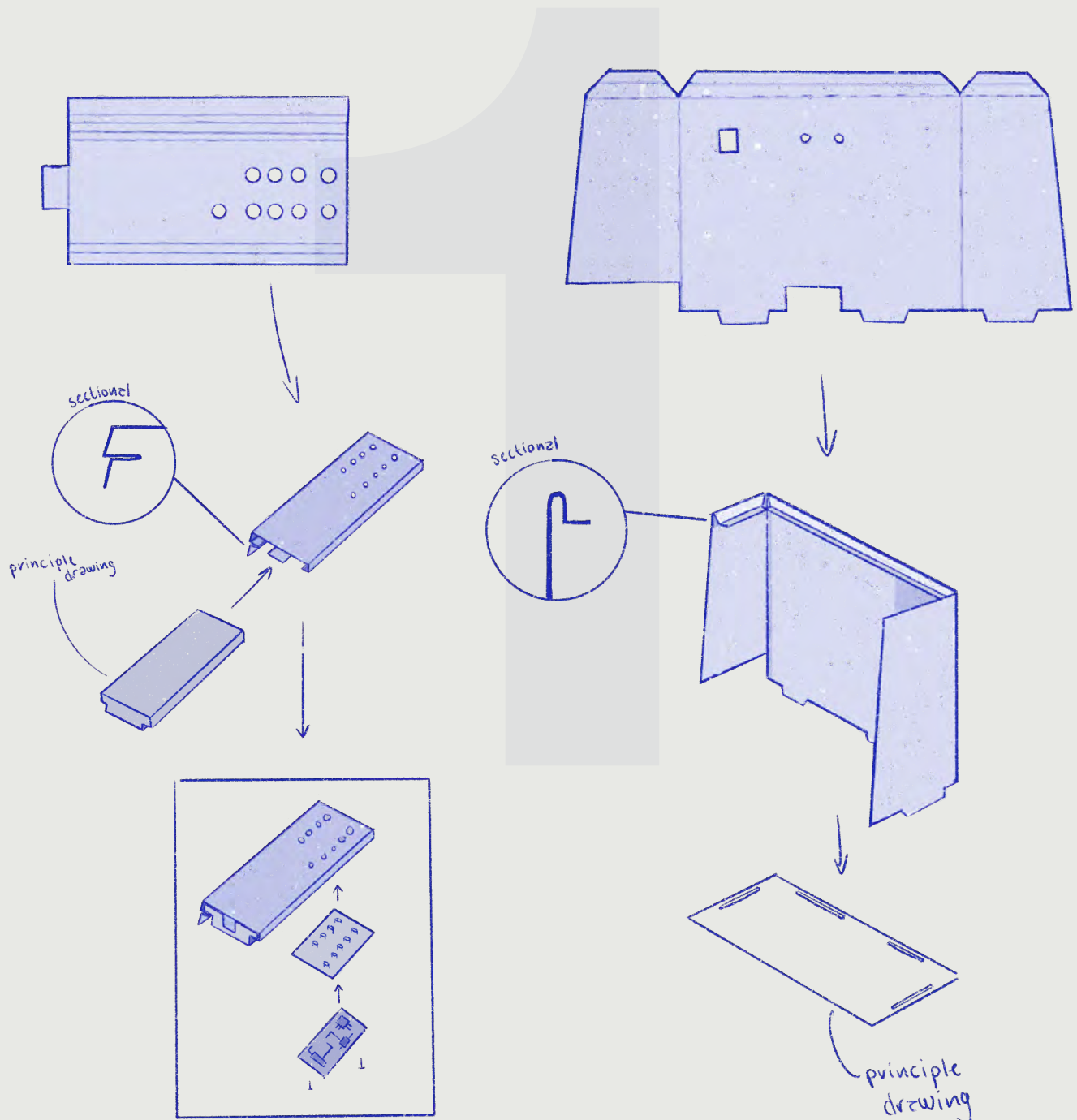
Acknowledging that a part of the problem might lie with the software, 3D modelling was switched to Autodesk Inventor and more simple bending principles were applied. Moreover, recognizing that simplicity should not only include the aesthetics but also the construction aswell as the production, the solution to the problem was found. On illustration 131, the solution includes minimal yet important bending. The production of the external panels is simply, fiber lasercutting, deburring and CNC press braking.

section2

principle drawing
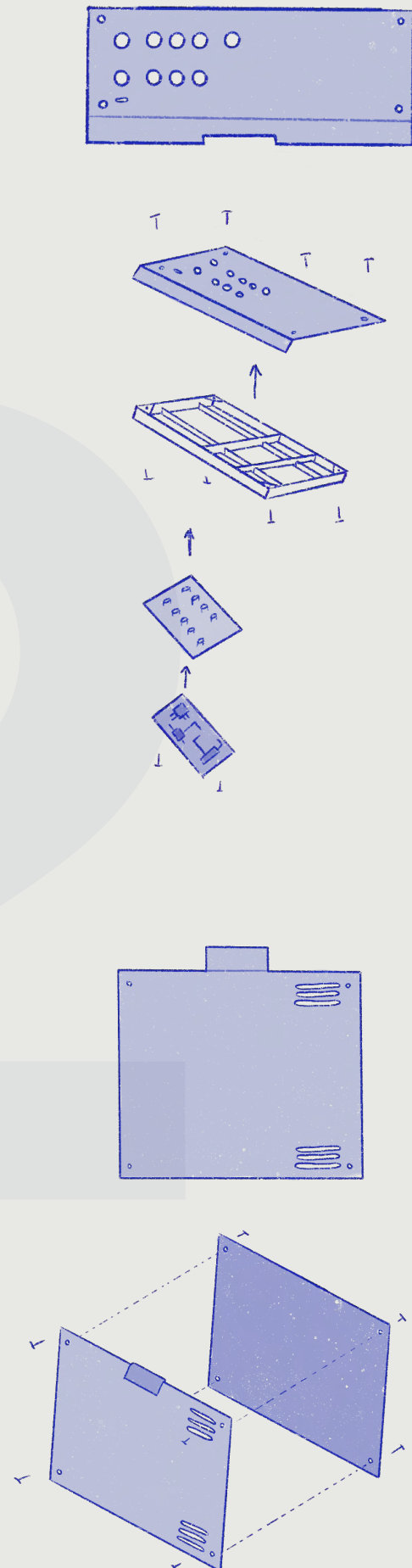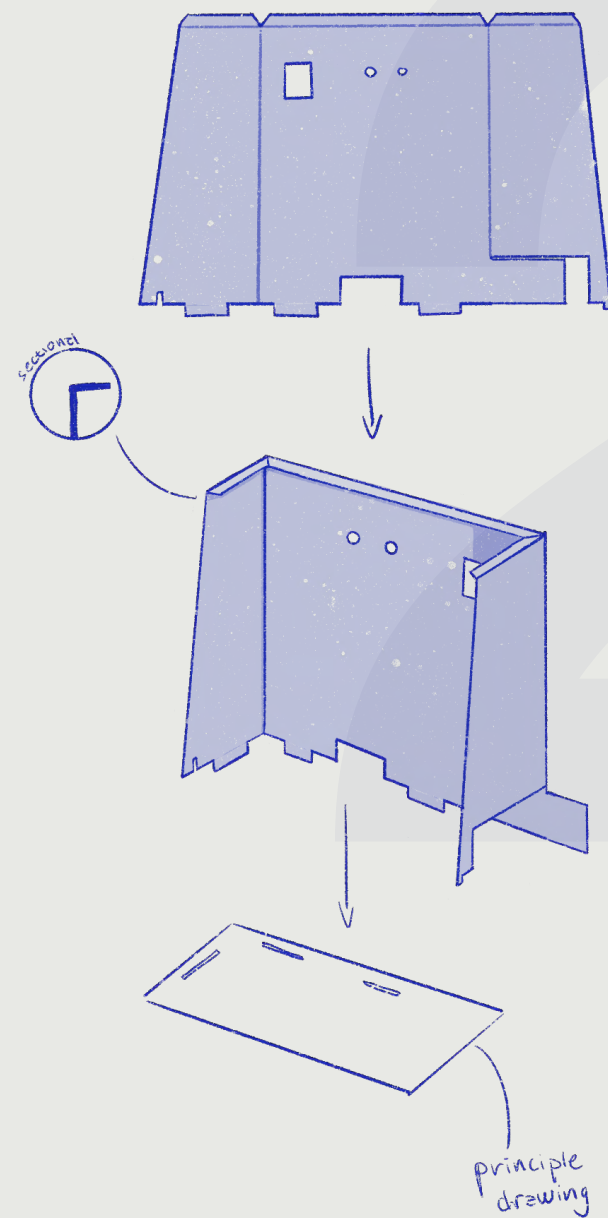
Ill. 131: Construction of the external panels 2

PRODUCTION

Main internal shell

PA66+25GF
Injection molding
To mount the main shell upon the bottom shell, the injection mold will have movable parts to create screw holes.

Solenoid valve mount

PA66+25GF
Injection molding , drilling

Water pump rubber mount

EPDM shore A50
Injection molding

Thermoblock shell

PA66+25GF
Injection molding
(app. 37)

Ill. 132: Production - Main shell
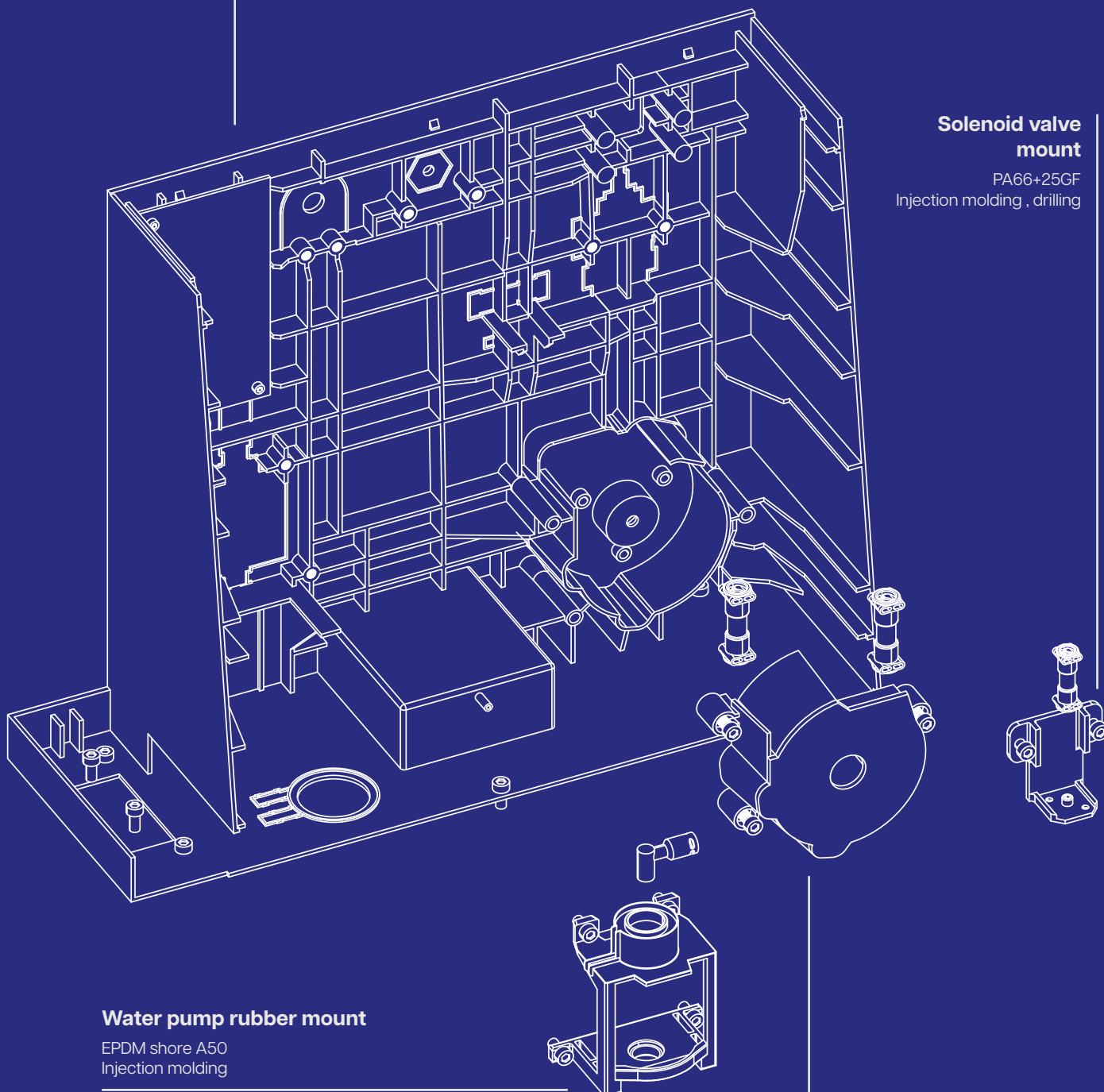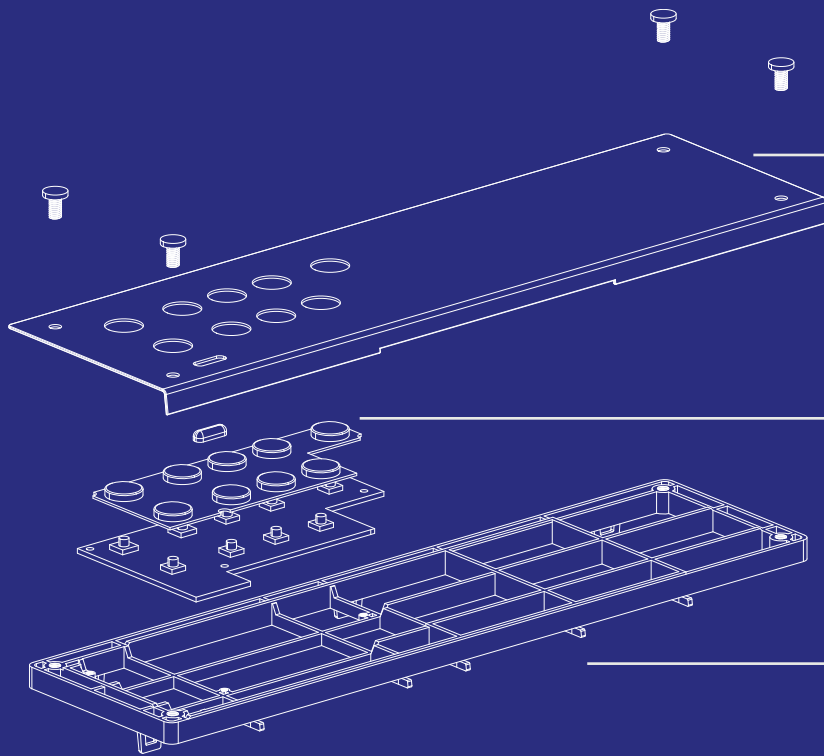
Top panel

SS304
Fiber lasercutting, deburring, press
brake bending

Buttons + PCB

Silicone rubber
Outsourced production

Top shell

PA66+25GF
Injection molding

Bottom shell

ABS
Injection molding

Rail

SS304 L profile
Cutting, drilling, polishing
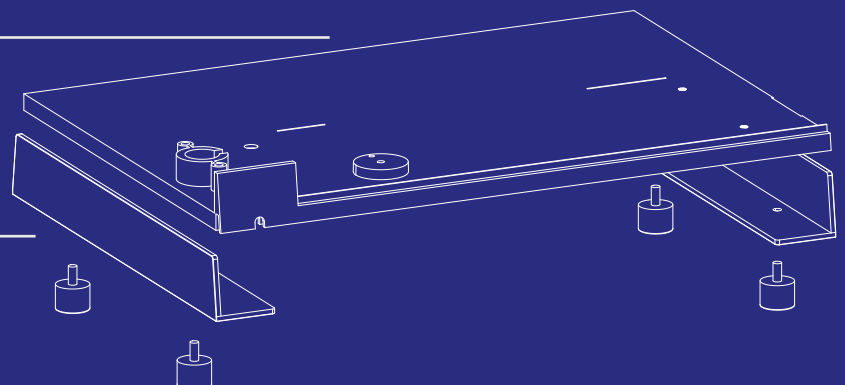
Ill. 132: Production - Top panel
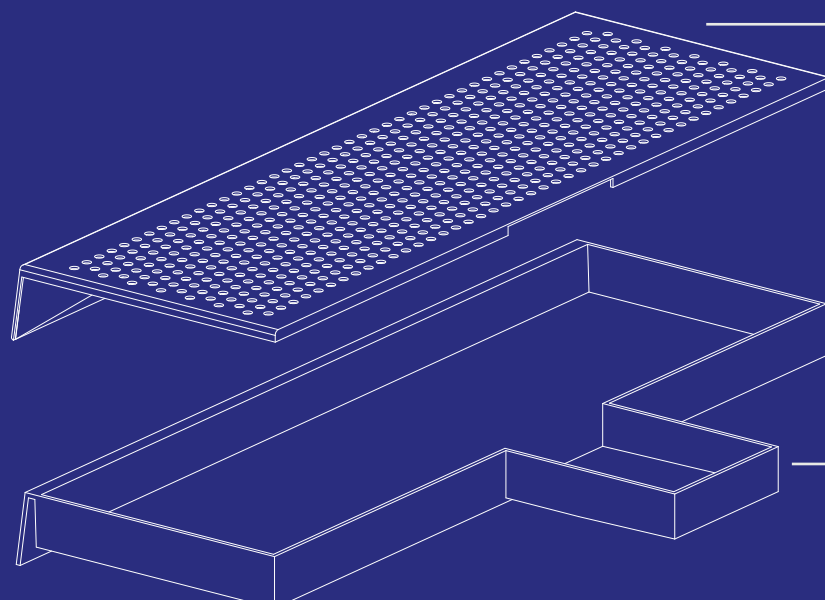
Drip tray grate

SS304
Stamping, deburring, press brake
bending

Drip tray

ABS
Injection molding

Ill. 133: Production - Drip tray & grate

Group head shell

SS316 (MIM)
Metal injection molding, sintering
(app. 38)
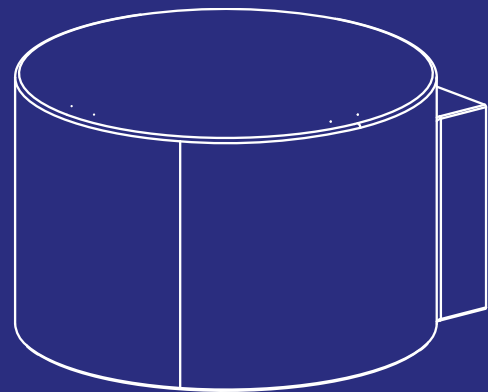
Group head plate

SS316 (MIM)
Metal injection molding, sintering, drilling
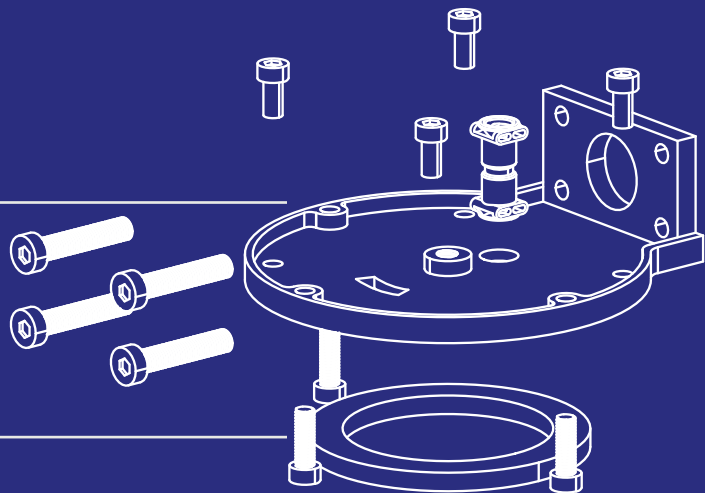
Gasket

Rubber
Outsourced

Water inlet plate

SS316
CNC milling

Portafilter mount

PA66+25GF
Injection molding

Portafilter mount

SS316 (MIM)
Metal injection molding, sintering

Diffuser / distribution plate

SS316
CNC Milling

Shower screen

SS316
Stamping, deburring

Ill. 134: Production - Group head
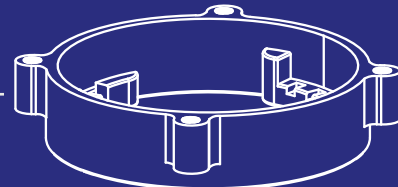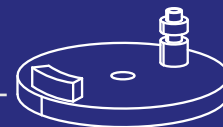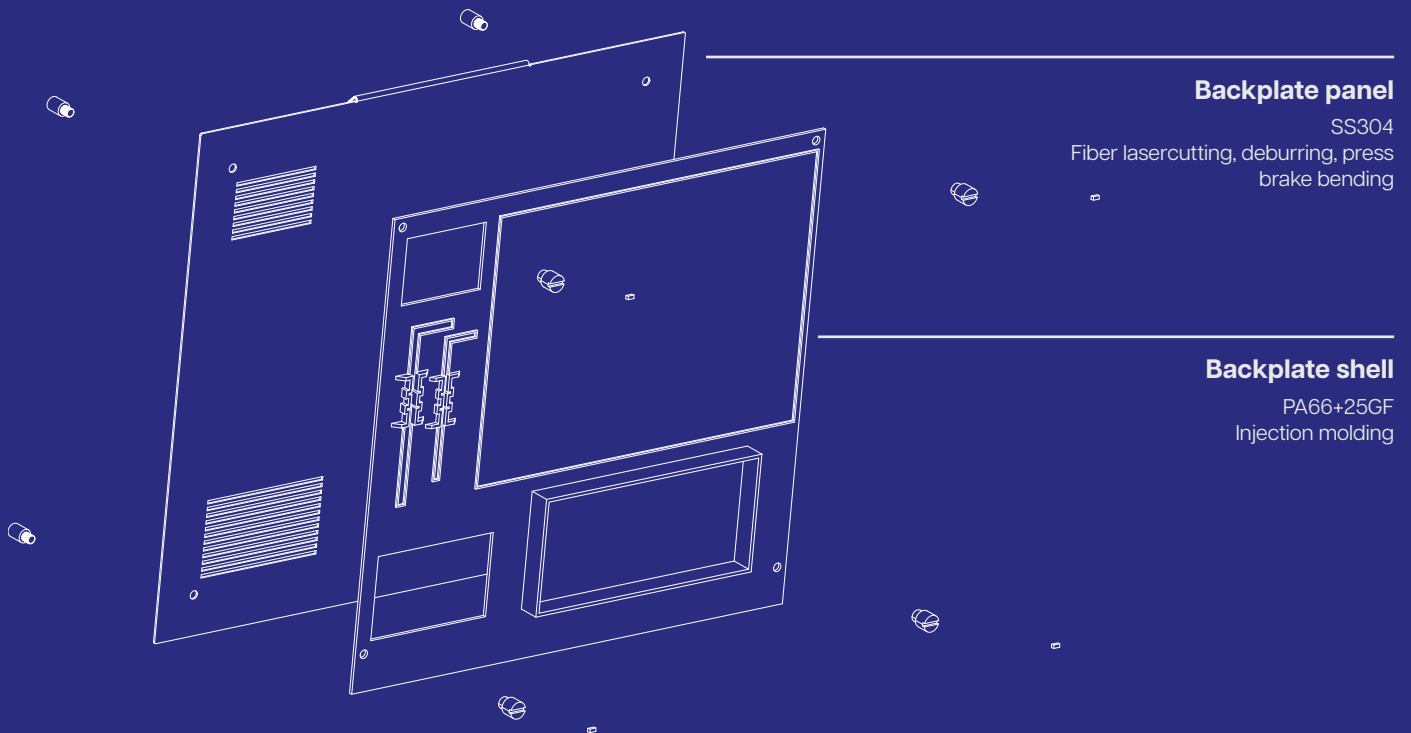
Backplate panel
SS304
Fiber lasercutting, deburring, press
brake bending

Backplate shell
PA66+25GF
Injection molding

Ill. 135: Production - Backplate panel & shell

Front and side panel
SS304
Fiber lasercutting, deburring, press brake bending
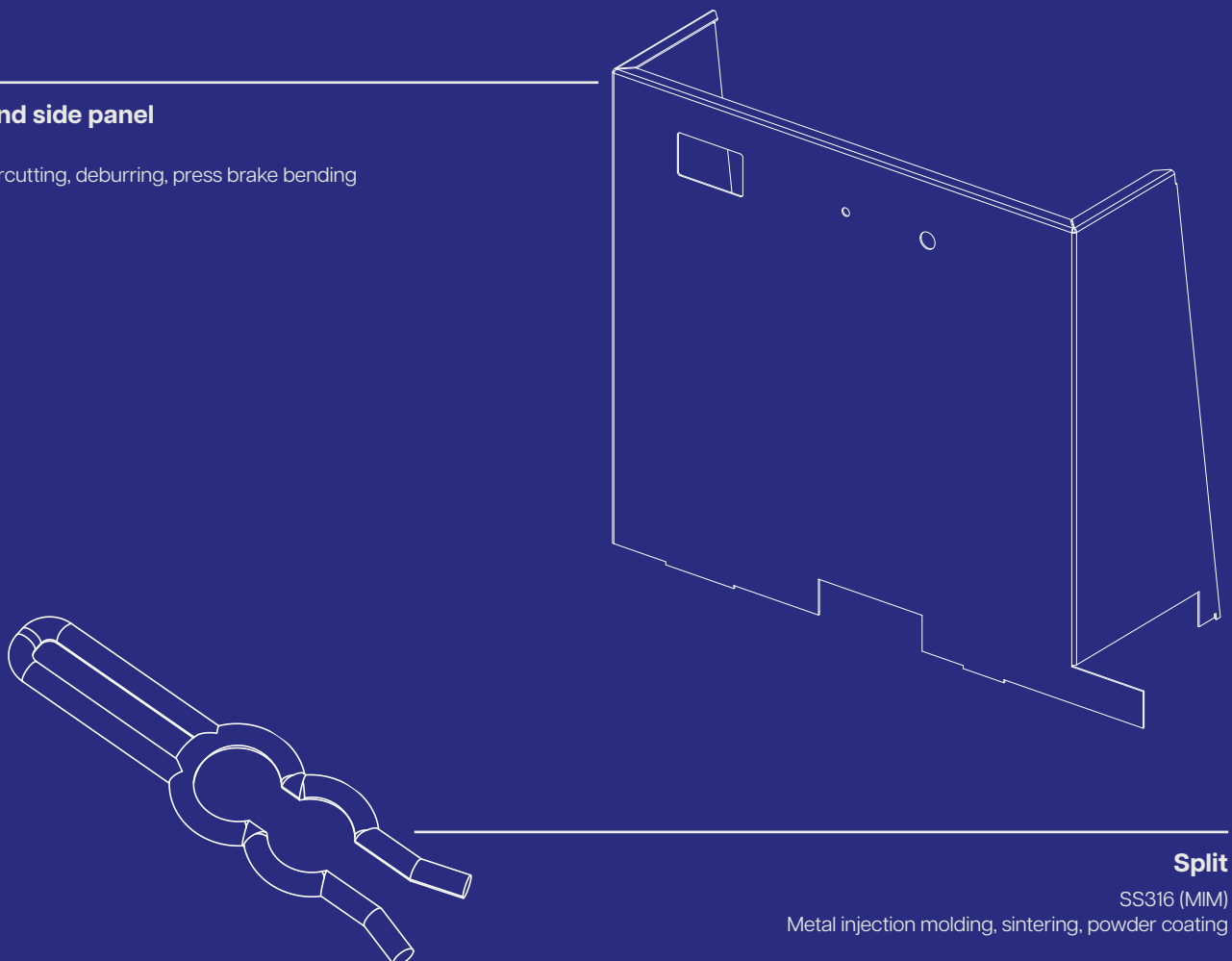
Split
SS316 (MIM)
Metal injection molding, sintering, powder coating

Ill. 136: Production - Front and side panels + split

Knob

SS304
CNC Milling

Ball joint housing

SS316
CNC milling, CNC
turning

Ball joint plunger

SS316
CNC Milling

Fitting

Brass or SS316
Outsourced

Ball joint

SS316
CNC turning, drilling

O-ring

Rubber
Outsourced

Water tank lid

Tritan
Injection blow molding

Steam wand pipe

SS316
Mandrel bending, CNC cut tapping

Steam wand tip

SS316
CNC turning, drilling
(app. 39)
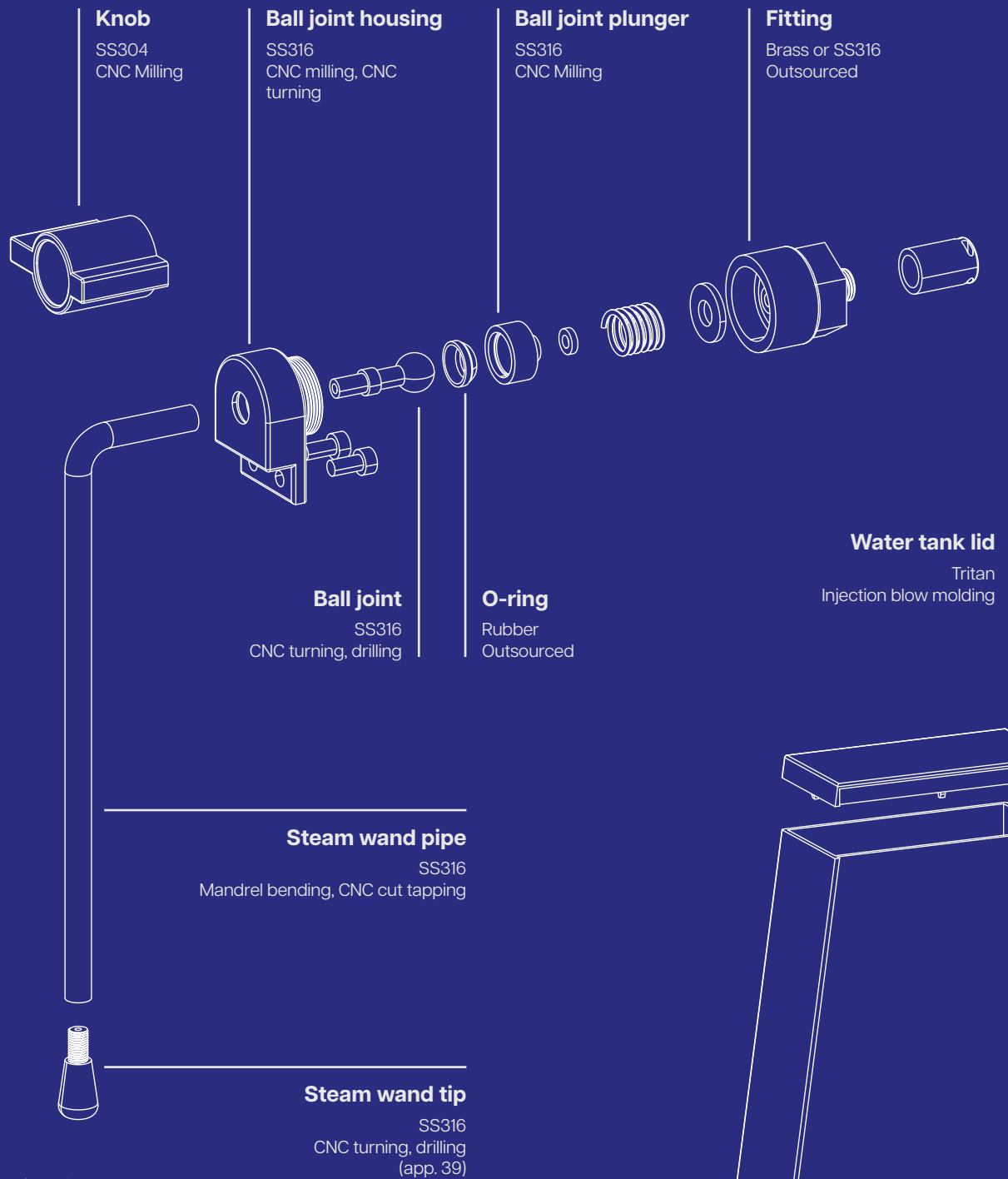
Ill. 137: Production - Steam wand

Water tank

Tritan
Injection blow molding

Water tank tube plate mount

SS304
Fiber lasercutting, deburring
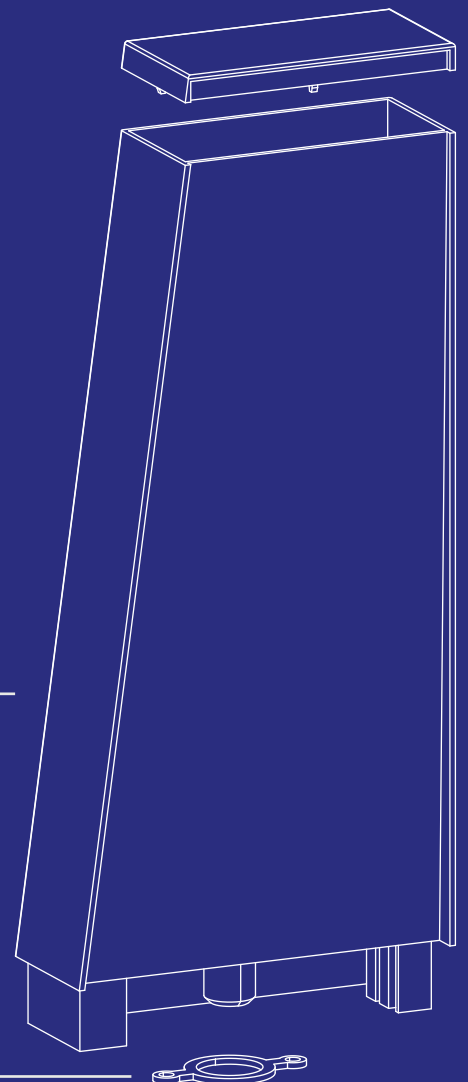
Ill. 138: Production - Water tank

ASSEMBLY
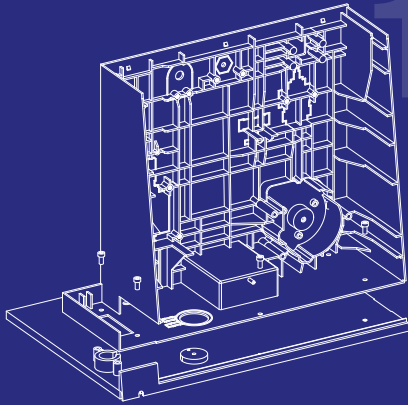
1 Screw main shell and bottom shell together.
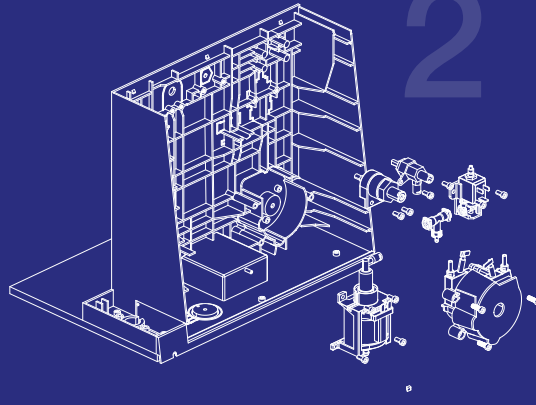
2 Insert internal components. Insert steam valve without the knob and the steam wand assembly without pipe and tip.
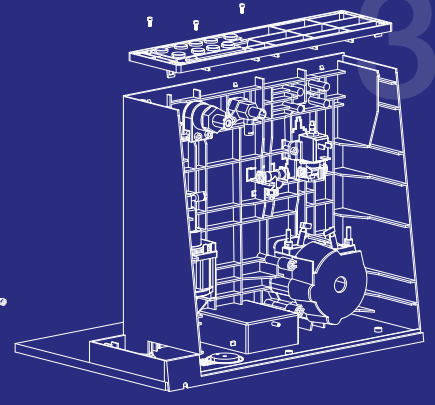
3 Assemble top without panel i.e. top shell, buttons and pcb. Click on the top assembly to the main shell.
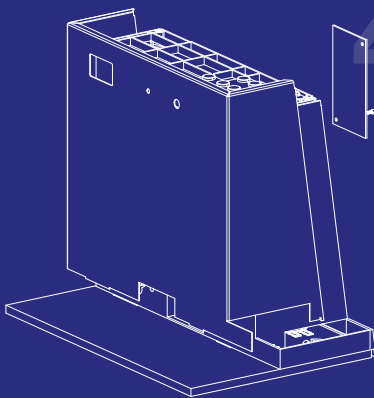
4 Put on front and side panel. Screw in the PCB in main shell
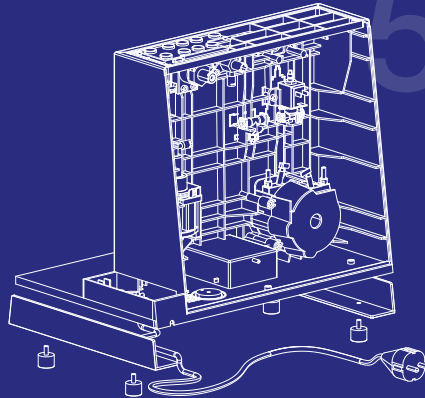
5 Connect wires and power cord. Screw on rubber feet and rails.
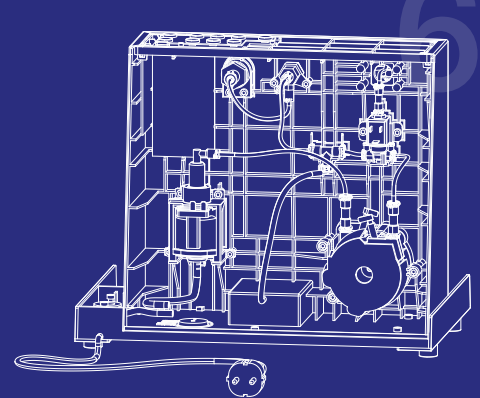
6 Insert tube connectors, tubes and splits. Screw on water tank tube.
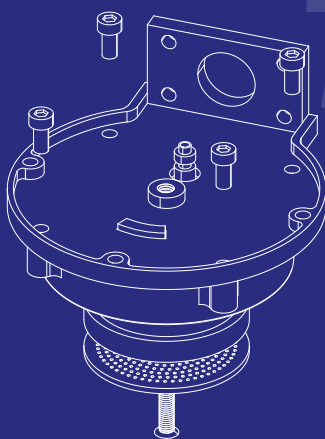
7 Assemble group head without external shell
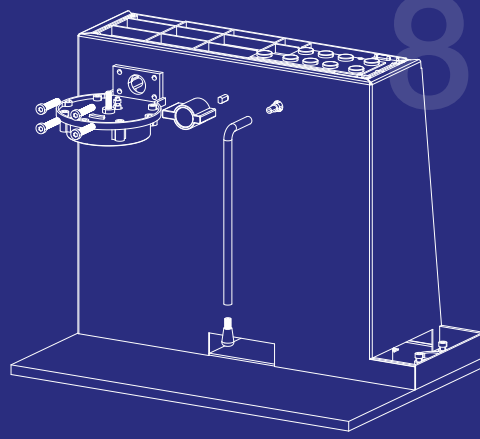
8 Screw on group head and attach steam wand pipe and tip.
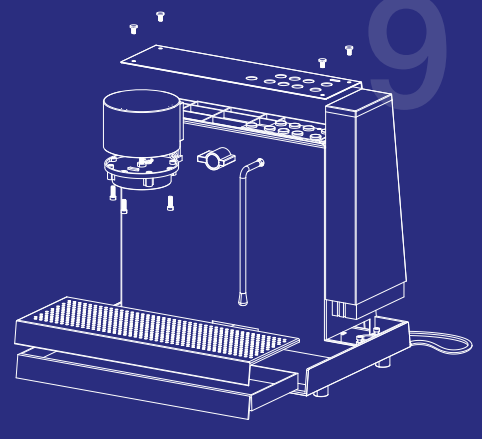
9 Screw on group head shell. Screw backplate shell and backplate panel together. Slide in drip tray, insert water tank and attach backplate.

Ill. 139: Production - Assembly

CHAPTER EIGHT
Business & strategy

This chapter focuses on the spiritual and contextual level of the value pyramid (p. 5). Strategies of how to launch the product proposal is developed and contains an analysis of the nearest competitors, a guide to how the product service system, price estimation, and business and implementation strategy.

Ill. 140: Team members checking tasks
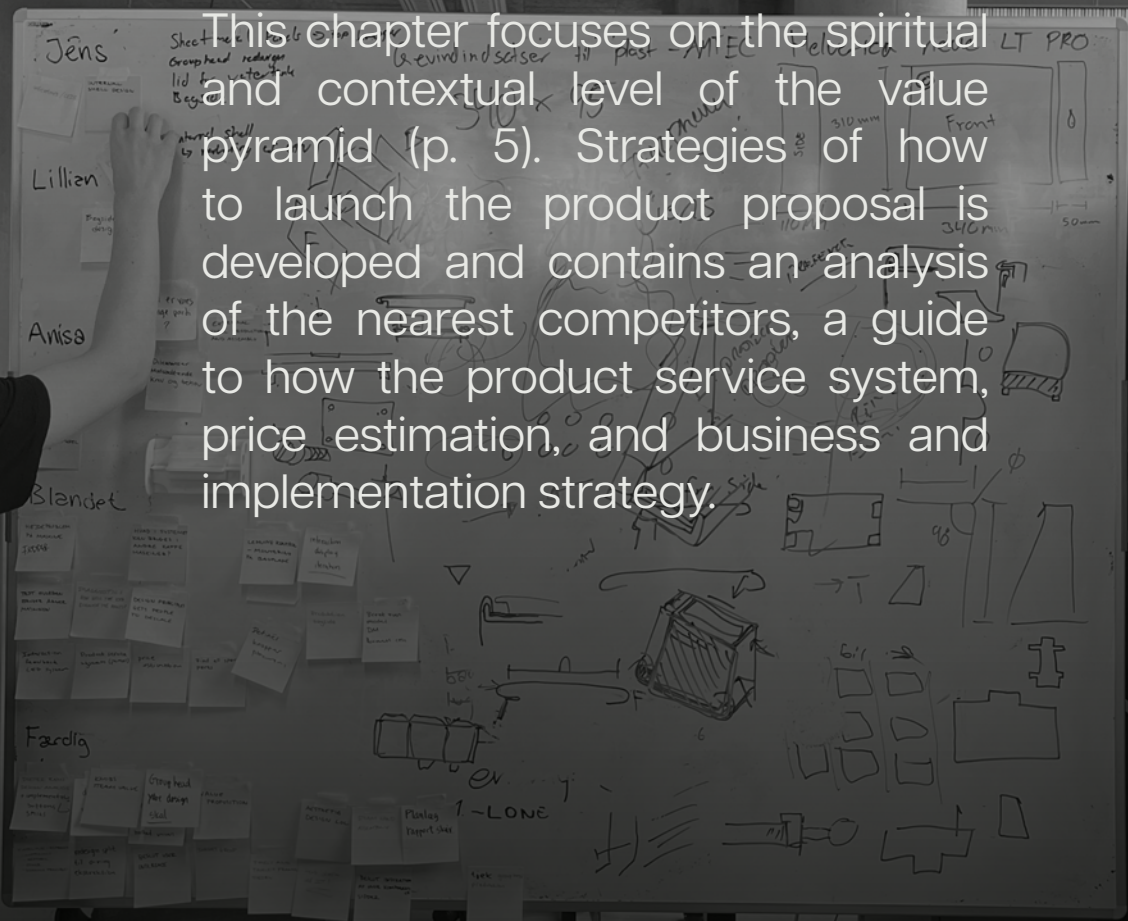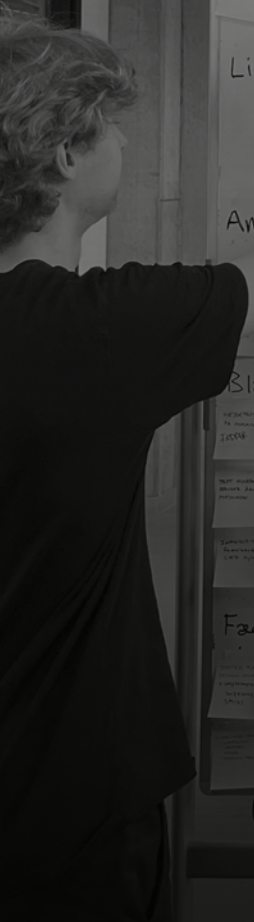
COMPETITOR ANALYSIS

The espresso machine market is a red ocean with a lot of competition. Many different actors are in play with their take on the best espresso machine. BRØK 58 attempts to open a new direction for a blue ocean approach by making the espresso machine repairable by the user for a prolonged lifetime. However, to gain traction and value in the competition BRØK 58 needs to be at least as good as the competition, otherwise it could end up as another Fairphone business strategy.

The market BRØK 58 wants to enter is the coffee enthusiasts, that want a good cup of coffee without having to do much themselves but still wanting to do enough to feel like "I made this cup of coffee". Concretely the market lies within the price range of 5000-7000 DKK and focuses on simple but good coffee.

The gaggia classic is a cheaper and smaller model of the bestseller GT version as their mainline espresso machine. It is inspired by their classic design from 1991 and is simplistic with only a few functions. The machine costs 4500 DKK and is the cheapest of the competitors, while also being the only one without an integrated grinder.

Ill. 141: Gaggia Classic

The Sage barista express is a modern classic having won some international design awards. The sage costs 6999 DKK and is one of the more expensive competitors. The sage offers great coffee with precise pressure and temperature. It is a larger machine and takes up a decent amount of space, but it does everything you need. With the grinder and steamer integrated everything is in one place.

Ill. 142: The Sage Barista Express 1

The KitchenAid espresso machine is a new competitor on the market, as it got launched in 2025. It has a sales price of 5999 DKK. It markets itself with a warranty of 3 years and 10-year repairability. Placing itself as a possible market leader in being repairable and for longevity. The design is more catered towards current design trends, making it susceptible for aesthetic obsolescence.

Ill. 143: KitchenAid
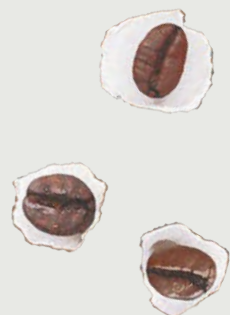
The De'Longhi La Specialista Opera is a classic espresso machine marketing itself as the perfect machine for the home barista. It has many different levels of customizability regarding the type of coffee it brews, temperature and grind levels of the grinder. Making it possible to get the exact coffee you want. The machine costs 7199 DKK and is the most expensive of the direct competitors.

Ill. 144: Dé'Longhi La Specialista

To stay competitive BRØK 58 needs to be cheaper than both the Sage and De'Longhi meaning a price less than 6999 DKK. The Gaggia's price is out of reach, but BRØK 58 has more functions and a more timeless design. A price close to KitchenAids would be preferred as it will stay competitive with its most direct competitor.

A plus for BRØK 58 is the fact that it uses some of the components inside the Sage, meaning if it is cheaper, it will deliver just as good coffee for cheaper, while you can keep BRØK 58 for much longer, and making it an even cheaper solution long term.

PRODUCT SERVICE & REPLACEMENT SYSTEM

To utilize the idea of a repairable espresso machine it needs to be even easier to buy spare parts than buying the espresso machine. This involves a product service and replacement system. It will give the user the needed confidence to repair while guiding them step by step. If the warning light flashes, there is a problem with the machine that the user needs to investigate. In the following scenario the espresso machine has stopped working properly and the user needs to do a deeper cleaning.
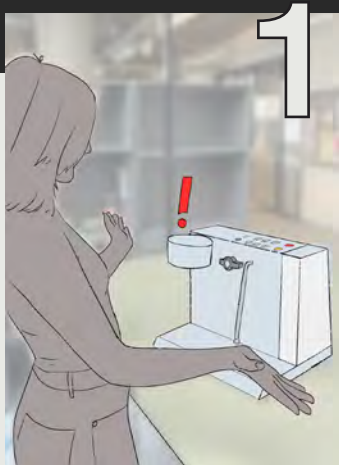
The user's BRØK 58 stopped working properly and should get looked at.

The user turns the espresso machine around and faces the backside.

The backplate is attached via magnets. By pulling on the handle close to the top, the user detach the backplate easily and takes a look inside the machine.
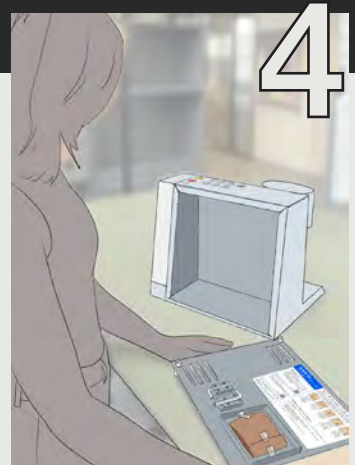
The user lays down the backplate on its back, using the outer knobs as feet. Here the user gets access to spare parts, tools and the maintenance guide.

Ill. 145: Storyboard: System concept

BRØK 58
Information guide

SERIAL NO.   123456789
MODEL   CLASSIC
POWER   100-240V ~ 50/60Hz 1.5A

CE ♻ ⚠

Maintenance Guide

Having touble? Scan the QR code and find our library of maintenance guides and videos. Here you will find information of every component in your BRØK 58 espresso machine and how to maintain or replace them. The guides provides step-by-step videos that ensures you are doing everything correctly!

Scan for more information.

In need of spare parts?

If you are in need of replacing components, tubes, o-rings or more, scan the following QR code to jump right into the store and order new parts.

Scan for more information.

⚠ Is the emergency symbol lit up? Scan the **Maintenance Guide** QR and follow the instructions.

When the descale symbol is pulsing, you have brewed 175 cups of coffee and need to clean the system.

Tube and rubber o-rings Maintenance and Replacement Guide

Limescale are the number one reason coffee machines break which is why maintaining, cleaning, and descaling your BRØK 58 espresso machine is essential. Remember to descale the machine when the icon starts to pulse. Sometimes the machine needs a little extra cleaning which is why this guide is here. The machine is designed for you to be able to fix it yourself - just follow the visual guide here.

To detach the tubes, locate the yellow splits and take them out.

Use the spare part tray on this backside to avoid loosing them.

Take out the tubes and check for limescale. Clean if needed using a pipe cleaner.

Use the yellow split to pry out the o-rings. If they are cracked or damaged replace them.

Clean the o-rings and apply the silicone based lubricant.

Insert the o-ring into the connection piece and press it down with the yellow split.

Insert the tube into the connection piece. Use some force to drive it into the o-ring where it is tight and secured.

Low flow or no coffee coming out? Read this!

If you are experiencing low pressure when extracting coffee, most often it is due to limescale buildup inside the machine in the tubes or components

1. Check tube connections and rubber o-rings inside. (Follow Tube Maintenance and Replacement Guide)
2. Replace **or** clean and regrease o-rings with silicone based lubricant.
3. Reattach everything and close up the machine.
4. Start descale program and rinse 3 times afterwards.

If you are still experiencing low pressure, scan the **Maintenance Guide** QR code for more information.

Ill. 146: Backplate guide sticker

5 The user needs to do a deeper descale task, and follows the guide provided on the backside of the backplate.

6
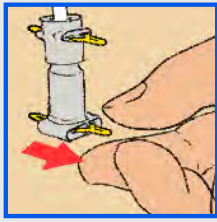
To detach the tubes, locate the yellow splits and take them out.

! Use the spare part tray on this backplate to avoid loosing them.

Take out the tubes and check for limescale. Clean if needed using a pipe cleaner.

Use the yellow split to pry out the o-rings. If they are cracked or damaged replace them.
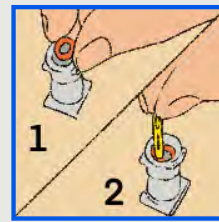
Clean the o-rings and apply the silicone based lubricant.

Insert the o-ring into the connection piece and press it down with the yellow s
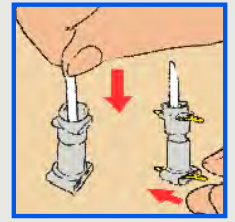
Insert the tube into the connection piece. Use some force to drive it into the o-ring where it is tight and secured.

Ill. 147: Tube Maintenance guide

7

Ill. 148: Scanning the QR

When the user is finished with tube and o-ring maintenance / replacement, the user needs a bit more help to finalize the task. They scan the QR code to the maintenance portal.

If the machine has a more serious problem the maintenance portal contains a diagnostic guide that will help the user understand what the current problem is in the machine. The diagnostic guide will lead the user whether they are trying to repair or order a spare part to replace the malfunctioning component. If the user needs to replace a component through the diagnostic guide, they will be led directly to a place where to order a spare part. If it is within the 3-year warranty period the price of the component will be covered. If it is outside the warranty period, the user must pay the price of the component, which is still a lot cheaper than buying a new coffee machine. The user is able to buy every single part of the machine including more splits, tubes and screws. When the spare parts have been ordered it will arrive a few days later with a QR code, leading to a specific guide of how to replace the component and combined with the outline in the internal shell, it will be easy to do so.
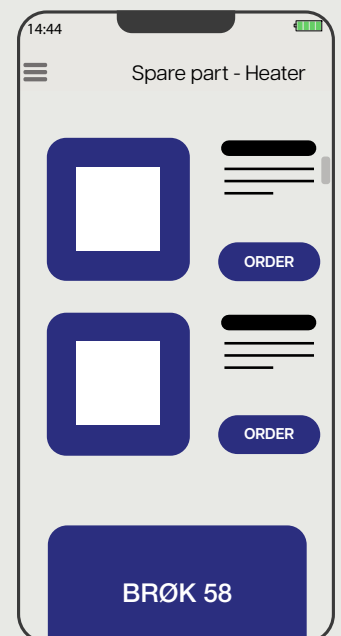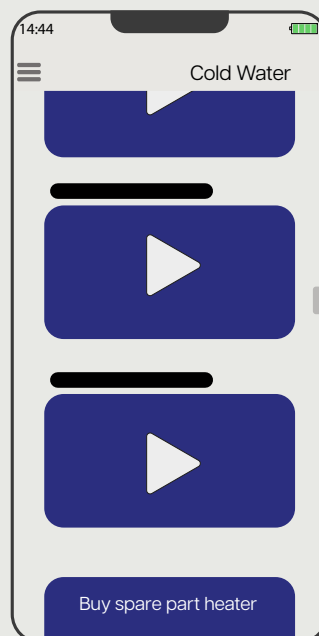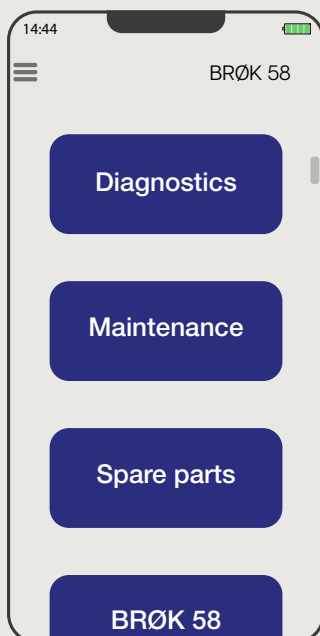
Ill. 149: Webpage UX concept

PRICE ESTIMATION

Earlier it has been determined that BRØK 58 needs to be less than 7000 DKK otherwise it would be competitive in the current market. To ensure the aesthetic and functional value is kept at a high level, there is a need to produce most of the machine from scratch. This means investments into molds and outsourcing production to companies able to produce and process the espresso machine parts.

Part	Mold material	Mold size	Price DKK - China	Price DKK - Europe
Main shell	Steel - CNC	60x60x30 cm	175.000	285.000
Bottom shell	Steel - CNC	60x60x10 cm	120.000	205.000
Top shell	Steel - CNC	60x30x10 cm	85.000	150.000
Drip tray	-	55x45x8 cm	85.000	150.000
Backplate	Steel - CNC	50x50x8 cm	70.000	130.000
Water pump mount	Steel - CNC	20x20x15 cm	30.000	50.000
Solenoid valve mount	Resin - 3D print	20x25x10 cm	3.000	5.000
Thermoblock shell	Steel - CNC	60x60x10 cm	30.000	50.000
Steam valve mount	Resin - 3D print	15x15x10 cm	2.000	4.500
Group head shell	Steel - CNC	25x25x20 cm	50.000	85.000
Group head plate	Steel - CNC	25x20x20 cm	45.000	75.000
Portafilter mount metal	Steel - CNC	20x20x15 cm	40.000	70.000
Portafilter mount plastic	Steel - CNC	20x20x10 cm	20.000	30.000
Water tank	Steel - CNC	60x30x20 cm	90.000	155.000
Water tank lid	Steel - CNC	20x15x10 cm	15.000	25.000
Split	Steel 16 cavity - CNC	30x15x10 cm	25.000	40.000
Control assembly tooling cost			25.000	35.000
Total fixed cost			**910.000 DKK**	**1.544.500 DKK**

This leads to a one-time investment of 910.000 or 1.544.000 DKK for the molds to produce the required parts in the machine. To reduce the short-term investments, the parts will be produced at outsourced companies. This will lead to a higher rate of success in launching the product (Formlabs, 2025).

It is possible to produce the parts in either China or Europe. While China is cheaper, there is also a higher cost on the CO2 aspect. The quality of materials and production is usually meant to be greater in Europe; however, China has improved their production processes to be more favorable than the European demands. The production in China is measured at an hourly rate that would most likely be 2-2,5 times cheaper than in Europe.

The price difference has been set as 2,5 times for European. These prices are estimates and will change when an agreement with the suppliers is reached.

There are also standard components that need to be bought directly from a manufacturer. These will be bought in bulk to achieve the most favorable and cheapest price possible. The specific prices have been assumed to be bought in bulk of 100-1000, with a reduction in the price for each component of 50% on the found resale prices. Most of these prices will change with a direct order from the manufacturer. (app. 40)

China

Variable cost per unit (in house)	Price DKK
Outsourced standard components	1368,54
Packaging	18
Stickers	1,4
Man hours (205 DKK hourly)	683,33

Variable cost per unit (outsourced)	
Price per unit in 1000 bulk	1152,75
Overhead 35%	1128,41
Gross cost	3224
Total variable cost	**4352,43**

Europe

Variable cost per unit (in house)	Price DKK
Outsourced standard components	1368,54
Packaging	18
Stickers	1,4
Man hours (205 DKK hourly)	683,33

Variable cost per unit (outsourced)	
Price per unit in 1000 bulk	1435,29
Overhead 35%	1227,30
Gross cost	3506,56
Total variable cost	**4733,86**

To determine whether to choose to produce parts in China or Europe is ultimately determined by the price. It has already been determined that the assembly and distribution of the espresso machine will be done in-house to ensure and control the high level of quality needed.

The overhead has been set to 35%, as it has been determined that the rent, electricity, marketing, sales and more will account for roughly 30%, while the last 5% comes the from the replacement service system, as there is need to account for possible losses in sending out spare parts to users before their warranty expires, as well as creating the guide and upkeeping the costs of the guide.

China - 6000 DKK
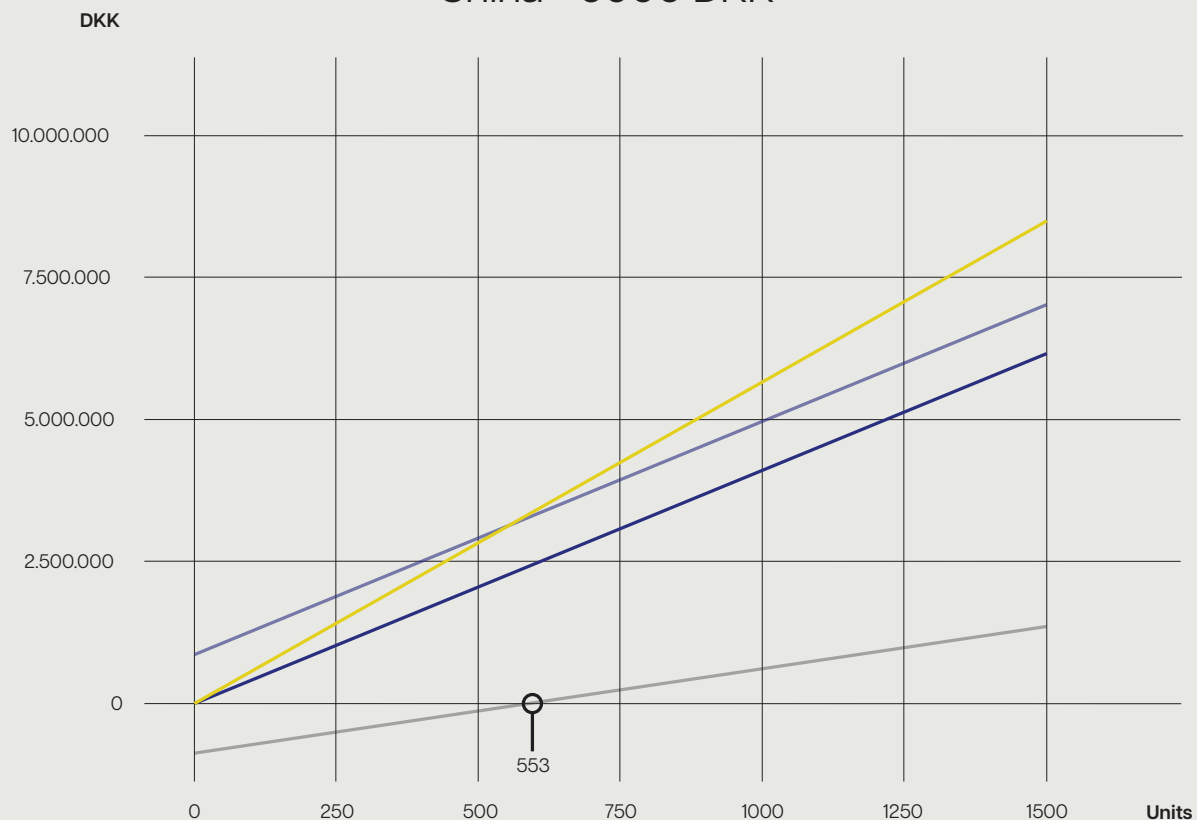
Ill. 150: Break even - China

Europe - 6000 DKK
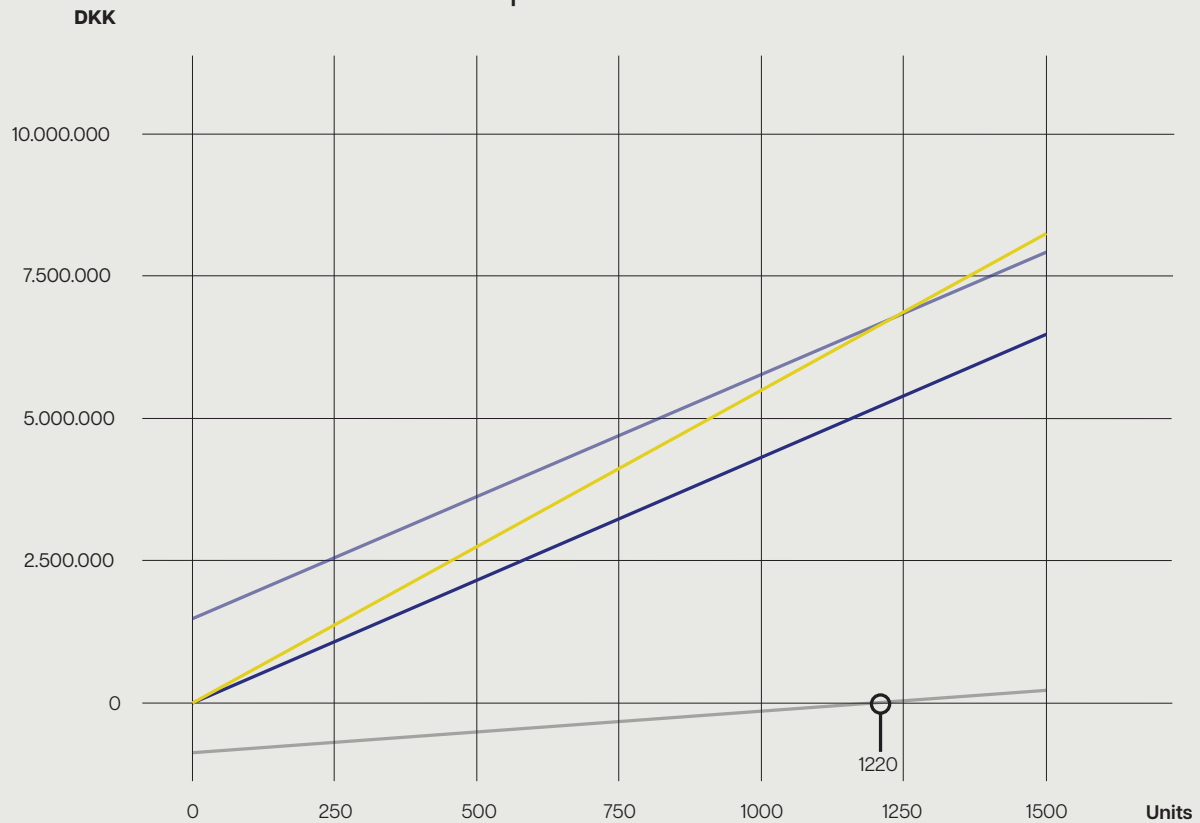
Ill. 151: Break even - Europe

The two graphs (ill. 150 and 151) shows the revenue and net profit according to the costs.

- Break-even point – China: 553
- Break-even point – Europe: 1220

The company will need to sell more than twice as much before generating a profit at the sales price of 6000 DKK. It is assumed that one employee working on the assembly line can produce and package around 12 espresso machines in a 37-hour week. With one worker the break-even point would be reached in Q1 of year 2 or Q4 of year 3. Hiring more employees would generate faster production, but also increasing the production costs and the amount of machine needed to be sold each month. (app. 40)

With this in mind, it has been determined the production would be in China, as profit in year 2 is needed, since it gives the possibility to expand the market much sooner. This also leads to a sales price of around 6000 DKK, allowing for a strategic advantage against some competitors and still being competitive with cheaper machines.

BUSINESS STRATEGY

As BRØK 58 is a start-up there is a need to gain traction and capital; a large sum of money is needed to buy the equipment and parts needed to start production.

Strategy 1 - Crowdfunding

There are two directions to crowdfund the start capital for BRØK 58. Either a rewards-based system or a small ownership of BRØK 58. Both require larger crowds to invest smaller amounts to either be given a reward or become a minority stakeholder.

The rewards-based usually generates a smaller amount of money as the crowd interested can be quite small in the beginning. There is a demand to deliver the rewards otherwise the company will gain a bad reputation and less customers.

The stakeholder based can generally generate a significant amount of money, however the amount of control over the company lessens with each bought stake. It creates a more complex ownership structure and requires more management of the ownership.

Strategy 3 - Investors

Getting an investor to raise the start capital usually requires the company to give up a significant part of their ownership stakes. This gives up some control of the company and could lead to disagreements over the direction the company is headed. It could however also give some expert knowledge and contacts that could be beneficial for the company. With the right investor this option is fantastic and with the wrong investor a nightmare.

Strategy 2 – Under a brand

Make another coffee machine invest in the idea as BRØK 58. This leads to a better pathway to manufactures and familiarity with the customer. It could even make the production cheaper, as BRØK 58 could get integrated into an existing supply chain. However, the risk is having to align BRØK 58's values with the investing companies' structure and ultimately risk getting bought off the product. Another risk is that a company's structure could risk a complete undermining of the repair implementations that BRØK 58 is built upon focusing a lot more on profit and economic obsolescence rather than user-repair.

Strategy 4 – Peer to peer lenders

To gain capital it could be necessary to lend some money. Lending the money can be difficult as you need to give some assets as collateral in case everything goes wrong. This loan will come with an interest that has to be upheld otherwise legal action can be taken. However, if a functioning company is successfully established, this option will become the most favorable, as the company would be able to repay the loan with interest and afterwards the profit is entirely in the company as well as the ownership. It is a high-risk high reward direction.

The risk of undermining the values of BRØK 58 eliminates strategy 2 from contention. The other 3 strategies each have their pros and cons and could all be correct solutions in the right circumstances. Strategy 4 is the strategy that allows BRØK 58 to stay true to its values, while giving up the least ownership. Making it a risky strategy, with the highest upsides.

IMPLEMENTATION

Along with the business strategy, there needs to be a strategy of how to implement BRØK 58 on the market and sustain its position.

BRØK 58 is an espresso machine like all other espresso machines, yet with an additional focus on user-repairability and long lasting design. However, being user-repairable is a less favorable selling point. Fairphone used a strategy of being repairable and being able to change every component, which was also the main marketing focus. This strategy only intrigued a very small customer base, making it very difficult to gain any traction.

BRØK 58 on the other hand will focus on being a user-friendly coffee machine, with a long-lasting design, that keeps delivering a good cup of coffee. With a note on the system how the user can order if new parts if their machine breaks down, so they do not have to send the machine to repair, thus saving money in the long term.

Market

The market BRØK 58 will enter is the Nordic and German market, as they are in close proximity to headquarters in Denmark, meaning less money spent on distribution. The target group in this segment already caters to Sage. With BRØK 58 entering the market, Sage now has a competitor that is cheaper, makes just as good coffee, the machine is smaller and has a timeless aesthetic design.

Vendors

To reach as many people as possible BRØK 58 will sell at stores like Elgiganten, Power, Salling and Magasin, as the competition is sold there. The downside of selling through these vendors is that they take some of the profit for being able to sell through their stores. The upside is there are more people getting to know BRØK 58 and therefore increasing the possibility of impulse buying or convincing a user to switch to BRØK 58.

First year

The business will likely take half a year to set up production and get a supply chain in place. Meanwhile, marketing will be making sales materials and reaching out to potential customers to make BRØK 58 noticed. For the latter six months of the first year, BRØK 58 aims to sell an average of 100 coffee machines each month. Ending the first year of 600 machines sold and having already made the break-even point or just below. The reason it could be below is the fact the profit would be a bit smaller selling through vendors and depending upon the loan and when the interest is due.

This would lead to a successful second year with a focus on generating profit and streamlining the production line.

PEER-TO-PEER LENDERS

3 MONTHS

SPONSORSHIPS & MARKETING

6 MONTHS

1ST LAUNCH

1

ESTABLISHING SUPPLYCHAIN

2

BRØK 58 CLASSIC
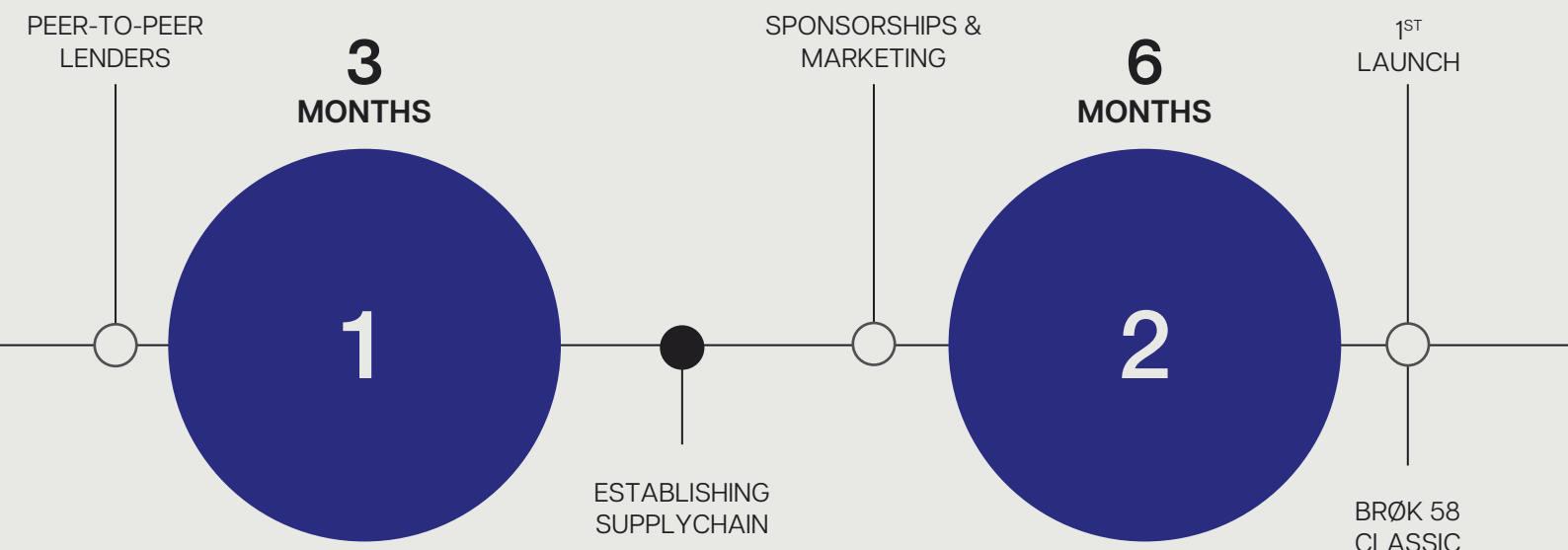
SCALING

To keep developing BRØK 58 as a big player in the market for the future, there needs to be some new product or variants developed over time.

Variants

BRØK 58 will develop variants with different colors of the shell as this would likely expand the target group.

BRØK 58 can over time expand with more variants on the market, where there is a possibility to create a high-end machine, with a heat exchange boiler and a group head specifically for precision brewing.

Grinder

As earlier mentioned, most of the competition has a grinder integrated into the espresso machine. As BRØK 58 does not have one integrated, it would be essential to develop a grinder that uses the same principles of user-repair. This enables an opportunity to sell a bundle with both the espresso machine and the grinder.

Parts integrated into other coffee machines

As many of these parts are made for this machine or are standard components there is not that much that can be integrated into other coffee machines. The splits are better than the ones already used in the industry and would easily be integrated into other coffee machines.

The success of BRØK 58 would incentivize other coffee machine brands to adapt the for repairability.
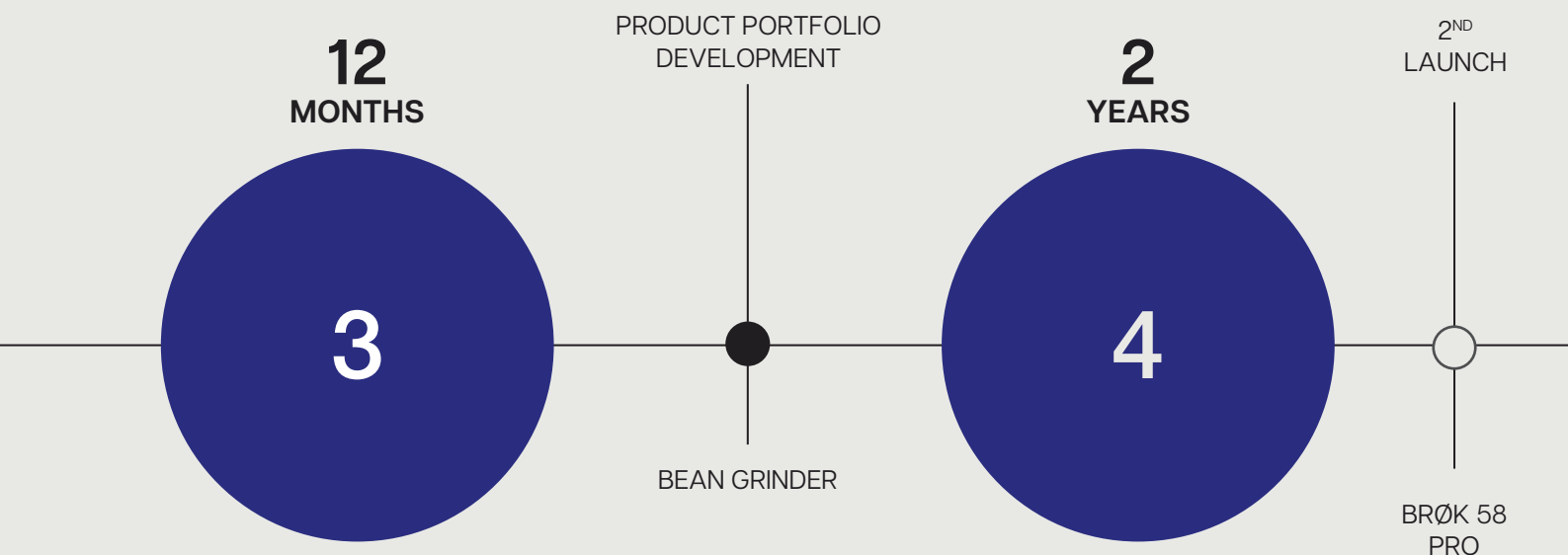
12 MONTHS **3**

PRODUCT PORTFOLIO DEVELOPMENT

BEAN GRINDER

2 YEARS **4**

2ND LAUNCH

BRØK 58 PRO

Ill. 152: Implementation plan

EPILOGUE

This chapter focuses on the spiritual level of the value pyramid (p. 5) and evaluates the product and its different layers on a product and process level, and final thoughts are presented.

Ill. 153: Render

Conclusion

This master thesis project aimed to design a coffee machine revolved around user-centered repair and maintenance to address ongoing world problems of e-waste and the right to repair regulations instated by the EU.

By seeking information and experience from users and professional repair technicians, it was found out that coffee machines are not made to be repaired by the ordinary consumer. The general understanding of such electronic products from the consumers perspective was products are not meant to be opened. Coffee machines are difficult to open and navigate, they are compact and complex for inexperienced individuals – even professional repair technicians primarily rely on years of experience. The combination of complexity and compactness results short product lifetimes that promotes replacement of over repair. Consumers avoid paying for repair because of the steep price, which is a result of the huge amount of time repair technicians must use to understand, disassemble, and assemble the machine.

Throughout this project the team initiated in research, prototyping, and tests with users to achieve an easier and more intuitive maintainable espresso machine. Using this knowledge the team managed to define a machine through aesthetics that replicates what is on the current market thus staying relevant, while completely reorganizing the product architecture inside to stand apart.

The aim was to stay true to what espresso machines deliver through functionality and aesthetics to show that innovative design does have to stray too far away from the current solutions, while respecting the culture and customer needs. It is further concluded that while the design aspiration was to increase users' confidence in self-repair and emotional attachments to products, it will also benefit professional repair technicians by providing faster and cheaper service thus happy customers.

BRØK 58 do not require users to go out and purchase a whole new machine if failure occurs but prepares them to engage with repair and maintenance through the direct available inside, familiarizing themselves with electronic products that are not scary. BRØK 58 breaks tradition to showcase a repairable product without compromising aesthetics, creating a reliable solution that extends product lifetime.

Reflection

Product

As BRØK 58 heavily relies upon users' willingness to repair and proof of concept will need further validation from real life scenarios.

Functionality
The espresso machine is designed to be as "transparent" as possible to encourage users towards repair and maintenance. Some of the more important gateways for users to do so, is to be able to diagnose the point of failure when it occurs. As part of the business, a landing page that provides maintenance and repair guides is included in the concept proposal, but actual design attributes that directly help diagnosing are somewhat absent. The emergency light helps users understand more serious problems; however, it does not directly explain what is causing it. Limescale is the biggest problem in coffee machines and is usually what causes them to fail, which is why that has been prioritized in the decision making.

When talking to professional repair technicians, a lot of diagnostic methods was based on trial and error, and from users' perspective might become redundant and demotivating when inexperienced with the process.

Usage
Coffee drinkers come in many different levels of expertise. At this state, BRØK 58 is semi-automatic as it has pre-programmed operations with determined settings which determines what kind of audience will show interest. Users will not have the opportunity to tweak their coffee experience and cannot choose to not care about it either. The features that make up this concept might contradict with the number of features provided and risk becoming irrelevant, as many espresso machines on the market offer otherwise. In this case, the aesthetic value and repairable features become the decisive factor where the latter might have no effect at all.

Aesthetics
The project aimed to create a long lasing espresso machine through timeless design principles with repairable features. However, this is fairly vague, as it depends on users' willingness to repair which cannot be forced and relies solely on their own interests. The product cannot only count on aesthetics, as coffee machines will eventually need maintenance service. Some decisions have been made to future proof the espresso machine, yet it cannot be avoided that some consumers might still choose to replace BRØK 58 by upgrading to another product or simply because they seek change.

Process

As visitations to professional repair technicians enlightened the teams' understanding of coffee machines and increased the interest in the problem statement, the teams' solution field became very broad. This led to many possibilities in multiple directions: filter, capsule, and espresso machines and clouded the teams' reasoning and decision making, relying on interest and what the team assessed as having the most potential. The level of complexity of the project due to repairability and consumers' willingness to engage with repair made it generally difficult to phrase the project externally and internally. Defining a target group was troublesome as uncertainties of behavior and interest collided with business, resulting in a lot of time used on understanding the problem and solution space on many occasions.

Prototyping
Lack of physical space and access to materials limited rapid prototyping which narrowed down the ability to evaluate properly. The absence of physical room leads to prioritizing other tasks than continuous bodystorming. The prototypes were constantly altered as the process progressed, essentially discarding old models, which could be used for reference or backtracking. This eventually resulted in the lack of external validation for some parts of the product proposal, as the model were not fit to be tested as wished. Despite these limitations, having engaged with tests regardless of this would have benefited the project and improved reasoning.

Product architecture
The team had limited experience with product architecture on this level prior to the project, thus it was difficult to navigate and steer the process. The projects primary focus was on components, their connections, functionality and how this is perceived by ordinary users. The added complexity created a steep learning curve but intriguing opportunity of experience. This resulted in a project that constantly switched between different levels of abstraction on the project level but pushing the team out of their comfort zone.

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Illustrations

AALBORG
UNIVERSITY

BR
ØK
58

a new classic
begins at 58'

Parts list

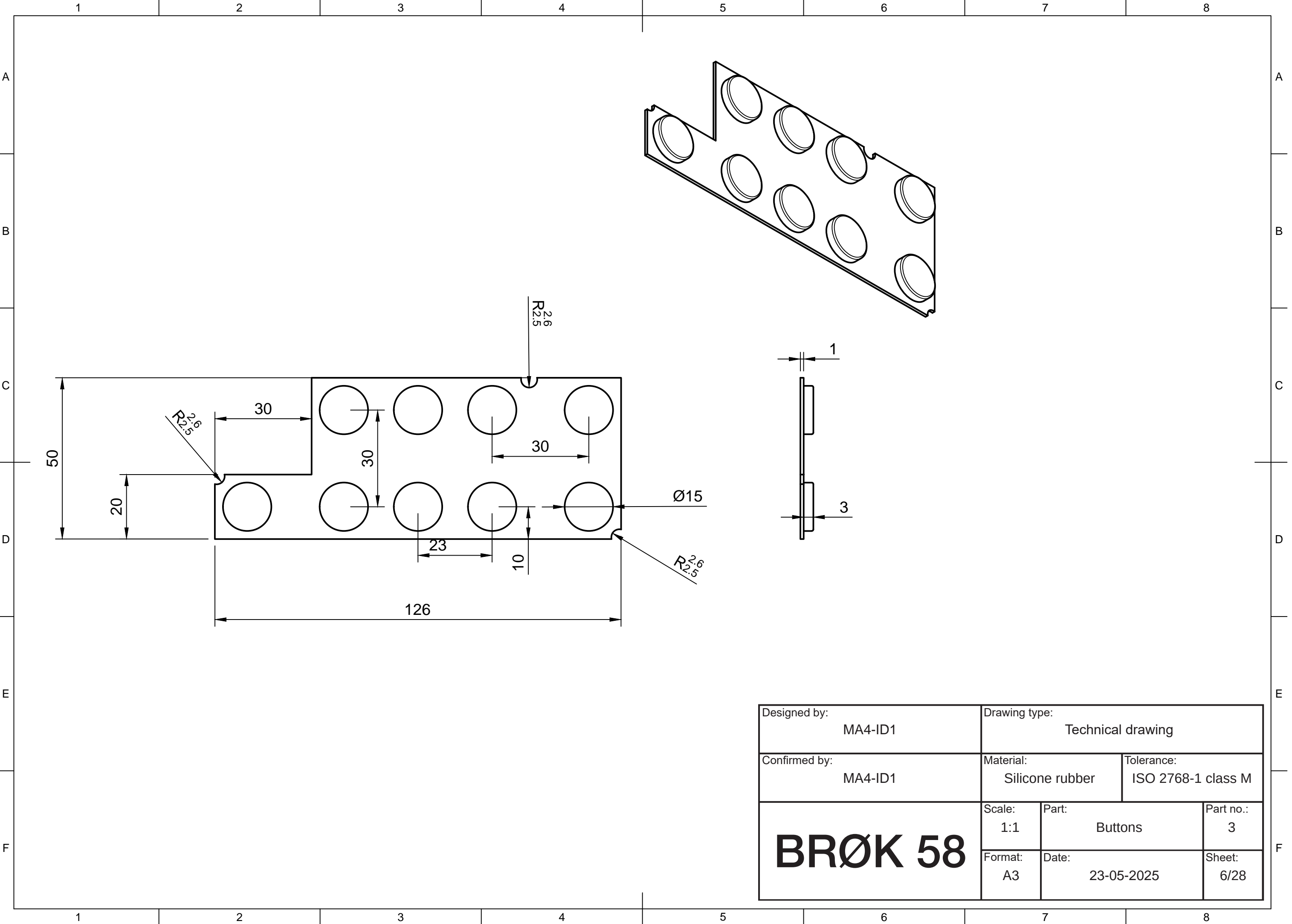| Part no.	Name	Qty.	Material	Description
1	Backplate panel	1	SS304	Fiber lasercutting, deburring, press brake bending
2	Top shell	1	PA66+25GF	Injection molding
3	Buttons	1	Silicone rubber	https://mekoprint.com/solutions/hmi-human-machine-interface/silicone-rubber-keypads/
4	Top panel	1	SS304	Fiber lasercutting, deburring, press brake bending
5	Top screws	4	Stainless steel	https://www.fastenright.com/
6	Backplate shell	1	PA66+25GF	Injection molding
7	Backplate screw	4	Stainless steel	https://www.accu.co.uk
8	Magnet	4	NdFeB	https://www.supermagnete.dk/neodymblok-magneter/blokmagnet-6mm-4mm-2mm_Q-06-04-02-HN?origin=pla&kwd=&adwords_dk_dan-shot&adgr=dk_dan-pmax_all&gad_source=1&gad_campaignid=21825132159
9	Portafilter mount metal	1	SS316 (MIM)	Metal injection molding, sintering
10	Portafilter mount plastic	1	PA66+25GF	Injection molding
11	Shower screen	1	SS316	Stamping, deburring
12	Diffuser plate	1	SS316	CNC milling
13	Water inlet plate	1	SS316	CNC milling
14	Group head plate	1	SS316 (MIM)	Metal injection molding, sintering, drilling
15	Group head shell	1	SS316 (MIM)	Metal injection molding, sintering
16	Gasket	1	EPDM	https://www.espressoparts.com/collections/browse-common-espresso-machine-parts-group-gaskets
17	Drip tray	1	ABS	Injection molding
18	Drip tray grate	1	SS304	Stamping, deburring, press brake bending
19	Water tank	1	Tritan	Injection blow molding
20	Water tank tube plate mount	1	SS304	Fiber lasercutting, deburring
21	Water tank lid	1	Tritan	Injection blow molding
22	Solenoid valve mount	1	PA66+25GF	Injection molding
23	Solenoid valve	1	-	https://www.cemegroup.com/solenoid-valves/v399-200
24	Thermoblock	1	-	https://fixpart.dk/produkt/smeg-693900065-varmeelement-kaffemaskine?_gl=1*10n9sqj*_up-*MQ..*_gs*MQ..&gbraid=0AAAAAoNOh0Ww-M4aLpMfB9Jp-eQqmJrsfW
25	Thermoblock shell	1	PA66+25GF	Injection molding
26	Flow meter	1	-	https://fixpart.dk/produkt/delong-hi-5213225251-stromningssensor-kaffemaskine?gad_source=1&gbraid=0AAAAAoNOh0Ww-M4aLpMfB9Jp-eQqmJrsfW#reviews

Parts list

Part no.	Name	Qty.	Material	Description
27	Steam valve	1	-	https://www.alibaba.com/product-detail/High-Quality-Coffee-Machine-Spare-Parts_1600948358371.html?spm=a2700.galleryofferlist.normal_offer.d_image.578013a0VD-Iwk3
28	Ball joint	1	SS316	CNC turning, drilling
29	Steam wand pipe	1	SS316	Mandrel bending, CNC cut tapping
30	Plunger	1	SS316	CNC milling
31	Plunger o-ring	1	Rubber	https://therubbercompany.com/gaskets-and-seals/cnc-machine-cut-gaskets
32	Ball joint housing	1	SS316	CNC milling, CNC turning
33	Fitting	1	Brass	https://brooks-parts.com/en/fittings
34	Tube connector steam valve	1	PTFE	https://www.alibaba.com/product-detail/Fuid-Parts-for-Coffee-Machine-Ptfe_1600988613608.html?spm=a2700.galleryofferlist.normal_offer.d_image.409313a0BQbbnO
35	Knob	1	SS304	CNC milling
36	Steam wand tip	1	SS316	CNc turning, drilling
37	Steam valve mount	1	PA66+25GF	Injection molding
38	Knob plate	1	SS304	Fiber lasercutting, deburring
39	Water pump	1	-	https://www.cemegroup.com/solenoid-pump/e505-fm-50
40	Water pump mount	1	EPDM shore A50	Injection molding
41	Overpressure valve	1	PTFE	https://fixpart.co.uk/product/delong-hi-7313219401-valve-coffee-machine
42	Rail 1	1	SS304	Cutting, drilling, polishing
43	Rail 2	1	SS304	Cutting, drilling, polishing
44	Rubber foot	4	Rubber, Stainless steel	https://dk.rs-online.com/web/p/vibrationsdaem-pere-fodder-fast-hojde/1712595
45	Power cord	1	-	https://www.alibaba.com/product-detail/Ac-Set-Black-Eu-Angle-Plug_62482555596.html?spm=a2700.7724857.0.0.10fd3dd8IVUGWt
46	Front and side panel	1	SS304	Fiber lasercutting, deburring, press brake bending
47	Water tank tube	1	Silicone	https://www.alibaba.com/product-detail/Customized-Silicone-Tubing-High-Quality-Flexible_1600713690292.html?spm=a2700.galleryofferlist.normal_offer.d_image.535613a0D58VMo
48	Tube connector group head	1	PTFE	https://www.alibaba.com/product-detail/Fuid-Parts-for-Coffee-Machine-Ptfe_1600988613608.html?spm=a2700.galleryofferlist.normal_offer.d_image.409313a0BQbbnO

Parts list

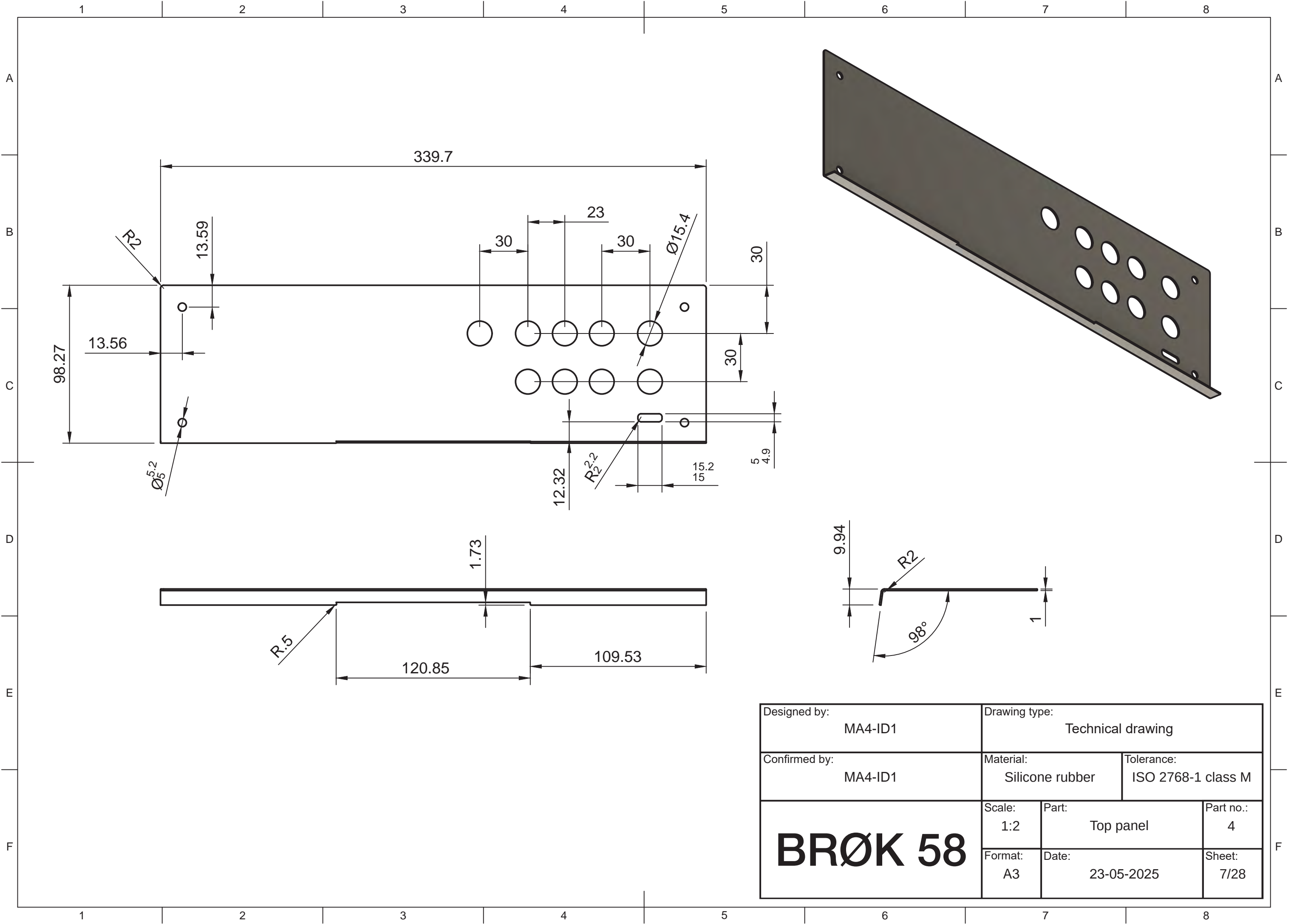| Part no.	Name	Qty.	Material	Description
49	Tube connector solenoid	1	PTFE	https://www.alibaba.com/product-detail/Fuid-Parts-for-Coffee-Machine-Ptfe_1600988613608.html?spm=a2700.galleryofferlist.normal_offer.d_image.409313a0BQbbnO
50	Tube connector thermo-block	2	PTFE	https://www.alibaba.com/product-detail/Fuid-Parts-for-Coffee-Machine-Ptfe_1600988613608.html?spm=a2700.galleryofferlist.normal_offer.d_image.409313a0BQbbnO
51	Spring	1	Stainless steel	https://www.thespringstore.com/pc054-540-3880-sst-0500-cg-n-in.html?unit_measure=me
52	O-ring housing	1	Silicone rubber	https://therubbercompany.com/gaskets-and-seals/cnc-machine-cut-gaskets
53	O-ring fiiting	1	Silicone rubber	https://therubbercompany.com/gaskets-and-seals/cnc-machine-cut-gaskets
54	O-ring		Silicone rubber	https://www.lindepolymer.com/products/coffee-machine-o-rings/
55	Tube connector water pump	1	PTFE	https://www.alibaba.com/product-detail/Fuid-Parts-for-Coffee-Machine-Ptfe_1600988613608.html?spm=a2700.galleryofferlist.normal_offer.d_image.409313a0BQbbnO
56	PCB	1	-	https://www.pcbway.com/
57	High pressure tube		PTFE	https://www.alibaba.com/product-detail/High-Temperature-Coffee-Machine-Components-Te_1601446768348.html?spm=a2700.shop_plgr.41413.1.799f7121X5WJMB
58	Tube	2	Silicone	https://www.alibaba.com/product-detail/Food-Grade-Silicone-Tubing-1-4_1601367450242.html?spm=a2700.galleryofferlist.topad_classic.d_image.7fd-513a0OuTNMu
59	Split		SS316 (MIM)	Metal injection molding, sintering, powder coating
60	Screw UM4 5x10	21	Stainless steel	https://www.mcmaster.com/products/~/military-specification~military-specification/?s=screws%2Fsocket-head-screws-2%7E%2Fmil-spec-alloy-steel-socket-head-screws%2F+-+MS16997-44%2C+NAS1352-3-8P
61	Screw UM4 5x15	6	Stainless steel	https://www.mcmaster.com/products/screws/socket-head-screws-2~/mil-spec-alloy-steel-socket-head-screws/ - MS16997-33, NAS1352-08-10P
62	Screw UM4 5x40	1	Stainless steel	https://www.mcmaster.com/91223A436/
63	Screw UM4 5x30	4	Stainless steel	https://www.mcmaster.com/products/~/thread-size~3-48/?s=screws%2Fsocket-head-screws-2%7E%2Fmil-spec-alloy-steel-socket-head-screws%2F+-+MS16997-48%2C+NAS1352-3-16P
64	Screw UM2,5 3x7	5	Stainless steel	https://www.mcmaster.com/90035A110
65	Bottom shell	1	ABS	Injection molding
66	Main shell	1	PA66+25GF	Injection molding

Wires have not been included in the 3D model and therefore the links to standard parts, i.e. wires and insulated flag terminal, have not been included in the exploded view and parts list.
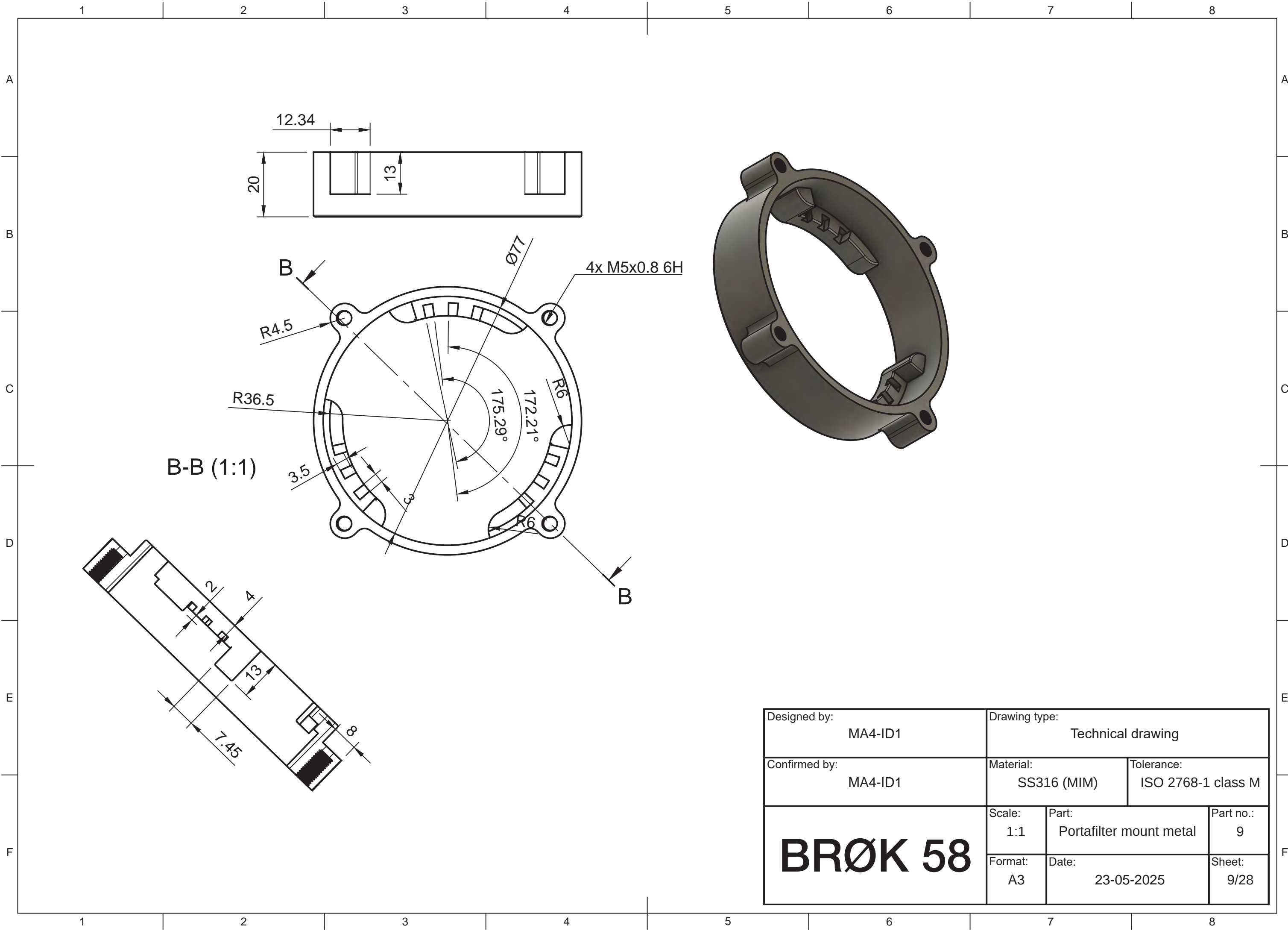
Wire:
https://www.alibaba.com/product-detail/Nylon-FLDNY2-250-FLD-NY-5-5_1600612360529.html?spm=a2700.galleryofferlist.normal_offer.d_image.5bc513a0CB1Gck

Insulated flag terminal:
https://www.alibaba.com/product-detail/Customizable-18-20-22-24-26_1601238021823.html?spm=a2700.galleryofferlist.normal_offer.d_image.1d0713a09jXeu8&selectedCarrierCode=SEMI_MANAGED_STANDARD@@STANDARD
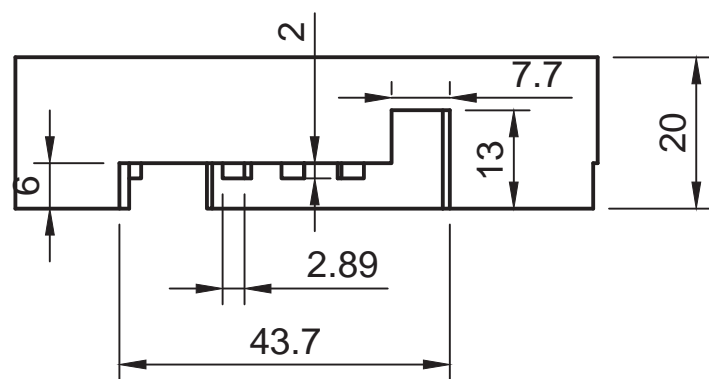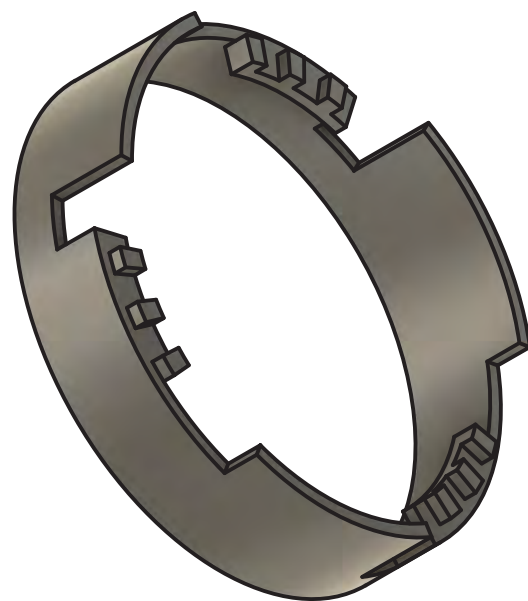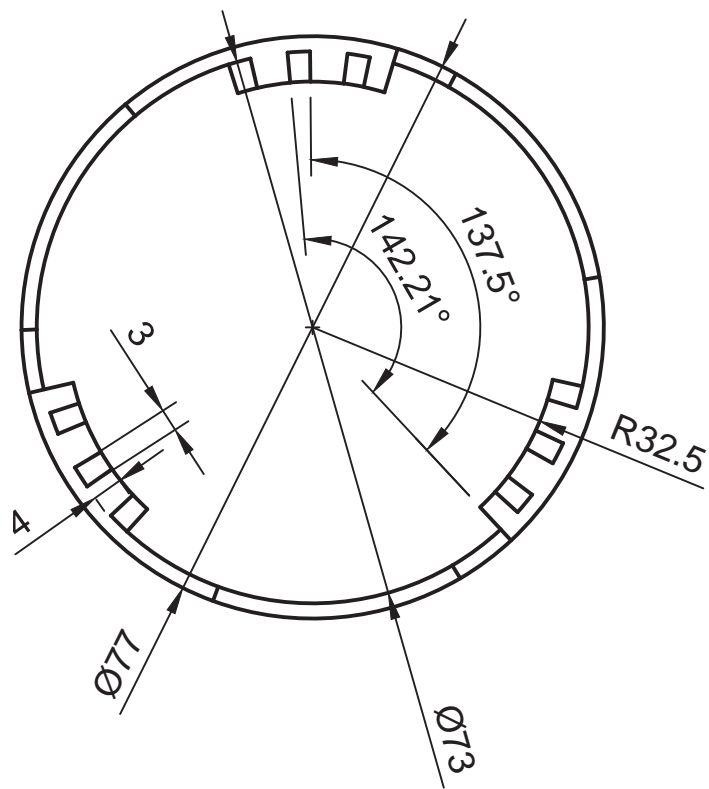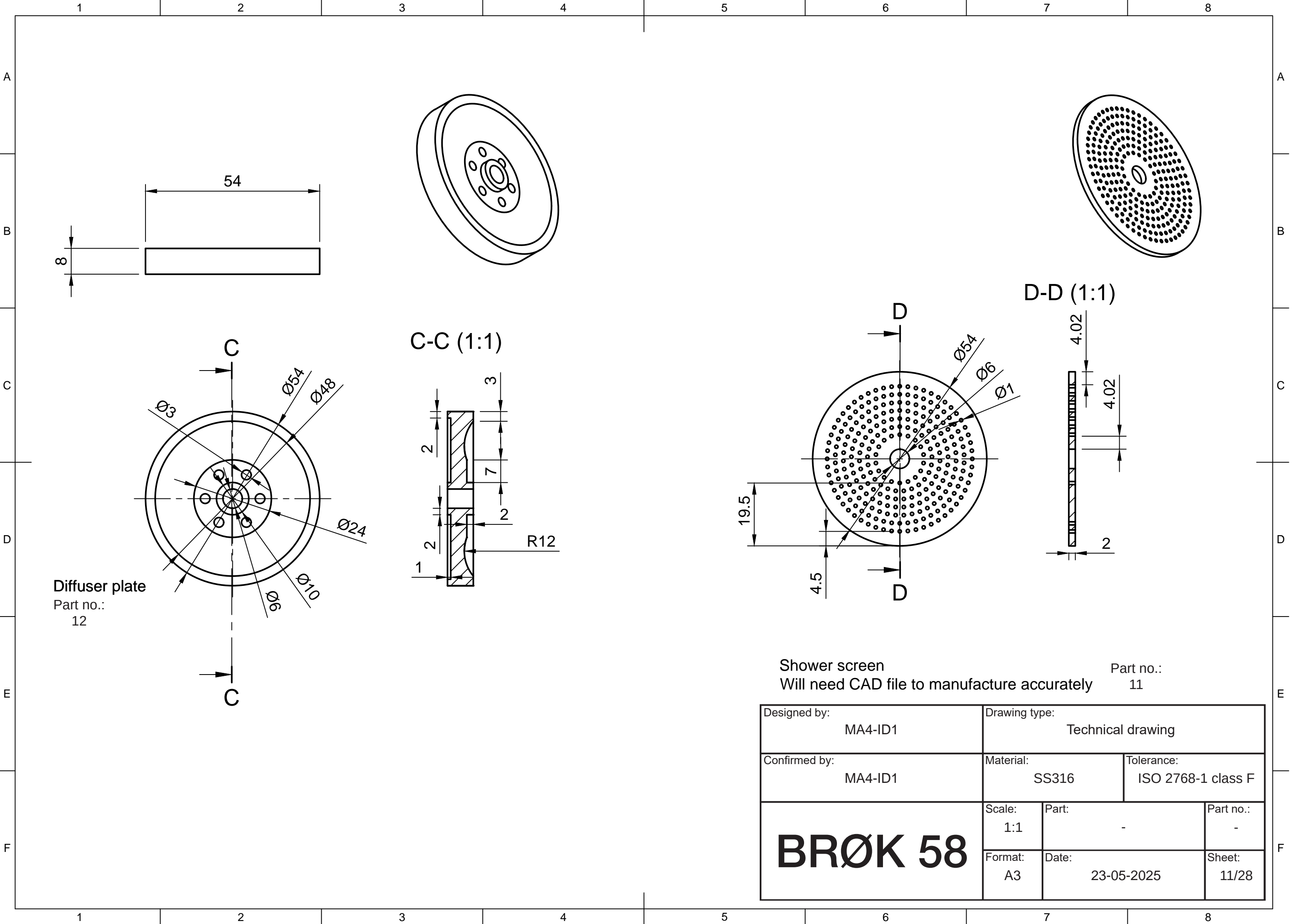
Sheet:
3/28

Designed by: MA4-ID1	Drawing type: Technical drawing		
Confirmed by: MA4-ID1	Material: SS304	Tolerance: ISO 2768-1 class M	
BRØK 58	Scale: 1:2	Part: Backplate panel	Part no.: 1
	Format: A3	Date: 23-05-2025	Sheet: 4/28

Dimensions shown: 28.75, 34.15, 24.75±.1, 24.75±.1, R2, R1, 10.17, 45°, 34, 2, 2, 55, 2, 303.05, 2, 2, 34.03, Ø5.2/5, 80, 28.75, R1, 337.5, 1, 10.43, 120±.2, 1

6.24

4.67

329.36

9

8.16

16.88

2

3.89

5.36

R4

R2

R4.5

4x M5x0.8 6H

28

3x M3x0.5 6H

28.41

5.36

R2

10.02

5.36

55

53

57.14

28

74

33.48

5.36

3

R.5

164.74°

88.66

8.96

1

Will need CAD file to
manufacture accurately

R2.6
R2.5

30

30

50

20

R2.6
R2.5

30

Ø15

23

10

126

R2.6
R2.5

1

3

339.7

R2

13.59

23

30

30

Ø15.4

30

98.27

13.56

30

Ø5.2/5

12.32

R2.2/2

15.2
15

5
4.9

1.73

9.94

R2

98°

1

R.5

120.85

109.53

S (1:1)

U-U (1:2)

Dimensions and annotations:

- 3.99
- .99
- 2.49
- 13
- 2
- 13.13
- 11
- Ø5.12
- 6
- 5.72
- 55
- 40
- 26.2
- 1
- 10
- 29
- 22
- 9
- 222
- 162
- S
- U
- 6
- 18
- 282
- 4
- 107
- 85.97
- 9
- 80
- 50
- 70
- 2
- 10
- 35
- 150
- 30
- 30
- 300
- 22.72
- 4.5
- 3.8
- 2.3
- 6
- 1
- 1.01

Detail S callouts:
- 5, 9, 9, 10, 4, 8, 6, 5, 2, 4, 8, 10, 6.2, 2, 1, 4.7, 1, 6, 1

12.34

20

13

B

Ø77

4x M5x0.8 6H

R4.5

R36.5

172.21°

175.29°

R6

3.5

3

R6

B-B (1:1)

B

2

4

13

7.45

8

137.5°

142.21°

3

R32.5

4

Ø77

Ø73

2

7.7

20

13

6

2.89

43.7

54

8

C-C (1:1)

C

Ø54
Ø48
Ø3
Ø24
Ø10
Ø6

Diffuser plate
Part no.:
12

C

3
2
7
2
2
1
R12

D

D-D (1:1)

Ø54
Ø6
Ø1

19.5

4.5

D

4.02
4.02
2

Shower screen
Will need CAD file to manufacture accurately

Part no.:
11

Designed by:	Drawing type:	
MA4-ID1	Technical drawing	
Confirmed by:	Material:	Tolerance:
MA4-ID1	SS316	ISO 2768-1 class F

BRØK 58	Scale: 1:1	Part: -		Part no.: -
	Format: A3	Date: 23-05-2025		Sheet: 11/28

Top screw   Part no.:
5

2

M5x0.8 6g

Ø10

Knob plate   Part no.:
38

Ø20

2

Part no.:
35

Knob   43.75

R.5

30

13.16

6.91
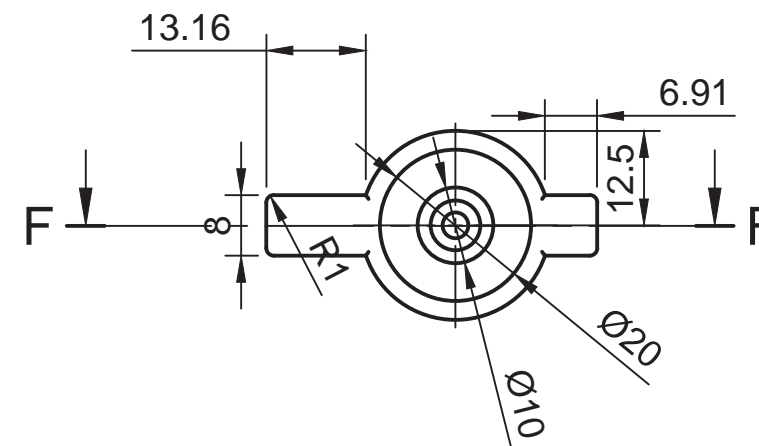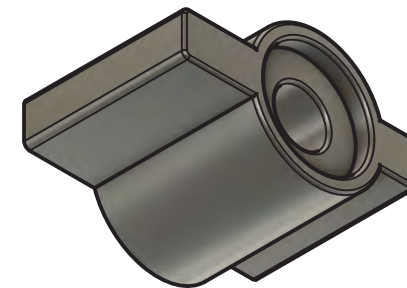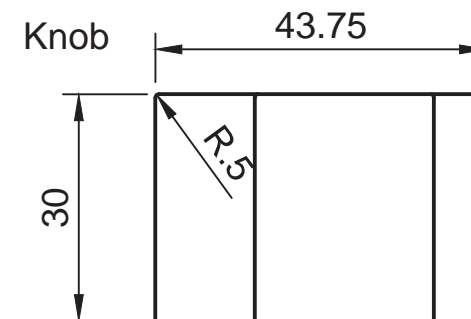
12.5

F   8   F

R1

Ø20

Ø10

4.6

3.4

9

2.3

14

6.6

3

F-F (1:1)

Water inlet plate
SS316
ISO 2768-1 class F
Part no.:
13

E-E (1:1)

E

Ø7

Ø54

Ø6

10

13.64

16.78

R24.75

R20.25

E

2.5

2.5

3

Ø4

6

5

5

4

14

3

3

27

Ø10

Ø5.2 / Ø5

M6x1 6H

43

17

R4.5

Ø12

Ø5.2 / Ø5

13.96

17.45

R52

2

45±.1

R20

R25

33

7

6

112

8±1

27.6

18

6.31±.1

5

Ø20

Ø5.1 / Ø5

54

A-A (1:2)

108

R.5

R1

68

A

64

R52

3x M5x0.8 6H

R2

R4.5

Ø108

A

13

6

17.38

40

2

8

53

61±.2

384

33

72±.2

151±.3

2

121

91.15°

88±.2

98°

88°

2

4.97

33.32

20

24

46.29

1

2

2

10

23

21

Ø4

15

15

10.95

133

4.48

20.05

387

8.7

5

R1

1.24

Will require CAD file to manufacture accurately.

34

4

73

1

I (1:2)

3
3
12
4.5
7
3
12.5

I

25.79
R1
40
Ø25
2
2
17

H (1:2)

R5
Ø17
13
3
5

G-G (1:4)

G

98.39
277
82.07°
5
4
23

49.01
8
2.01
18.5
8.5

R5
G
2
17
59.5
H
12
G

38.05
91.2°
8

137
Ø13
2
67
38.05
2.21

H

Designed by:		Drawing type:		
MA4-ID1		Technical drawing		
Confirmed by:		Material:		Tolerance:
MA4-ID1		Tritan		ISO 2768-1 class M
BRØK 58	Scale: 1:4	Part: Water tank		Part no.: 19
	Format: A3	Date: 23-05-2025		Sheet: 17/28

Water tank lid
Tritan
Part no.:
    21

Water tank tube plate mount
SS304
Part no.:
    20

50.01

3

9

R1

J-J (1:1)

98.08°

78.69°

5

2

5

108.43°

R1

1.5

J

21.99

19.8

2

46.2

98.39

46.2

2.21

J

R4.5

Ø5 5.2

R15

Ø22

55

2

4.95

6

Solenoid valve mount
PA66+25GF
Part no.:
22

24
5.48
5.8
12
5.8
12
24
8.48

R5
2.5
Ø5
21
10
24
2
5
4
5.75

7
21
3
R2
3

K

K-K (1:1)
Ø5
2
K

Ø5.2
Ø3.3
1.75
Ø2
Ø2.6

Backplate screw female
SS314
Part no.:
7

5
8
2
1.5

M5x0.8 6H
V-V (1:1)

Ø10
Ø7
Ø4.23
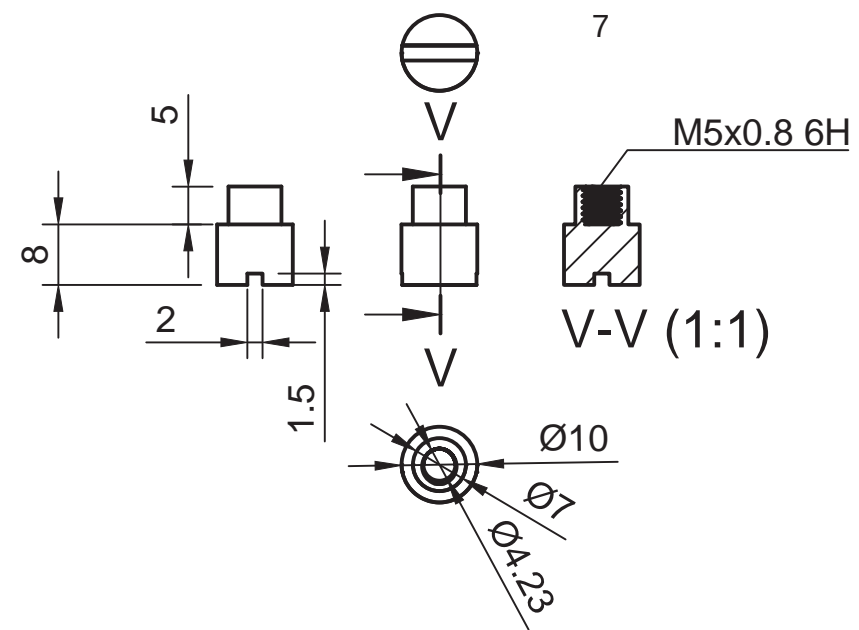
Backplate screw male
SS314
Part no.:
7

10
6
M5x0.8 6g

Ø8

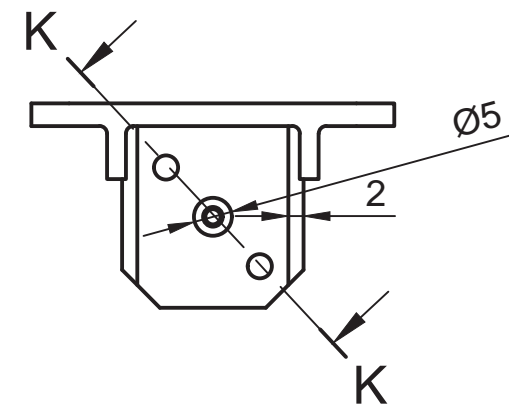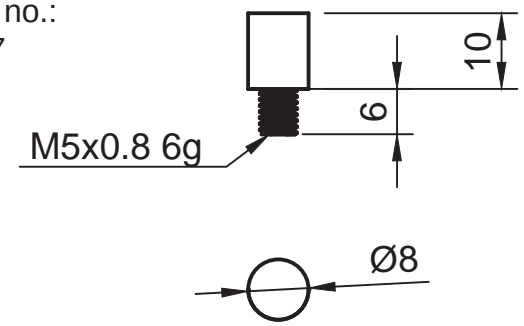| Designed by: MA4-ID1	Drawing type: Technical drawing		
Confirmed by: MA4-ID1	Material: -	Tolerance: ISO 2768-1 class M	
BRØK 58	Scale: 1:1	Part: -	Part no.: -
	Format: A3	Date: 23-05-2025	Sheet: 19/28
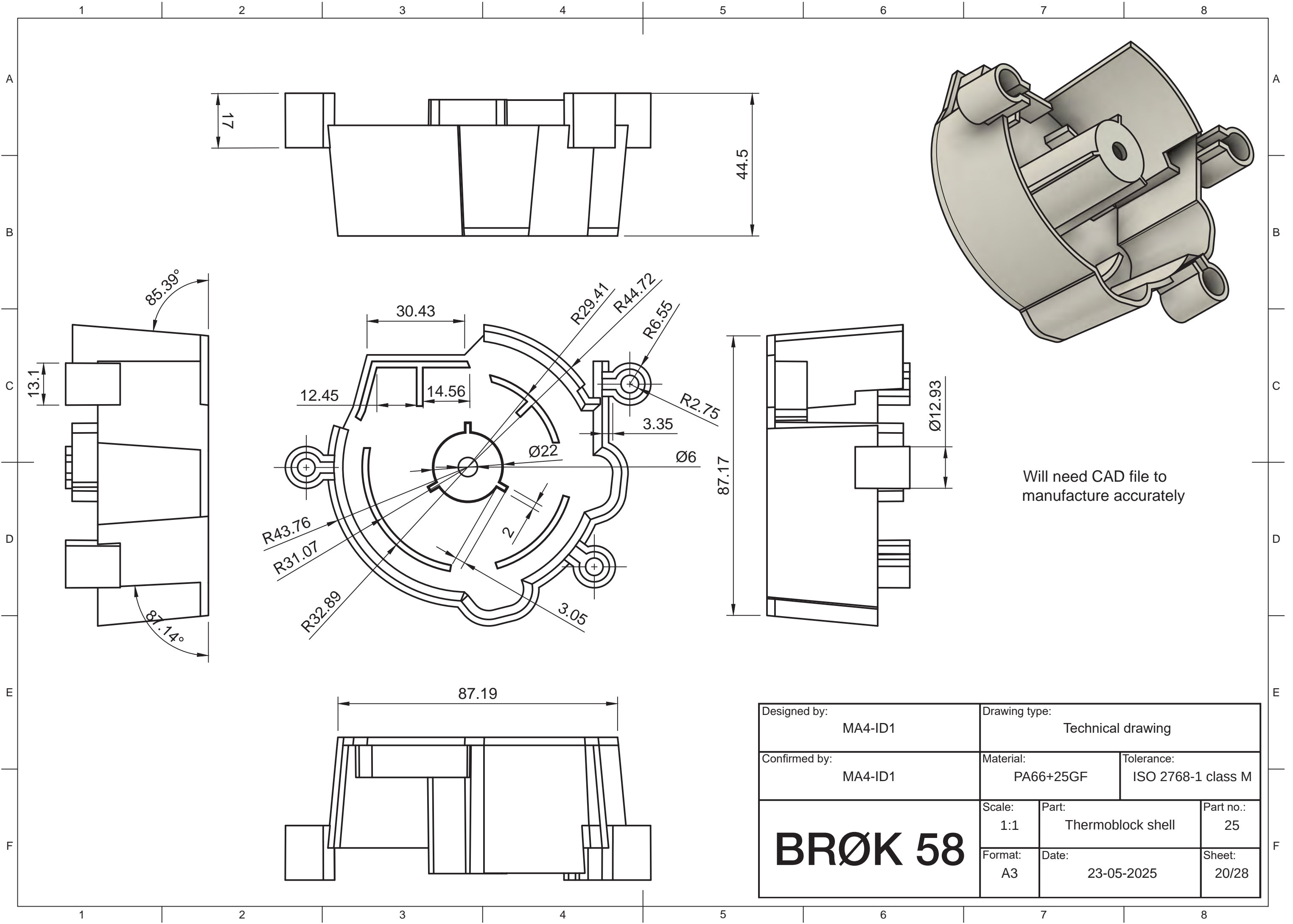
Will need CAD file to
manufacture accurately

Designed by:		Drawing type:	
MA4-ID1		Technical drawing	
Confirmed by:		Material:	Tolerance:
MA4-ID1		PA66+25GF	ISO 2768-1 class M
	Scale:	Part:	Part no.:
BRØK 58	1:1	Thermoblock shell	25
	Format:	Date:	Sheet:
	A3	23-05-2025	20/28

Ball joint
Part no.:
28

L-L (1:1)

L

L

Ø12

Ø3

4

8.8

Ø8

Ø6

M6x0.75 6g

33.81

Steam wand tip
Part no.:
36

N-N (1:1)

N

N

Ø1.3

Ø12

2

13.86

10

28

R3.5

8

M6x0.75 6g

Plunger
Part no.:
30

Ø4

Ø18

M-M (1:1)

M

M

R7

Ø8

4

8

Ø13

Ø14

Designed by:		Drawing type:		
MA4-ID1		Technical drawing		
Confirmed by:		Material:		Tolerance:
MA4-ID1		SS316		ISO 2768-1 class F
BRØK 58		Scale: 1:1	Part: -	Part no.: -
		Format: A3	Date: 23-05-2025	Sheet: 21/28

Steam valve mount
PA66+25GF
Part no.:
37

12.93
10.62
2
R4.5
Ø5.2/5
7.48
11.64

12
2

Ball joint housing
ISO 2768-1 class F
Part no.:
32

R-R (1:1)
R5
Ø14
16
Ø18

R
R16
Ø10
16
12
R1
Ø5.2/5
8
16
32
R

M24x1 6g
R1
R1
14
5
22

P-P (1:1)
10
30
M6x0.75 6H x 10
5.28
1.36
170
10
M6x0.75 6H x 10

Steam wand pipe
Part no.:
29

P
184
P

R6
R14
Ø8

Designed by:		Drawing type:		
MA4-ID1		Technical drawing		
Confirmed by:		Material:		Tolerance:
MA4-ID1		SS316		ISO 2768-1 class M
		Scale:	Part:	Part no.:
BRØK 58		1:1	-	-
		Format:	Date:	Sheet:
		A3	23-05-2025	22/28

R17.36
R.5
17
3
Ø13
36
R23.5
R25.5
42

4
17
.5
12.37
48
46
65
40
Ø5.2 / 5
78

4

Will need CAD file to manufacture accurately

8
7

1.5
R15
Ø20
73.3°
12.37
26.77
9.97
31.57

Rail 1
Part no.:
42

Rail 2
Part no.:
43

55.09

279.06

38

57.3

Ø5.2 / Ø5

38

33.26

2.75

82°

35

55.09

3

279.06

57.3

Ø5.2 / Ø5

35.75

33.26

35.02

82°

2.75

82°

R2
390
78.29
1

95.79
1.2
9.32
R.5
82.1°
119.72
140
23
Q
Q (1:1)
2.25
98°
1.41
3.75

339.7
232
172
$\emptyset^{11.3}_{10.90}$
40
R2
40
48
28
$\emptyset^{5.8}_{5.5}$
310
50.3
49.8
2
76
40.1
62.1
23.5
30.1
29.8
102.1
23.99

3.21
94.07
R2
10
T
T
45°
45°
T-T (1:4)
R2

95.79
1.2
9.32
R.5
82.1°
O
39.8
32.35
2
62.1

O (1:1)
4.25
3.75
1.41

Designed by: MA4-ID1	Drawing type: Technical drawing	
Confirmed by: MA4-ID1	Material: SS304	Tolerance: ISO 2768-1 class F
BRØK 58	Scale: 1:4	Part: Front and side panel	Part no.: 46
	Format: A3	Date: 23-05-2025	Sheet: 25/28

Ø3.8   .5   Ø3.8

10

1.7

Ø4.7   R.8   Ø7.3

Ø4.7   Ø7.3

1.2

2.93   3.74

3.01   2.81

Ø1.3

27.64

6

Ø1.3

R4.5

6

14

Ø31.79

390

6

25

25

82°

2.02

4.9

263

10

Will require CAD file to manufacture accurately.

6.92

42.42

50

8.92

5x M5x0.8 6H

22

22

1±.05

1±.05

5x M5x0.8 6H

23

50

30

269.92

40

128.5

128.5

102

Will require CAD file to manufacture accurately.

10x M5x0.8 6H
10x M5x0.8 6H
10x M5x0.8 6H
2x M3x0.5 6H
10x M5x0.8 6H

Designed by:		Drawing type:		
MA4-ID1		Technical drawing		
Confirmed by:		Material:		Tolerance:
MA4-ID1		PA66+25GF		ISO 2768-1 class M
BRØK 58		Scale: 1:4	Part: Main shell	Part no.: 66
		Format: A3	Date: 23-05-2025	Sheet: 28/28