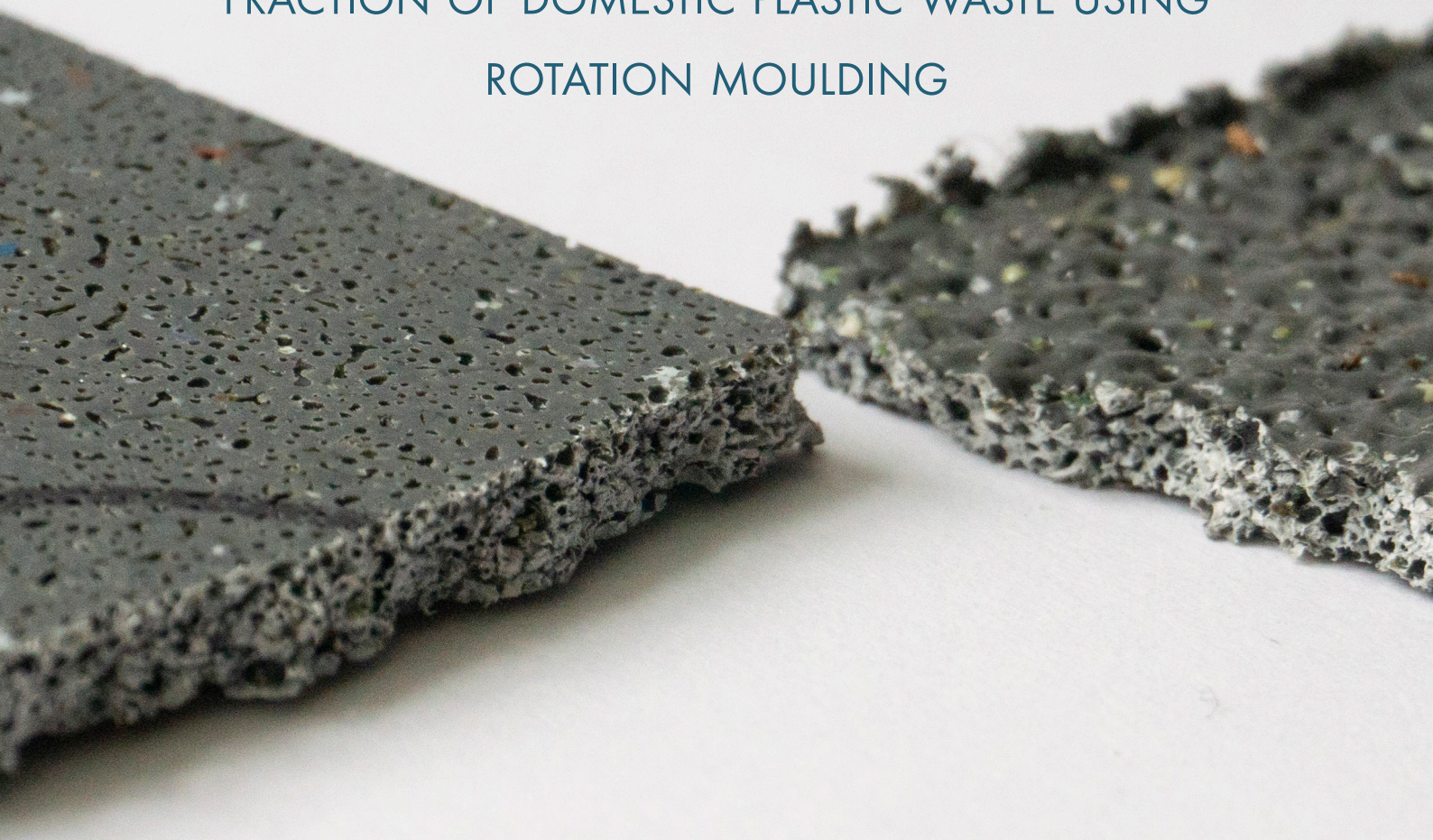
Appendices

Researching possibilities for the leftover mix fraction of domestic plastic waste using rotation moulding



Midwaste

Emma Wisse || December 2018

TU Delft

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December, 2018

TU Delft

Midwaste

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A Introduction

A1. Graduation assignment

GRADUATION ASSIGMENT A1

THE OFFICIAL DOCUMENT SENT TO BOARD OF EXAMINERS

This was the official document sent to the Board of Examiners. However, during this project, the focus of the assignment is slightly shifted. Besides a product, a complete market for this material is created in this project.

IDE Graduation Assignment (version 2017.09.21)
incl. the student's study progress (Appendix 3)

TU Delft Delft University of Technology

To be completed by the student
Please save your assignment as (format): IDE Graduation Assignment_family name, name_student number_dd-mm-yyyy
Place the proper document name on each page of your assignment in the headline, number the pages

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Bachelor [1]	Master [1]	Specialisation [1]
■ TUD Bachelor IO	■ IPD	☐ Medisign
☐ TU/e or UT Bachelor IO	☐ DfI	
☐ TU Delft non-IO BSc	☐ SPD	**Annotation [1]**
☐ Other Dutch University Bachelor	☐ ..... = 2nd non-IDE master	☐ Techn. in Sustainable Design
☐ HBO Bachelor	☐ Individual programme, date of approval [2]	☐ Entrepreneurship
☐ Foreign Bachelor	☐ Master Honours Programme	
Name Chair	Stefan van de Geer.....	

GENERAL INFORMATION

Title Graduation Project [3]	**A research in product possibilities of a leftover mix of plastics out of domestic waste**		
Chair of Supervisory Team [4]	Ir. Stefan van de Geer		
Department / Section	Design Aesthetics		
Mentor of Supervisory Team [4]	Ir. Henk Crone		
Department / Section	Advanced Manufacturing		
Project commissioned by [5]	☐ Faculty	☐ Company	☐ Other, e.g. entrepreneurial
Project type [5]	☐ Design	☐ Research [6]	☐ Other, e.g. entrepreneurial
Company name, if applicable	Midwaste		
City & Country	Delft, Netherlands		
Company Mentor	Ing. Jurgen de Jong		
Start date	15 May 2018		
End date			

CONTENT

Ascertain that the text of your Graduation Assignment clearly meets and reflects the general and specific requirements for your specific IDE master. [7]
Write your assignment in a neutral form.
When inserting images or schedules in colour, make sure a print in black and white is still readable.

Introduction

Give a sketch of the context of your assignment. Historical developments, if applicable relevant published scientific research results, new trends, status quo; materials, technologies, usage, etc.

- *In case of a faculty project: describe how your assignment reflects the research portfolio of the IDE Faculty [6].*
- *In case of a company project: provide company information.*
- *If other, e.g. entrepreneurial: describe the future enterprise and how your assignment will be of value to the enterprise.*

Include an illustration or visual which depicts the context of your assignment.
In case one or more extra parties are involved in your project, indicate which role they play.

Figure 1 Plastic waste management Suez Rotterdam

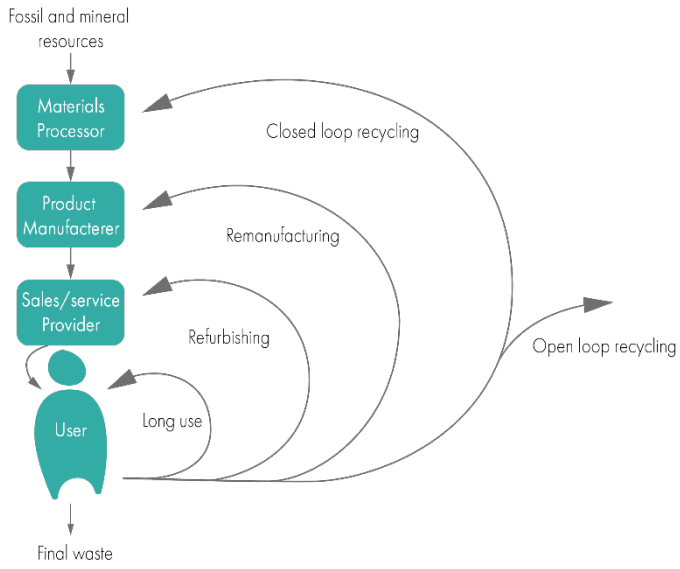


Figure 2 Ways to reach a circular economy (After Berg van de, M.R., Bakker, C.A.,2015)

We live in a world with an uncountable amount of products made out of different plastics. It is estimated, that in 2017, 8300 million metric tons as of virgin plastics have been produced since its appearance (Greyer, R., Jambeck, J.R., Law, K.L., 2017). The ecosystem cannot process this and plastic waste mostly ends up in landfill. The world is changing tackling this. For instance; making lightweight asphalt concrete mixture, where plastic waste replaces the aggregate (Hassani, A., 2005), making liquid fuel out of plastic waste (Panda, A.K., Singh, R.K, Mashra, D.K., 2009), fishing the plastic waste out of the ocean, making bricks of plastic waste (ByFusion, 2018) and so forth.

Circular economy

Also in the Netherlands tackling the plastic waste problem is also changing. The Netherlands is working towards a circular economy (CE) in 2050. One of the five aspects with the highest priority are plastic and plastic waste (Rijksoverheid, 2016).

There are many ways to work towards a circular economy, which are briefly summarized in figure 2. Recycling is one, and at the same time the most important, way to work towards a circular economy (Berg, van den, M.R., Bakker, C.A., 2015). In 2016, the Netherlands recycled 53.1% of the municipal waste (Eurostat, 2018). In 2014, the Netherlands recycled 50% of the plastic, but this should become way more, up to 100% in 2050. If we look further to Europe, The Europe Commission aims to recycle 75% of domestic waste in 2030 and recycling 55% plastic in 2025 (KIVD, Stichting Mileu en Natuur, 2016).

** Marketing means bringing it back to into the circle (Midwaste, 2017).*

[7] For general master specific requirements, consult article 4 of the Master Teaching and Examination Regulations, and the IDE Graduation Manual, especially paragraph 2.4 and 3.1.4.

Since 2015, municipalities are responsible for collecting, splitting and the marketing* of plastic packaging materials, an extra category besides glass, paper, green and rest waste. However, this plastic waste still contains different plastics. The management of this 'plastic waste' is among others, done by Midwaste, the graduation company (see the next paragraph).

Midwaste

Midwaste is a non-profit cooperative association, existing out of thirteen garbage and cleaning companies. They take the responsibility to relief partners and municipalities. Midwaste covers around 130 municipalities in the Netherlands for which they do the transhipment, transfer, storage, splitting and marketing* of the packaging materials (plastics, tin-plate and paper drink bottles) (Midwaste, 2017), shown in figure 3. The plastic waste is collected by the municipalities and brought to SUEZ in Rotterdam (figure 1) where this is further split into different kinds of plastics. However, not everything can be split (yet), resulting in a leftover mix of plastics which will be 31 000 tons in 2018 (Midwaste, 2018). This partly is consists out of non-recyclable plastics (WUR) and partly mono streams. For example this is because the machinery is not sophisticated enough or because products itself consists out of a mix of plastics. Also regulations say that the mix of plastics has quality requirements (Midwaste, 2018). Out of this mix, a granulate is made. Midwaste is looking for a product that can be made out of this low quality material to show companies the value of plastic waste and especially this mix of materials. They stand for a circular economy, social return, sharing knowledge and efficiency by collaboration (Midwaste, 2017).

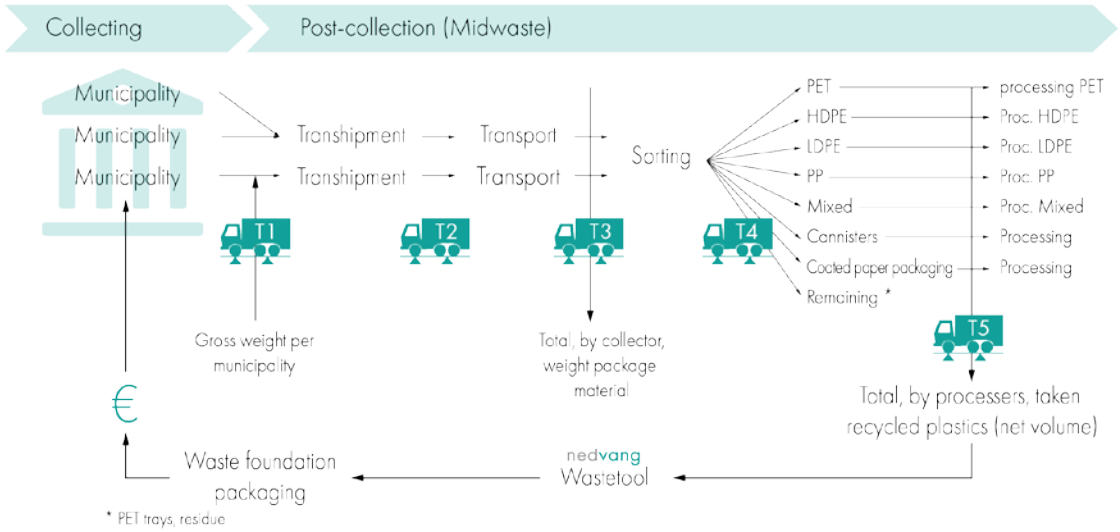


Figure 3 Flowdiagram Midwaste (After Midwaste, 2017)

** Marketing means bringing it back to into the circle (Midwaste, 2017).*

Problem definition

Indicate clearly, what should/could be improved compared to the present situation. When executing a research project: indicate the knowledge gap. What opportunities exist, what contradicting demands should be addressed, etc.

The problem consists out of a business part and a technology part which are described below.

- Out of plastic waste, different plastics are split into (almost) raw material again and sold to suppliers. However, Midwaste ends up with a mix of materials that cannot be split further (yet). Midwaste has to pay between €120 and €180 per ton, among other things due to a lack of demand for this material. Recyclers take out the usable parts and a rest part will be burned (preferably with energy recovery). Midwaste would like to show suppliers the value of this mixed material, by searching for new applications. They are looking for a product which shows the possible beauty and function of this material.

- The properties of this mix of materials fluctuate, resulting in an unstable material from which it is harder to control the quality. The mix still has specification requirements, but there is still a lot unknown in processing this material. Additionally, it is not as easy to process as a pure material. Currently, this results for example in a variation of quality of the product. There is a field of tension between designing a product which does not require high material properties and designing a product that is smart and visually attractive.

Assignment

Briefly and to the point, describe what you are going to design, create or generate to solve (part of) the problem.
In case of a Specialisation and/or Annotation, address specifically how this is/these are included in the assignment.

This project is a research through the possibilities to make products out of this mix of plastics. Therefore the material itself and the possible production methods will be researched.
Moreover, a smart and attractive product will be designed for a later defined target group. This product has to show the partners of Midwaste, the value of this material; a showcase product for Midwaste.

Approach

What will be the approach to deal with the complexity of the assignment? What has to be done to meet the challenges? Indicate the main methodologies to be used. Indicate the same project phases as you distinguish in your planning. If one or more extra parties are involved in your project, indicate which role they play.
In case of a Specialisation and/or Annotation, address specifically how this is/these are dealt with.

The approach is to look into the specifications of the material which gives a good base to look into possible applications. By doing tests, literature research and talking with experts in the field of production techniques, a specific production technique is chosen. Simultaneously, possible designs will be designed so the design could evolve together with the specific production technique. Moreover, the strategic part will be involved in this project; which parties are involved and for which target group will be designed.

During my project, the (personally adapted) phase model of Pahl and Beitz, will be my guideline to manage this project (see figure 4). This consists out of four main design phases; planning and clarifying the task, concept design, embodiment design and detail design.

Planning and Clarifying task

In this phase, the analysis part of the project is done. A research will be done into existing products made out of this mixed material. Moreover, looking into the material specifications and possible production methods will give insight into the possible applications. In the material research, testing will be done. A material study will be done to get more insight in the material specifications to find a constant factor in all the variables of this material. Therefore, if there is no information existing or available, test pieces will be made (with different processing methods, for instance injection moulding and pressing) and tests will be done (for instance: a tensile or a durability test).

Besides the material research, the stakeholders of Midwaste will be defined. Out of this analysis phase, a list of requirements will be given as a base to develop ideas. At the end of this phase, it is plausible that an extra party is involved (in agreement with Midwaste) in this project, a company for who a specific solution with this material will be designed.

Concept Design phase

In this phase it is time to create! Out of the research part, the possibilities have become clear which form the base to develop feasible and viable ideas. With sketching, 3D modelling and prototyping, ideas will be developed to come to one or more reliable concepts. This is an iterating process in which the different ideas are optimized to reach the list of requirements. As a deliverable, a final concept design proposal will be proposed.

Embodiment Design phase

In this phase, the concept design proposal will be optimized and the production steps will be defined. Errors will be checked and weak spots will be eliminated. In this phase, possible first product prototypes will be tested, mechanically and/or ergonomically (depending on what is necessary for the designed product) and validated; a proof of principles.

Detail Design phase

In this phase, the final design is elaborated upon with making a prototype. Also the documentation of this project will be done.
During this phase, the greenlight meeting will be planned and the graduation project will be finished.

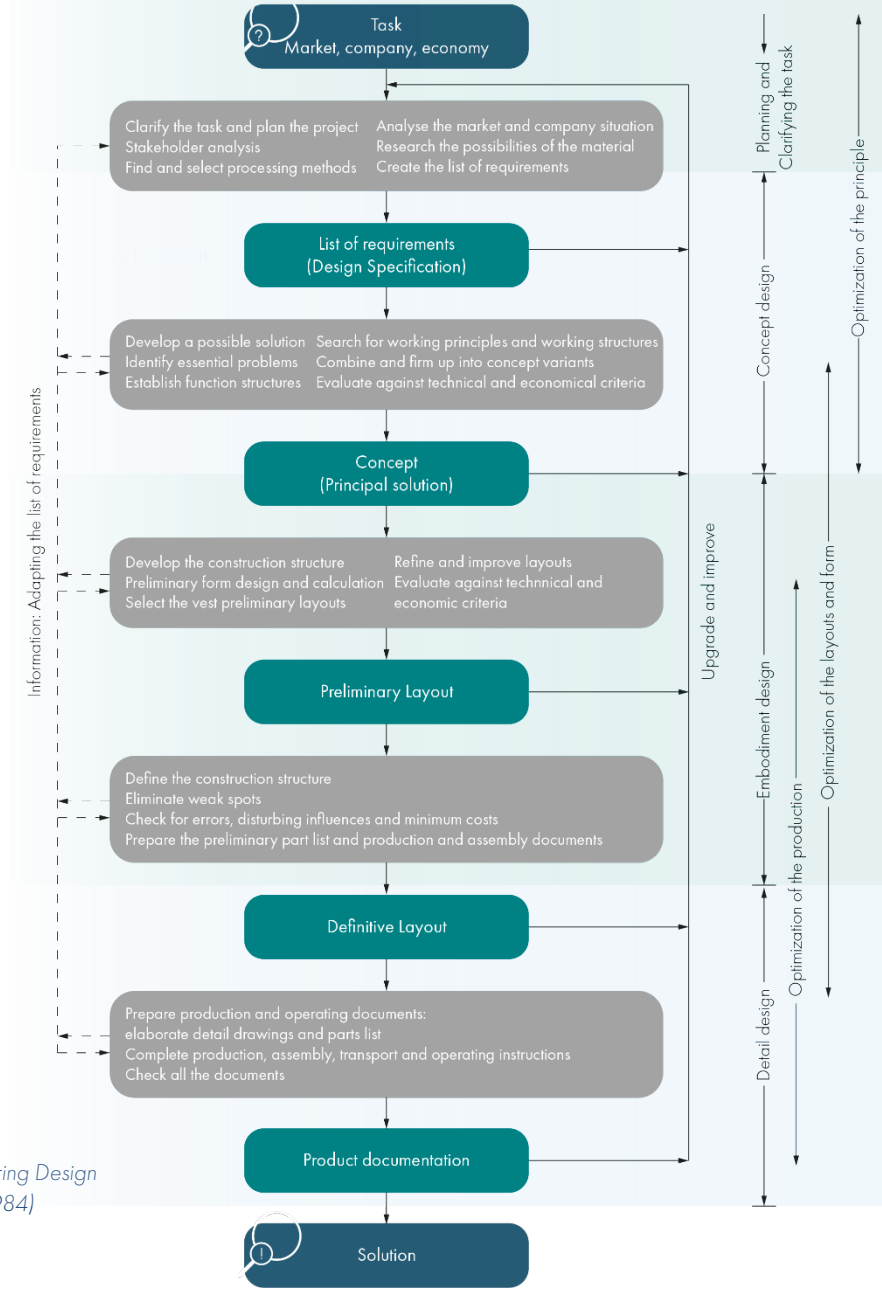


Figure 4 Personalized Engineering Design process (After Pahl & Beitz, 1984)

Graduation Project results

1. *Describe the expected results or outcome of your Graduation Project. For instance, a product, a product-service combination, a strategy illustrated through product or product-service combination ideas.*
2. *Indicate the expected scientific and/or societal and/or commercial significance of the outcome of your project.*
3. *In case of a Specialisation and/or Annotation, address specifically the relevant results to be expected.*

Proposal of a final product that is made out of this mix of plastics.

Deliverables

List the extra graduation deliverables, if any (apart from the mandatory deliverables being the thesis report, annexes if any, the poster and the representative pictures). For instance, a working prototype or a paper.

A proof of concept.

Relation and relevance to the domain of Industrial Design Engineering, the chosen master direction and the IDE pillars

Explain the relation of your project with the domain of Industrial Design Engineering and your master direction IPD, DfI or SPD.

1. *Relation of you project to the master IPD, DfI or SPD*

Furthermore describe the interface of your project with each of the IDE pillars:

2. *Business*
3. *Human Interaction*
4. *Technology*

This project will be based on material driven design. Designing and developing a product to solve a design problem, which is made out of this left over mix of plastics. Therefore it is necessary to dive into the specifications of the product, the material itself and the production method, which makes it a typical IPD project. However, the attractiveness of the product will need some DfI and the business side of this project also requires some SPD.

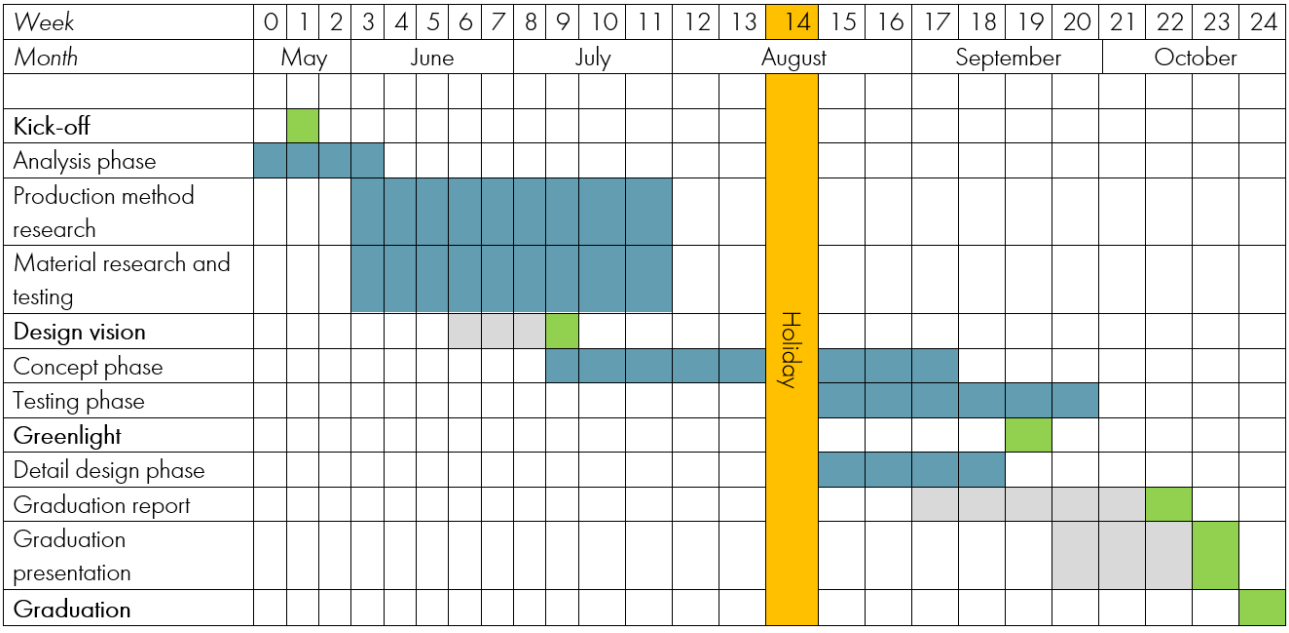
The business aspect of this graduation project will be projected in the research phase. During this phase, the possible applications of this material will be researched and a direction of possible applications will be given. Since a "showcase" product will be designed, Midwaste will have a product to show the value of this mixed material to their partners.
Another business aspect in this project will be the price. The price needs to fit into the budget of the target group, make sure the product is affordable.

Depending on what kind of product is going to be developed, the ergonomics could be an important aspect of this project. This can be projected in many ways; for example human size and assembling possibilities. Moreover, the possible interaction with the user will be part of this project, which also could be projected in how people interpret the product. At last, the communication with Midwaste, my supervisor team and a possible company or municipalities is an important aspect of this project.

The technology part of this project is clearly in the development of the product, the technology used to process this mix of materials in the most optimal way. The recycling part and the specifications of the product will enhance the technology part of this project.

Planning

Present your planning in a Gantt Chart, which can easily be made in Excel, see example underneath. Make sure a print in black and white is still readable. Mention the main phases of the project as described at Approach + number of weeks. Indicate only main activities, milestones, meetings. Take notice: 33 EC = 22 full-time weeks! Indicate periods of part-time graduation project activity and/or periods of not spending time on your graduation project, if any, for instance because of holidays [8].



Brief explanatory remarks on the planning, if any.

[8] *Only by approval of the Board of Examiners , a not yet passed course may be combined with the Graduation Project. In such case, show the approval to your Chair and indicate the period of not spending time on your Graduation Project for this reason.*

In this planning, the different phases of this project can be seen in the blue bars. The weeks of the greenlight meeting and the graduation are completely highlighted and if there is an in between deadlines are green. There is one week of Holiday, now planned in August, but this week might shift to another week. This automatically shifts the tasks, but the deadlines, if possible, will remain the same.

Further comments and information *In case your Assignment needs further comments, please add any information you think is relevant.*
During the analysis phase, it could be that an extra party will be found to develop a product for. If this is the case, there will be an extra company involved. Midwaste will stay the main client.

APPROVAL BY CHAIR

Date of approval	
Signature of Chair	

1. Check study progress	*To be completed by the Shared Service Centre O&S after approval of the assignment by the chair. The study progress will be checked for a 2nd time just before the green light meeting.*		
Bachelor degree:	☐ Yes	☐ No	☐ N.A.
Missing 1st year Master courses	1. ..... 2. ..... 3.	4. ..... 5. ..... 6.	
Master electives, no. of EC credits accumulated:			
Name:	Date: ..... / ..... / 20.....	Signature:	

2. Formal approval Graduation Assignment by the Board of Examiners	*To be completed by the Board of Examiners*	
Approval of the content of the Grad. Assignment:	☑ Approved	☐ Not Approved
Procedural approval:	☑ Approved	☐ Not Approved
Comments:		
Name: A Ruwaa	Date: 12 / 6 / 20..... 18	Signature:

B TECHNOLOGY

B1. Separation techniques
B2. Visit Hubert Eing
B3. Production techniques
B4. Powder
B5. Design parameters

Separation techniques B1

Mechanical and chemical separation

B1.1 Mechanical separation

There are several methods to separate packaging material mechanically. In a later stage, mechanical separation is also used to separate different kind of plastics. These mechanical methods can be divided into six sub groups: cleaning, fragmentation, size, weight, magnetism and optical separation.

Cleaning separation

In the cleaning separation is further divided into washing and drying. Washing can be done in a hydrocyclone, where alse weight plays an important role in separating different kind of plastics, therefore, this technique is presented also in weight separation. During washing, a swim sink separation method can also be applied, which is also like the hydrocyclone, a weight based technique to separate different plastics.
Then, there is drying which can be done with hot air, thermal, and also mechanically, by shaking.

Fragmentation

Secondly, there is the fragmentation. Actually, this is in a pre and in an post stage of the separation. Before separating different kind of plastics, products are shredded into pieces to make them ready to go into the separation chain. The agglomeration is the last stage, when the plastics are separated, the shredded material is melted and agglomerated so it is ready to be used again.

Optical separation

Then, there is optical separation, which of course can be done manually. Besides that, there is the Near-Infra-Red technique. This technique detect specific kinds of plastics after which pieces are blown out of the chain. This is also shown in figure 2.3.

Magnetic separation

Moreover, magnetism is used to take out ferrous or non-ferrous metals. A magnet is used to take out ferrous metals. This if often done by a magnet in an upper belt.
To separate non-ferrous metals, like aluminum, Eddy-Current is used. This principle is based on every material that has its own electrical conductivity. By creating a strong electric field and a turning belt, parts with higher conductivity sticks to the belt longer, than parts with lower conductivity. Then, there is magnetic density separation (MDS), which will be explained below.

Weight separation

Besides magnetism, there is also weight separation which is also mentioned before in the cleaning part. So, the first technique is sink swim separation that separate different plastics based on their density. This same principle is used in MDS, but in this technique, a magnetically loaded fluid is used under which a magnet is placed. When this is put under current, all the different kinds of plastics can be separated. However, plastic compounds or plastic in which chalk is added, can disrupt this separation process. Another drawback of this relatively new technique is the small scale. It would need some more development before it can be used on large scale. Another way to separate with weight is air classification. With air blowing onto the different parts, the light parts will be blown away and the heavy parts will fall down.
As discussed in the washing section, the hydroclone technique is also based on weight where the heavier parts will be thrown to the outside.

Size separation

The last subgroup is separation based on size. The ballistic separator is based on the ballistic effect. It consists out of a couple of disks where flat material (think of foils and paper) will stay on the disks and move upwards. At the same time, round material (like bottles) will 'dance' and move downwards. Besides size, ballistic separation is also partly based on weight.

The second method based on size is trommel screening where a rotating tube with holes in different sizes turns around. This tube has small holes at the start and bigger in the end. With the slope, bigger parts move downwards and fall out of the trommel when it fits the right hole.

B1.2 Chemical separation

Besides mechanical separation, there is chemical separation. There are four ways of to separate chemically: solvolysis, pyrolysis, cracking (low temperature gassing) and high temperature gassing. The KIDV presented a research in 2017 where these techniques are explained.

Solvolysis

In solvolysis, different parts are solving in a fluid. This technique is very helpful with plastic compounds like PET-trays and composites. This process results in polymers from which plastics can be made again. An advantage is that it can filter impurities in plastic waste. A drawback however is that only very pure materials (max 10% impurities) can be processed, which makes it not suitable for the mix fraction.

Pyrolysis

Secondly, there is pyrolysis or depolymerising. In this technique, a solvent is used together with heat to decompose polymers to monomers. These monomers needs to be polymerised again to make new plastics.

Similar as with solvolysis, it can filter impurities and also has a limited input of mono streams. Recycling the mix fraction with this method is impossible.

Cracking

The third method is cracking, or pyrolysis where polymers are splitted by heating them without oxygen (500-800^{o}C). This results in a oily substance or gas, depending on the input. Out of this substance, fuel can be made or it can be a raw material to make new plastics.
The input stream is more diverse for plastics like PE,PP or PS. Similar as with solvolysis and pyrolysis, cracking is not applicable for the mix fraction.

High temperature gassing

High temperature gassing is the only technique that is applicable for the mix fraction. In this technique, plastics are heated in a high temperature range (900-1200^{o}C) which results in a gas that can be used as a resource in the chemical industry. The options are as wide as with oil and can be used for much more than only production of new plastics. Impurities are not a problem for this gassing technique.

B1.3 Conclusion

Chemical separating will probably never substitute mechanical separation (KIDV, 2017). An important drawback of chemical recycling is that a lot of energy is needed for the processing. In a circular economy, chemical separation shows potential, but needs further development, especially to process the leftover mix fraction.

Visit Hubert Eing B2

Getting insight into the methods of making agglomerate out of mix fractions

To get more insight in how mix fractions are processed, Hubert Eing Kunststoffverwertung is visited. This section will give a description of the visit and how they process mix fractions.

B2.1 Visiting Hubert Eing

On June 6th, I have visited Hubert Eing, one of the sorting and processing company partners of Midwaste. Hubert Eing located in Gescher, Germany, just across the border at Winterswijk. They have been founded in 1992 and they are still a family company that makes agglomerate out of mix fractions coming from the Netherlands, but for instance also from Norway, Sweden and Germany. They make the following agglomerates:

Polyolefin Agglomerate

- PO85
- PO90
- PO95
- PO99
- POMix

Polypropylene Agglomerate

- PP
- PP-Etiketten

Polyethylene Mahlgut

- Bottle Caps Grist

During my visit, I spoke with Michael Sudhaus and Mechtild Ahaus. After a short introduction, Mechtild gave us a walkaround tour and explained how they process different bales of plastic into mixes or pure material as order from their clients. Dependent on what clients want to have in the agglomerate, Eing mixes and processes the bales differently. For instance, if the client wants a material which is a little bit more stiffness, they take bales which also contain PET from a specific sorting company. Also, depending on the required quality, the plastic is washed before processing or not. In the flowchart in chapter 2, the techniques are shown.

They have four installations in one hall to process four different agglomerates at the same time and in 2019, they will have an even more sophisticated installation to process different plastics even better.

After the walkaround in the factory, we also had a short talk with Michael to discuss the strategy of Eing. They work on a client wishes based strategy in which they do not deliver DKR standards, but process the material in a way the client wants for the product they are producing.

B2.2 Conclusion

The overall experience was very good. It helped me to get a better idea of how the processing of the mix is going and that it is an iteration process of finding the recipe of the mix together with the production technique and the product requirements.








WESTFALIA
Spielgeräte


PRODCUTION TECHNIQUES B3

BASIC KNOWLEDGE OF DIFFERENT PRODCTION TECHNIQUES

In this section, the basic information of four different techniques is given. The left over mix fraction is already processed with injection moulding and extrusion. Thermoforming and rotational moulding are potential new techniques.

B.3.1 INJECTION MOULDING

Injection moulding is the most used technique in the plastic industry. With this principle, shown in figure B3.1, granulate is fed to a hopper into the extruder where it melts. Then, the fluid plastic, melt, is injected into a mold with high pressure. Therefore, the machinery needs to heavy. When the material had cooled down, the product(s) are ejected with pins. From this ejection, sprue marks will be visible in the product since it has not cooled down completely (Crawford, R.J., 1992).

The mould are made out of machine steel (sometimes aluminum) which makes them expensive, but suitable for long term use. It is possible to make multiple moulds in one so more products are made in one moulding to shorten the processing time of one product. This process is thus very suitable for mass production. The investment costs are high, but the cycle time relatively short (from seconds to a couple of minutes, depending on the product and the material), which could make a product cheaper if the series become larger. Big or complicated moulds can cost millions.

With this technique, there is much freedom in shapes. Undercuts, variety in wall thicknesses and using multiple materials is all possible. However, the more complex the product becomes, the more complex the moulds will be which makes it more expensive. High pressure and variety in wall thickness cause however internal stress.

VARIATIONS

There is much variety in injection moulding and this is a developing world of possibilities. A couple of often used varieties are shortly described.

2K injection moulding

2K injection moulding allows the injection of than one shot of different plastics into the same mould to create one integrated product. Each component in injected by a separate injection unit. It also happens already with 7 different plastics. This method allows to combine different materials and/or colours which can be jointed tightly, or have the freedom to move relatively from each other. For instance, this could be used for a hinge principle (Tempelman, E., Shercliff, H., and Ninaber van Eyben, B., 2013).

Insert/outsert-moulding

In this method, specific parts or components are placed inside a cavity before the moulding. During the injection, the material flows around the 'inserts'. This allows integration of parts into the product. If this part which is integrated than the actual moulded part, then it is called outsert-moulding (Tempelman, E., Shercliff, H., and Ninaber van Eyben, B., 2013).

Injection moulding using gas injection

During this method, a gas, usually nitrogen, is injected into the product into locations where internal cavities are needed. To do this, a thin needle is used just after the melt in injected and partially fills the cavity with a pressure of around 300 bar. Then, the melt blows up until it fills the mould completely and starts cooling down. This is applicable for relatively easy shapes and provides expensive sliding cores and it allows a large reduction of wall thickness (Tempelman, E., Shercliff, H., and Ninaber van Eyben, B., 2013).

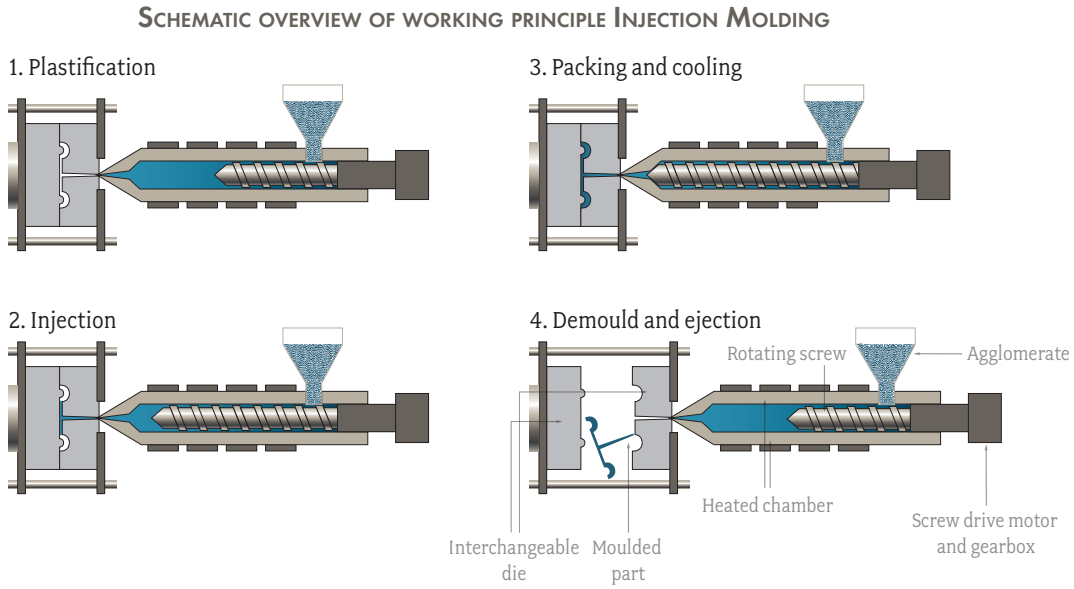


Figure B3.1 A schematic overview of the working principle of injection moulding.

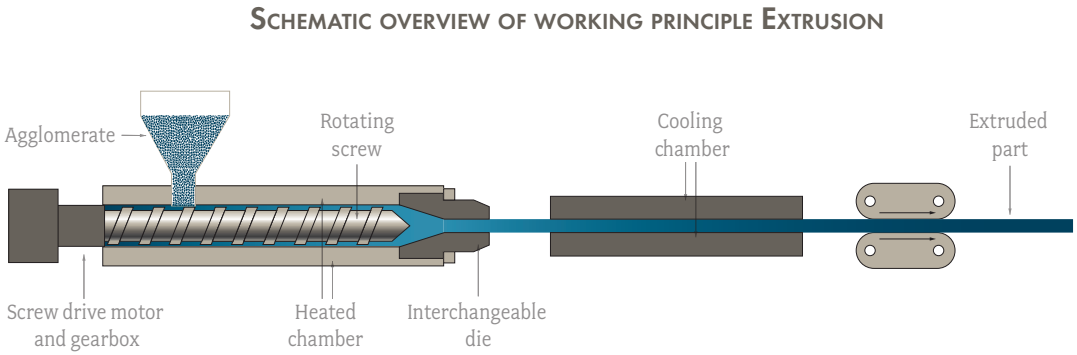


Figure B3.2 A schematic overview of the working principle of extrusion

Injection moulding with in-mould decoration (IMD)
With IMD, prior to the moulding, a thin decorative skin in placed inside a cavity in the mould. This skin can be a prior thermoformed thin shape or a foil that shapes itself through the process. This could for instance give a wood grain look (Tempelman, E., Shercliff, H., and Ninaber van Eyben, B., 2013).

B.3.2 Extrusion

This process, also shown in figure B3.2, is used to produce items of uniform profile such as curtain rails and plumbing pipes. Plastic granules, pellets or agglomerates are fed via a hopper through an extruder, like with injection moulding.The plastic is heated in the chamber before it enters the die and then pushed through the die. Afterwards, the extruded part is cooled by air jets or water as it leaves the die. The extruded parts are then cut into lengths or coiled. As with injection molding, extrusion is suitable for mass production. However, the dies are not as expensive as injection moulds (think of thousands, instead of hundred thousands or millions), which makes this technique is also suitable for smaller series.

There are many profiles possible, but it is almost a 2D shape, variable in 2 dimensions. Materials that are commonly extruded are Polythene, PVC and nylon.

Also similar with injection moulding, internal stress occurs because of the pressure during the extrusion process (sites.google.com, n.d).

B.3.3 Rotational moulding

This techniques was described elaborately in paragraph 2.2. All the information about this technique can be found in this section.

Powder B4

The input of rotational moulding

The process to create small particle sizes of the PE pellet, granule or agglomerate, is called 'grinding' or 'milling'. However, it is more likely to be described as disintegration by a series of high speed cuts. A normal milling or grinding process would result in shredding and tearing the particles in such a way that the resultant shape of each particle would be unsuitable for the rotomoulding (Crawford, R.J., 1992).

The detail in figure 2.7 in paragraph 2.2 shows the principle of 'disintegration'. The granules of PE are fed into the centre of two plates, each with a series of radially arranged cutting edges. Usually, one plate is stationary, while the other plate is rotating at high speed. The gap between the cutting edges of the two plates gets more narrow towards the outside. Since every single particle is subjected to a cutting action, the original size is reduced. By centrifugal force, the smaller parts are carried outwards where the size is even further reduced. At last, the particles are ejected from the gap at the edge of the circular cutting plates. Frictional heat increases the temperature of the metal cutting plates, the individual particles and the surrounding air, so the temperature must be controlled so it does not rise above the melting temperature of PE. When the disintegrated particles have passed through the gap, they fall into an airstream which conducts them to a sieve (or a series of sieves) through which the finer particles will fall and be collected for use. Oversize particles held on the sieve are conveyed back to the mill to be disintegrated again, shown in figure 2.11.

Particle shape

The shape of the powder is important for the quality. This is strongly related to the bulk density. The apparatus to measure bulk density is shown in figure B4.1. The bulk density is a measure for the deviation of particles when it is stored without pressure. Under a microscope, the particles look irregular. The sharpness and condition of the cutting edges of the plates and the temperature of the particles at the time of cutting will have a significant bearing on the quality of the powder. The irregular shape of the particles is inevitable but is actually beneficial in the subsequent rotational moulding process. Uniform spherical particles can roll too easily before melting takes place, which could result in an uneven distribution, especially at complex mold shapes. However, 'hairiness' or fibrillation of the powder, caused by a tearing action, can reduce its free flow properties. If there are tails on the powder, there is a higher chance 'bridging' occurs. Bridging means that material cannot reach every part of the mould, because material got stuck in a more narrow part, like ribs, of the mould. Therefore, different types of plastics requires different grinding parameters to obtain the maximum shape (Crawford, R.J., 1992).

Powder parameters

So, the most common parameters to define the quality of a powder for rotational molding are:

- Particle Size Distribution (PSD) 95 % < 500 µm with maximum 15 % < 150 µm
- Dry flow < 27 s
- Bulk density > 320 kg/m^3
- Density (PE) 0.924-0.947 g/cc.

  If this range moves up, stiffness, brittleness and shrinkage increases.
- Melt low index (MFI). This index describes how fast the material flows in ten minutes through the capillary of the mould. *

  1.9 - 8g/10 min. Less than 2.0 becomes difficult to rotomold and above 8, the parts become brittle.

(Crawford, R.J., Throne, J.L., 2002)

Melt strength is an engineering measure of the extensional viscosity and is defined as the maximum tension that can be applied to the melt without breaking.

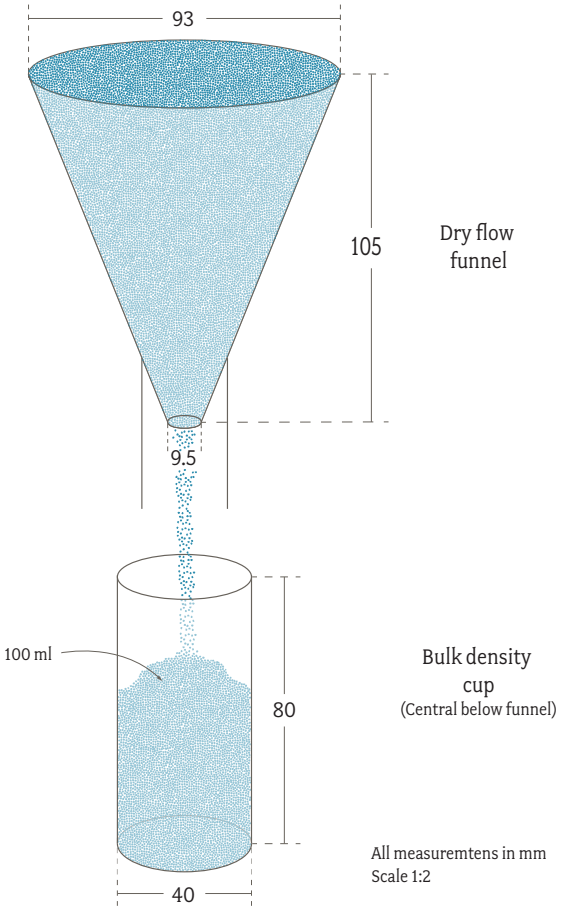


Figure B4.1 The apparatus to measure dry flow and bulk density (after Crawford, R.J., 1992).

A good balance of these parameters make sure that key requirements are met:

- Good heat transfer
- High initial bulk density
- Good cavity filling
- Good surface finishing, with less pinholes (little holes on the surface)
- Limited degradation in the mould
- Process without dusting

Additives

Then, there are additives which influences the material specifications. This could be:

- Colorants
- Anti static agents
- Cross-linking agents
- Flow modifiers
- Foaming agents
- Heat stabilizers
- Impact modifiers
- UV stabilizers

(Theplasticprofessionals.com, n.d)

For instance, carbon black is a uv-stabilizer and a colourant and the same time, which is the best screen against the effect of UV light, which causes degradation of the product quality and colour (Crawford, R.J., Throne, J.L., 2002).

* See list of definitions

Design parameters B5

Important parameters in the design phase of rotational moulding

In this section, the necessary parameters in the designing phase are described and explained. These parameters will help designing a realistic product made with rotational moulding to provide many compromises in the embodiment phase.

B5.1 Introduction

A good quality piece design is the result of a good combination of the capabilities, limitaitions and unqiue requirements of the material, the tooling and processing technique together with attention to design details. In this section, general design rules are explained. All the information comes from Crawford (1992), unless indicated otherwise.

B5.2 Mould design

To make an appropriate mould there are some major factors to take into account: Parting lines, removable cores, kiss-off ribs and heat transfer. These factors are briefly explained below.

Parting lines

The parting lines is the point where the two parts of the mould pieces meet. The location of the parting line is critical, since this will be a visible line in the product. This parting line is also critical to maintain the mouldability of the product.

Removable cores

It is possible to have an undercut in the design that cannot be removed from a plastic part design, for instance because the critical aesthetics or function. Therefore, removable cores can be designed into the mould. This part must be attached to the mould, prior to the filling operation and removed, prior to demoulding the plastic part. This could for instance contain a thread of a filler neck. Therefore the core must be unscrewed from the moulded plastic piece before demoulding.

'Kiss-offs' ribs

In order to strengthen the sides of a hollow plastic part, ribs or kiss-offs are design to extend through the hollow wall or the part. They connect the walls from the inside, creating an internal rib in the part (See figure B5.1).

Heat transfer

Since rotational moulding requires heat for the forming process, the rate and evenness of the heat transfer from the ambient air through the mould and eventually to the resin, is the most critical part of the process. Mould with deep cores tend to shield a part of the mould from the heated areas inside the machine furnace. Providing a network of heat absorb fins that have been cast right into the mould in the deep core areas help alleviate this insufficient heating.

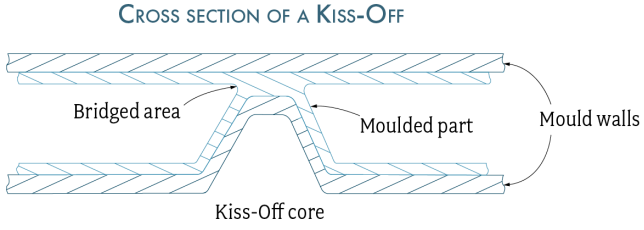


Figure B5.1 A cross section of a kiss off design in a mould (after Crawford, 1992)

B5.3 Product design of rotational moulded products

The most important thing to include in the design is maintaining a uniform wall thickness to control internal stress. This is automatically applied in rotational moulding. The type of plastic and the thickness of the nominal wall determines the strength and load bearing capability of the finished product.
One of the special characteristics of rotomoulding is that there are no forces which push the material into the mould as is the case with injection or blow moulding. This results in products with no, or barely any internal stress.

B5.4 Rotationally moulded plastic part design

Besides the design of the mould, there are some design rules for the product design as well. Basic design rules are discussed in this section.

Wall thickness (W)

A higher wall thickness requires longer heating cycles. Material degradates thermally due to this heating cycle which cases loss of mechanical characteristics. This degradation differs for different types of plastics. PE provides the widest range of wall thickness and will be at its best in the range of 1.5 to 13 mm. However, a wall thickness of 25 mm is not uncommon, but this requires long moulding cycles. One half minute of additional heating will be required for each 0.6mm increase in the wall thickness of a PE part.

Since there are no internal cores in rotational moulding, the wall thickness cannot be controlled exactly. Depending on the shape of the part and the material, wall thickness can be controlled to ± 20%, which can be reduced to ±10% if wall thickness is more important than cost. Therefore, the tolerance is expressed in 'nominal wall thickness, with a minimum allowable wall thickness'. By weighing the part, this is controlled. Blow moulding and twin sheet thermoforming share these limitations. However, rotational moulding maintains more uniform.

Closely spaced parallel walls

The bulk factor of the moulding powder is approximately three times higher than the solidified part. Taking this into consideration, the average distance between parallel walls needs to be three times the nominal wall thickness (see figure 2.14). A smaller open space would not provide enough volume for the powder. In extreme cases, the mould vibrates in order to get all the material into the cavity. There is also a tendency for the powder to bridge across closely spaced walls, which prevents the powder form freely flowing into every area in the cavity. Thick solid sections can result in stress and increased warpage, because these section stay hot longer and shrink more than surrounding thinner sections. Therefore, wherever it is possible, the distance between closely spaced walls should be five times the nominal wall thickness (see figure B5.2).

Warpage

During the cooling of the moulded part, the plastic can shrink and pull away from the inside surface of the cavity. This condition allows the mouled part to warp. Especially in large flat surfaces, warpage is almost impossible to eliminate. Large flat surfaces can be reinforced against warpage by using ribs.

Stiffening ribs

One of the advantage of rotomoulding is that is has the capability of producing products with very thin walls relatively to their size. However, many products require a higher stiffness than

Design rules for closely spaced walls

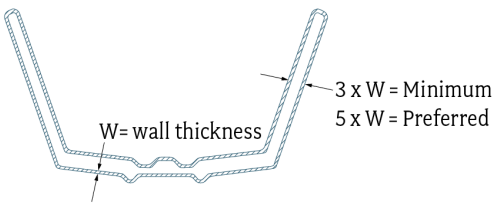


Figure B5.2 A cross section of design rules for closely spaced walls (after Crawford, 1992)

Recommended minimum hollow rib proportions

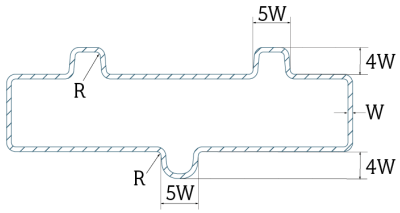


Figure B5.3 Recommended minimum hollow rib proportions (after Crawford, 1992)

Recommended minimum solid rib proportions

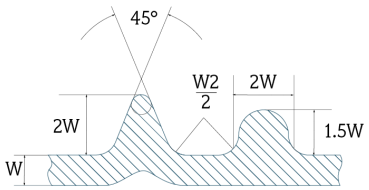


Figure B5.4 Recommended minimum solid rib proportions (after Crawford, 1992)

the wall thickness provides. In this situation, incorporating stiffness in the geometry is one of the solutions. Depending on the load and the direction of the load, hollow ribs can be designed. Hollow stiffness ribs, the preferred type of rib for rotational moulding, are actually closely spaced walls. As shown in figure B5.3, the prefered distance across a stiffening rib should be at least five times the wall thickness. Significant increased stiffness is provided when the height of the rib if four times the nominal wall thickness.The width of the rib should be increased proportionally, if this dimension becomes more than four times the wall thickness. Generally speaking it is preferable to limit the distance the rib projects above the wall, because a short rib may not provide the required stiffness. Multiple short ribs instead of one tall rib is better provide this stiffness. Alternatively, less desirable solid ribs can be used. Proportions of these ribs are shown in figure B5.4. The thicker the wall, the more the shrinkage will be. Moreover, when the thicker, stronger rib shrinks more, it can overpower the surrounding walls and contribute warpage.

Kiss-Off ribs

Another method to provide stiffness, especially in products with closely spaced walls, is kiss-off or tack off ribbing. This connection creates a very strong 'box beam type structure'. This is shown in figure B5.5. The exact thickness of the material in the kiss-off area is established by trial and error, but 1.75W is a good starting point.

A variation on the kiss-off rib is the 'almost' kiss off rib, shown in figure B5.6. This variation provides a lot of vertical support. It provides the same vertical support, while eliminating stress concentration by allowing the horizontal wall to move relatively to the vertical support. This 'almost' kiss-off rib allows the inner hull to gain support from the outer hull, while allowing the two hulls to move relatively from each other in response to in- or outside forces. However, both sides of the horizontal walls of the kiss-off bend in response to the load. This creates stress concentration at the junction of both the supported and unsupported walls.

Draft angles

Draft angles is one of the features that reduce the

Recommendedminimum kiss-off proportions

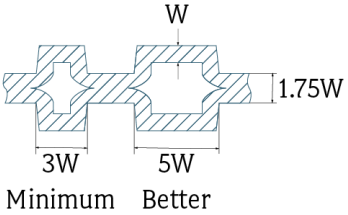


Figure B5.5 Recommended minimum kiss-off proportions (after Crawford, 1992)

Cross section of a Kiss-Off and an 'Almost' Kiss-Off rib

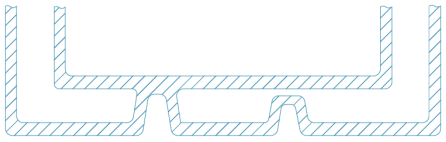


Figure B5.6 Crossections of a kiss-off and an ' Almost' kiss-off rib (after Crawford, 1992)

Recommended draft angles in degrees for inside and outside				
	Outside surface		Inside surface	
	Minimum	Better	Minimum	Better
PE	0°	1°	1°	2°
PVC	0°	1.5°	1°	3°
Nylon	1°	1.5°	1.5°	3°
Polycarbonate	1.5°	2°	2°	4°

Table B5.1 Recommended draft angles in degrees for inside and outside, for common used materials (after Crawford, 1992)

cost of rotationally moulded parts. The limiting factor on a rotational moulded part's cooling cycle time is that it has to be cool enough to have regained sufficient strength to retain its shape when it is demoulded. It also has to withstand demoulding forces. This force significantly decreases when liberal draft angles are used. When these forces are reduced, the cooling time, warpage, cost and induced stress are minimized. However, draft angles are not always required, since straight hollow parts shirk away from the mould. This shrinkage works reverse on inside surfaces such as kiss-offs and ribs. There is a difference in shrinkage per material. For instance PE and nylon shrink more than polycarbonate. Besides that, softer, self-lubricating materials like PE are easier to remove from the mould, even with minimal draft angles.

Depending on the shape of the product, more or less draft angles are required. To stay safe, and especially for inside surfaces that shrink tightly to the mould, liberal draft angles should be incorporated. In general, bigger parts require larger draft angles. Table B5.1 gives an overview of recommended draft angles for both inside and outside for common used plastics.

Surface finishing

The smoothness of a part, especially on the inside, goes hand in hand with draft angles. Stiff materials (nylon and polycarbonate) require a smoothly polished surface and even more when minimal draft angles are specified. When rough finishes are used, the draft angles should be increased with 1° per 0.25 mm of texture depth. The higher the requirements for the surface finishing, the higher the cost of the mould.

Undercuts

An undercut is the exact reverse of a draft angle. To remove a part with an undercut, the part needs to be deformed in order to demould the part. However, undercuts provide a lot of beneficial features, both functional and aesthetically, to the moulded part. Complete hollow products allow inside deformation and are more easy to demould than parts with internal cores like kiss-offs. To pull out the product, the shape of the undercut must be

Rotationally mouldable holes

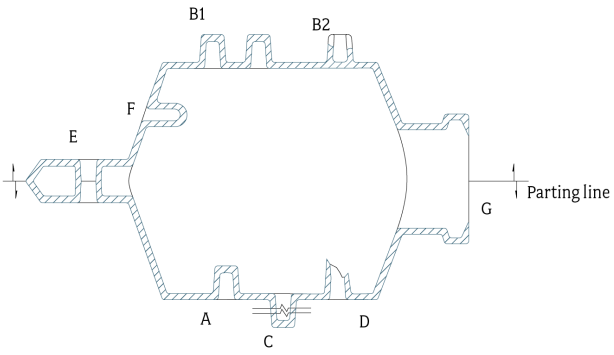


Figure B5.7 Rotationally mouldable holes (after Crawford, 1992)

Corner angle limitations

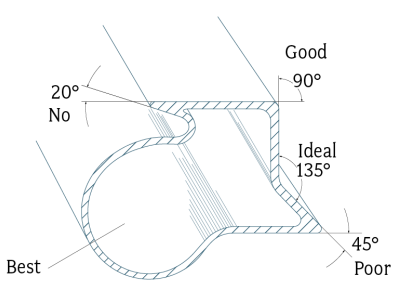


Figure B5.8 Corner radius limitations (after Crawford, 1992)

Recommended radius size in different materials			
Material		**Inside radius (mm)**	**Outside radius (mm)**
PE	Ideal Commercial Minimum	12.5 6.5 3.2	6.5 3.2 1.5
PVC	Ideal Commercial Minimum	9.5 6.5 3.2	6.5 3.2 2.0
Nylon	Ideal Commercial Minimum	19.0 9.5 4.7	12.5 9.5 4.7
Polycarbonate	Ideal Commercial Minimum	12.5 9.5 3.2	19.0 9.5 6.5

Waarom zo hoog?

Table B5.2 Recommended radius size in different materials (after Crawford, 1992)

designed to develop a bending force in the direction that the moulded part must deform. Internal undercuts are always more difficult to remove than external undercuts, due to the shrinkage. Loose cavity parts can be built into a mould in order to accomodate special details such as undercuts, side cored holes or moulded-in inserts. Extra cavity components however add significantly to the initial construction and ongoing maintenance costs.

Holes

Figure B5.7 shows all the possible examples of holes, except for hole B2. This hole could be seen as a solid rib and cannot be filled completely. Moreover, hole F requires a special removable component since the direction of this hole is parallel to the parting line.
The holes are made in an additional step, after the moulding itself, except for hole E and G.

Corner radii

A common feature in rotomoulding is the large corner radii. This feature has two primary functions. First, distributing stress in corners over a broader area to produce a stronger part. Stress tend to concentrate in corners and with sharp corners this stress concentrates even more. Secondly, improving the material flow in the mould. Sharp outside corners tend to accumulate extra material. Providing generous radii both on inside and outside corners improves the wall thickness uniformity.
In table B5.2 and figure B5.8 an overview is made of the recommended corner radius size in different materials. A larger corner however, will always be better.

More complicated shapes often creates shallow angles leading into the corners of the part, which could evoke bridging. If the degree angle is 90, this can be processed easily, as long as corners are radiused. Harder flow materials (polycarbonate) have difficulty with filling angles less than 45 degrees without bridging. That would result in unfilled corners or solid sections. Up to 20 degrees has been produced, but a low flowing rate is required, as with nylon. However, an adequate radius is required. This is shown in figure 2.20.

Tolerances

There are always some minor variations in the uniformity in batch-to-batch, which is mostly due to variables in improperly grounded plastic. Small parts can have closer tolerances than large parts which should be remembered when finalizing a product design. A thin walled product will contain

Dimensional tolerances							
Material		**A**	**B**	**C**	**D**	**E**	**F***
PE	Ideal	0.020	0.020	0.020	0.015	0.010	0.020
	Commercial	0.010	0.010	0.010	0.008	0.008	0.010
	Precision	0.005	0.005	0.005	0.004	0.004	0.005
PVC	Ideal	0.025	0.025	0.025	0.015	0.015	0.025
	Commercial	0.020	0.020	0.020	0.010	0.010	0.020
	Precision	0.010	0.010	0.010	0.005	0.005	0.010
Nylon	Ideal	0.010	0.010	0.010	0.008	0.008	0.010
	Commercial	0.006	0.006	0.006	0.005	0.005	0.006
	Precision	0.004	0.004	0.004	0.003	0.003	0.004
Polycarbonate	Ideal	0.008	0.008	0.008	0.005	0.005	0.008
	Commercial	0.005	0.005	0.005	0.003	0.003	0.005
	Precision	0.003	0.003	0.003	0.002	0.002	0.003

Note: in ± cm/cm, plus cavity tolerance
Ideal tolerance = minimum care required
Commercial tolerance = possible with reasonable care
Precision tolerance = possible with diffiulty and added cost.
* plus 0.25mm for parting line variations

Table B5.3 Tolerances of different materials (after Crawford, 1992)

more precision than the same size and shape of a thicker wall. Materials with smaller shrinkage factors generally create dimensionally more stable parts. Table B5.3 together with figure B5.9 presents an overview of the possible tolerances for different materials. The letters in the table referring to the figure. Theoretically there are no limits to the level of precision that can be built into a mould, but more precision brings costs.

Since rotational moulding is a pressureless process and no high pressure clamping between the mould

Dimensional tolerance considerations

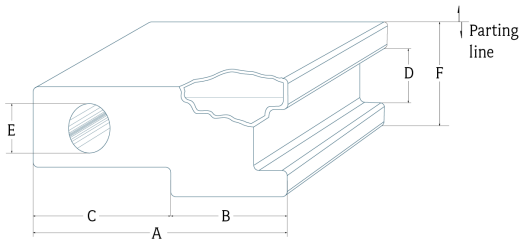


Figure B5.9 Dimensional tolerance considerations (after Crawford, 1992)

parts is required, larger tolerances are required on part dimensions that are perpendicular to the parting line of the mould.

Insights

There are many ways to come to a good design which is suitable for rotational moulding. Big flat surfaces should be avoided wherever possible, otherwise ribbs or kiss-offs should be used to stiffen the product. Rounded edges in the product to make it as easy as possible to make the product with rotomoulding.

C CONTEXT ANALYSIS

C1 Email to municipalities

A first step in this project

Before this project officially started, an email was sent to 140 municipalities in the Netherlands. The details of this email and the responses are given in this section.

Before this project started an email has been sent to all the municipalities that are affiliated with Midwaste to introduce the project and to ask is municipalities have specific things that they are currently missing or need which might be made out of plastic waste. The email that has been sent to about 140 municipalities is given in the box.

Email

Beste Gemeente,

Momenteel ben ik, Emma Wisse, student aan de faculteit Industrieel Ontwerpen TU Delft, (https://www.linkedin.com/in/emma-wisse-7a298081/) bezig met mijn master afstudeerproject waarin ik kijk naar mogelijke toepassingen van plastic verpakkingsafval. Op dit moment zijn gemeenten en burgers goed bezig om kunststof verpakkingsmateriaal in te zamelen, waarna Midwaste dit verder laat sorteren en een deel van kunststof verpakkingsmateriaal weer terug kan brengen in het keten. Echter blijft er op dit moment nog een mix van plastics over, waarvoor het lastig is een hoogwaardige toepassing te vinden (nu worden hier voornamelijk producten als plantenbakjes of bermpaaltjes van gemaakt). Gedurende mijn onderzoek wil ik kijken hoe er van deze mix kunststof-fractie ook hoogwaardige producten kunnen worden gemaakt.

Nu denk ik dat het mooi zou kunnen zijn als dit materiaal in een product terug zou kunnen komen in gemeenten, want samen werken we naar een circulaire economie. Daarom vraag ik jullie als gemeente of er nog wensen zijn op productniveau voor bijvoorbeeld publieke ruimtes (denk aan bijvoorbeeld straatmeubilair, vogelhuisjes, speeltoestellen, tegels, prullenbakken etc). Een kanttekening bij dit materiaal is dat dunwandige producten of slanke producten (zoals lantaarnpalen) lastiger zijn.
Al uw ideeën mag u met mij in welke vorm dan ook met mij delen via ewisse@midwaste.nl. Ook als u specifieke vragen heeft of meer zou willen weten over dit onderwerp of over mij, kunt u via mail contact opnemen via de mail.
Alvast ontzettend bedankt en ik kijk uit naar al uw ideeën!

Met vriendelijke groet,

Emma

A few responses from municipalities came back. Of course it was a hard for municipalities to come up with very creative ideas, but at least I got some idea of what municipalities think concerning this material and products made out of it. The responses of municipalities are listed in table C1.

Product	Municipality
Banken	Hendrik-Ido-Ambacht Zevenbergen Heemskerk Wormerland of Oostzaan
Damwanden	Hendrik-Ido-Ambacht
Beschoeiing	Hendrik-Ido-Ambacht Langedijk Wormerland of Oostzaan
Speeltoestellen	Hendrik-Ido-Ambacht Zevenbergen
Steigers	Hendrik-Ido-Ambacht
Fietsbruggen	Hendrik-Ido-Ambacht
Tegels	Hendrik-Ido-Ambacht
Diamantkoppalen	Hendrik-Ido-Ambacht
Tafels	Hendrik-Ido-Ambacht
Geluidscherm	Bergen op Zoom
Afvalmanden	Uden Utrecht (binnenbak)
Tuinafscheidingen	Uden
Kruiwagen	Uden
Compostsilo's	Uden
Voorgevormde vijvers (in combinatie met een bepaalde vorm van wapening)	Uden
Tuinkasten voor opslag gereedschap en of kussens van tuinmeubilair	Uden
Keerelementen	Uden Heemskerk
Stapel-elementen t.b.v. tuinmuurtjes	Uden
Verkeersborden/ straatnaambordjes	Langedijk Heemskerk

Table C1
The products municipalities suggested

Brainstorm Municipality of Breda C2

Getting inside of what municipalities want and how they see plastic recycled products

On the 4th of July, a brainstorm was executed with the municipality of Breda about possible applications of the mix fraction. In this section, this visit is described and insights are given.

C.2.1 Introduction and method

During this brainstorm, six people from different departments participated. We started with an introduction, because not everyone knew each other. Afterwards the agenda was instructed with the people attending the meeting.

C.2.2 The brainstorm

We started with two ice breakers to try to make people more open minded. Then, I gave a short briefing about the limitations of the material and boundaries of the project. After a short explanation of the rules of not being critical; do not use 'yes, but', but 'yes, and', we started a 'How can you' workshop in which the next questions were asked:

- What does Breda likes to see in recycled plastic?
- How can you make the plastic problem worse?
- How can you make products out of the mix fraction?
- How can you express sustainability?
- How can we recycle plastic as less as possible?
- How can you create awareness for plastic products?

To be more diverse, the last two questions are formulated as reverse brainstorm questions. During this session, I was keeping track of time and guiding the team.
The setting of this "How can you" session is shown in the pictures on the next spread. The results of this session are shown in figure C2.1.

After this "How can you" session, we started a discussion about the subject; how Breda sees the problem of plastic waste and how this can become a new source for products.
At this point, I also presented first ideas to give some material to associate with (see figure C2.3). After explaining these ideas, a mind map is made on a flip over of the ideas that came up (figure C2.2).

C.2.3 Conclusion and discussion

The visit was not as fruitful as I expected it to be. Apparently, the "how can you" session was tough. People did not come up with useful information or ideas. This might be due to the formulation of the questions. Secondly, people considered the two 'reverse brainstorming' questions confusing. On the other hand, people did write down more, so this reverse brainstorming might work better if all the questions were formulated reversed and split it up into two sessions.

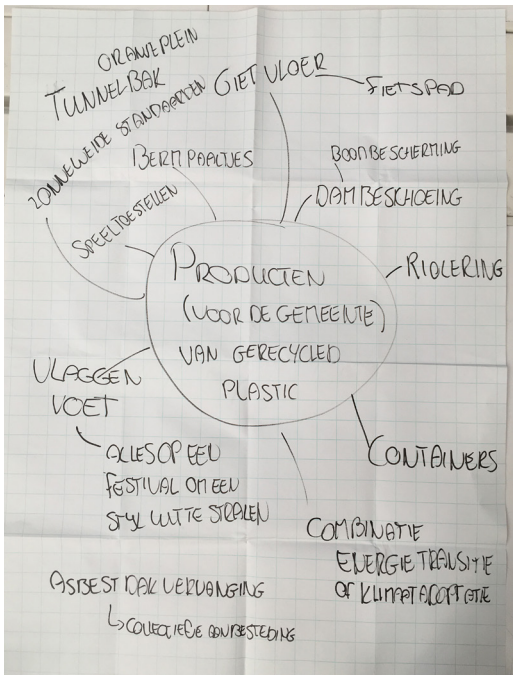


Figure C2.2 The flipover with ideas of participants.

Figure C2.1 The how to's of the brainstorm session

During this session, also one of the participants just stood up to take coffee, which was pretty annoying since every question was switched every two and a half minutes. (Normally this time is shorter, but I noticed that people start writing things down after one and a half minute, so I gave them extra time.)

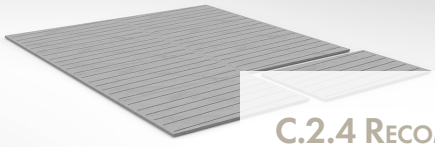
This same participant also came into the meeting late and missed most part of the introduction round. Even though I asked everyone to be open minded and not critical, especially this participant had a very sceptic attitude. Honestly, I did not know what to do about it except ignoring it and be as open as possible to everyone and keep them updated of what we were going to do next (also announcing break times).

The plenary discussion worked out better. Everyone was participating evenly and people were associating. I noticed that similar ideas came up that I had so during this discussion I felt it was helpful to present my ideas. This one participant staid very critical in finding the purpose of the meeting and he kept asking what we were doing.

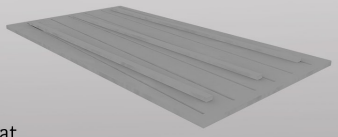
Figure C2.3 The two posters used during the brainstorm at Breda

Modulaire vloersystemen

Voor evementen in en rondom de stad



Plastic mix platen, in plaats van hout



Plaat bevat dunne spleten en wordt gelift van de grond zodat water weg kan

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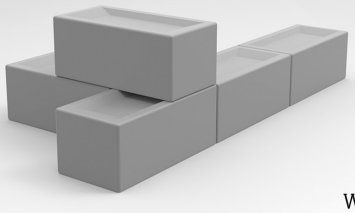
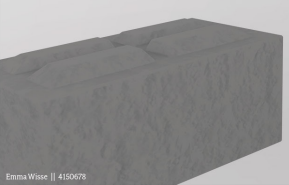
Modulair straat meubilair

en tevens terrorisme bestrijding



Wegafzetting en bescherming

Binnenstuk verwijderbaar om plantenbak te maken



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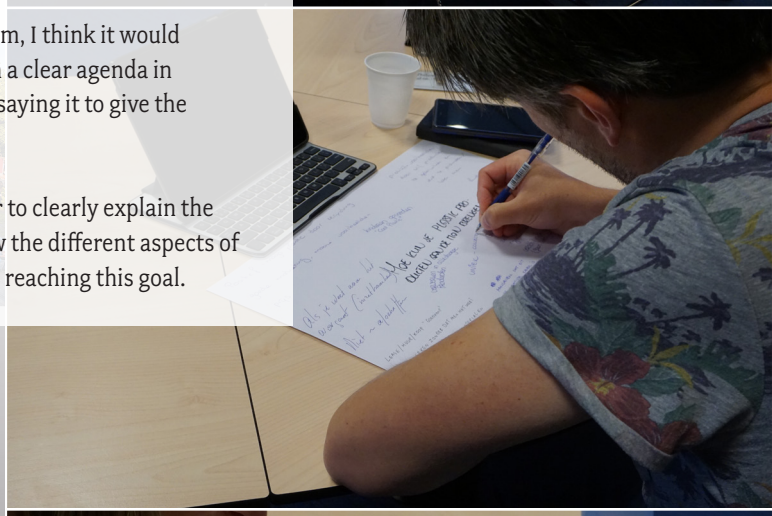
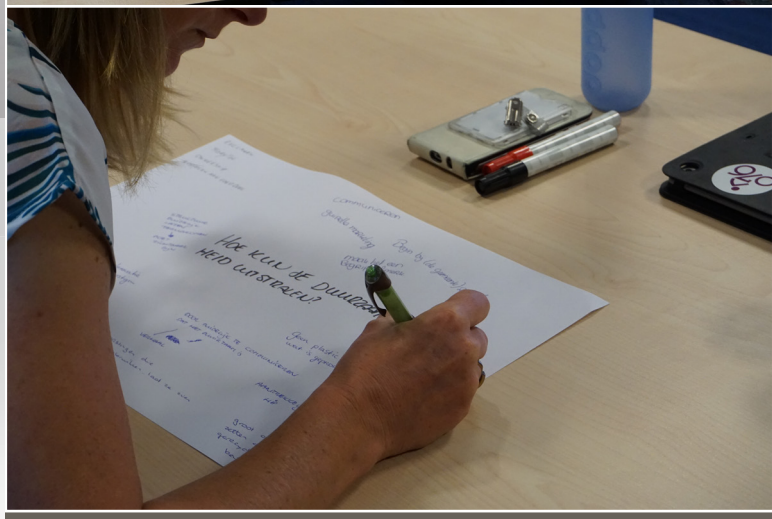
C.2.4 Recommendations

If I would do another brainstorm, I think it would be better to may be write down a clear agenda in a presentation instead of only saying it to give the brainstorm more structure.

Besides that, it would be better to clearly explain the goal of the brainstorm and how the different aspects of the brainstorm contribute into reaching this goal.





Insights

Breda is open minded towards projects in cooperation with this material.
A combination with the energy transition or the climate adaptation to achieve a circular economy would make a good story. A story will make the idea a lot stronger.

C3 Fair for public spaces

Utrecht, 26th and 27th of September

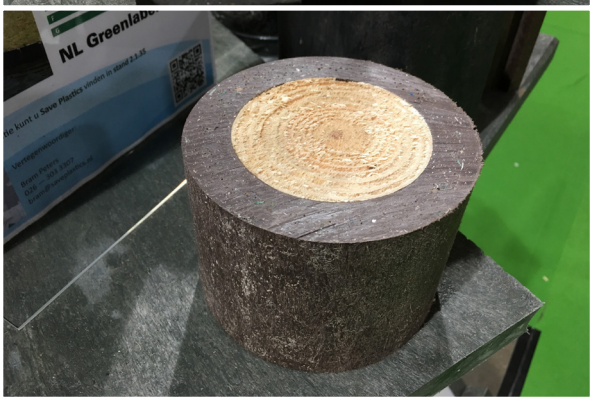
In this section, the visit to the "Vakbeurs voor openbare ruimte" is described. The insights out of this visit is are summed up in the end of the section.

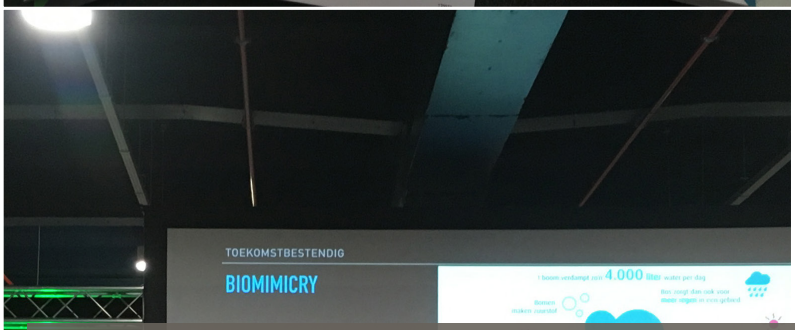
C.3.1 Introduction

On the 26th and 27th of september, the Fair for public spaces was visited. In advance, some lectures were chosen to visit. Besides this lectures, the main goal was to get inspired in what is happening in public spaces and what kind of solutions are found to tackle the problem of water management in urban areas.

C.3.2 The visit

During this visit, I spoke with several people about what is happening already with sustainability in public space. Besides that, I talked with a company that also had rotomoulded products, Water2keep and developed Rainblocks. This is a product that is a wall separator and a rain barrel as well. These barrels can be connected (see the photo with the pvc pipe and the black silicone rings) to create one big rain barrel. Each barrel contains 165L of water and their focus group is companies. Jos van Dam explained to me how these barrels were connected. It is very useful to design with standard elements, also because it makes particles cheaper. Moreover I spoke with Saveplastics that develop products made out of the same material, DKR350 that is used in this project. They strengthen their products with steel or wood (see the three pictures on the left page) and product their product with intruding, which is comparable with a slow version of injection moulding. They develop products for road construction, nature and recreation, and water management. Saveplastics process the bales with a DKR350 standard themselves.





Insights

Green in cities help with water management and everyone want green in the city. However,to make a change and make it work, it is important to stimulate the emotion (Leur, van H., 2018).

An important thing to optimize recycling is to give a material passport to everything. Packaging should get this as well (Leur, van H., 2018).

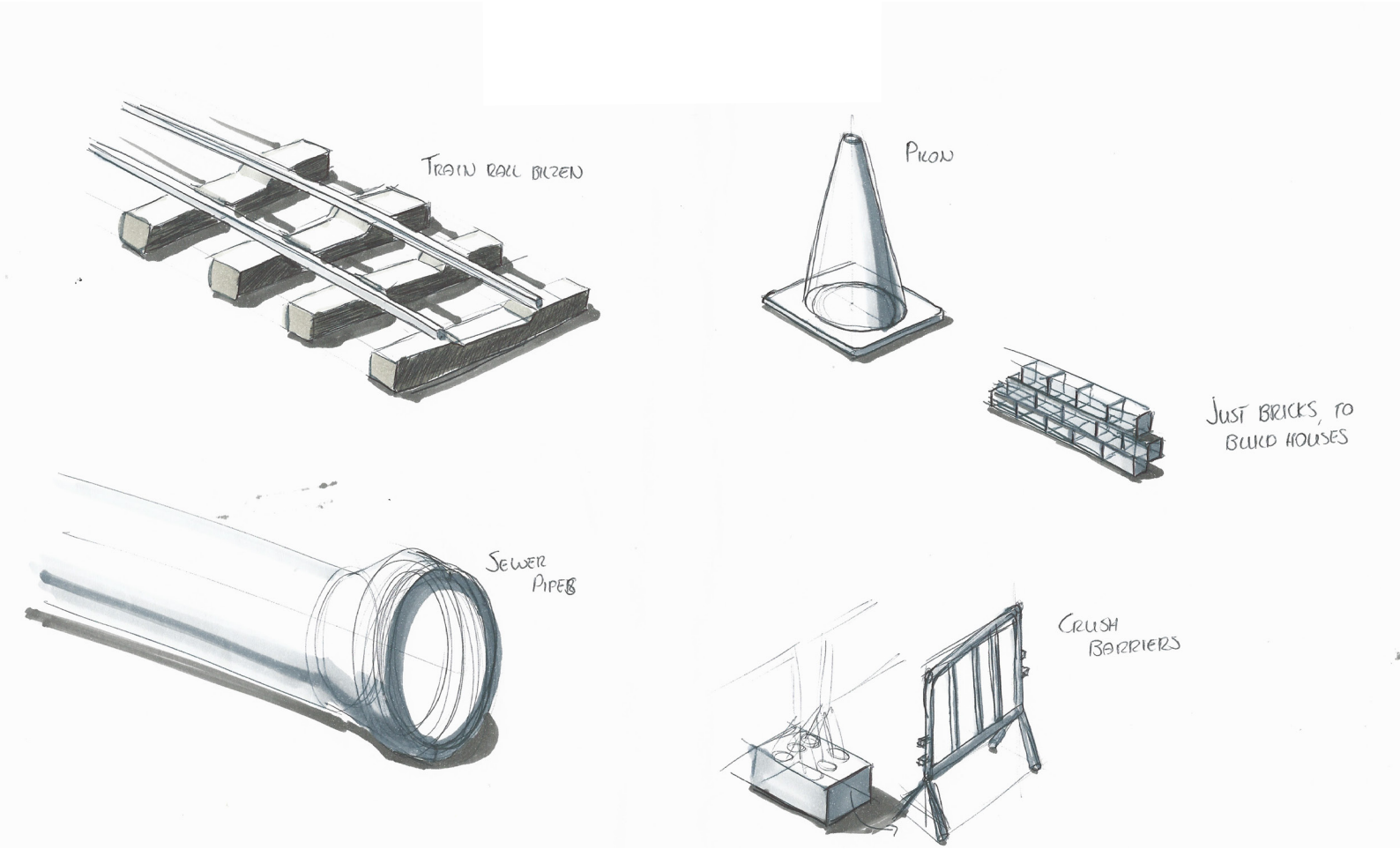
Climate adaptation is shifting from public pace to private area, to the user (Verlinde, J., 2018).

C4 Ideat generation

The discussed ideas with in between conclusions, the guidance of this project

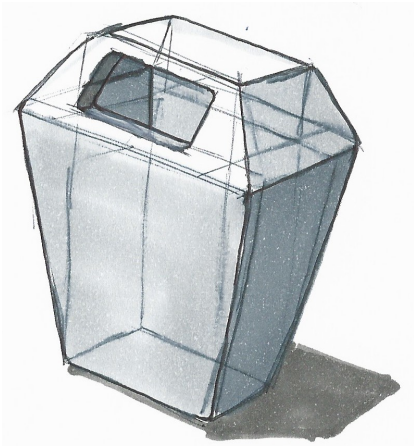
Construction material

This materialcould be used for a wide variety of construction applications. Think of isolation material. Besides that, it could be used to make train sleepers, sewer pipes, pylons and crush barriers.



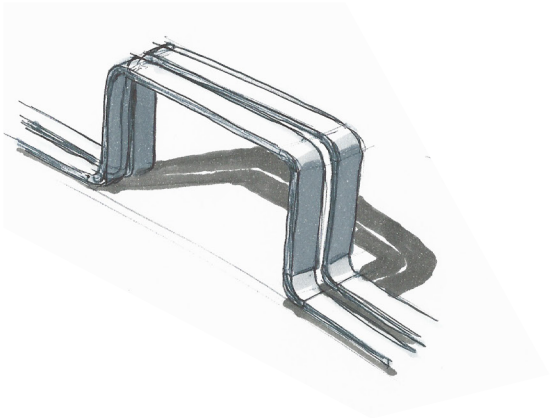
Garbage for garbage

Another option would be garbage bins. In public spaces, a lot of cabins are placed. In the future, these can all be made out of this mix fraction.



Grey line

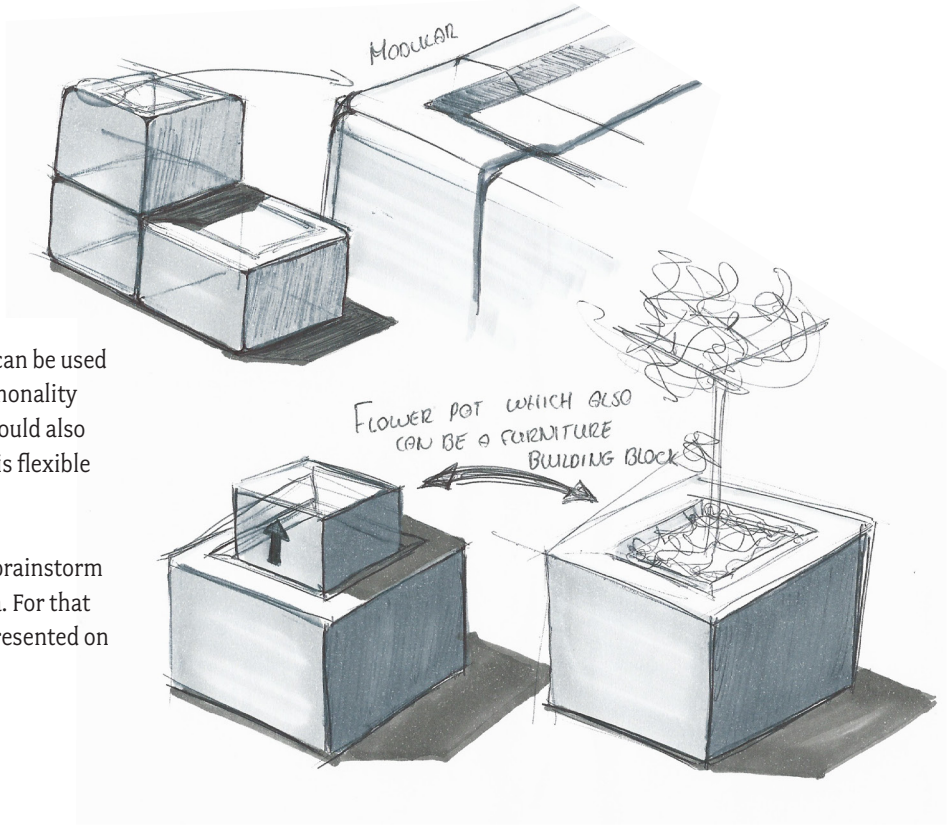
An interesting other approach would be furniture that emphasizes nature and goes around it. Think of a couch around a tree. Then, this material would be like a red thread throughout a city.

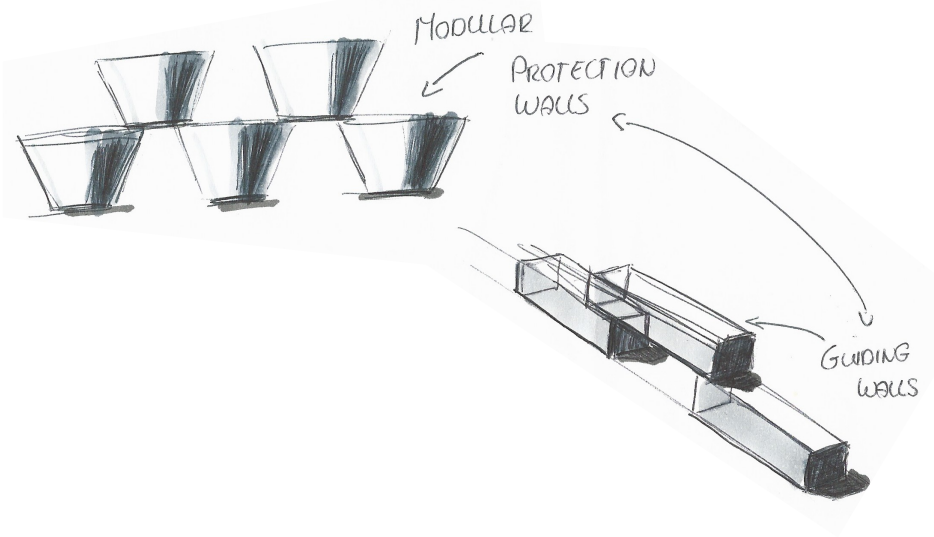


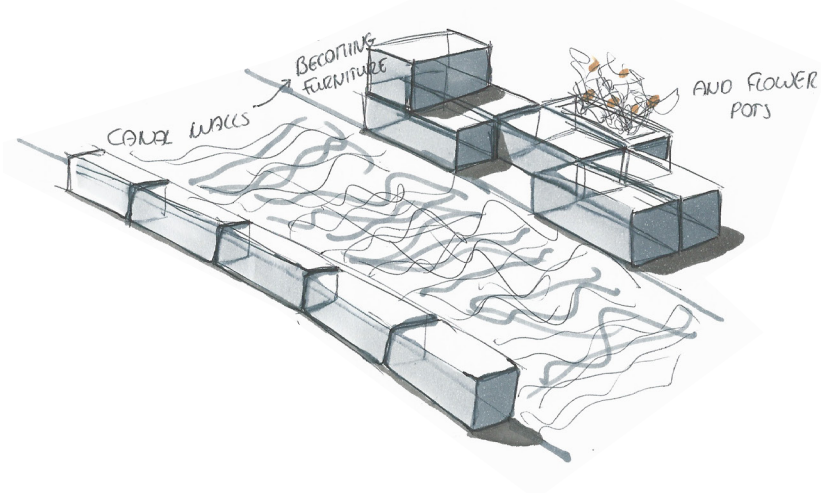
MoiDeas

This idea responds to a modularity. It can be used as roadblocks that provides the commonality safety during events. Besides that, it could also serve as public furniture. This system is flexible and could be both temporary or not.

This idea is also discussed during the brainstorm session with the municipality of Breda. For that session, a poster was made which is presented on the next page.

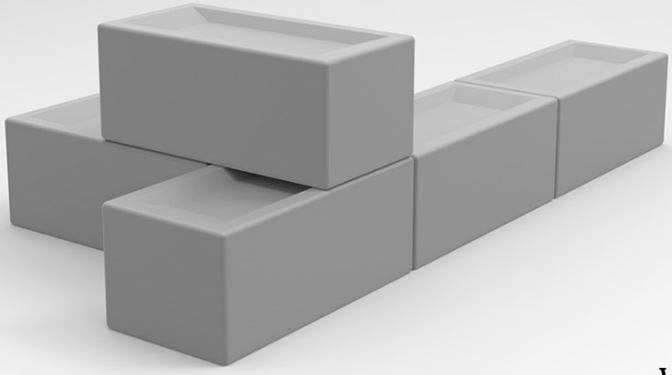




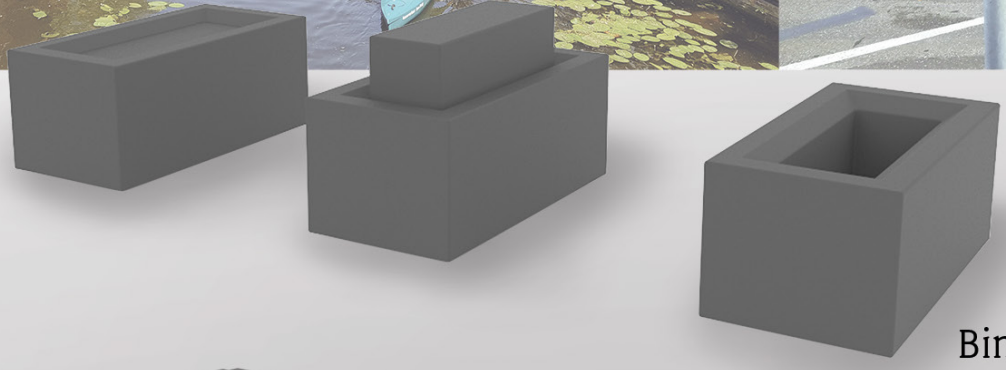


Modulair straat meubilair

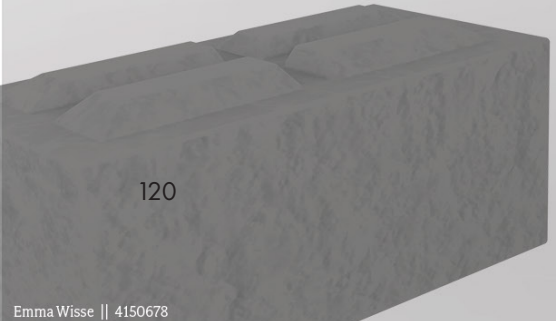
en tevens terrorisme bestrijding



Wegafzetting en
bescherming



Binnenstuk verwijderbaar
om plantenbak te maken



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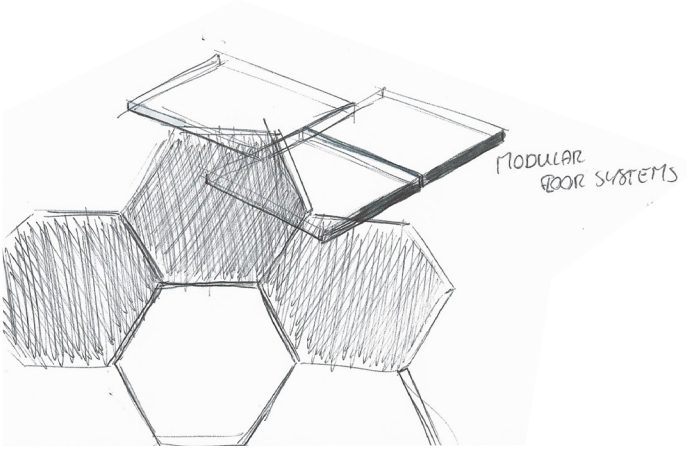
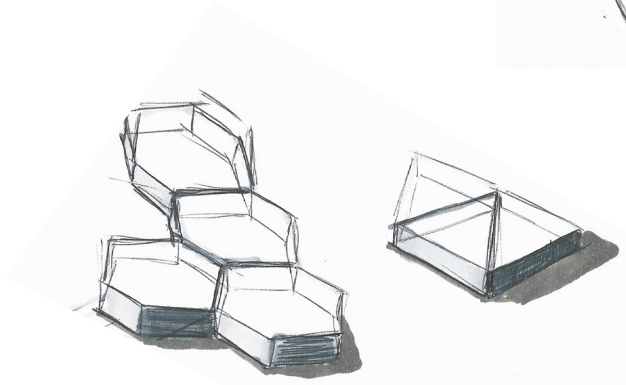
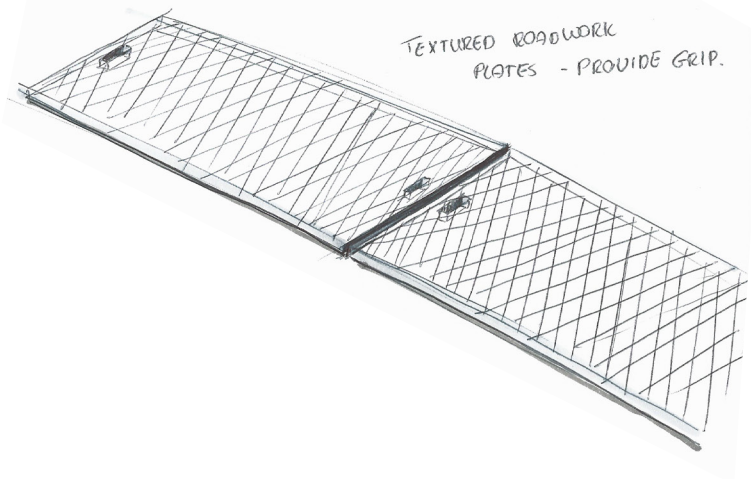
Modular floor systems

During festivals or events, the ground is often protected with temporary flooring. For instance, this is made from wood. However, this could also be made out of the leftover mix fraction of PMD.

Also, this idea is discussed during the brainstorm session with the municipality of Breda. As well as with the modular street furniture, a poster was made for this session.
It was more to give the participants inspiration to come with ideas than the idea itself was intensely discussed.

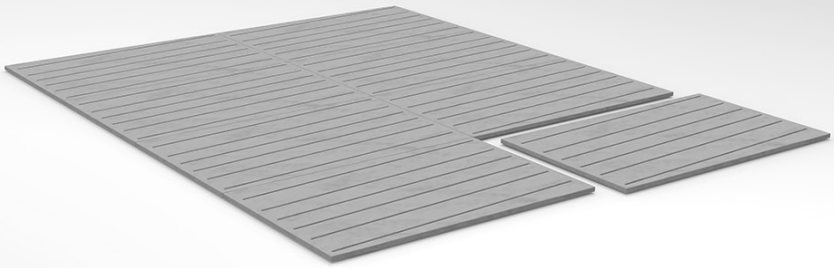




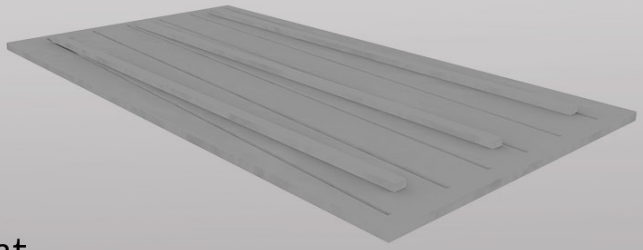


Modulaire vloersystemen

Voor evementen in en rondom de stad



Plastic mix platen, in plaats van hout



Plaat bevat dunne spleten en wordt gelift van de grond zodat water weg kan

TU Delft Midwaste

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3 Directions C4.1

A summary of three ideation directions

In this section, three directions are discussed. These ideas are not defined towards a concept level. The latitude of this project asked for a different approach and the concept detail concept developement will be done in the phase after choosing a direction.

C4.1.1 Introduction

Throughout this project, ideas are generated. Afterwards, three directions were chosen. These three diretions guided the project towards CirculEm.

C4.1.2 Enlighted safety

During a solo brainstorm session, some ideas were sketched on a flipover (figure C4.1).
The first idea direction can be seen on the top of this figure. An enlighted object in public space like a park. This could be a couch or (re)building blocks and could function as furniture as well. This idea in general responds to the trend that people tend to feel unsafe in the dark in public areas. When it turns out that the material is not having mechanical properties, this idea could still work, but then it would not be an object to sit on.

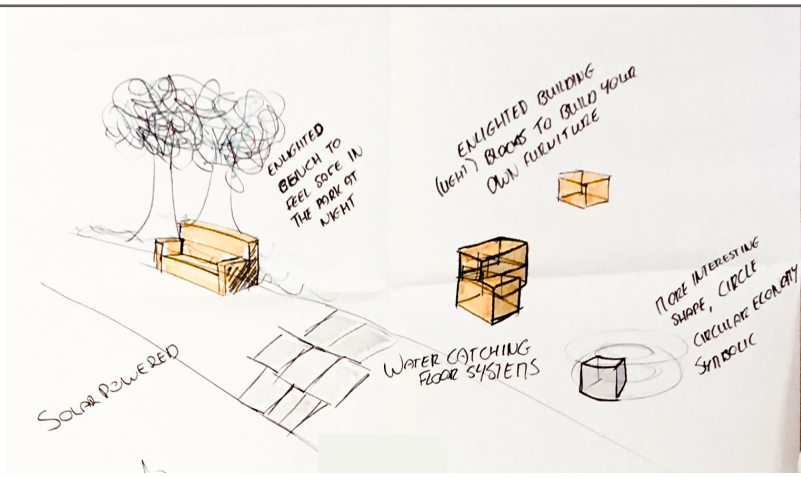


Figure C4.1 First part of the flip over of the solo brainstorm

C4.1.3 Blikvanger (eyecatcher)

The second direction, Blikvanger, is also about safety, only then literally. The modular street furniture idea which was also discussed during the brainstorm session with the municipality of Breda. These blocks, which also could function as furniture or as planter, could be filled with water and stacked to build a big object or a wall, which could be temporary or not, and protect people during events. Simply said, it then functions as a nice looking roadblock, which could be an eyecatcher and catching 'blik' (tin-plate), literally.

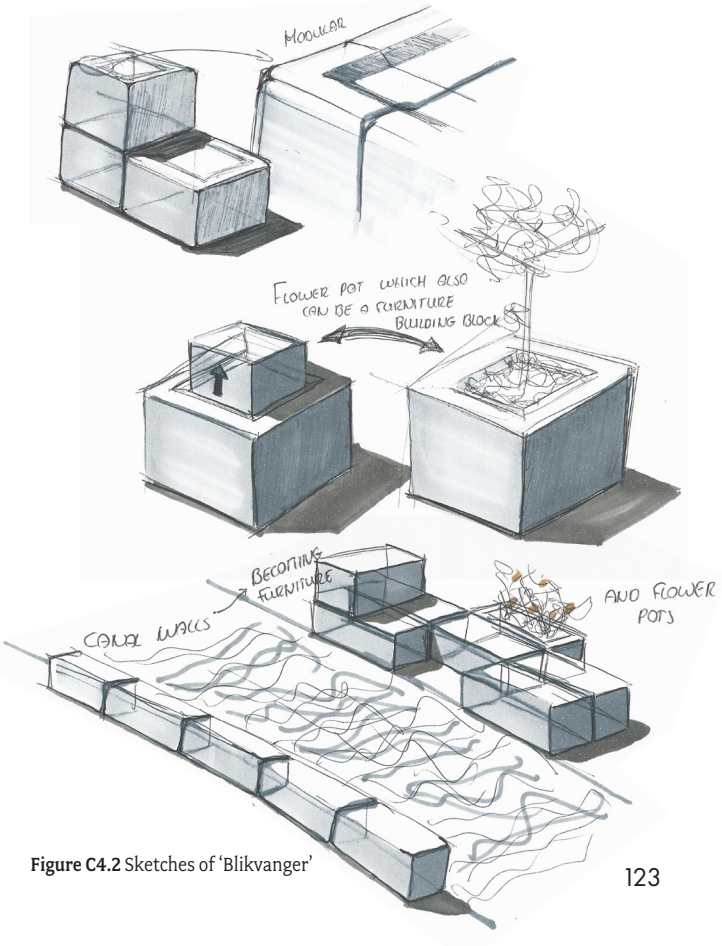


Figure C4.2 Sketches of 'Blikvanger'

C4.1.4 Water care

The third directions responds to another trend, water management. In urban areas, rain ends up in the sewage system. The groundwater level drops and sewage systems gets overloaded during a heavy shower. In this idea direction, an object collects rain water, providing it going into the sewage system. One idea in this idea is a rocking chair which covers rainwater at the same time. On top of that, the sound of the water during rocking, might be relaxing, which even responds to another trend that people nowadays are more stressed.

This idea of being a chair could also work in a more public space without the rocking part. Then it could be a couch with an open area to collect rain water.

Another idea in this direction would be a rain barrel in a citygarden, could be enlighted as well, and can be used by everyone who shares the city garden.

C4.1.5 Choice of direction

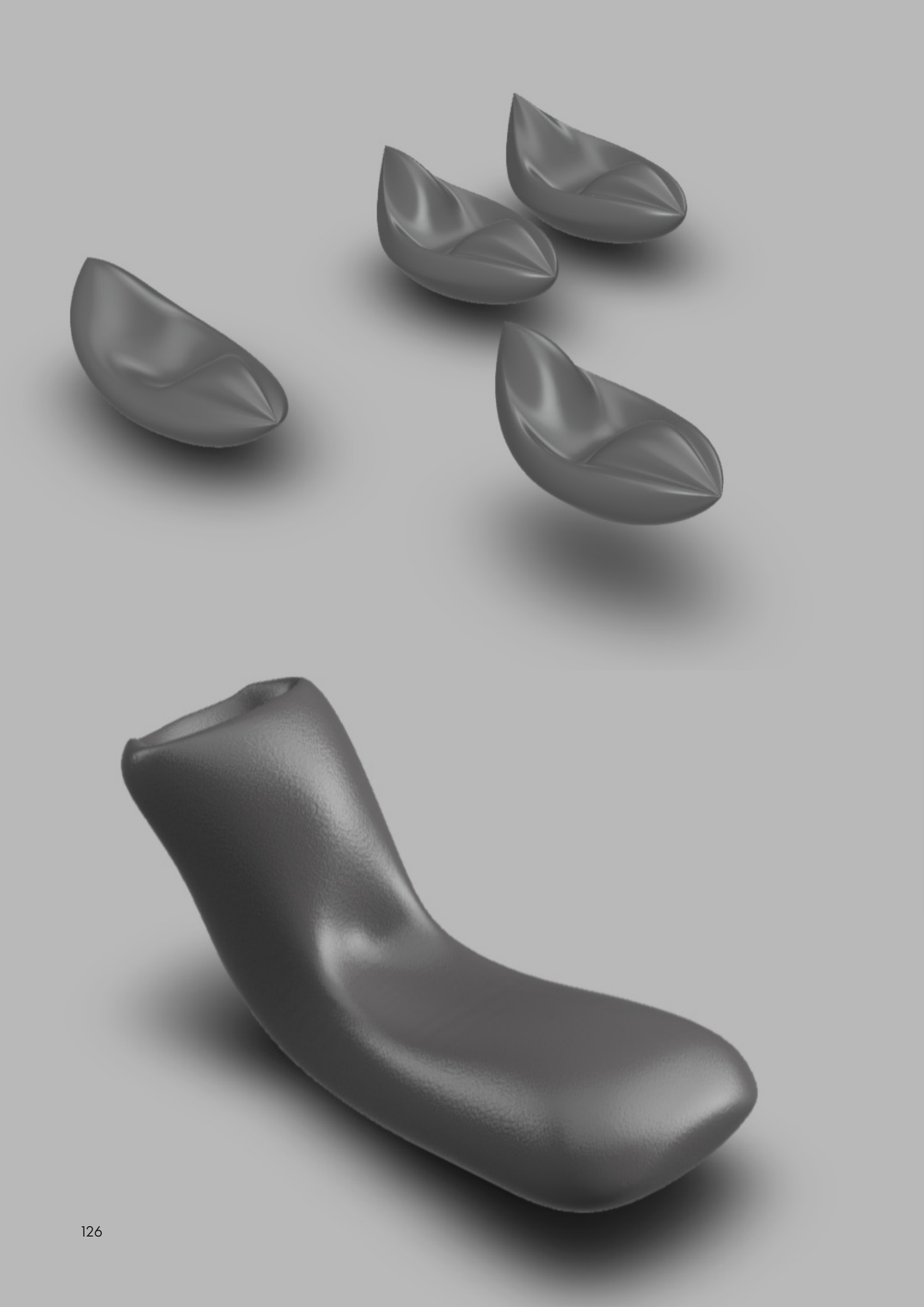
Each idea direction responds to a relative trend. However, the last idea direction strengthen the idea of a circular economy responding to water management within the climate change. Therefore, this water care idea direction seems the most interesting one.

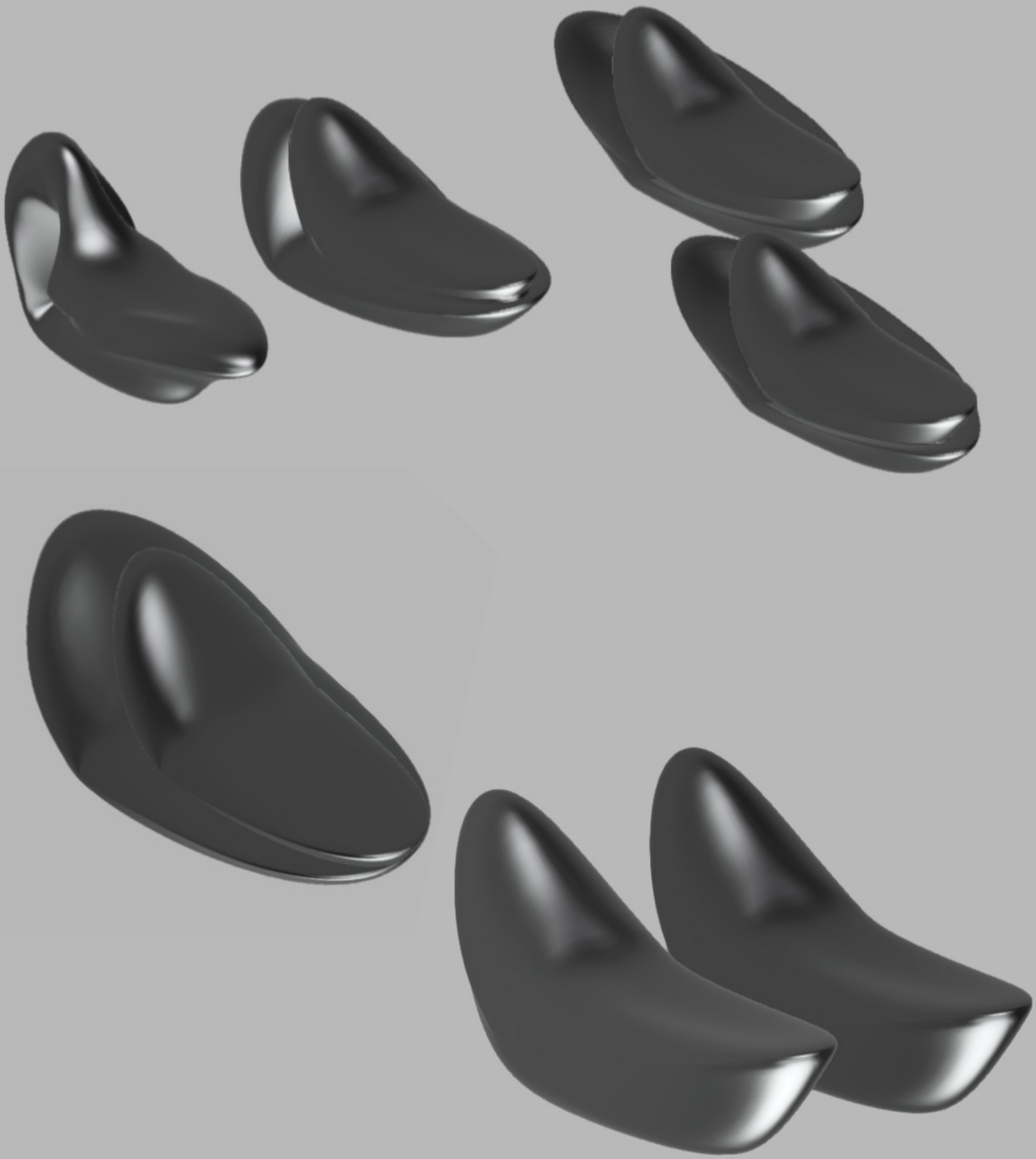
Looking further into the third direction, Climate adaptation is an interesting trend to combine the leftover mix with. To create awareness, coming close to the user is important, so a product for personal belonging is a solution. Moreover, being original was one of the wishes.

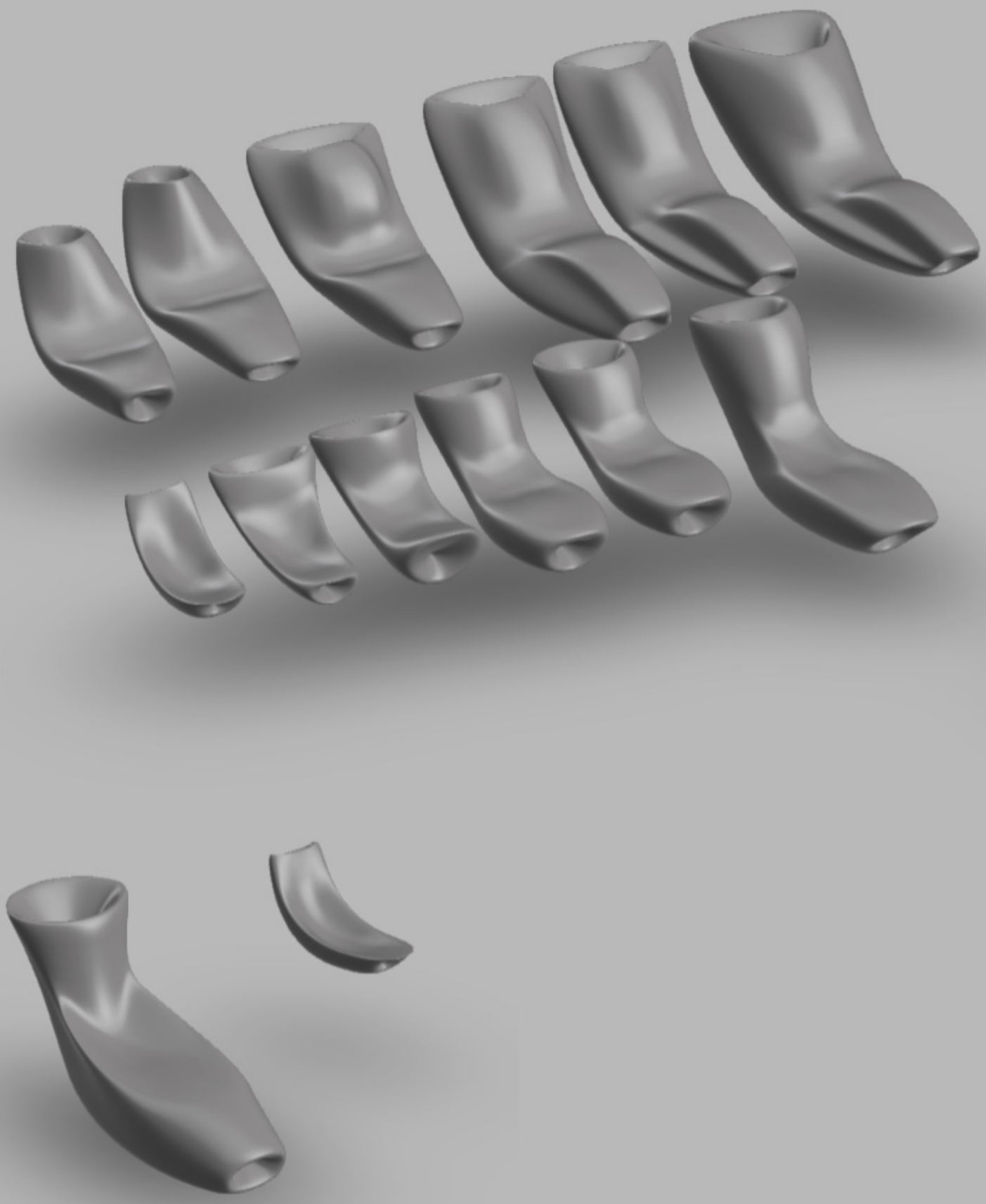
Figure C4.3 Second part of the flip over of the solo brainstorm

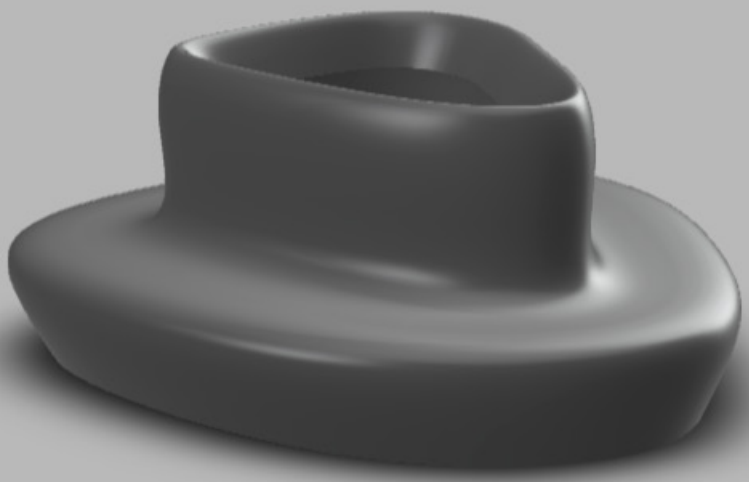
EXPLORATION OF THE ROCKING CHAIR AND ROCKING DECK CHAIR

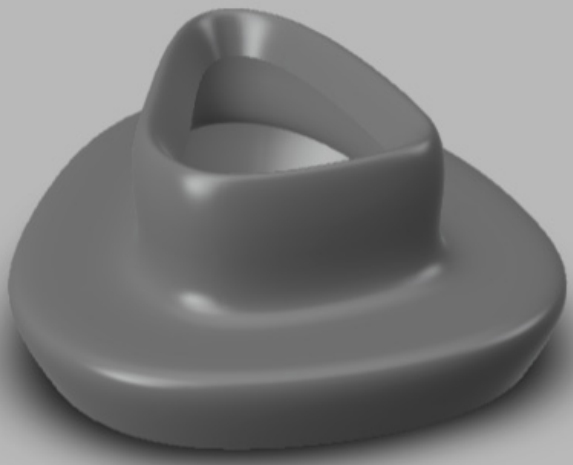
C4.2

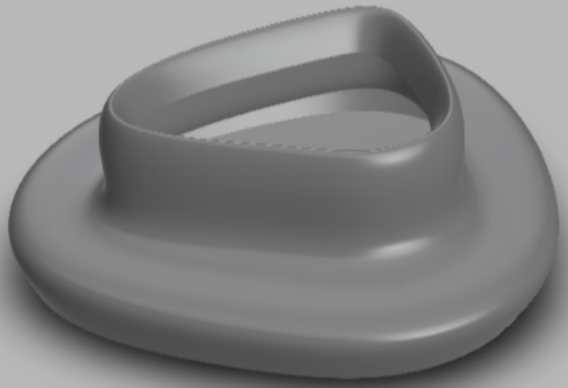


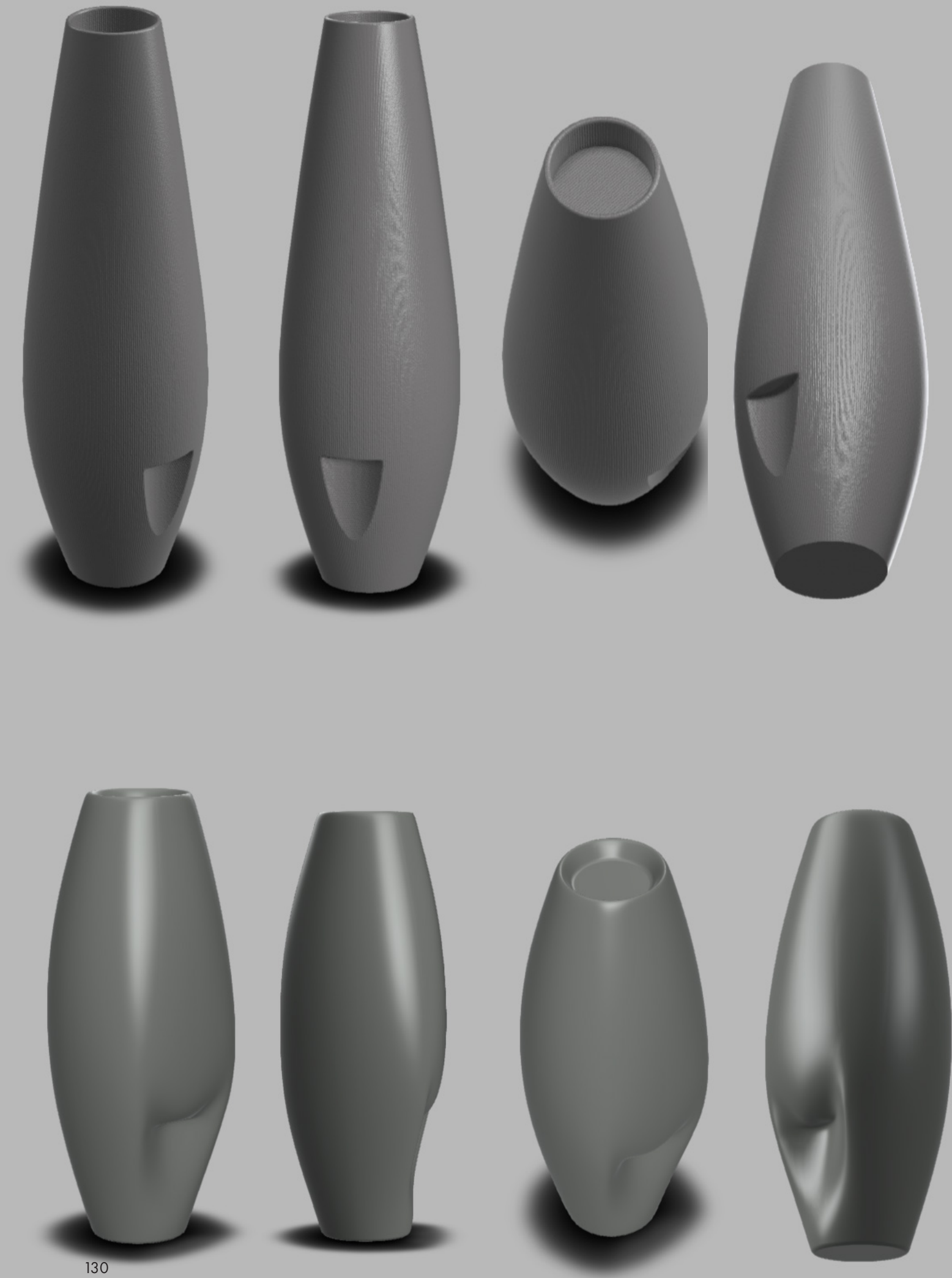












Workshop Midwaste C5

Defining the expression of sustainable products

To get a better insight of what aspects in products make it looks sustainable, a workshop is done with some people of Midwaste during a lunchbreak.

C5.1 Introduction

To do this workshop a set of cards was used. All the people got a couple of cards which they had to divide into two groups, looking sustainable or not. When everyone was done, all the cards were spread over the table into these two categories. It was discussed why an image was looking sustainable or not.

C5.2 Insights

During this meeting I found out that for a lot of people, quality and durability was closely associated with sustainability (figure C5.1). If a product looks decent that last long, it is much more considered sustainable than products that should be replaced within a short time (less than five years).

Moreover, also the application of the product was considered important. If the product can be used for only one specific application, it was also considered less sustainable and a waste of material use.
A natural look, without heavy paint looked also more sustainable to the employees of Midwaste, also because they thought the recyclability would be better. In a word map (figure C5.2), the overview of what sustainability expresses in products is represented.

Using a lot of different materials in one product also is considered less sustainable, especially when it seems not possible to disassemble.

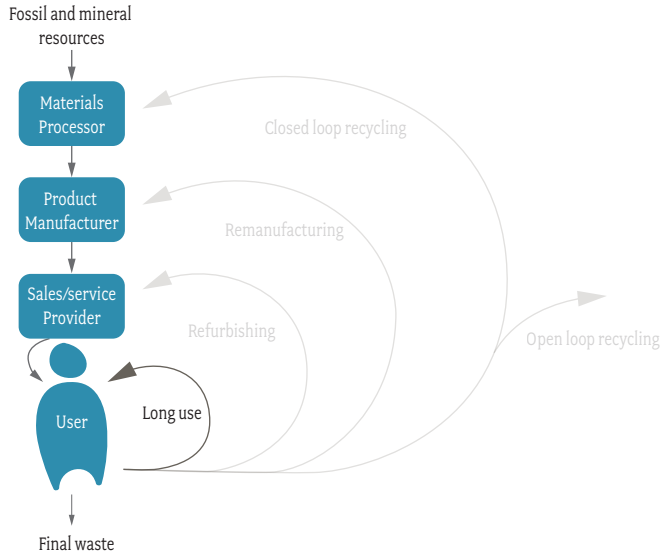


Figure C5.1 The long lifespan closely associated by people, contributing in 'looking' sustainable.

Figure C5.2 An overview of the words that express sustainability in products

The two clusters of images that looked sustainable and products that did not look sustainable.

Wooden materials in general came out looking sustainable, as well as products out of steel.

Sometimes it was hard to say why an image was not looking sustainable, but this triggered a good discussion about which was.

Aesthetics C6.1

What is aesthetically appealing?

In this section, the aesthetic design principles of Hekkert (2006) are explained. Afterwards, two moodboards are presented to give direction on how the product should look like and what is should express.

C6.1.1 Aesthetics being an experience

As a future design engineer, I want to make something aesthetically appealing. But what exactly is aesthetically appealing? Paul Hekkert (2006) argues that the full experience of products should be considered as being aesthetic, which means pleasurable to the senses. So aesthetics is not only about products looking beautiful, it is about the complete experience, attained on sensory perception. This means that an experience of any kind, in a product, a landscape or anything else includes an aesthetic part, but the experience as a whole is not aesthetic.

Hekkert argues that the entire set of effects that is elicited by the interaction between product and user is experience. This includes the degree to which all our senses are gratified) the meanings we attach to the product (experience of meaning), and the feelings and emotions that are elicited (emotional experience).

C6.1.2 Principles of pleasure in design

Aesthetics in design is accomplished, looking into four main design principles.

Maximum effect for minimum means

The first principle, which can be considered as the overarching principle, is about the maximum effect for minimum means. This principle explain the fact that if we can smell, see, hear or decide something faster or with less effort, we prefer it over the more demanding alternative. For instance patterns help us to get informed faster. Thus, a pattern is pleasing to the eyes. When a pattern is ambiguous, it allows for more than one interpretation. Besides ambiguity, there is also a metaphor, which long has been seen as a stylistic device to say something that is difficult to express in words. Now, it also has been acknowledged that the application of metaphors is much more widespread and that we use metaphors (figure C6.1) as an economical and efficient way of expression that is not restricted to language (e.g., Forceville, Hekkert, & Tan, 2006; Ramachandran & Hirstein, 1999).

Unity and variety

The second principle is about unity and variety in products. Our sensory systems constantly try to detect order in chaos, in other words, unity in variety. We have our senses to gather information about the world and to identify bad or harmful things or what is good or contributes to our survival. However, we cannot pick up all information and therefore it is beneficial to perceive connections and make relationships. Besides that, we like to see connections and we consider it aesthetically pleasing to invest effort in finding these connection. A design should not give everything away at onces, such as translucent materials in products that partly conceal the inside components. At last, symmetry, good continuation, contrast and closure are good mechanisms to achieve a good balance in unity and variety. It is important that our senses have to be sensitive enough to perceive the, sometimes hidden, structures (Hekkert, 2006).

Figure C6..1 Methaphor design (pinterest.com)

Most Advanced, Yet Acceptable

Most advanced, yet acceptable, MAYA is the third principle, by the American designer Raymond Loewy (1951). This principle means that product designs can have an increased novelty while preserving its typicality and we tend to prefer products with an optimal combination of both aspects (Hekkert, 2006). This principle leads often to individual differences since we all have different experiences and qualities.

The optimal match

The last principle is about the optimal match. Products adres various senses simultaneously which makes them multi-model. This principle concerns the relationship between these various sensory impressions. It is important to define the function of a product which could be experimental, to enrich, to inspire, etcetera. Nowadays, many people believe that a product experience as a whole is more decisive in people's buying behaviour than the primary function.

C6.1.3 From abstract to concrete

These principles help defining aesthetically appealing products, but differences will arise since people have different backgrounds or previous experiences. Besides that, these principles are a bit abstract. Sam de Visser (2014), came up with a presentation in which he tries to give more concrete design rules to come up with a good design. Within these principles, there is much overlap with the principles of Paul Hekkert.

Basic design understandings

At first, there are some basic understandings about designing a product, according to Sam de Visser:

- It is important to know the material, since these could determine the design freedom. In this project, the material is a starting point. This is agglomerate made out of the DKR350 fraction of domestic plastic waste.
- Make splitlines part of your design. If you cannot hide it, show it.
- The product should be producible. Think of draft angles and curved edges. With rotational moulding this means that sharp edges and deep ribs should be avoided.
- The product has to look as solid as the handling requires, in other words trustworthy.
- The product should be easy to operate.

C6.1.4 Design principles of De Visser

To continue, the design principles of Sam de Visser are described to give a grasp of how to tackle and implement the principles from Hekkert. The principles Sam describes are:

Balance

Balance is a feeling of weight, attention, or attraction of the various elements within the composition as a means of accomplishing unity. This principle is responding to two principles of Hekkert: unity and variety and the optimal match.

Balance can be physically (so literally), but the designer also needs to create an illusion of balance, referred to visual balance. This happens is a three dimensional work of art and can be distributed in three ways: horizontally, vertically and radially. The parts are distributed in such a way that the viewer is satisfied that the piece will not pull over itself. This can also be both symmetrical, which is known as formal balance and asymmetrical, known as informal balance. The different aspects of this principle are visually explained in figure C6.2.

Symmetrical balance can be achieved in two ways: pure symmetry and approximate symmetry. Pure symmetry can be recognized by identical parts equally distributed on either side of the central axis, in a mirror-like repetition. For instance, butterfly or a human face. This kind of symmetry in products can become too monotonous and uninteresting to look at easily. Approximate symmetry on the other hand had a greater interest and appeal for the viewer. Even though the sides are varying somewhat, they are still similar enough to make a repetitious relationship symmetrically balanced.

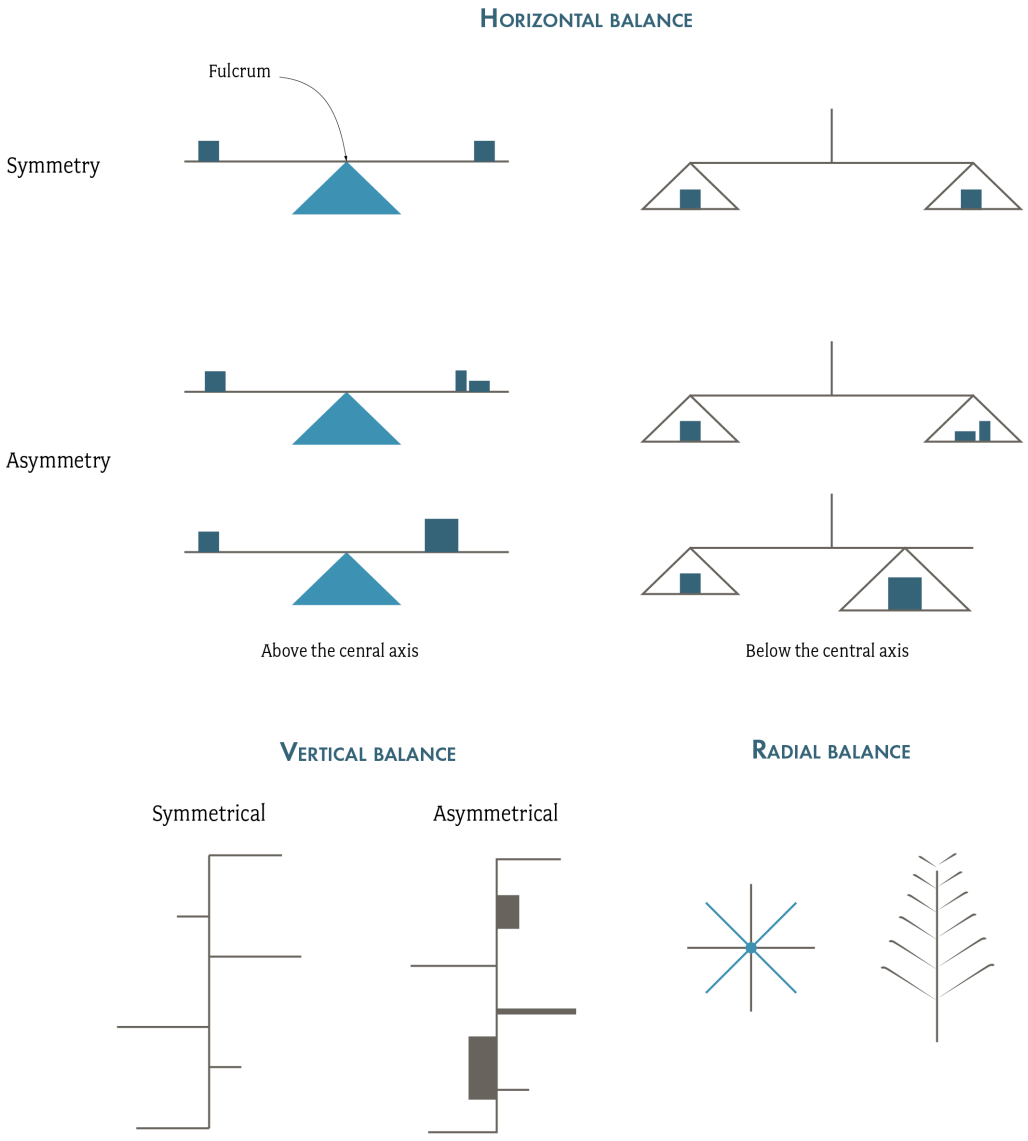


Figure C6.2 Different aspects and types of balance (after Visser de, S.,2014)

Asymmetrical balance is when both sides of the central axis are not identical. However, they appear to leave the same visual weight. This type of balance allows more freedom in shape, because there are unlimited arrangements. By balancing two or more unequal components on either side of the fulcrum and varying their size, value or distance, asymmetry can be used.

Movement

The suggestion of action or direction, the path our eyes follow when we look at a product. With this movement, designers can control and force the movement of the viewer's eyes on and around the composition of the design. The eye will 'travel' along an actual path, like a solid or dotted line, but this path can also be more subtle. For instance from large to little elements, from dark to lighter elements, from colour to non colour and form unusual shapes to usual shapes. Graduation of size, and repeated shapes and size of related elements also subtly leads the eye (Visser, de. S., 2014).

Repetition and rhythm

The act of repeating an element either regularly or irregularly in a rhythm of the repeating elements. When using an element repetitively, it can create visual rhythm. Repetition does not always mean an exact duplication, but can also mean similarity or near-likeness. Moreover, slecht variations will add interest. Rhythm is the result of repetition which leads the eye from one area to another. It can be produced by continuous repetition, periodic repetition or by regular alternation of one or more forms or lines. This form may slightly change, or repeat with periodic changes, in size, colour, texture or value.

Emphasis

Emphasis in design is necessary, but a good composition is one in which all elements work

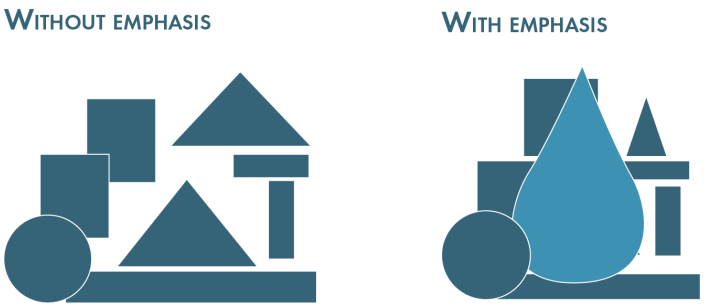


Figure C6.3 Designing with emphasis (after Visser de, S.,2014)

together for a unifying effect. This principle actually responds to every aspect of Hekkert. The stress placed on a single area of a work or unifying visual theme. By placing emphasis on certain areas in a design, elements of interest are created which causes the eye to return to again and again.

To achieve emphasis, a center of interest, also known as a focal point, can be created (see figure C6.3). This focal point can be created by making one area or element of the design dominant by being the largest, brightest, darkest or most complex part of the whole. Another way to create emphasis is by contrasting the primary element.

Simplicity

The elimination of all non-essential elements or details to reveal the essence of a form. Less is more. Simplicity or minimal design is an addition of the emphasis principle in order to emphasize what is important.

Contrast

The difference between elements for the opposition to various elements. The bigger the difference, the bigger the contrast. Contrasts adds variety and unity to the total design at the same time. It adds visual interest and design with lack of contrast could become monotonous. However, too much contrast can become confusing. Just the right of amount of contrast engages the viewer's participation in comparing various components of the product.

Proportion

Proportion in design is the comparative harmonious relationship between two or more elements in a composition with respect to size, colour, quantity, degree, setting, etc. Proportion can be seen as an addition to balance. Good proportions (see figure C6.4) adds harmony (see figure C6.5) and symmetry or creates balance among the parts of a design as a whole. This principle is usually about size. For this relationship of the size, a comparison is made between the:

- Height, width and depth of one element to another.
- Size of one area to the size of another area.
- Size of one element to the size of another element/detail.
- Amount of space between two or more elements/details.

Arrangement of space should be in such a way that the eye does not perceive a standard mathematical relationship. Dividing in halves, quarters and thirds should be avoided. A subtle relationship between elements creates dynamic design.

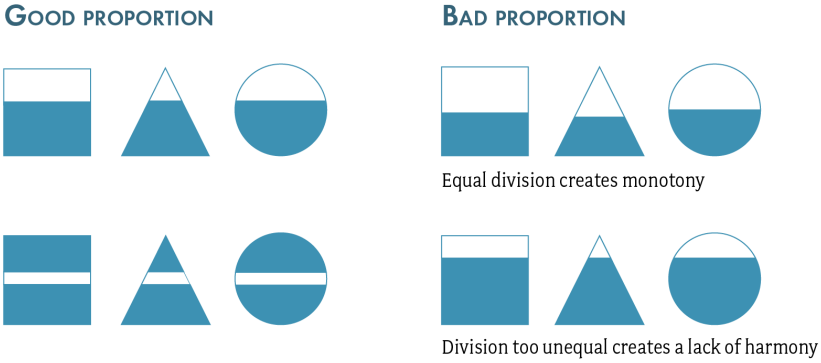


Figure C6.4 Good proportions in design (after Visser de, S.,2014)

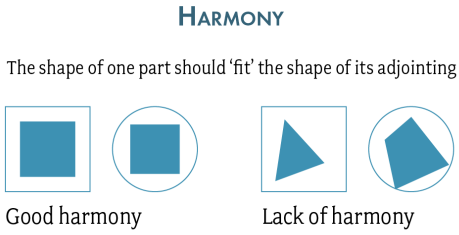


Figure C6.5 Creating harmony in design (after Visser de, S., 2014)

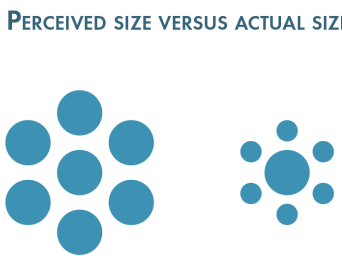


Figure C6.6 Real size versus perceived size(after Visser de, S.,2014)

Space and size

The interval or measurable distance between two objects or forms. This can be both two dimensional and three dimensional. There are two sorts of sizes: actual and perceived size. Actual size is mostly about size of components that need to fit into the space and is playing an important role with ergonomics, for instance with handheld products. Be playing around with the proportions and/or some of the elements, a product will look smaller or bigger. This relates to perceived size (see figure C6.6).

Unity

The relationship between the individual parts and the whole of a composition. Unity is the hallmark of a good design. When all the design elements work harmoniously together with giving the viewer a satisfying sense of belonging and relationship, unity is achieved. This requires a correct appliance of all principles (balance, movement, emphasis, simplicity, contrast, proportion, and space and size) and creates a sense of order. It gives the elements the appearance of completeness, that the elements belong together. This unity is strongly related to the optimal match principle of Paul Hekkert, since that principle is also about the combination of all sensory impressions which can be translated and result into design elements.

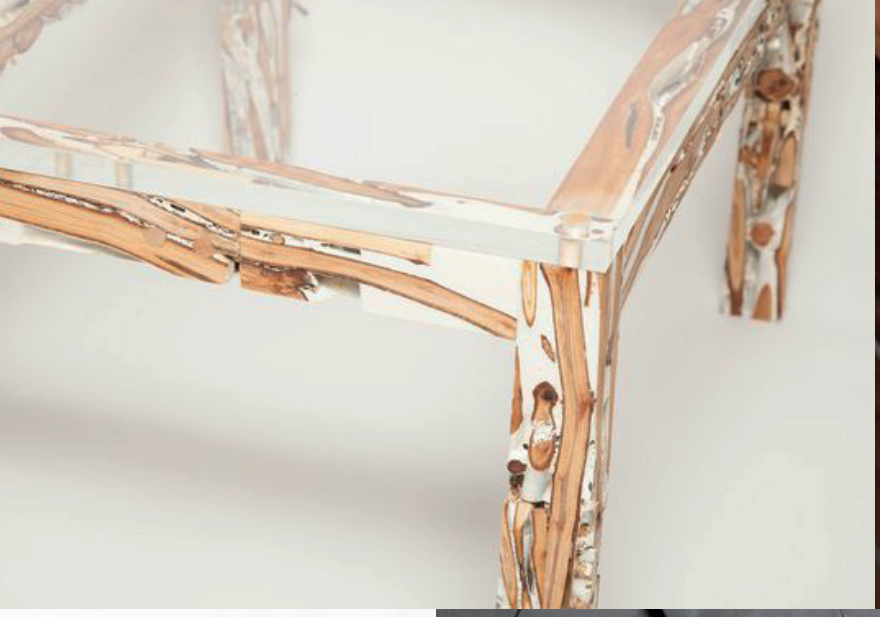
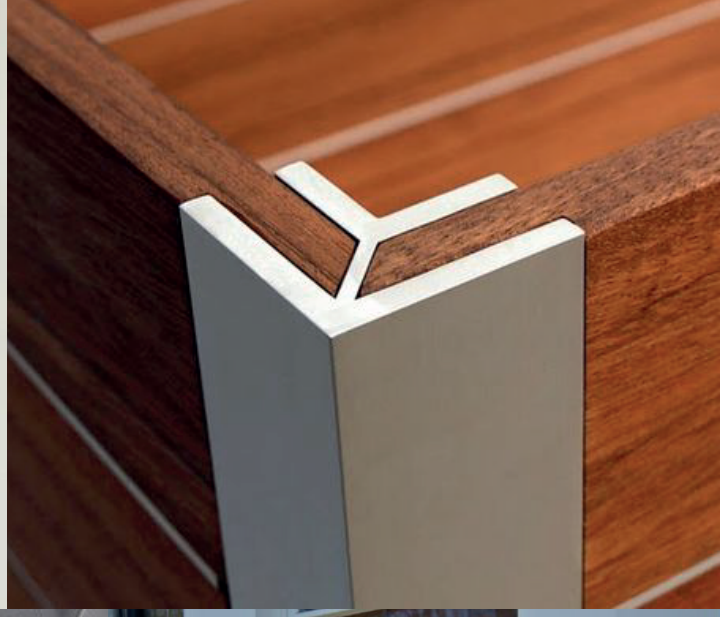
C6.1.4 Moodboards

To get a first idea of what is aesthetically appealing in products, a collage is made out of cards which are also used to do a workshop with Midwaste to look into what images looked sustainable to them (appendix C5). In this moodboard, figure C6.7, the three images on the top express interesting textures. In wood and marble, irregularities can be found, something which the mix fraction will also have (when it is not coated). The transparent object could refer to be transparant, be pure in what the material is.
The second row is about the detailing. Straight lines, combined with smooth curves and edges that evoke looking more into how the object is build.
The last row projects the combination of materials in such a way that these parts are disassemblable and also more interesting to look at. The black object in the middle of this row also represents a possible texture, with again irregularities.

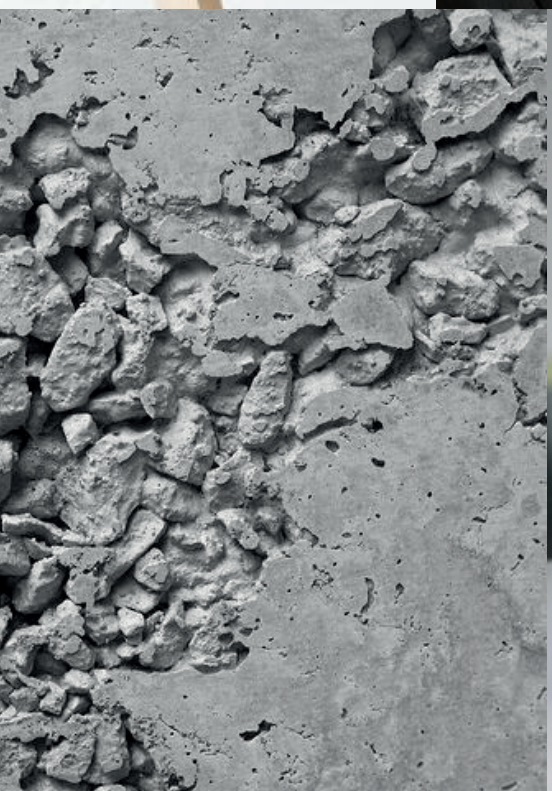
In the second moodboard (figure C6.8), the purpose was to get more insight in the material expression, modularity and the possibility to disassemble the product if there are more parts, made from different materials.

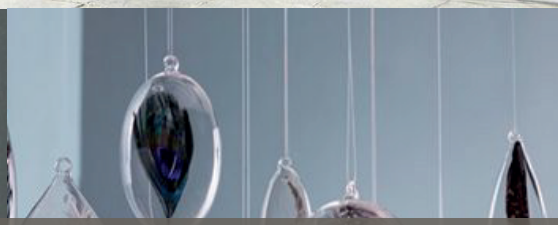
Figure C6.8 ->
A collage that shows the possible expression of the product.

Figure C6.7 A first impression of how the product could look like in aspects like texture, detailing and shape.







Insights

The beauty in design is mostly based on theories. Taking all the aspects that Sam de Visser describes into account will help creating an interesting shape and a beatiful total product. The product should be an experience as a whole.

C6.2 Robust and elegant

Material expression and product shape

In this section, the robustness in products is elaborated upon. By making a mind map and a moodboard, the term robust is getting more defined. Robust seems contradictional with elegant, but it seems an interesting combination.

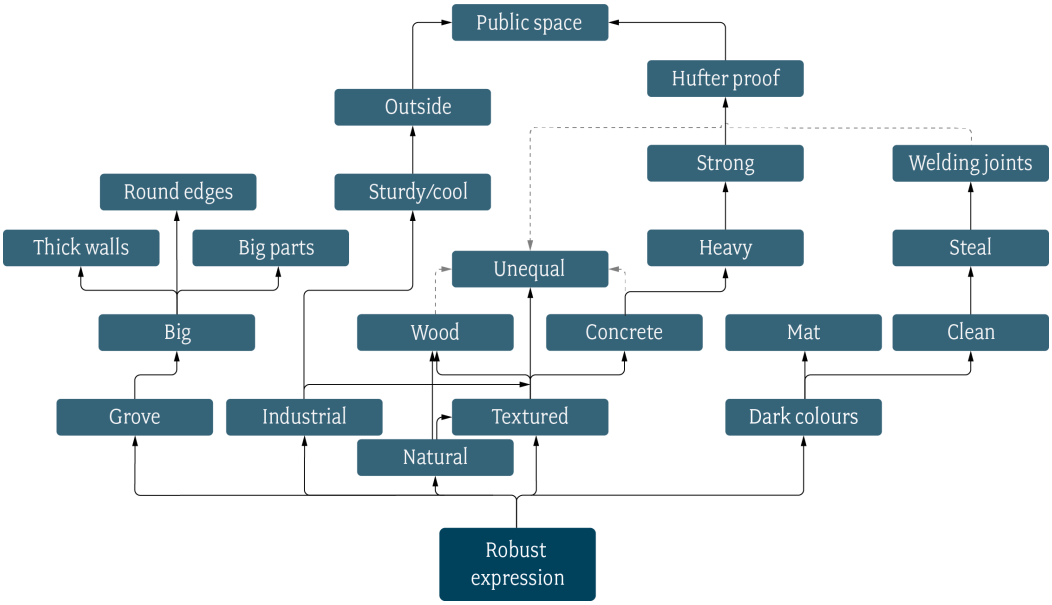


Figure 4.8 A mindmap of association of a robust expression

C6.2.1 Introduction

The material has a robust expression (see section 4.6), something which has to be used positively. To get an idea of what products look robust and why they look like that, a mindmap and a collage are made.

C6.2.2 What expresses robustness in a product?

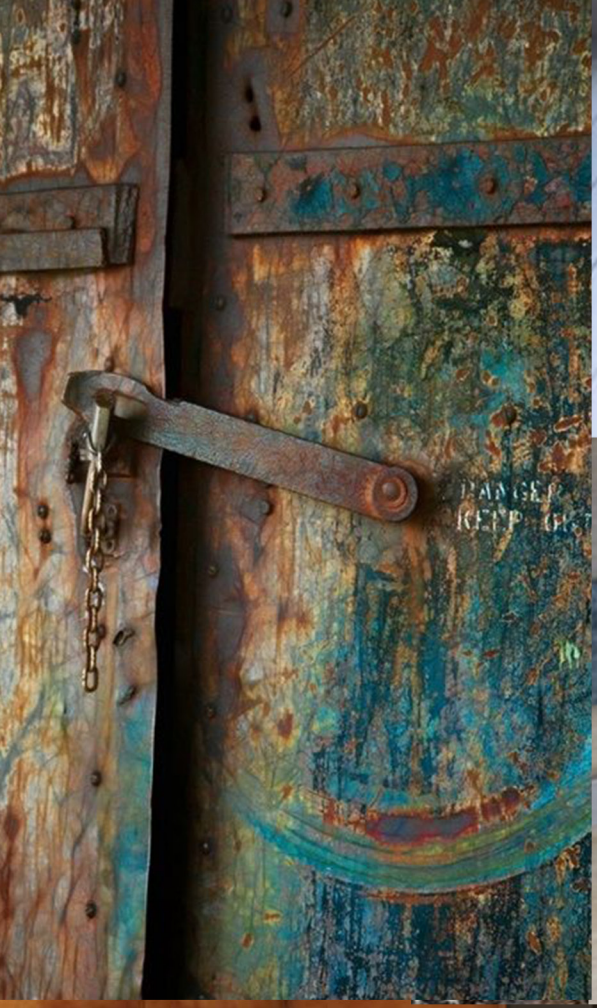
The collage expresses all the words listed in the mind map. Big parts, heavy materials, dark colours and textured surfaces. In some of the images also colour irregularities can be seen. Especially the irregular aspect is an interesting one since the material will naturally have that because it exists out of different materials combined into one mix.

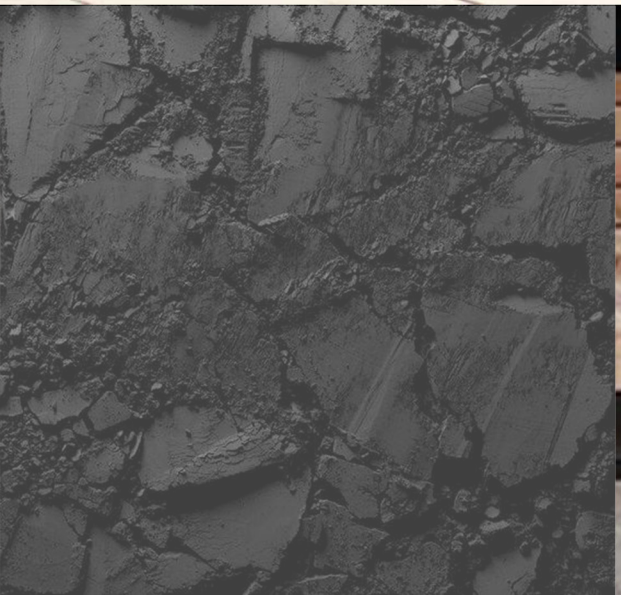
C6.2.3 Robust versus elegant

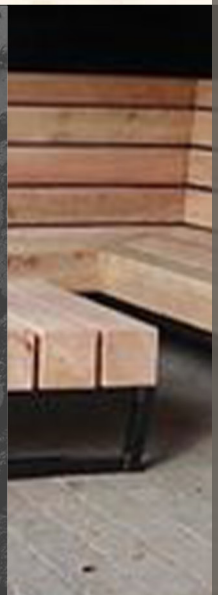
Using a robust material, does not necessarily

mean that the shape also has to be robust. Looking back into the aesthetics part, balance is created if the shape is elegant.

Figure 4.9 A collage that expresses robustness and elegance







Insights

Irregularities are associated with robust, which can be used, since the mix fraction also has this irregularities. This is the same for bigger shapes with thick walls. Together with an elegant shape balance can be found in the design of the product. Using the limitations as a tool to give the material its right expression. If you cannot hide it, show it.

C7 Questionnaire rocking chair

A rocking chair or a rocking deck chair?

In this section, the results of the online questionnaire are presented. Some additional analysis has been done to get more insight in which chair people prefer and if their preference changes when they look into their available outside space.

C7.1 Results

For this questionnaire, there were 60 respondents found. In figure C7.1, the two types of chairs are shown. The results are shown in the piecharts. It is clear that people prefer a rocking chair over a rocking deck chair. It can be seen that people choose a rocking chair more, after looking into their personal available outside space. If the focus group is narrowed down to people with small otside space, this result would be even more clear.

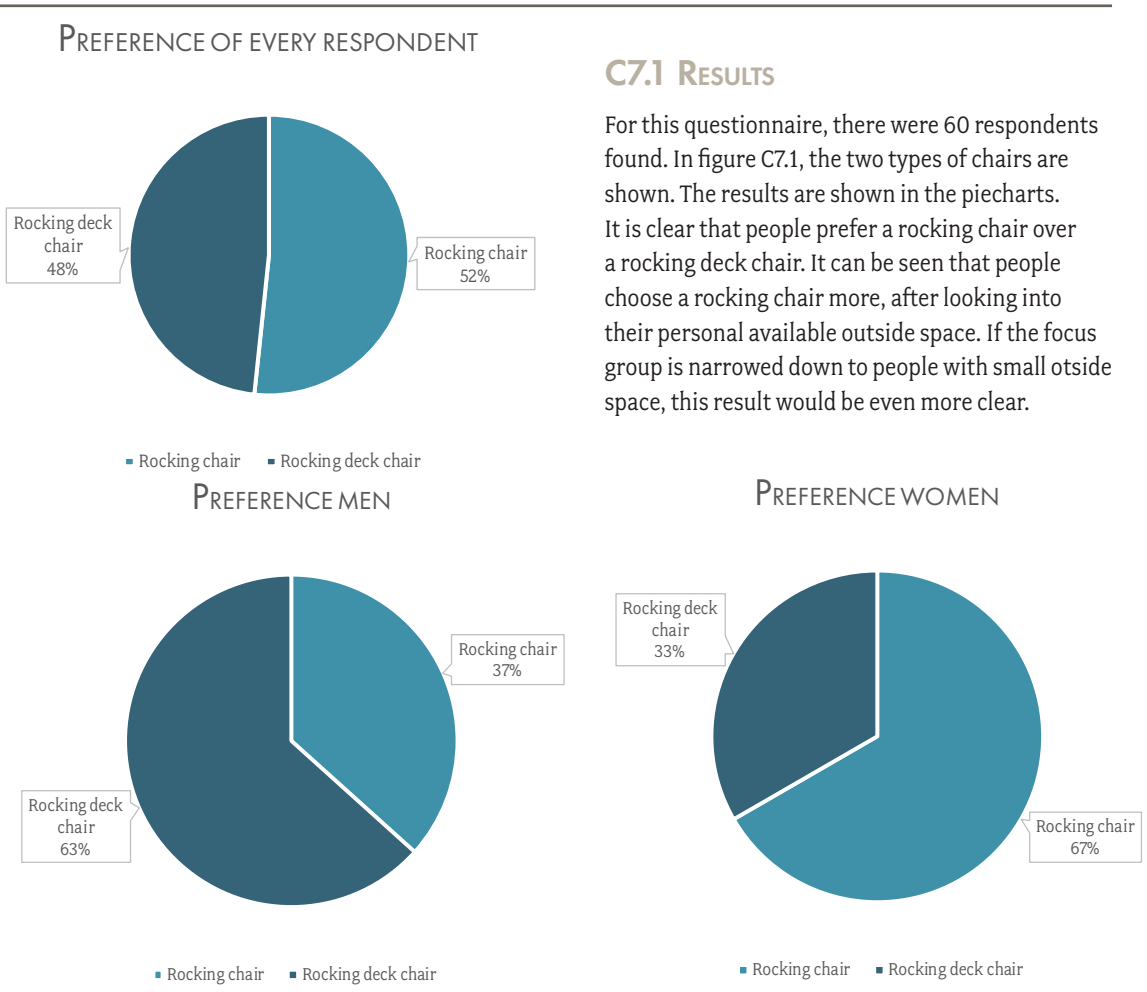
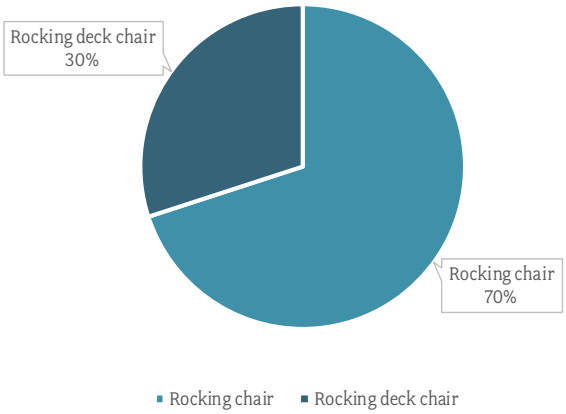
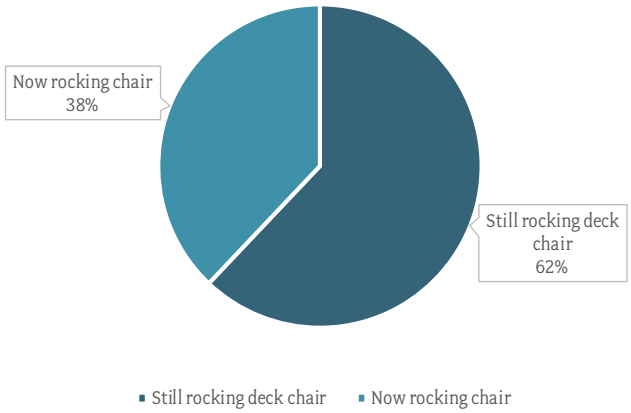


Figure C7.1. Left, the collage of a rocking chair, right, a collage of a rocking deck chair

Preference after people looked into their available outside space



Preference after comparing with outside space, firstly choosing rocking deck chair



C7.2 Open questions

Why would you choose this type of chair?

Je deze voor alles kan gebruiken, ook voor alleen een kopje thee drinken. Dan is een liggende stoel niet zo fijn. En ik heb niet heel veel plek buiten.
Once I would like to relax, I prefer laying down. I would not use it all the time, so I would like to use it next to a 'normal' chair, in which I can sit upright.
I would mainly use it in the evenings. Which is the time to enjoy a cup of tea or a glass of wine. This is easier done sitting up. Besides, I don't really like deck chairs in general.
I have a very small outside space, thus a chair that is takes up less space would be ideal. Additionally, I prefer to read a book outside and a rocking chair is more comfortable than a deck chair to do this.
I would rather rock in a chair to relax then when im laying down.
Looks more modern, and more comfortable
Looks more comfortable and you can still hold conversations, work on your laptop and whatever while in a normal rocking chair.
Ligt lekkerder in het zonnetje
because it is easier to go sit in it, it creates a good posture to read in, you can have drinks in the chair and not in the deck chair. (drinking while laying down is not advisable) the chair is also more social (sitting straight up makes conversation easier)
a rocking deck chair would be too big for my balcony
takes up less space
Since it is outside I mostly would use to lie in the sun or something like that.
Sits better
Mogelijk om zo te lezen/laptoppen. (Of trombone te spelen)
If I want a rocking chair, I want to relax in it. So lying down serves that purpose better.
Zodat ik kan slapen
zodat je een gesprek kunt voeren, thee kunt drinken, omdat je wat meer beschermd zit, omdat je anders voornamelijk de lucht ziet, omdat het minder ruimte inneemt en omdat je het op meer manieren kunt inzetten.
More relaxed position, e.g. For reading (or sleeping)
This chair seems more comfortable and relaxing. I'm not a big fan of 'rocking' on a piece of furniture and to me it seems that the rocking deck chair rocks the least since your body mass is lower to the ground.
I like the rocking part when sitting, but when I lay down, I prefer to lay still.
If I am to acquire something for relaxation purposes, I would look for these types of products. However, I would relax even more when my whole body is in general in a rather horizontal position, which leads me to prefer the rocking deck chair over the rocking chair. In the latter my feet and legs would not be up but rather being pulled down by gravitation force.
Daarin kun je beter zonnen en dat zou toch de hoofdreden zijn waarom ik erin ga liggen. En je wil gewoon wegdommelen in zo'n stoel toch :-)
Al ik lig wil ik echt liggen om te zonnen buiten
Design is more present thanks to the size
Space, rocking deck chair would be my first choice if my garden was bigger
Seems more comfortable
Can use it more often.
More relaxing than a rocking chair
More comfortable
I do not see the benefit of rocking while lying
Rocking is especially nice if you lay down
Enough space. Normal chairs already there. Nice to read, different than sitting.
Easier to move, better to control, can go faster, smaller surface that it Would take in the garden
Als ik lig, lig ik graag stil
It seems better suitable for reading a book
leuker
Deck chair won't fit
It seems more for outdoors
Een ligstoel is groter en stabieler en beweegt minder snel
Seems more comfortable to me
Ik lig niet graag
I'm not a big fan of laid back chairs
lack of space for choosing the other type of chair
It's seems more fun to sit in a rocking chair. To touch the ground with your toes once in a while or to stretch your legs to swing/ rock faster.
Ontspannen houding.
Ruimte. Daarnaast lijkt een ligstoel niet echt comfi schommelen.
For my age ii is the right choise
I would actually not choose a rocking chair ever, but if I had to choose one I'd choose the desk version, since rocking back and forth while lying down seems more comfortable/fun to me then when just sitting.
zittend schommelen lijkt me leuker en comfortabeler dan liggend schommelen
oog comfortabeler
Much better to relax and read, which is what I do in the garden.
It can also be used as a sun lounger
You can arise easely
laying down is more relaxing while rocking
Limits space, I have a balcony, and if it becomes chilly in the winter, it is still an item I would use, a rocking deck chair seems more suitable for the summer period. Why not explore of people are interested in a chair that can adapt to both (2-in-1 foldable chair)
I only have a little roofterrace so a rocking deck chair would take op too much space. And a rocking chair is a bit more suited for more activities than a rocking deck chair (like eating etc.)
REminds me of festivals

The only time i would sit on a balcony is when I would like to lie down
No need for moving so much but prefer rest and enjoy the sun :)
You are more lying down so more relaxed

Could you explain your previous answer?

This question was asked after letting people choose between a rocking chair and a rocking deck chair again after looking into their personal outside space.

Ik had dat al meegenomen in mn antwoord hiervoor. ;) Succes Em! Nog eventjes :)
There is enough soace on my rooftop garden to fit both a rocking chair and a 'normal' chair.
Same as before
I've already given that reason. small space = smaller chair. Otherwise I would have no space for my plants ;)
A Rocking chair also uses less space, so my preference still holds
A rocking chair takes up less space than a rocking deck chair.
My balcony wouldnt be able to fit a rocking chair or deck chair
I just like the upright position more than the lying down position. Nothing to do with available space.
Lijkt me lekker en ruimte genoeg
because it has my preference.
I already took space into consideration
space was already my concern.
I based my first answer more on what I would generally like for outside, but basing it on my current living space a deck chair would be cumbersome.
Its smaller
Ik zie niet in hoe mijn mening nu anders zou zijn.
I have enough space for it, so no reason for change.
Ik hou van slapen
omdat de meeste argumenten van mij niet iets met de plaats/ grootte te maken hebben.
I'm actually looking for a rocken deck chair (ligstoel) because I have unused space in my garden
There is enough space for the rocking deck chair. If I would only have a balcony or small terrace I would prefer the rocking chair.
My reason does not depend on available space.
There is just enough space for one big relaxing furniture and a table set for four persons. So if I am to acquire something so to become fully relaxed whilst enjoying the sun, i would still choose the rocking deck chair over the rocking chair. (ofcourse this would need consultation as well)
t
No
The deck chair is Nice but also consumes a lot of space, it should have enough empty space around like in a bigger garden or so
If i had more space i would like both :)
No
A rocking deck chair takes more space
In a smaller space I would go for a rocking chair, but if I have the space I would choose a rocking desk chair
No space for a rocking deck chair
I was already more fan of the rocking chair, and I do not have place for the rocking deck chair
It fits
See previous
I chose the rocking chair for its positives over rocking deck chair. Not because of the space.
Same answer as given before
A deck chair wouldn't fit
-
I dont Think i need to rock while laying down
I have enough space for it
Hoewel ik een ligstoel fijner zou vinden, past hij niet in mijn kleine studentenflat
It still seems more comfortable to me
Ik lig niet graag
The actual space doesn't matter
more conviement
I guess a rocking chair could also be placed indoors. It's true that rocking deck chairs seem quite 'lomp' and take up a lot of space. So if I would ever buy one it would be nice if it is lightweight or easy to remove to a storage space.
Way of life
Zie vorige
A rocking deckchair is difficult to get out of it
Yes, I could
Ik heb geen tuin, maar als ik een tuin had gehad zou het me erg leuk lijken om hier een schommelstoel in te hebben staan. Vooral een stoel die lang mee gaat en niet snel rot wordt. Binnen zou ik niet snel een schommelstoel van plastic zetten.
Eigenlijk heb ik in het geheel geen ruimte ervoor :')
My garden is long and narrow. There is currently a couch which I use to lie on. This is nice because more people can sit on it. If the long rocking chair could fold away when not in use that would be great
Outsite I want to lay
No space for big furniture
Well.. there is much more I could buy to put on my balcony, I think choice depends as well on if it matches with the items I already have, the price, the style, if I can have 2 on the balcony, one for my partner as well, etc. I think there is much more that comes to mind regarding context, you seem to have chosen a large scope with various contents and focus groups, focussing on both balconies and Gardens, cities and coubtry side. I wonder if you can get your answers by means of this short survey only. Good luck!
I just picked my answer based on the available space I have as it was asked to consider it in your outside space. So see answer on the previous fill in question.
I would go for neither, because i dont have any space, but the rocking chair I guess, because it takes less space in my house
The space allows it
See earlier answer
The rocking deck chair takes up to much space on my small balcony

Looking into outside saces C8.1

The analysis of an online questionnaire and additional interviews

In this section, the results of an online questionnaire and additional interviews are discussed. The insights of this questionnaire give direction to what people would like to see in a rain barrel.

C8.1.1 Introduction

To get idea of what people prefer and do not like in rain barrels, a questionnaire was conducted. This questionnaire had 30 respondents and 5 additional interviews with respondents has been conducted by phone. The purpose of the additional interviews was to get a better insight of what people think about a rain barrel combined with another function and modularity of the rain barrel. At first, the most relevant results of the questionnaire is presented. Afterwards, a summary of the additional interviews is given. Concluded with final insights. The answers to the open questions of the questionnaire and the personal interviews are listed in the end of this appendix .

C8.1.2 Results questionnaire

At first, some general questions were asked to get an idea of the situation of the respondents. Then, it was asked what kind of outside space they have (figure C8.2). Almost everyone has plants in their garden (figure C8.1) People who have a small garden or smaller, so a balcony or a (roof)terrace, are using a watering can, or something similar, to water their plants more often with a watering can than people who are having a big garden (figure C8.3). 5% of the people with a small garden use a garden use, while 70% uses something like a watering can (people mentioned a measuring cup and a pul). Since the focus of this project is on households with a small garden, a (roof)terrace or balcony, developing something to make it possible to use garden hose is not necessary.

Most of the people are aware of the problem that a city can flood during a heavy rainfall. Some people also mention that this problem of flooding during a heavy rainfall is not a problem in their neighbourhood.
13% is not open to do anything about this problem, even when there is a subsidy. 30% might want to do something about it and 57% is open to collect rainwater to unburden the sewage system (figure C8.4).

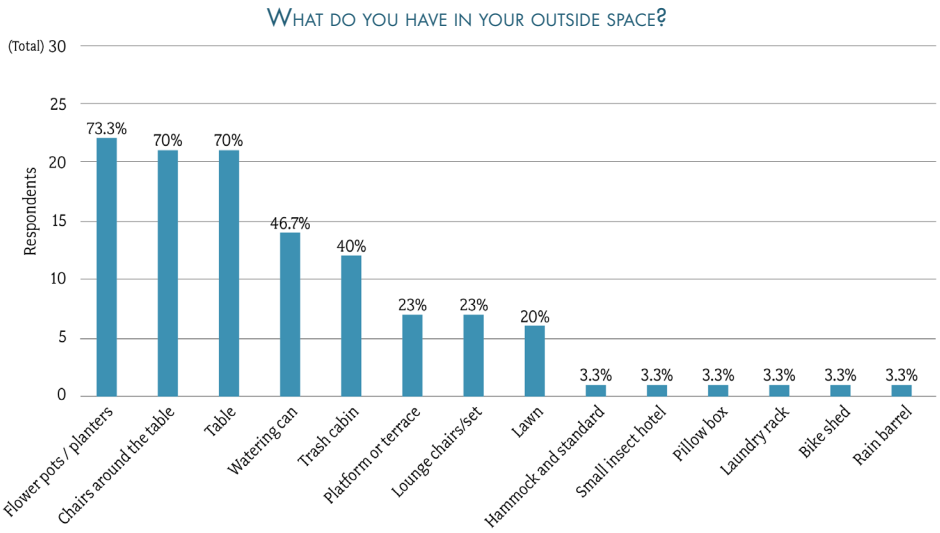


Figure C8.1 What people have in their private outside space. Options wre given an dthere was space to bring up additional items

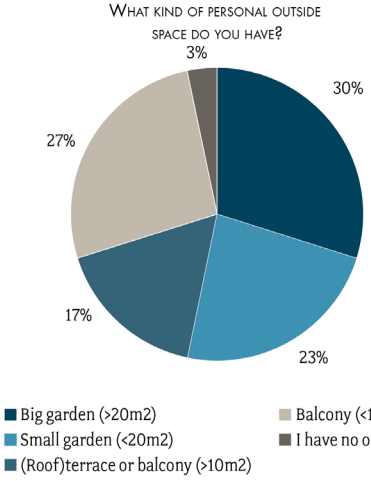


Figure C8.2 Available private outside space of respondents

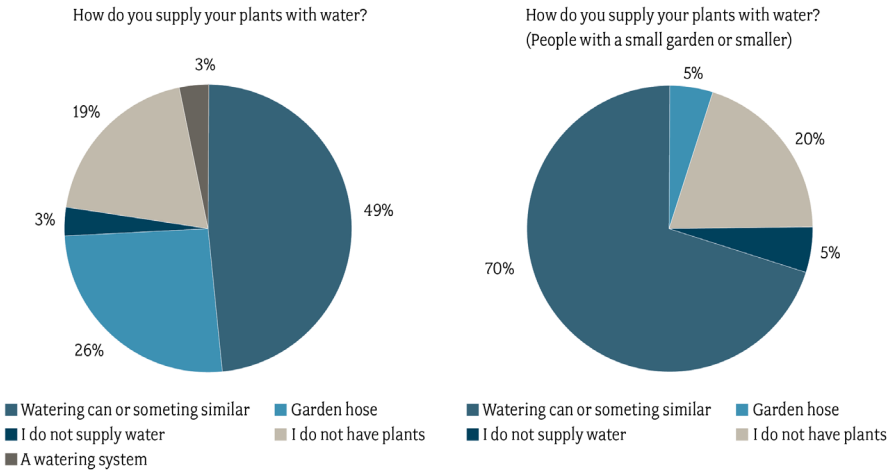


Figure C8.3 How people supply water to their plants. On the right, the people who have a big garden are filtered.

Most people do not want to give up more than 1m². None of the people with a small garden or smaller want to give up more than 2m², as shown in figure C8.5.

Some people say that they do not do anything about it, but they also do not know what to do (3 respondents). Some people have a lawn, but not everyone specifically for water collection. Some people have a balcony or (roof)terrace, where it is not really possible to have a lawn. Of all the respondents, only one person has a rain barrel. Besides having a lawn, some people also mention a sedum on their roof or plans to have this on their roof to absorb water. The person who wanted sedum of the roof, wants to cool her home during summer time with sedum.

C8.1.3 Additional interviews

Insights after additional interviews with 5 people and they sent a picture of their outside space (see appendix C8.2).

People are all positive about this idea of having a rain barrel. However, current shapes are blunt and most of these things are big. Something which is not practical when you have a small outside space.

People think making it a modular system is a good idea. Modularity makes the shape more flexible so you can decide in which direction you want to extend it.
Making the rain barrel multi functional is something people are also enthusiastic about. "If you have a small outside place, you want everything that you have there, to be nice" - Man with a balcony, living in Rotterdam.
Making it a flowering pot could be a solution, but also making it possible to sit on would be nice, or using it as a small table. "I think I would like to have something like a block to sit on that is a rain barrel as well. I think that could look nice." Man with balcony, living in Utrecht.

Respondents all say that rain barrels are often ugly and unpractical. A nice looking rain barrel could be something people want. Making it more squared

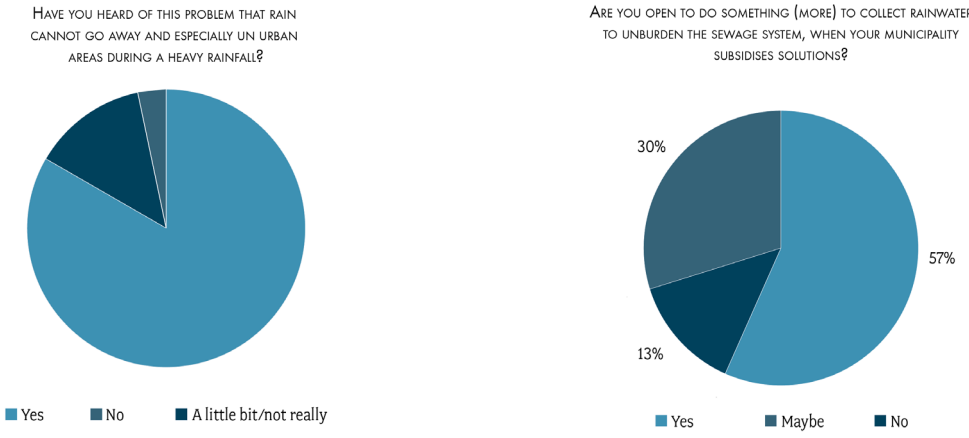


Figure C8.4 Almost everyone has heard of the problem of flooding after a heavy rainfall and most of the people are open to contribute to avoid flooding when there is a subsidy.

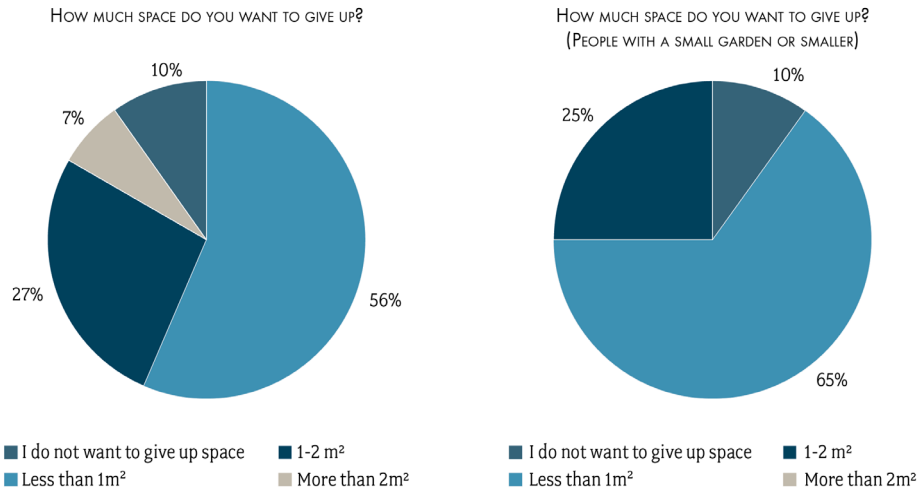


Figure C8.5 How much space do people want to give up for a rain barrel?

would really help taking less space.
They think it is a shame that they are watering the plants with drinking water.

On of the respondents said that he did not have a rain barrel because it also takes time to install. "Combining it with a social workplace that installs it for you, would really work out. Or making it very easy to install" - Man with a big garden, living in Ede.

C8.1.4 Conclusion

People with a small garden often use something like a watering can to supply water to their plants, which makes it unnecessary to store the garden hose. People are willing to give up space for something like a rain barrel but generally, not more tahn 1m2. Giving it multiple functions, makes a the product more attractive. The barrel should be practical in shape, and making it modular would be interesting, especially to make it more flexible in how you shape it.

C8.1.5 Discussion

Unfortunately there were not so many respondents for this questionnaire. Therefore, the conclusions taken out of this questionnaire are not significant. The additional interviews on the phone were very helpful to get extra insights. However, the way these interviews are conducted is not completely right. Some questions were not asked openly, which could lead to an answer that is hoped for. The first interview was not recorded, but notes were taken with care. The rest was recorded. However, something went wrong with recording during the third interview. Since I was listening carefully, not making notes, a lot is reproduced, but may be information is missing. Listening back the conversations was helpful to listen critically again to answers of respondents.

Insights

It helped to ask more personalized questions in the additional interviews, by looking into their answers before. Also these people sent photos of their outside space which was helpful to get an idea of how their place looks like and what the possibilities and limitations are.

C8.2 Detailed results

Online quetionnaire and additional inteviews results

C8.2.1 Answers at open questions

Do you like to spend time in your outside space and if yes, what do you like to do?

I do not spend a lot of time outside
working in the garden, watering plants, removing weed, eating outside, sunbath etc.
sitting in the sun, reading, swimming in the pool
Yes. Having dinner outside
Have drinks with friends
sit on a chair, reading, getting a tan
Sunning, smoking, reading and playing with the toddler
yes, mainly to have diner when it is sunny.
Drinking beers on the terrace
Read and eat
Reading a book or barbequing/eating outside
sunbathing, outside breakfast, reading the newspaper
Not applicable
Chilling and eating
Relaxing, enjoying Nice wheater, gardening
Drinking coffee
Just nothing, enjoy good weather
Yes! I like to hike, bike and walk around the city. A nice walk in the city centre on a sunny afternoon is nice. A coffee on the balcony as well. I enjoy bike rides to work, especially when the sun is rising and it's a bit chilly & sunny.
Eating, drinking & sunbathing.
No, not really
"I like taking care of my plants and seeing how they grow.
I like to eat breakfast or lunch at my balcony."
Yes, eat , drink, chill look at the sunset, be busy with plants
Eat, read, have a drink
Mostly for relaxation and enjoying the sun
Yes I do, I like to relax outside and to read something in a chair. Or sometimes I eat dinner/breakfast or bbq together.
yes, barbecuing
Enjoy the sun, play soccer, play with the kids
Yes Smoke a blunt
Yes, chillen in de loungeset, bbq, eten, drinken, lezen, spelen met kind
Smoke

Do you do some gardening once in a while? If yes, when do you do this and what do you usually do?

No
water plants, remove weed, mowing, scarifying (verticuteren), plant new plants/flowers, usually in the weekends or in the evening,
No I do not, my husband does
Weekends. Cutting the hedge
water the plants, remove dead plants
No
Spring summer, new plants in the flowerpots
no
Never
No
In spring, plant some flowers/herbs
In the weekends: prune, remove dead flowers and mow grass. I hate lawn mowing.
No
I personally don't, but sometimes my roommates do
Onkruid wieden, bollen planten, planten onderhouden
No
As less as possible. But if I have to then; remove weeds and water plants
I don't really have a garden, but like to do gardening on the balcony. I have some herbs and try to grow some vegetables. I normally do it on Saturdays or Sundays. I change plants to other pots and clean the balcony.
Watering flowers, not on a specific day. Removing weeds, mostly during weekends.
I had small plant in pots when I was in University for my Bachelor's study.
I water my plants, check the edible plants for ripe fruits or vegetables. If necessary I repot my plants. Every once in a while new plants are added too.
Yes, mostly outside. I do a lot of 'stekken' to create new plants to give away
No
giving water to the plant/flowers after a sunny day
No, not at my balcony. It is too small.
no
Now the lawn
No
Onkruid wieden
No

Is there something you already do (or did) about this problem? If yes, what is it? Or do you want to do something about it? If no, why not?

No, I do not know what I can do about it.
circa 80% of our garden is grass
yes, we do not have just tiles, but also a big pond and lots of plants in the soil
Having a lawn
we bougth a rain barrel to gather rest water
No, because it doesn't happen in my neighbourhood
I shame people with tiled gardens
no, we have a lot of space for water to go to already.
No, because there was no problem.
No, don't know what
Would like to help, but currently did not do anything
I want to do something about it. It's way we did not remove the grass.
No, I don't do anything about it. I don't know what to do and I don't think I can do anything as I do not have an outside space by my house
No, didn't really think about that
We're thinking of redoing our garden. We will think about a rain barrel, put grass and borders instead of only pavement.
No
Create space where water can drain down
No, actually not. I have heard about it, but don't really know how to do it. In my street, small gardens in front of the buildings have recently been built.
Our communal roof is covered with sedum, which absorbs water.
No, because the garden is the common one and someone else is taking care of it.
By putting plants on my balcony in pots, they can soak up some of the water. I was also thinking of putting sedum on top of the 'dakkapellen', but I need to find out via my landlord whether this is possible.
Yes, I graduated on the polder roof xD.
If I owned my house I would install a rain collection system for toilet flushing etc
No. beceasue I cant fix this problem on my own.. It is somthing the government/municipalities should solve.
No, I will when I have a garden myself. I can't do something to this problem on my balcony.
no, locally it is no problem
I have a lot of grass, but I want a barrel to collect rainwater
No
No
-

C8.2.2 Additional interviews after questionnaire

Lianne Duinkerken, 20-35, Delft, together with partner Big garden, garden hose, would give up 1-2m2

Pitures of the garden of Lianne can be found in figure C8.2.1.
Hoe groot is je tuin?
Ze woont er pas drie maanden. Haar tuin is 30 à 40m2.

Je hebt op dit moment geen regenton, hoe zou een regenton voor jou aantrekkelijker kunnen zijn?
Regentonnen zijn vaak ontzettend lelijk en de regenpijp zit in het looppad. Hij zou dus momenteel in de weg staan als ze er eentje aanschaffen. Ze denkt erover om een afdakje te bouwen en dan dus iets met een regenton te doen aangezien de regenpijp dan verlegd moet worden.
Ze zijn nu zo lomp rond en onpraktisch. En duur, dus aanschaf met hulp subsidie zou zeker helpen.
De investering, de moeite en de belemmering is op dit moment de reden waarom er nog geen regenton is aangeschaft.
Op dit moment hebben ze wel overlast van water dat blijft staan. ¼ zijn planten en gras en de rest tegels. Ze haat grasmaaien, maar laat het gras liggen om wateroverlast te beperken.
"Ik vind het eigenlijk belachelijk dat ik nu mn planten water geef met schoon water dus ik zou wel graag een regenton willen."

Als gecombineerde functie gaf je aan een soort storage voor je containers of een dakje voor fietsen. Zou het je ook wat lijken om het te combineren met bijvoorbeeld een plantenpot of een badje waar vogelts in kunnen badderen?
Niet per se. Ze zou dit puur praktisch aanschaffen.
Mijn focus ligt eigenlijk op mensen die wat minder ruimte hebben buiten en eigenlijk minder ruimte zouden willen opgeven dan 1m2.

Hoe denk je over modulariteit zodat je de grootte van de ton kunt veranderen?
Dat lijkt me echt heel tof. Modulair sowieso, je kunt alleen hele grote kopen nu, niet iedereen heeft die ruimte. Het maakt het praktischer, omdat je zelf kunt bepalen of je omhoog gaat of in de breedte. Zodat je plekken die je eigenlijk niet gebruikt kunt opvullen. Die hoekjes heb je stiekem best veel. Wij zouden gaan voor een lange smalle.

Een slimme regenton zou je regenton leeg, of bijna leeg laten lopen

Figure C8.2.1 Garden Lianne

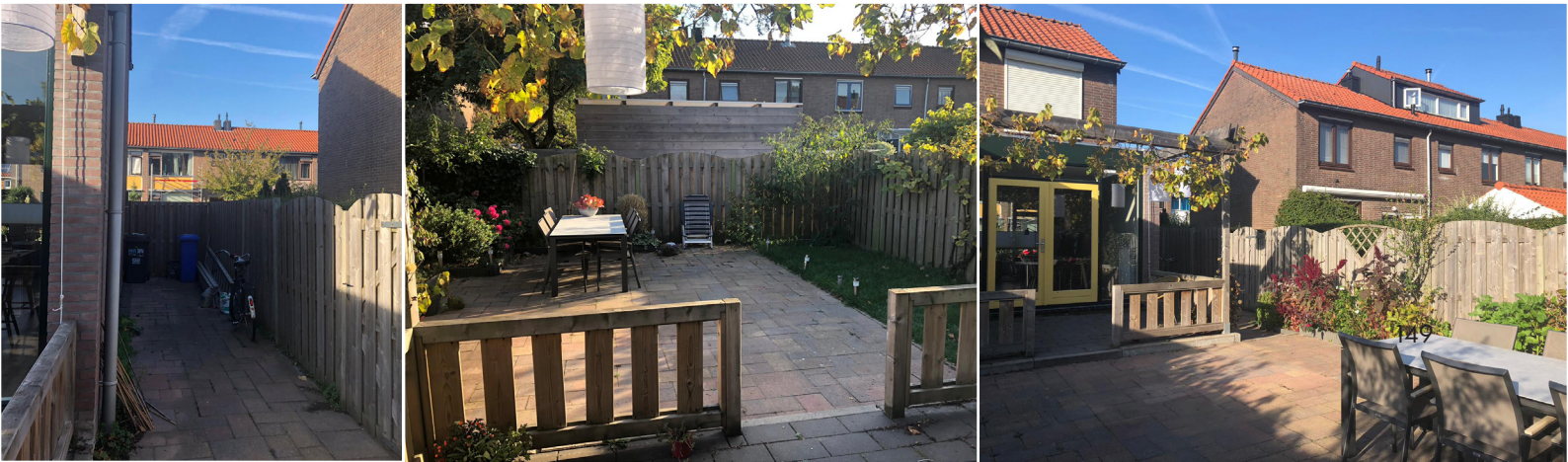


Figure C8.2.2 Balcony Gerben

Figure C8.2.3 Balcony Niels

als er een hevige bui voorspeld is. Hierbij loop je de kans dat de ton leeg is gelopen terwijl het uiteindelijk misschien niet heeft geregend. Zou je dat een groot probleem vinden, als je ton niet helemaal leeg loopt?
Lijkt me handig, maar je kan gebruik misschien beter bevorderen, bijvoorbeeld dat mensen dat water gebruiken in plaats van het in de riolering weg laten lopen. Ook zodat de grond natter wordt van te voren, zodat het water beter opneemt. Misschien kun je het combineren met langzaam leeglopen. Ik wil namelijk wel mijn planten water kunnen geven. Het is prima als ie leegloopt, maar misschien kan er een alarmmelding komen met dat de regenton leeg gaat lopen, dat je er zelf invloed op hebt.

Je gaf aan dat je je tuin water geeft met een tuinslang. Doe je dit ook wel eens met iets anders?
In juli pas in dat huis gekomen. Er is alleen een kraan buiten dus vandaar met een tuinslang. En er is geen andere watervoorziening. Maar geef nooit mn planten water met een gieter oid, want ze hebben alleen maar borders, geen losse planten in potten.

Zou je nog een foto willen sturen van je tuin? Misschien met regenpijp erbij ook een?
Ja geen probleem!

Unfortunately, the conversation itself has not been recorded, but during this conversation the notes were taken pretty complete.

Gerben Hofmeijer 0621439818 , 20-35, Rotterdam, with partner and kid, balcony (10m2), watering can, <1m2.

The picture of the garden of Gerben is show in figure C8.2.2.

Je woont dus in Rotterdam en je hebt een balkon dat minder groot is dan 10m2 Hoe groot is je balkon ongeveer? Heb je een regenpijp?
Ongeveer 4 bij anderhalf meter, dus dat is 6 vierkante meter.
Ja, ik heb een regenpijp.

Je hebt aangegeven dat je niet meer ruimte zou willen opgeven als een regenton gecombineerd zou zijn met iets anders. Zou een regenton voor jou aantrekkelijker zijn wanneer hij gecombineerd is met iets anders?
Ja, als je zo'n kleine buitenruimte hebt, moet je die ook slim gebruiken denk ik. En ik zou niet heel snel een regenton op mn balkon zetten, ik weet ook niet of je constructief ook wel een regenton mag op een balkon. Je bent sneller geneigd is te kopen als het niet alleen heel erg passief is en direct terugziet. Combineren is goed, zeker bij kleinere buitenruimte.

Mijn focus ligt eigenlijk op mensen die wat minder ruimte hebben buiten en eigenlijk minder ruimte zouden willen opgeven dan 1m2. Hoe denk je over modulariteit zodat je de grootte van de ton kunt veranderen?
Zodat je hem om de kattenbak heen kunt klikken. Ik wil eigenlijk niet heel veel moeite doen om een regenton uit te zoeken dus dan moet het wel echt heel makkelijk zijn. Verder denk ik wel dat het een goed idee is, want alle balkons zijn anders en je zit altijd te stoeien met openslaande deuren en dat soort dingen en als je hem een beetje zou kunnen aanpassen zou het wel kunnen werken.

Bij ons zit de regenpijp achter de openslaande deur aan de rechterkant, dus dan heb je zo'n 30 cm over een regenton neer te zetten. Ik denk dat het wel werk als je hem kunt aanpassen qua vorm en qua grootte. Het is best wel slim om een regenton aan te kunnen passen in zn vorm.

Een slimme regenton zou je regenton leeg, of bijna leeg laten lopen als er een hevige bui voorspeld is. Hierbij loop je de kans dat de ton leeg is gelopen terwijl het uiteindelijk misschien niet heeft geregend. Zou je dat een groot probleem vinden, als je ton niet helemaal leeg loopt?
Het idee van een regenton is toch ook dat het zichzelf gewoon ook regelt. Wanneer geef je je plantjes water, als er droogte is. Dus dan zorg je ervoor dat de ton leeg is op het moment dat het weer gaat regenen.
Anders, antwoord op je vraag: nee ik zie dat niet als probleem, je hebt altijd nog een kraan. Als je echt nodig je plantjes water te geven.

Je gaf aan dat je je planten water geeft met een gieter. Doe je dit ook wel eens met iets anders of op een andere manier?
Ik doe het eigenlijk zelden met een gieter. Met een maatbeker, 1L maatbeker.
Ik zou geen tuinslang aanschaffen, heb wel een aansluiting maar die gebruik ik niet daarvoor.

Zou je nog een foto willen sturen van je tuin? Misschien met regenpijp erbij ook een?
Ja geen probleem.

Hugo Stoevelaar, 36-65, Ede, Alone, big garden, 1-2m opgeven.

The pictures of the garden of Hugo are shown in figure C8.2.4.

Hoe groot is uw tuin?
5,5 bij 12 - 7m2= 59m2

Heeft u gras of een vlonder of tegels in de tuin liggen?
Heel veel tegels en twee borders van 4m2.
Wil geen tijd vrijmaken voor gras maaien en in de tuin werken dus vandaar dat ik veel tegels heb. Ik heb twee plantenpotten en wat

klimop die af en toe onderhouden moet worden.

U zegt dat u water geeft met de tuinslang. Doet u dit ook wel eens met iets anders?
Ook wel eens met de gieter, eigenlijk vaker met de gieter. Deze zomer was er zoveel water tekort, dus heb ik juist alleen een gieter gebruikt. Daarnaast, kost het me minder tijd om een gieter te vullen dan om de hele tuinslang uit te rollen en dergelijke. Ik combineer m'n plantjes water geven graag met werk, aangezien ik gemiddeld twaalf uur op een dag werk, met bellen. Ik kan prima met een gietertje door de tuin lopen en bellen tegelijk.

Op dit moment heeft u geen regenton in de tuin?
De kosten zijn geen belemmering, maar het aansluiten zelf is ook een drempel om een regenton aan te schaffen. Als ik het dan gekocht heb weet ik hoe dat gaat. Dan ligt het er weken later nog steeds on aangesloten. Ik ben onhandig en werk veel dus heb ook weinig tijd om zo'n regenton dan te installeren, en ik ben gewoon te lui. Ik weet dat het geen excuus is, maar het is wel zo. Wellicht kun je het concept aanbieden met hulp bij het aansluiten.
Het concept zou overigens wel een probleem kunnen zijn met huurhuizen. Daar mag je niet zomaar een regenpijp kapot maken, omdat het aan de buitenkant van het huis is. Misschien zou je een samenwerking met een woningbouwvereniging aan kunnen gaan of een woningcorporatie. Dan zouden zij het hun bewoners kunnen verplichten, of gewoon aanbieden.
De regelgeving is namelijk lastig met huurhuizen. Ook zou een samenwerking met een investeerder interessant kunnen zijn. Bedrijven als BAM of delta lloyd hebben veel huizen in bezit, daar zou je ook mee kunnen samenwerken. Daarnaast zou je nog kunnen kijken naar subsidies van rijksoverheid en huisvesting.

Het verhaal achter je product is mooi, maar helaas zijn de in Nederland die producten kopen met een milieu overtuiging nog steeds in de minderheid. Houd mensen dat rekensommetje voor met wat water kost en laat ze zien wat ze zouden kunnen besparen, dan maken mensen de keuze misschien sneller om toch voor een product te kiezen. Daarbij zou het interessant kunnen zijn om een sociale werkplaats in te schakelen. Wel een goed verhaal als een regenton uit afval die je krijgt en ook nog eens geïnstalleerd wordt door iemand anders.

Ik: Mijn insteek is niet dat het gratis moet zijn, dan neigen mensen minder waarde te hechten aan het product en verandert het gedrag.

Daar heb je wel gelijk in. Dan wordt het natuurlijk makkelijker kapot gemaakt. Maar op zich zou het geld voor mij dus sowieso geen probleem zijn, alleen de moeite die het kost om het te kiezen, dan aan te schaffen en vervolgens nog te installeren.

Zou een modulaire regenton voor jou interessant zijn?
Ja cool, dan zou je het kunnen combineren met verschillende kleuren en materialen. Of een andere uitstraling geven. Bijvoorbeeld een soort houtnerf erin maken ofzo.

Toen er dit jaar een keer wateroverlast was, liep iedereen in Ede te zeuren dat ze niet droog van hun voordeur naar de auto konden lopen en ze natte voeten kregen, maar zodra ze hoorden dat tuinen dan eigenlijk groener moeten worden was iedereen stil. Mensen hebben geen zin om gras neer te leggen omdat je dat moet onderhouden. Ik heb liever een grote regenton in mn tuin dan dat ik mn tegels eruit moet halen en gras moet neerleggen. Ik heb namelijk in het weekend, als ik de kinderen niet heb, geen zin om nog in de tuin te werken. Dan werk ik of doe ik liever niets, dus kom maar op met die regenton.

Een slimme regenton zou je regenton leeg, of bijna leeg laten lopen als er een hevige bui voorspeld is. Hierbij loop je de kans dat de ton leeg is gelopen terwijl het uiteindelijk misschien niet heeft geregend. Zou je dat een groot probleem vinden, als je ton niet helemaal leeg loopt?
Nee, helemaal niet. In het geval dat de ton is leeggelopen en je hebt het nodig, ben je misschien net een badkuip aan water kwijt. Je had er toch al niet voor betaald, dus nee ik zou dat niet erg vinden.

Als laatste vraag, zou je nog foto's willen sturen van je tuin?

Ja natuurlijk geen probleem.

Unfortunately, the conversation itself has not been recorded due to a technical issue. Some details are lost, but the main story stands on its own and the most important parts are reproduced.

Figure C8.2.4 Garden Hugo

Niels Defize, Utrecht, woont samen, balkon <10m2, Gebruikt een gieter, geen regenpijp, <1m2.

The picture of the garden of Niels is shown in figure C8.2.3.

Hoe groot is je balkon?
Twee balkonnetjes, in totaal 8 a 10 m2. Een balkon van 6m2 en een van 3m2 ongeveer.

In wat voor appartement woon je dat je geen regenpijp hebt?
Nee heel stom, want ik had voor mn afstuderen een regenton gekregen, zo eentje van elho, die druppel die mooie. Maar die kan dus nergens. Ik heb wel gezocht, maar die zit waarschijnlijk verstopt in de gevel.
Ik zit in een jaren 60 appartement, de regenpijpen zijn verstopt.

Mijn focus ligt op mensen die wat minder ruimte hebben buiten en eigenlijk minder ruimte zouden willen opgeven dan 1m2. Hoe denk je over modulariteit zodat je de grootte van de ton kunt veranderen? Lijkt me interessant om te kijken naar, niet per se iets modulairs, maar meer dat je er blokken van maakt waar je ook op kunt zitten. En op zich modulair, uhm wat voegt dat dan toe?

Ik: Dat je ze aan elkaar koppelt zodat je meer water af kan vangen.

Wat is daarvan het voordeel ten opzichte van een grote regenton kopen die functioneel is. Ik kan me voorstellen dat het handig is als ik zou verhuizen en opeens meer water nodig zou hebben, maar opzich als ik een perfecte maat regenton voor mijn appartement kan kopen is dat net zo ideaal als dat ik een modulaire delen koop die die maat opleveren.

Ik: dat is een goed punt. Een voordeel zou kunnen zijn, omdat ik me focus op kleinere buitenruimte, dat je de vorm aan kunt passen, en uit kunt uitbreiden in de richting hoe het het beste past. Dus niet per se voor de grootte van de regenton, maar meer om invloed te hebben over hoe die regenton er in z'n totaliteit uit gaat zien.

Figure C8.2.5 The balcony of Elsemieke

Ja dat kan wel voordelig zijn, als je dunne wandjes hebt of iets dergelijks. Daar zie wel voordeel in, als je heel makkelijk om dingen heen kunt werken, maar je hebt dan wel weer veel materiaal nodig voor je wateropslag, maar het wel een goed idee. Je moet ze dan wel koppelen, het ligt er een beetje aan hoeveel je er moet koppelen.

Het is wel voordelig als je kunt combineren.
Ik heb er wel naar gekeken of je het zou combineren met een stoel of schommelstoel, zodat het echt een meubelstuk is. Het is wel interessant om het niet per se die functie te geven, maar wel dat het die functie zou kunnen bekleden.
Ik zat te denken wat je zou moeten opofferen, qua ruimte. Als ik naar mn balkon kijk staan er een paar stoelen en een tafeltje en een opslag doos ofzo. Dan denk ik dat ik het wel mooi zou vinden als ik één of meerdere stoelen zou kunnen vervangen door een blok waar water in is opgeslagen. Dat zou ik geen moeite vinden. Je moet wel er voor kiezen om dan zo'n meubel neer te zetten, dat wel, maar je hebt offert niet per se stoel ruimte op. Je krijgt er gewoon een stoel met een extra functie voor terug.

Een slimme regenton zou je regenton leeg, of bijna leeg laten lopen als er een hevige bui voorspeld is. Hierbij loop je de kans dat de ton leeg is gelopen terwijl het uiteindelijk misschien niet heeft geregend. Zou je dat een groot probleem vinden, als je ton niet helemaal leeg loopt?
Ik heb hier best veel naar gekeken met mn afstuderen en het is best moeilijk om te bepalen wanneer je m leeg moet laten lopen.
Ik zou het opzich prima vinden, maar dan denk ik wel dat de gemeente moet helpen met financieren van de regenton omdat zij er baten bij hebben. En het wordt sowieso wel duur, want voor zo'n slim systeem zit je al snel boven de €100. Ik heb het namelijk toen gemaakt voor dakdokters. Ik denk dat het eigenlijk niet echt nodig is om een slim te maken. Ik denk dat het überhaupt nuttig is om een regenton te hebben. Dan heb je het risico dat ie vol zit bij een hevige regenbui.

Wat zou je over hebben voor een regenton?
Ligt eraan hoeveel liter. Als ik een regenton zou willen neerzetten waar ik nu woon. Ongeveer 50 tot 100 euro. Ik zou er wel meer voor over hebben als het dan bijvoorbeeld een stoel vervangt en er mooi uitziet enzo.

Zou je nog een foto willen sturen van je tuin?
Ja geen probleem, misschien moet je me nog wel even herinneren.

Elsemieke Minnema, 20-35, Rotterdam, with partner, balcony, <1m2

The pictures of the balcony of Elsemieke are shown in figure C8.2.5

Je hebt alleen bloempotten en een klein insectenhotel op je balkon. Zijn er dingen op je balkon die je mist?
Nou, ik woon hier nu ongeveer een jaar en het was een lekkere zomer dus we hebben een opklapmatras gekocht zodat je wat lekkerder kan zitten. We hadden ook een vuurkorf gekocht, maar eigenlijk is dat dan te dicht bij het huis of te dicht bij het hek.
Ik woon op een zolderverdieping dus het balkon loopt over de breedte van het huis. Iets meer dan een meter breed een zes meter.

Ik kon de regenpijp op je balkon niet zo goed zien. Zou je daar nog een foto van kunnen sturen?
Aan de rechterkant zit een regenpijp met een lage afscheiding. Er zitten aan beide kant een goot met een regenpijp die op het balkon uitkomt, waarvan er een bij de buren uitkomt en een bij ons. Eerst hadden we ze allebei. En toen het zo hard ging regenen deze zomer was het een zwembad op ons balkon.

Je wilt sedum op je dakkapellen zei je. Waarom zou je dat willen?
Onze keuken is in de dakkapel en in de zomer komt er heel veel warmte binnen. Misschien komt er met sedum iets minder warmte binnen. Voor het water op het balkon heeft het niet super veel zin want de rest van ons dak is hellend.

Mijn focus ligt op mensen die wat minder ruimte hebben buiten en eigenlijk minder ruimte zouden willen opgeven dan 1m2. Hoe denk je over modulariteit zodat je de grootte van de ton kunt veranderen?
Ik vind het wel een leuk idee, want vooral ook voor ons is het probleem dat de goot super laag zit en dat een regenton er niet onder past. Ze zijn allemaal te hoog, ik heb er wel naar gekeken. Toen het zo hard regende dacht ik ook, super zonde dat al dat water nu in de kelder loopt van de buurman, uiteindelijk. En ik sta mn gietertje te vullen bij de kraan. Qua vorm, ze zijn vaak rond en ik weet nou niet of dat heel praktisch is op je balkon.

Een slimme regenton zou je regenton leeg, of bijna leeg laten lopen als er een hevige bui voorspeld is. Hierbij loop je de kans dat de ton leeg is gelopen terwijl het uiteindelijk misschien niet heeft geregend. Zou je dat een groot probleem vinden, als je ton niet helemaal leeg loopt?

De voorspelling klopt hier wel vaak, maar als het gebeurt zou ik het niet super erg vinden. Ik zou wel hem pas laten leeglopen bij een significante regenbui. Ik denk dat je op het moment dat het heel droog is dat je het water wel gebruikt, dus dat je regenton vaak al wel bijna leeg zou zijn als het dan zo hard gaat regenen.

Zou combineren je aanspreken, bijvoorbeeld dus met een plantenpot?
Ja, combineren. Gewoon een soort blok lijkt me het handigst want dan kun je het multifunctioneel inzetten. Dan kun je er op zitten, of een tafel te maken. Het hoeft de vorm aan te nemen van een specifiek meubelstuk. Dan kun je zelf nog bepalen wat je wilt dat het wordt. Ik vind dat wel echt een tof idee.

D IDEATION

D1. List of requirements and wishes

D2. Principle solutions

List of Requirements and Wishes D1

The complete list

In this section the complete list of requirements and wishes are given. Throughout the project this list has changed a couple of times. The progress in this list is not documented, only the final list of requirements and wishes is given.

D1.1 List of requirements

For the list of requirements the method of Pugh (1990) is used.

Performance

- The product has to be producable with rotational molding.
- The product has to be demouldable and has to meet the design requirements of rotational moulding. These requirements are explained in section 2.4.
- The rain barrel should house a minimum of 40L and a maximum of 60L.
- The product should be stackable up to 2 pieces, when filled.
- If the rain barrel is filled, the overload of water has to flow into the sewage system.
- The product should have a facility to collect rainwater.
- It should not be possible for objects, for instance leaves bigger than 30x30x30mm leaves to come into the barrel.

Environment

- The product needs to be weather resistant in a Dutch climate, which means that it could withstand environmental temperatures between -20OC and +40OC. (This could not be tested within this project.)

Ergonomics

- It have to be possible to tap water out of the barrel, using one hand
- A watering can of 60cm high, has to fit under the tap.

Lifespan

- The product should have a minimum lifespan of 5 years.

Maintenance

- The product have to be easy to clean with water, natural soap and a brush. (This requirement is also hard to test within this project)

Production costs

- In hoeverre is een gemeente bereid dit product te subsidiëren?
- Looking into the costs of other rain barrels, this barrel have to be cheaper than €500, also depending on how much water it covers.

Transport

- The product has to be stackable, when packaged, up to 4 pieces.
- The product should fit on a europallet with the dimensions of 800x1200mm (mol-logistics.nl, n.d.)
- If there will be a packaging, this has to be 100% recyclable.

Aesthetic, Appearance and finish

- If more materials are used, the product have to be disassemble.
- The product should be interesting for municipalities that can provide the commonality (by selling, optionally with subsidies) with the product.
- The product should take less than space than 1m², based on a questionnaire of how much space people want to give up for something like a rain barrel.

Investments

- The investments are the production of the moulds of the product.
- The optimisation of the material.

D1.2 List of wishes

For the list of wishes, this same method of Pugh is used.

Performance

- The products uses the lowest quality of the mix with the minimum amount of residue.
- The product should respond on meaningful trend or trends, regarding climate change and water management.
- The product being a user product, not static.
- Objects bigger than 5x5x5mm cannot enter the barrel.

Size and weight

- The product should be variable in size, modular.
- The product should contain as less as possible different particles.
- The product should use standardized connections.

Aesthetic, Appearance and finish

- The product does not need any colour additives, if so, biodegradable additives are prefered.
- The product should be aesthetically appealing (see paragraph 3.2).
- The product does not require a high surface quality.
- The colour of the product should be the original colour.
- The product has to impress people.
- The product should be original.
- The product should be a high-quality product. which could be in different aspects; tolerances, shape or product category.
- The product should have a high value, which could be on five aspects; functional, economic, sustainable, symbolic and emotional.

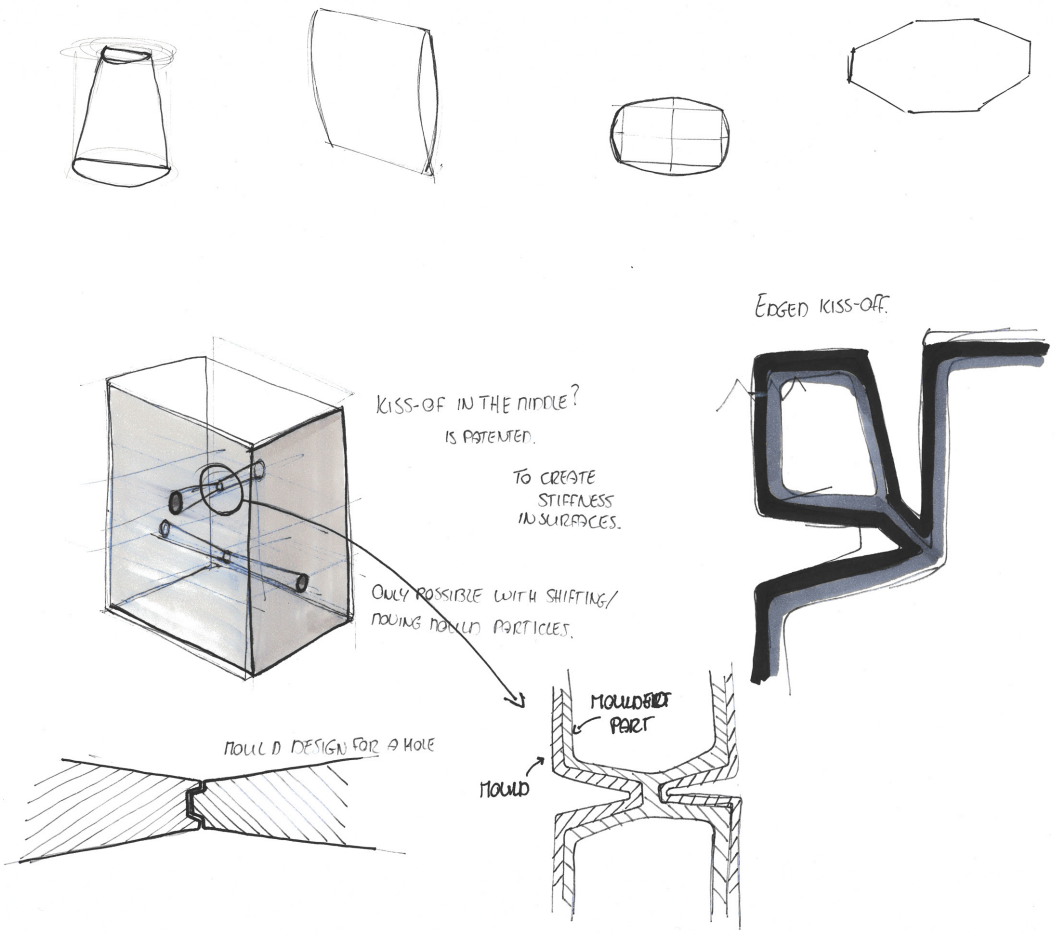
Lifespan

- The product preferably has a lifespan of 20+ years.

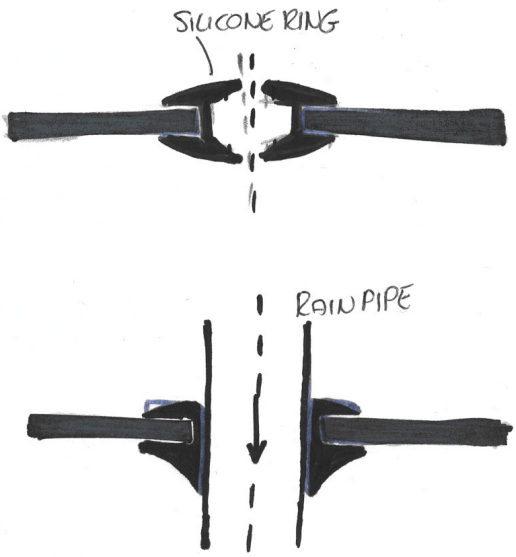
Quantity

- The product should use as much kilotons as possible of the mix fraction which could be both in weight, or in the amount of produced products.
- There should be made ten thousands of products.

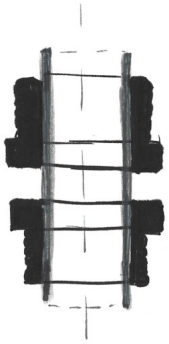
PRINCIPLE SOLUTIONS D5



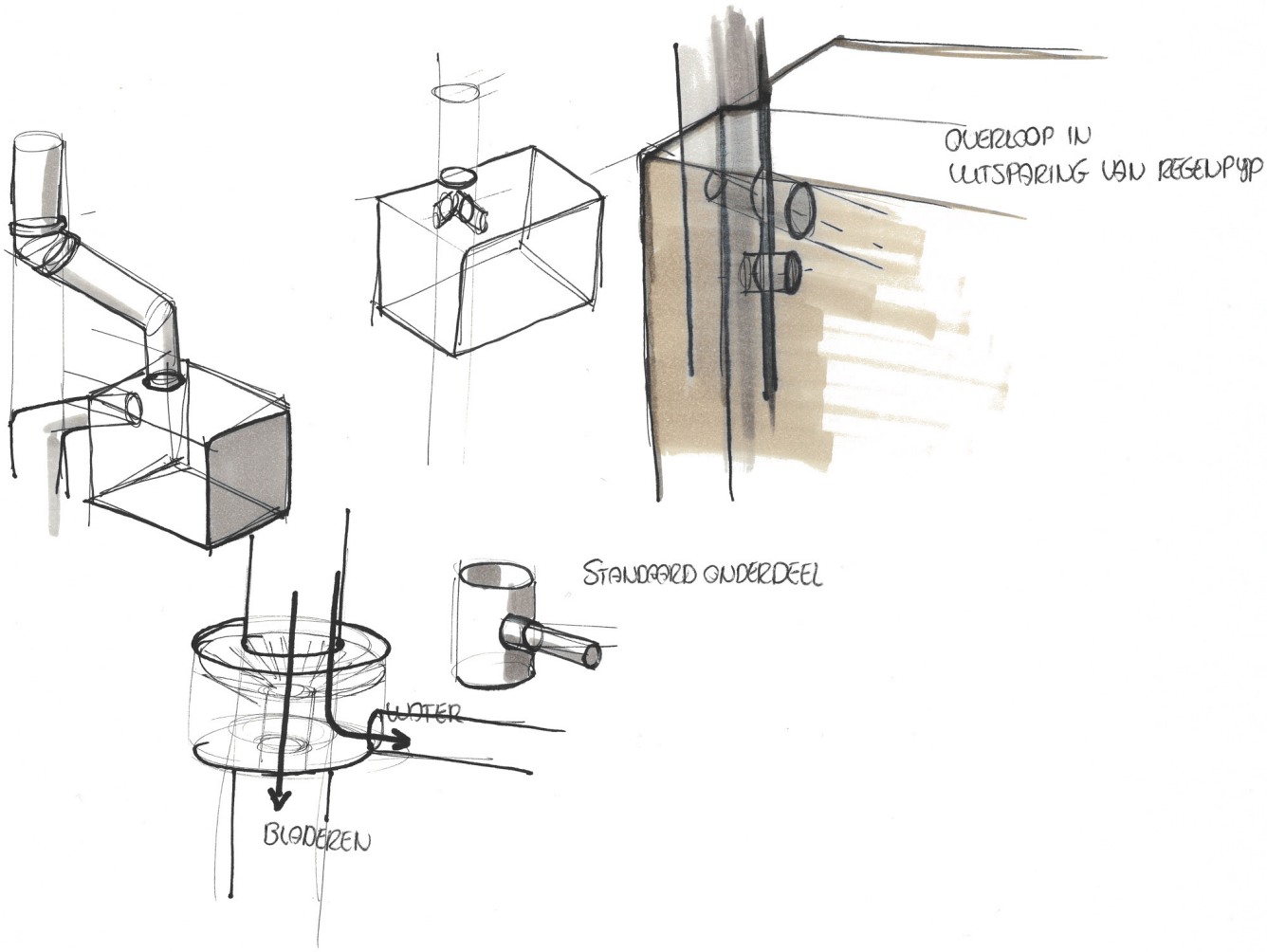
CONNECTION FOR A WATERPROOF WATERFLOW

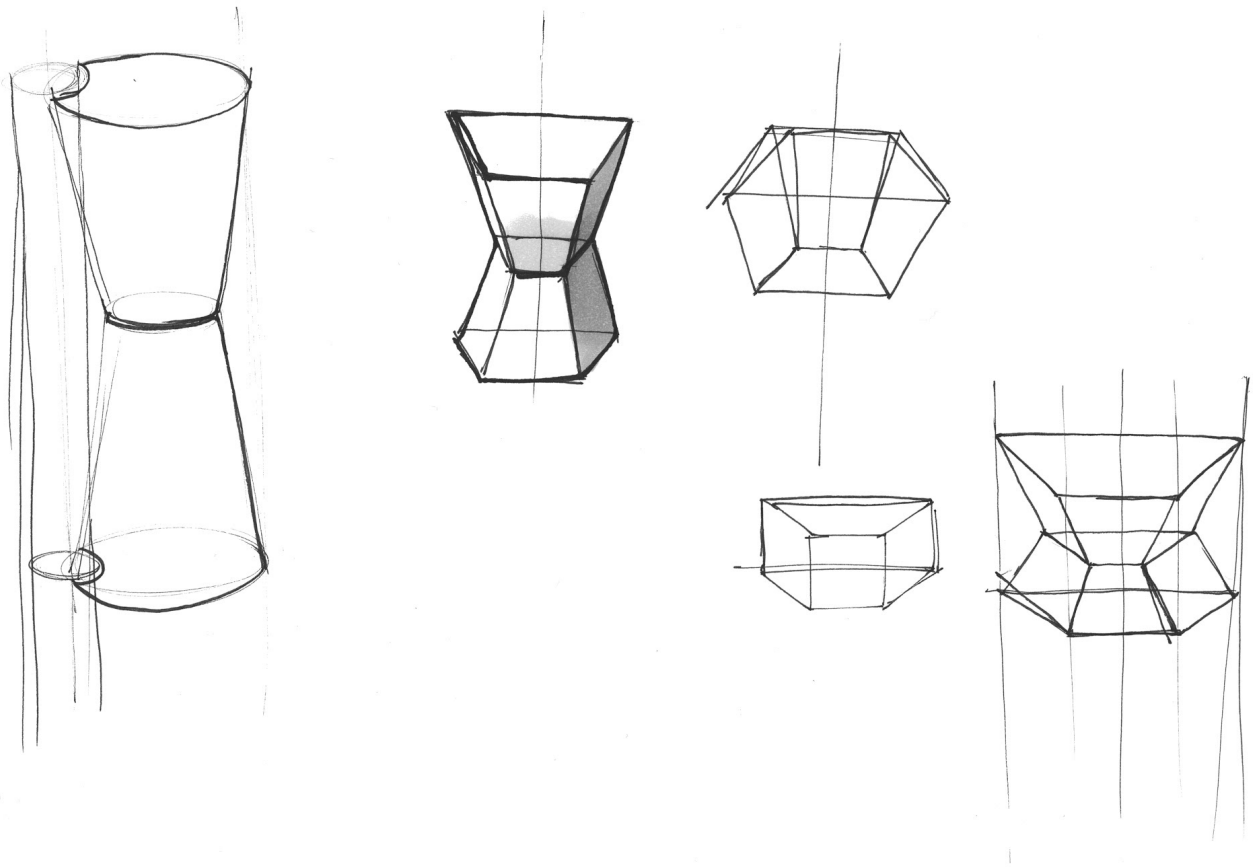


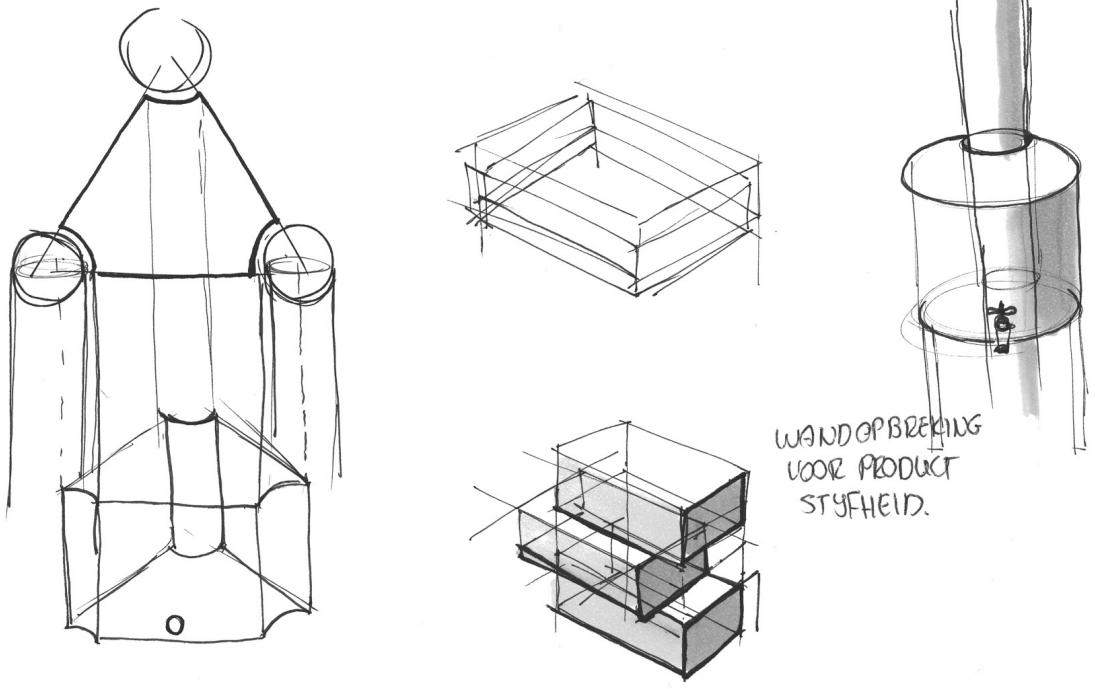
STANDAARD OVERGANGSMANCHET



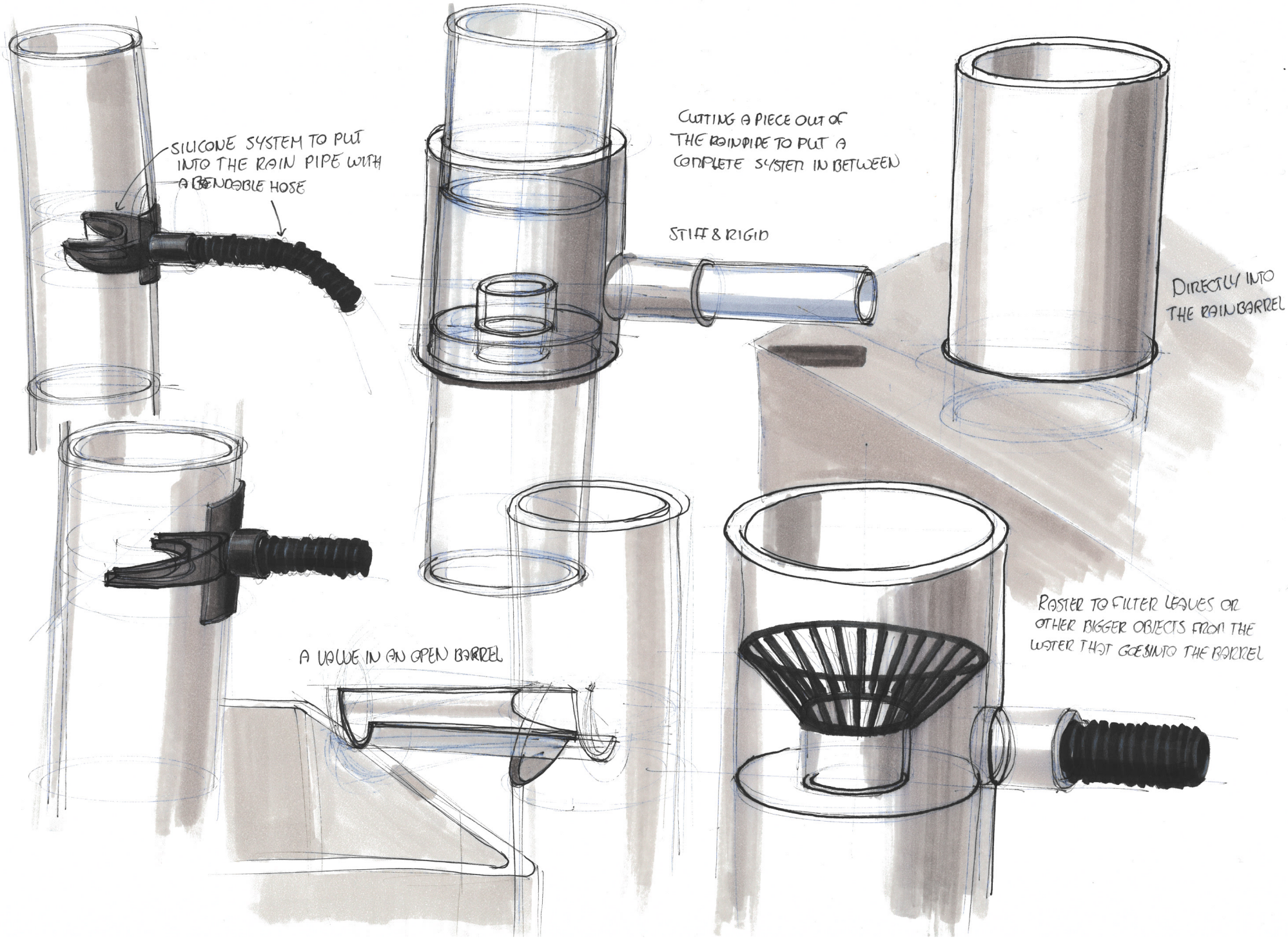
BETWEEN TWO BARRELS



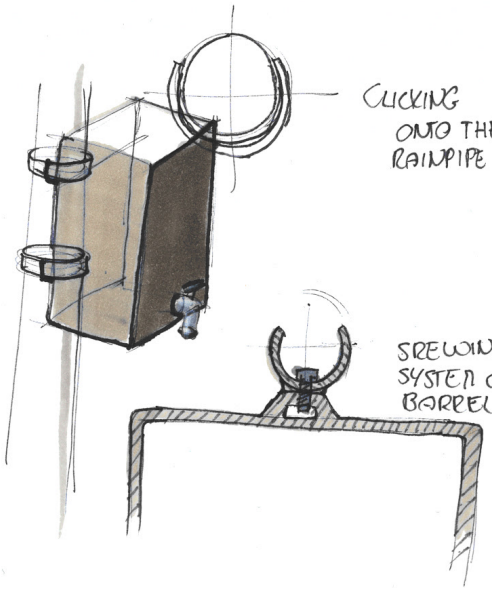


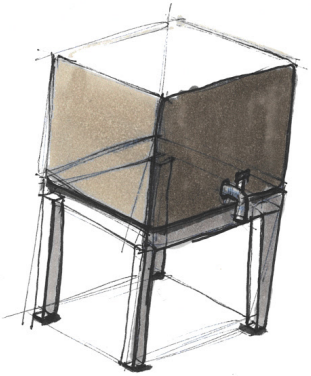

WANDOPBREKING
VOOR PRODUCT
STYFHEID.

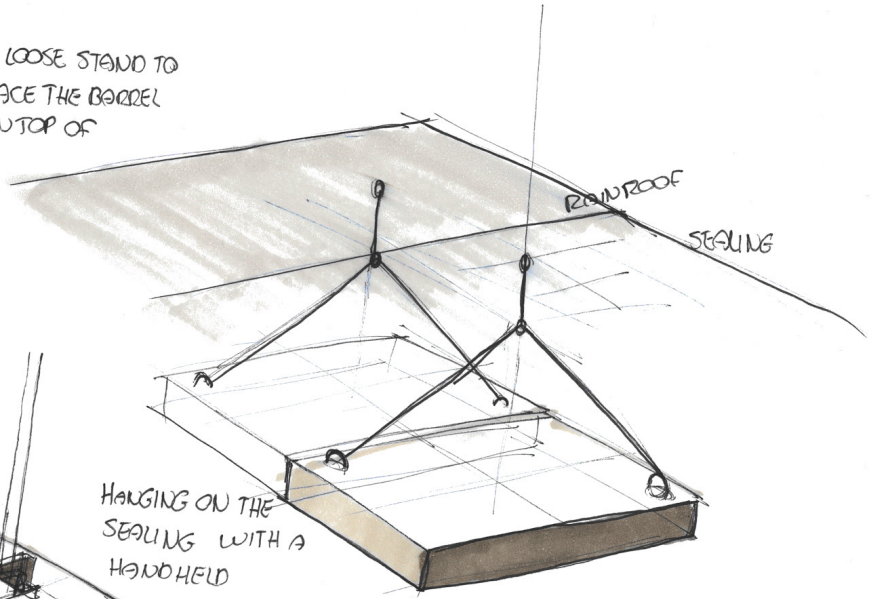
RAINPIPECONNECTION

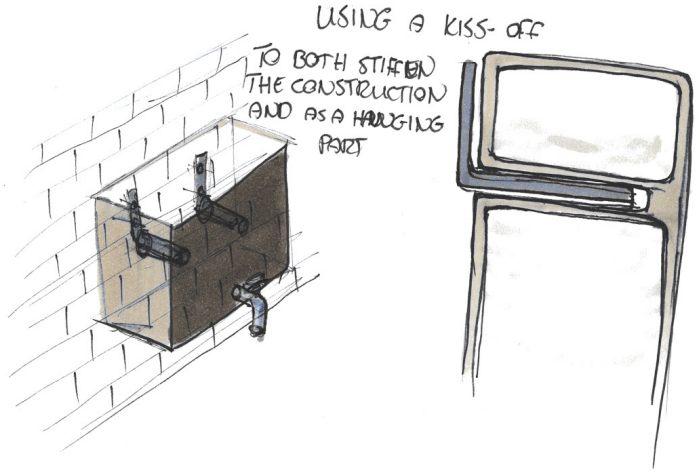


INSTALLATION

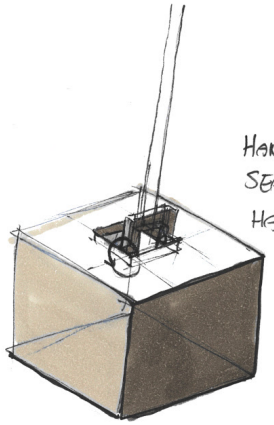


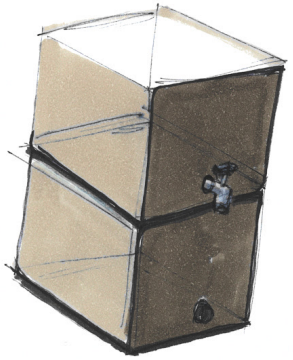




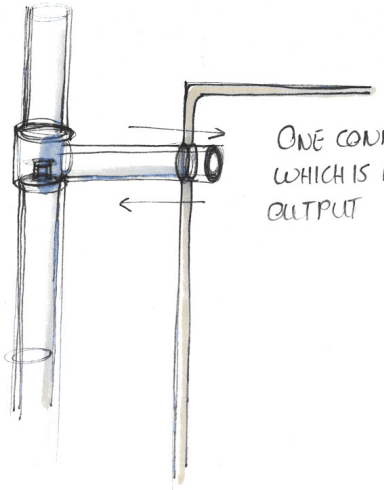


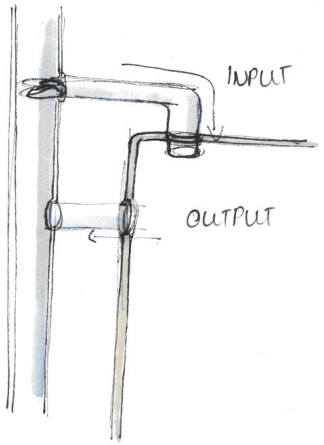
The drainage pipe might not hold the barrel, for hanging it on the wall, a wall is needed but that inclines the possibilities of placement. Also hanging on the roof reduces the placement since a (roof) terrace or garden does not have a sealing.

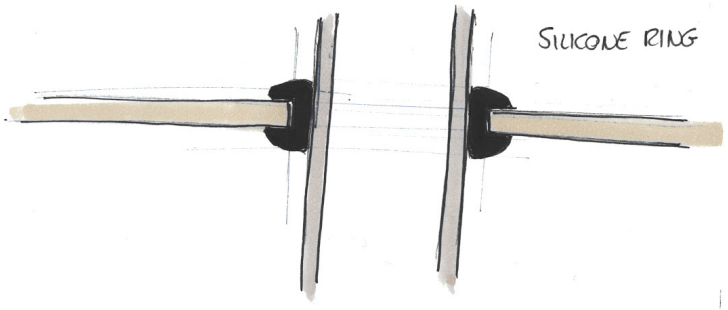


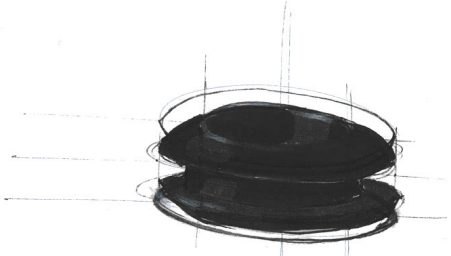


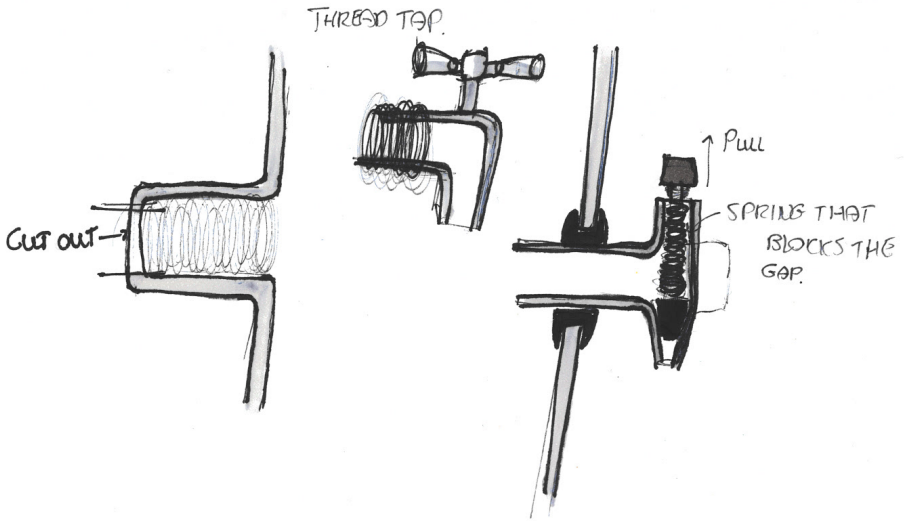
Overflow

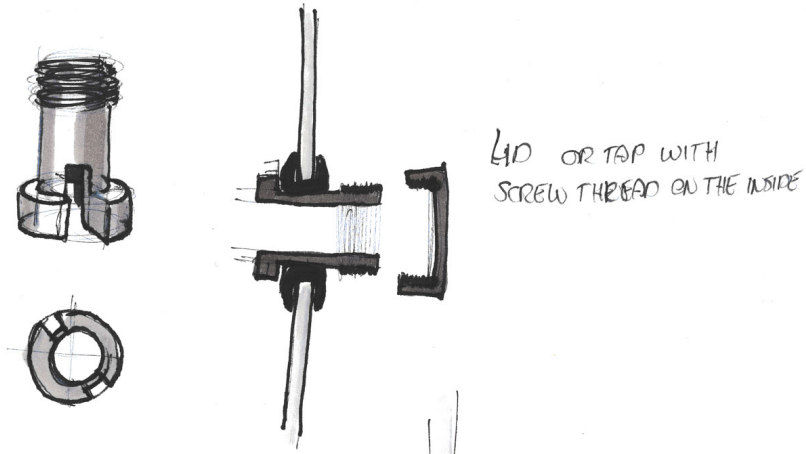

One connection which is in- and output

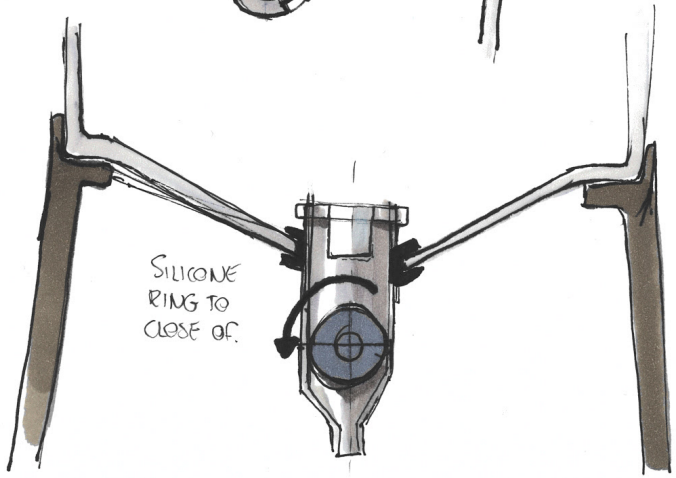

Input
Output


Silicone ring




Thread tap
Cut out
Pull
Spring that blocks the gap.

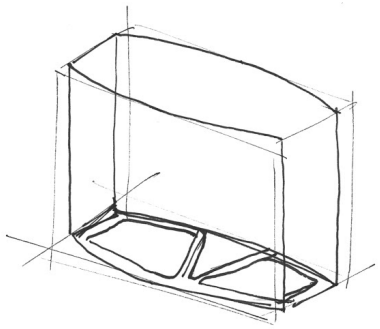

Lid or tap with screw thread on the inside

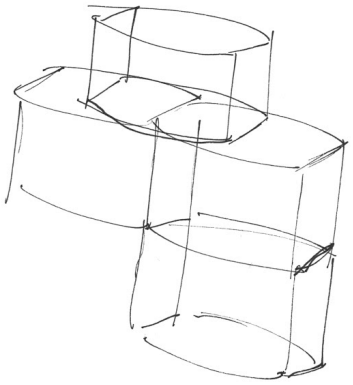

Silicone ring to close of.
Tap under the barrel, making the stan higher.

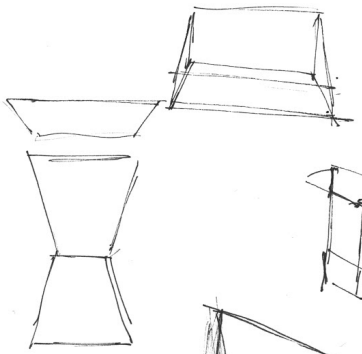
50 L PER MODULE

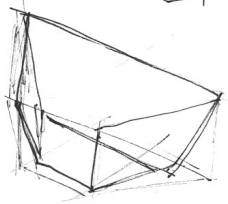
30 cm × 40 × 50 = 60L

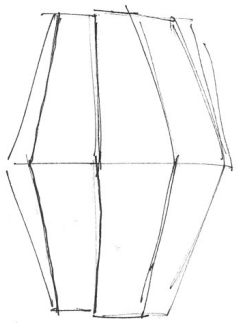
30 × 30 × 55 = 49,5L

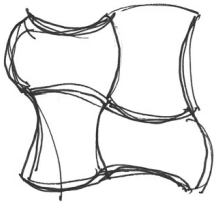


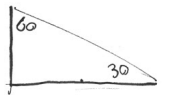












60

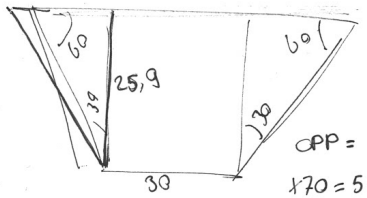
30

$\frac{\cos 30}{1} \mid \frac{30}{S}$

S = 34,64

$\frac{\cos 30}{1} \mid \frac{A}{30}$

A = 25,9



60

25,9

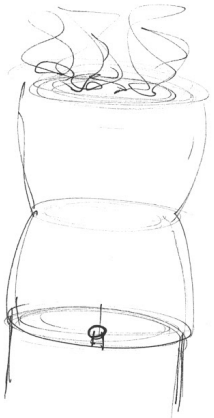
60

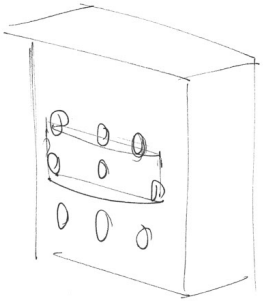
30

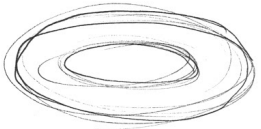
30

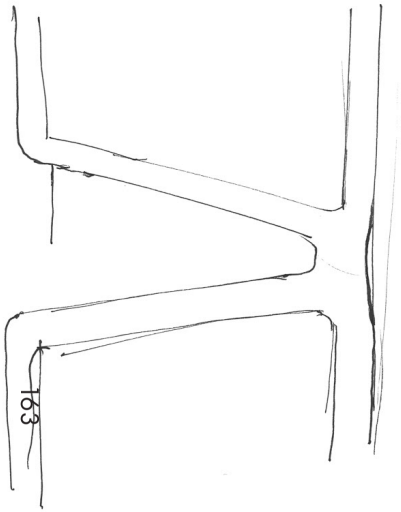
OPP = 779,4

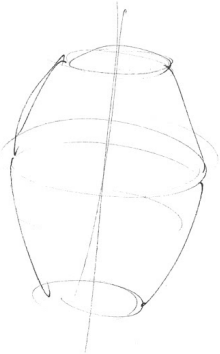
×70 = 54L

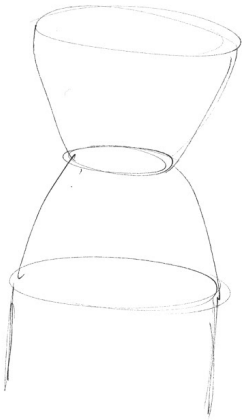




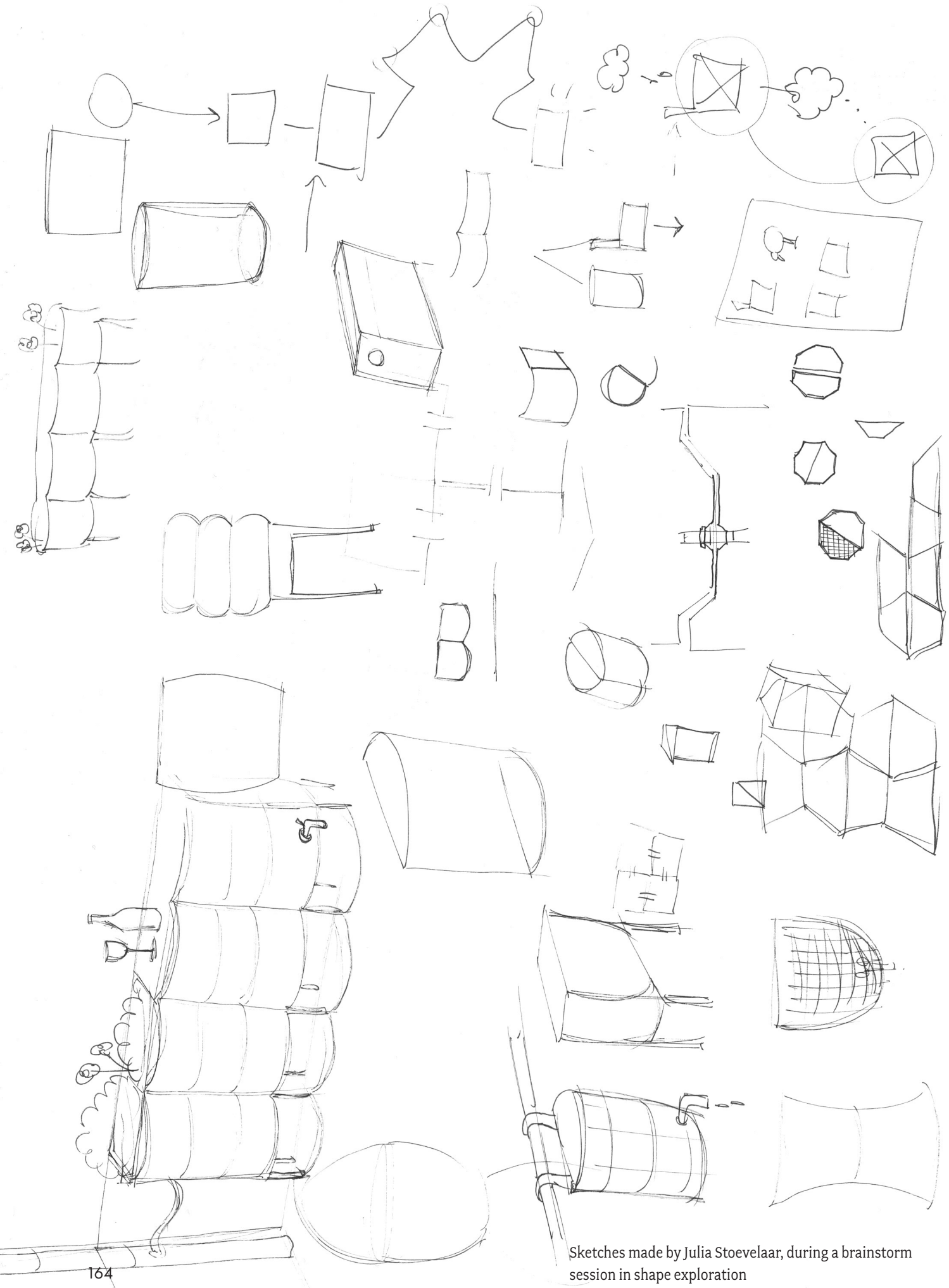






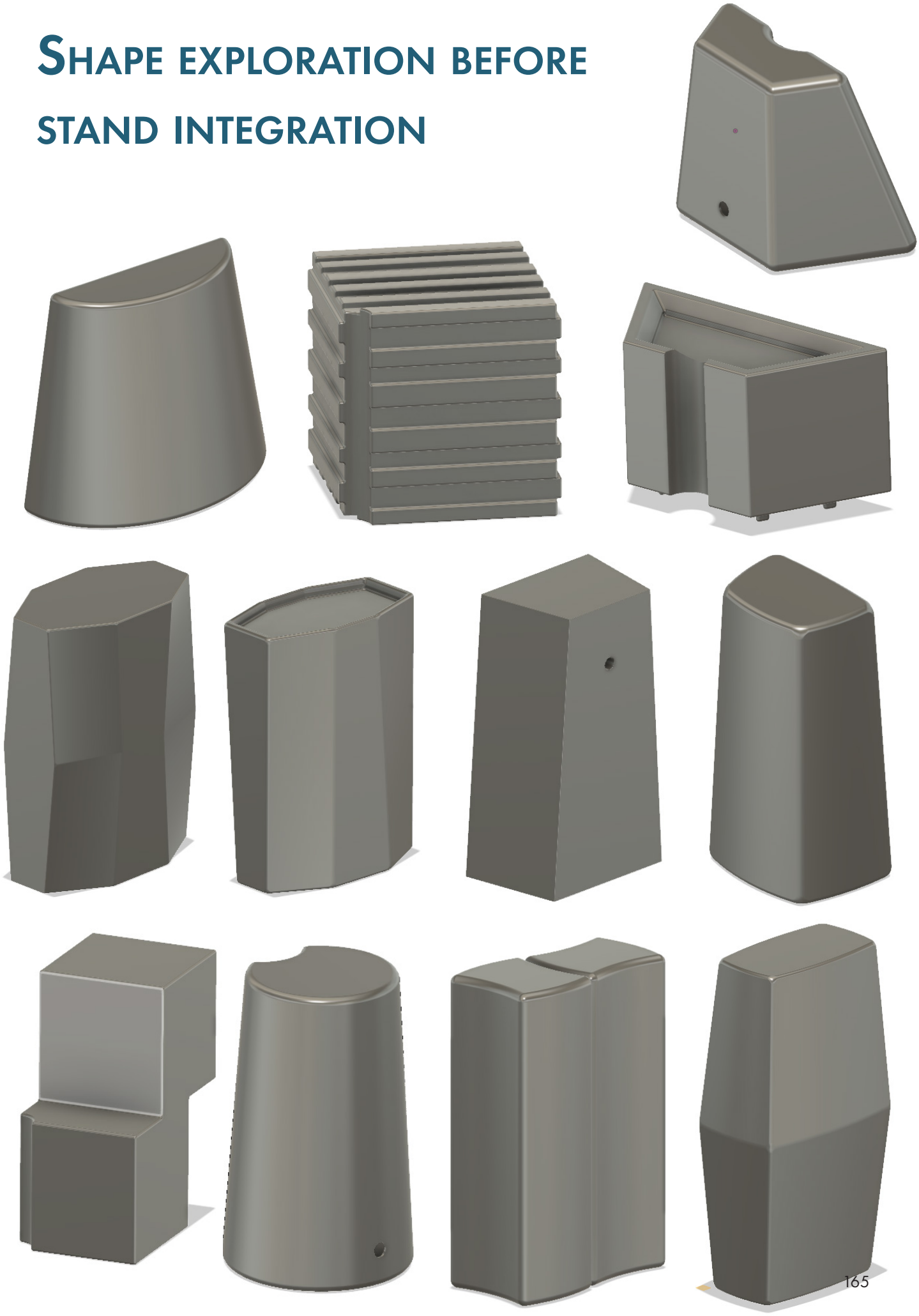


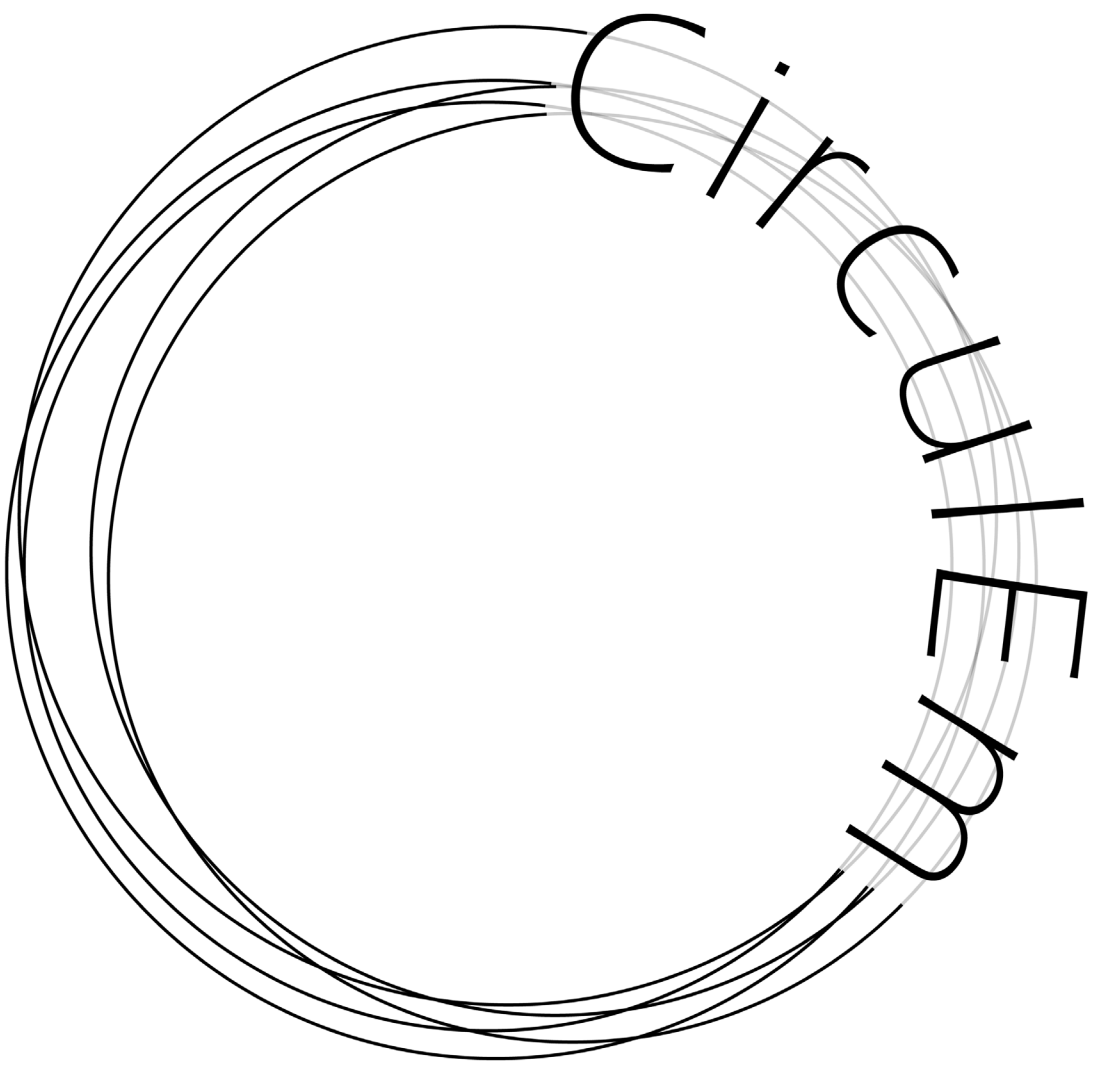
Sketches during a brainstorm session with Julia Stoevelaar to explore shapes.



Sketches made by Julia Stoevelaar, during a brainstorm session in shape exploration

Shape exploration before stand integration




Circuit End

E
Detail design

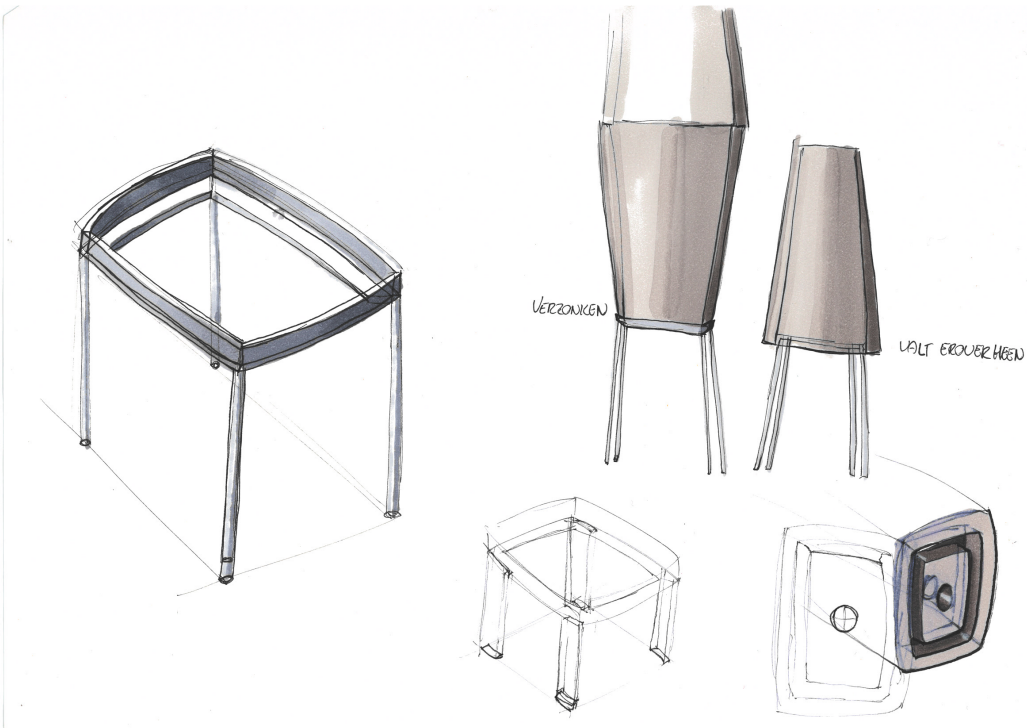
E1. Formstudy stand integration
E2 Stability of CirculEm
E3. Wall thickness
E4. Simulations
E5. Cost calculations
E6. Packaging

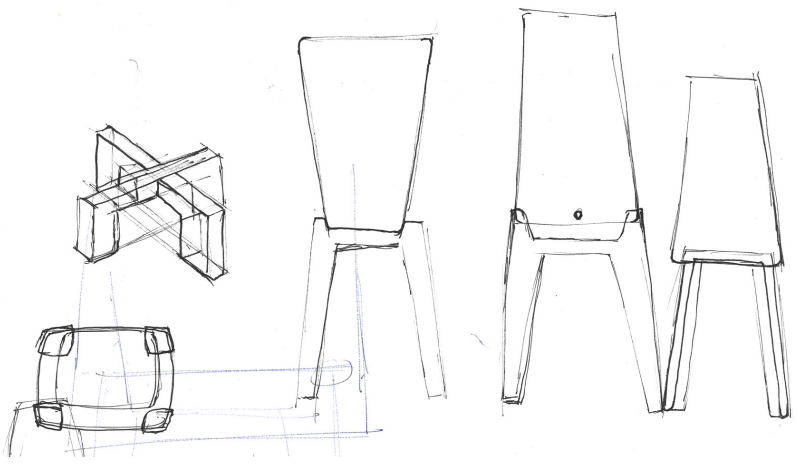
E1 Formstudy stand integration

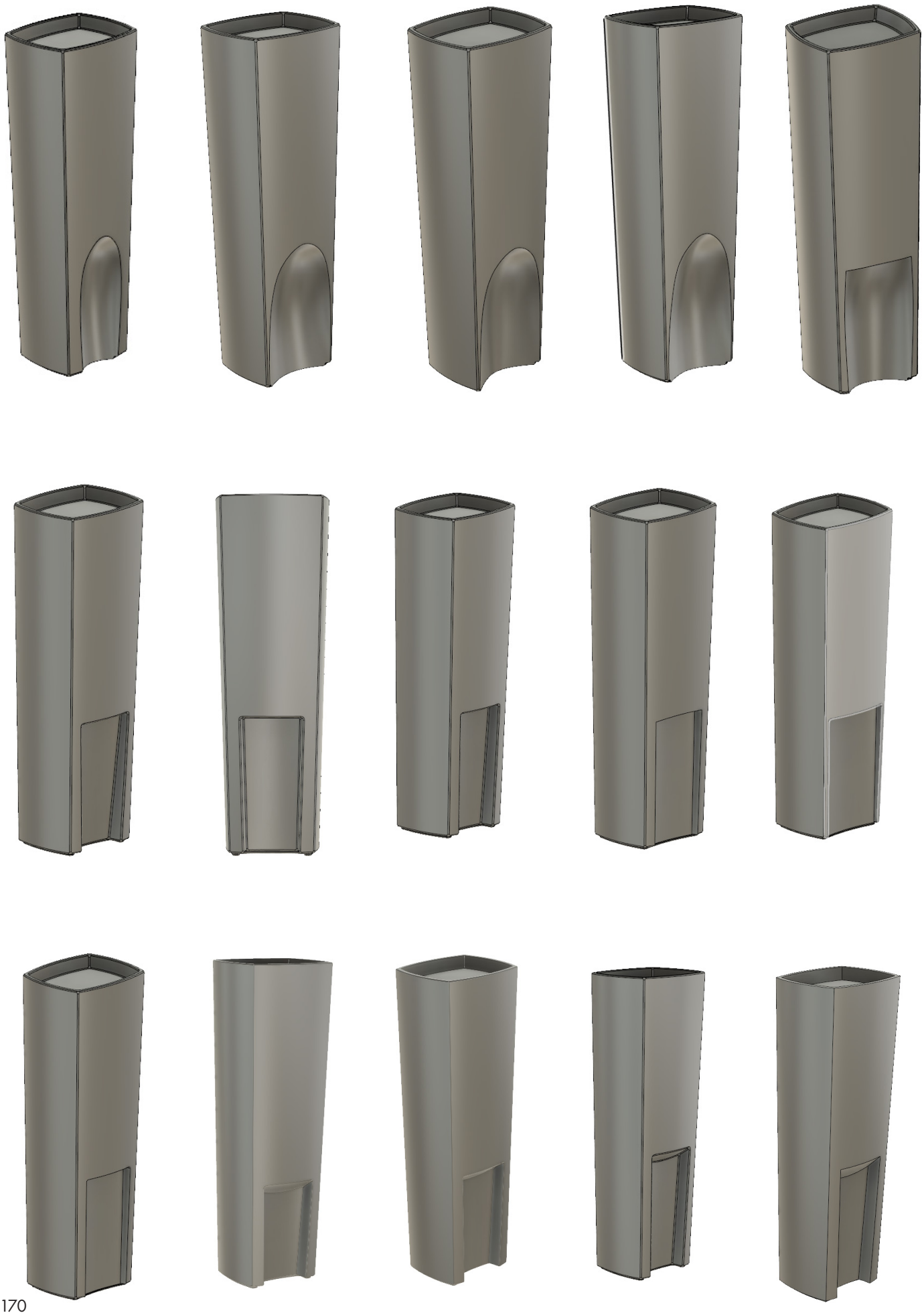
A study made in Fusion 360

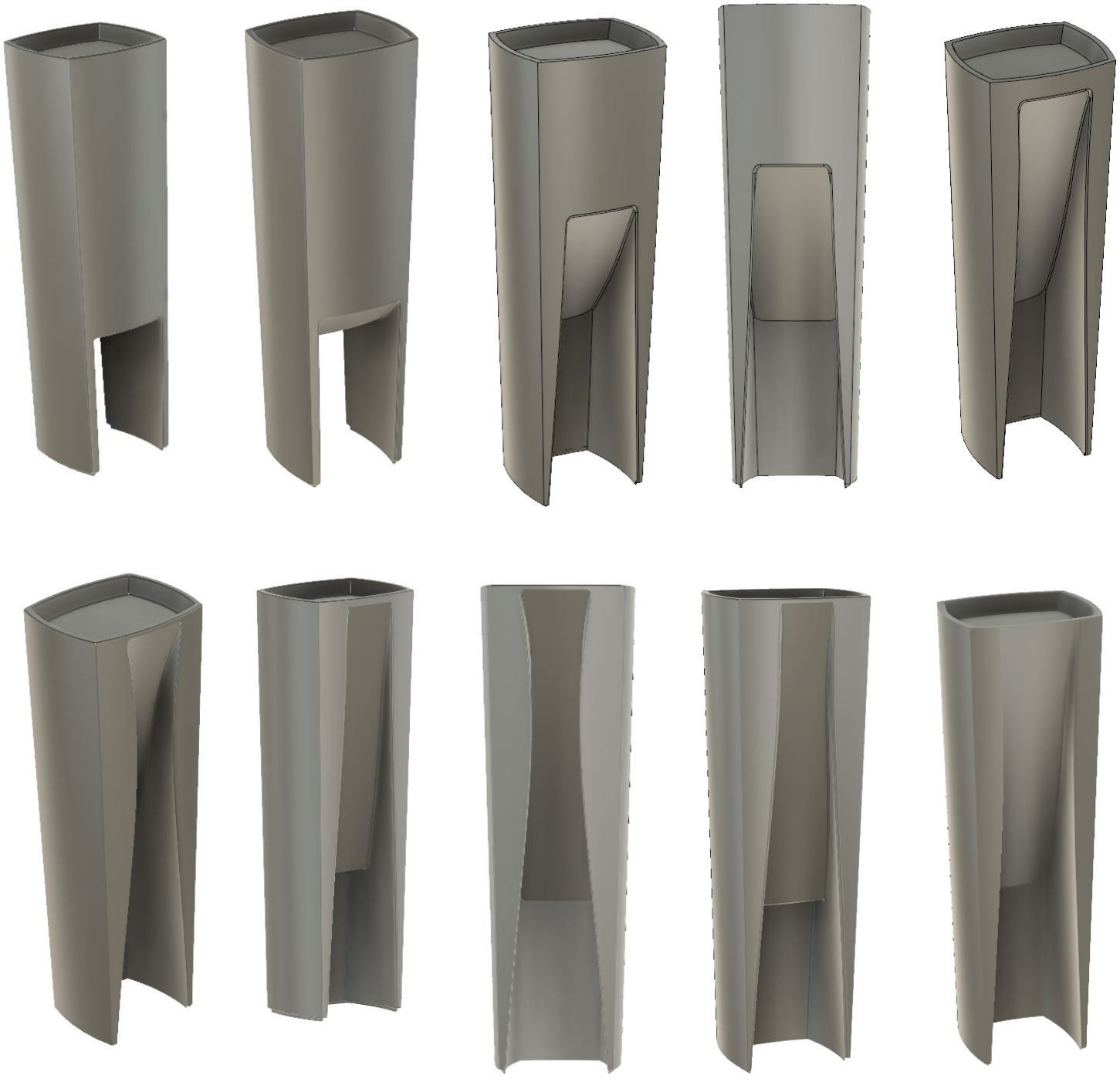
A form study was conducted towards a shape in which the stand was integrated with the barrel. Before it was decided to integrate the stand, a brief formstudy was done with sketces.

After the greenlight meeting, the stand was reconsidered and it was chosen to integrate the stand of the barrel with the barrel. This provides stability of an empty barrel and preventes complex connections. Looking into existing designs, a caption is made under the tap of the barrel for the watering can. This is where the form study began. However, no caption could be found without breaking up the total minimal shape. After looking critically to the requirements of this caption, a caption appeared to be unnecessary, since the tap is also creating some space already.









E2 Stability of CirculEm

Force to titlt the barrel and wind load on the barrel

E2.1 Force

Talbe E1 is the overview of the different values to tilt the barrel on different heights, and at three different water levels.

r (m)	Filled completely (mass=81kg)	Filled half (mass=56kg)	'Empty' * (mass=33kg)
1.05	120	83	31
1	126	87	33
0.9	140	97	37
0.8	157,5	109	41
0.7	180	124	47
0.6	210	145	55
0.5	252	174	66
0.4	315	218	83
0.3	420	290	110
0.2	630	435	165
0.1	1260	870	330

Table E1 The required forces to tilt the rain barrel

* Empty not actually empty, but at this point, the water level will be below the height of the tap.

These values are based on a weight of the barrel of 8kg, which is on the light side, so the numbers are conservative. The values and formulas that are used are:

$M = F^*r$

F_{barrel} = Mass (kg)* G(m/s^2)

G = 10m/s^2

$M_{left} = M_{right}$

E2.2 Wind load

Looking at a windload, half the height should be taken into account, simplifying the formula.

$qw = 1/2 * \rho * V_{wind}^2$

qw = Windpressure (N/m^2)

F=qw*A

A = 0.24m^2 (see figure E1)

ρ = 1.3 kg/m^3

F_{filled}= 252 N

F_{half}= 174 N

F_{empty} = 66N

qw_{filled} = 1050 N/m^2

qw_{half} = 725 N/m^2

qw_{empty} = 275 N/m^2

Thus

$V = \sqrt{(qw/(1/2\ \rho)}$

V_{filled} = 40.2 m/s *3.6 = 145 km/h

V_{half} = 33.4 m/s *3.6 = 120 km/h

V_{empty} = 20.6 m/s *3.6 = 74 km/h

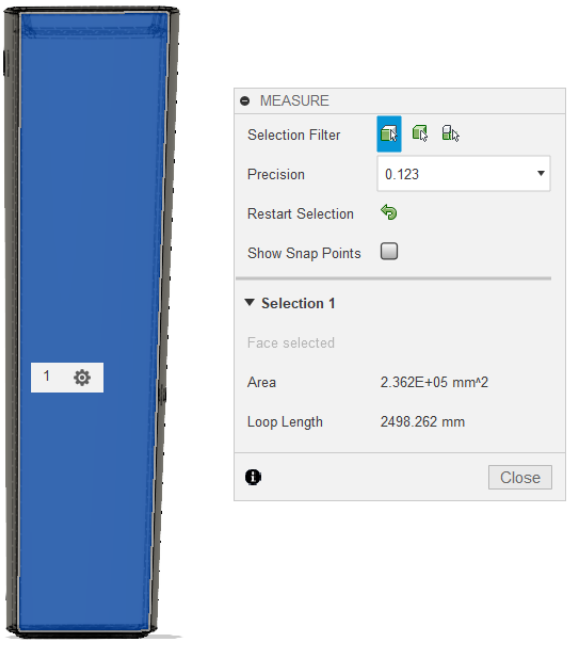
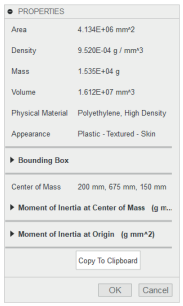


Figure E2.1 the surfaca of the barrel

WALL THICKNESS E3

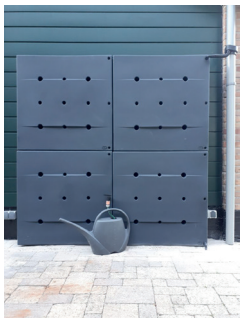
LOOKING INTO EXISTING RAIN BARRELS

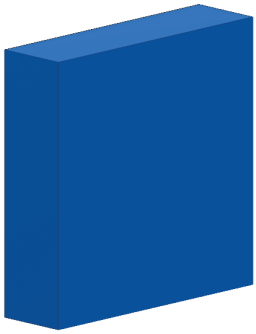
BLOKKER - 320L

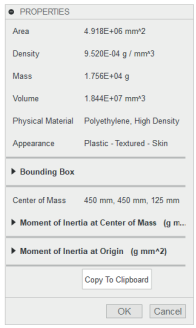


€230,-
7.8MM

RAINBLOCK - 165L

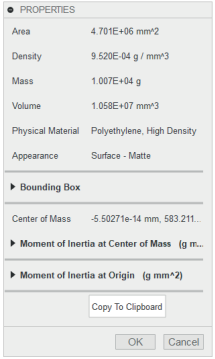






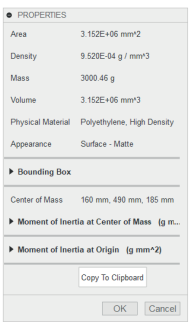
QUATATION
7.5MM

INTRATUIN - 150L



€199
4.5MM

SLIMLINE - 100L



€39,95
2MM

E4 Simulations

Stress and displacement

E2.1 Simulation set-up

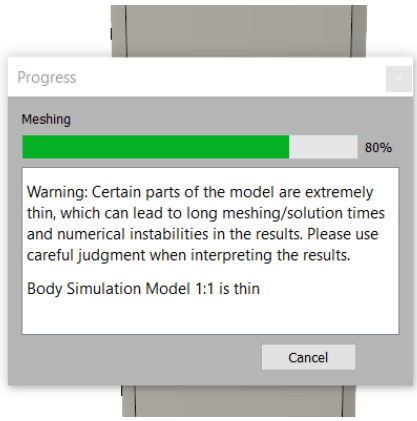
For all the simulations, the same method has been used. The maximum water level in the barrel is 950mm, so this is culculated with. The surfaces that touches the floor are fixed. On the other surfaces, a hydrostatic pressure is simulated.

For the droptest, the empty barrel is simulated with gravity (yelow arrow) falling down from 1 m height on a vulnerable corner. The arrow therefore represents a force of 100N if the barrel has a weight of 10 kg and the gravity is also 10 m/s^2.

E2.2 Wall thickness 1 mm

As can be seen in the figures, the maximum displacement within the barrel is 2 mm and the maximum stress is 4.4MPa in the droptest. For the hydrostatic pressure, the maximum displacement is 0.16 mm and the maximum stress 0.22MPa. However, since this wall is considered very thin, it could contain numerical instabilities. This data is therefore considered unusefull for this research.

Figure E4.1 The warning of Fusion 360 for the thin wall mesh



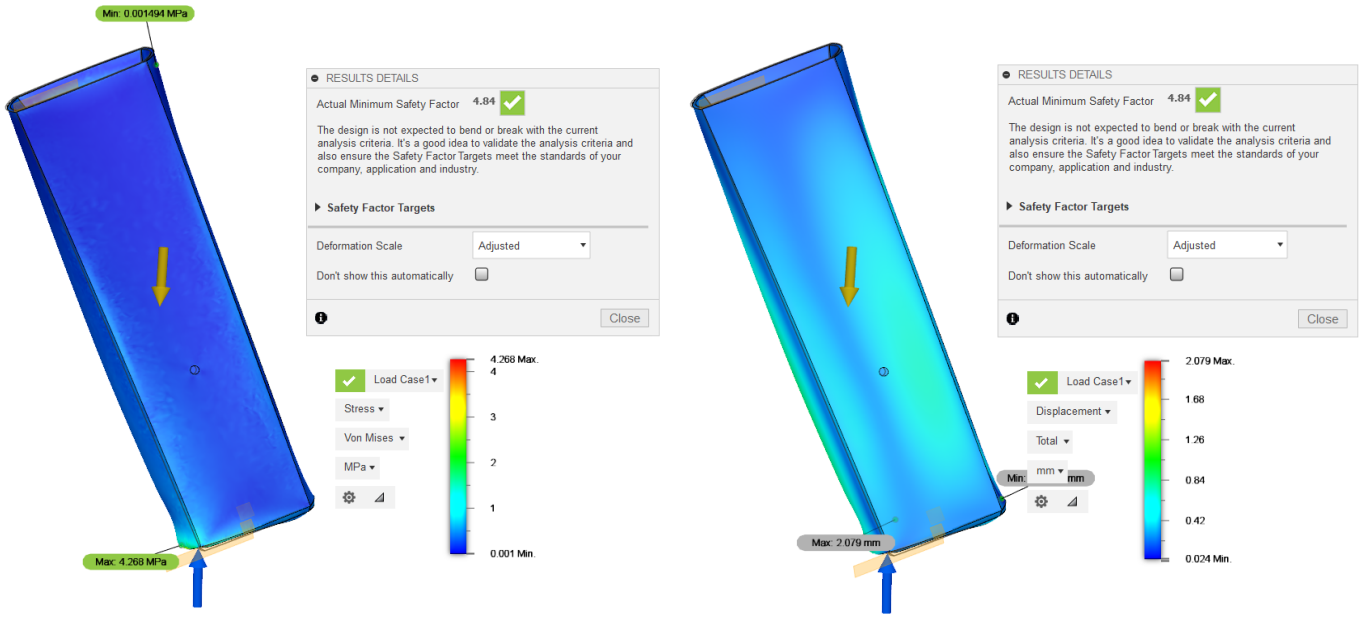


Figure E4.2 Droptest (1mm), left the stress, right the displacement

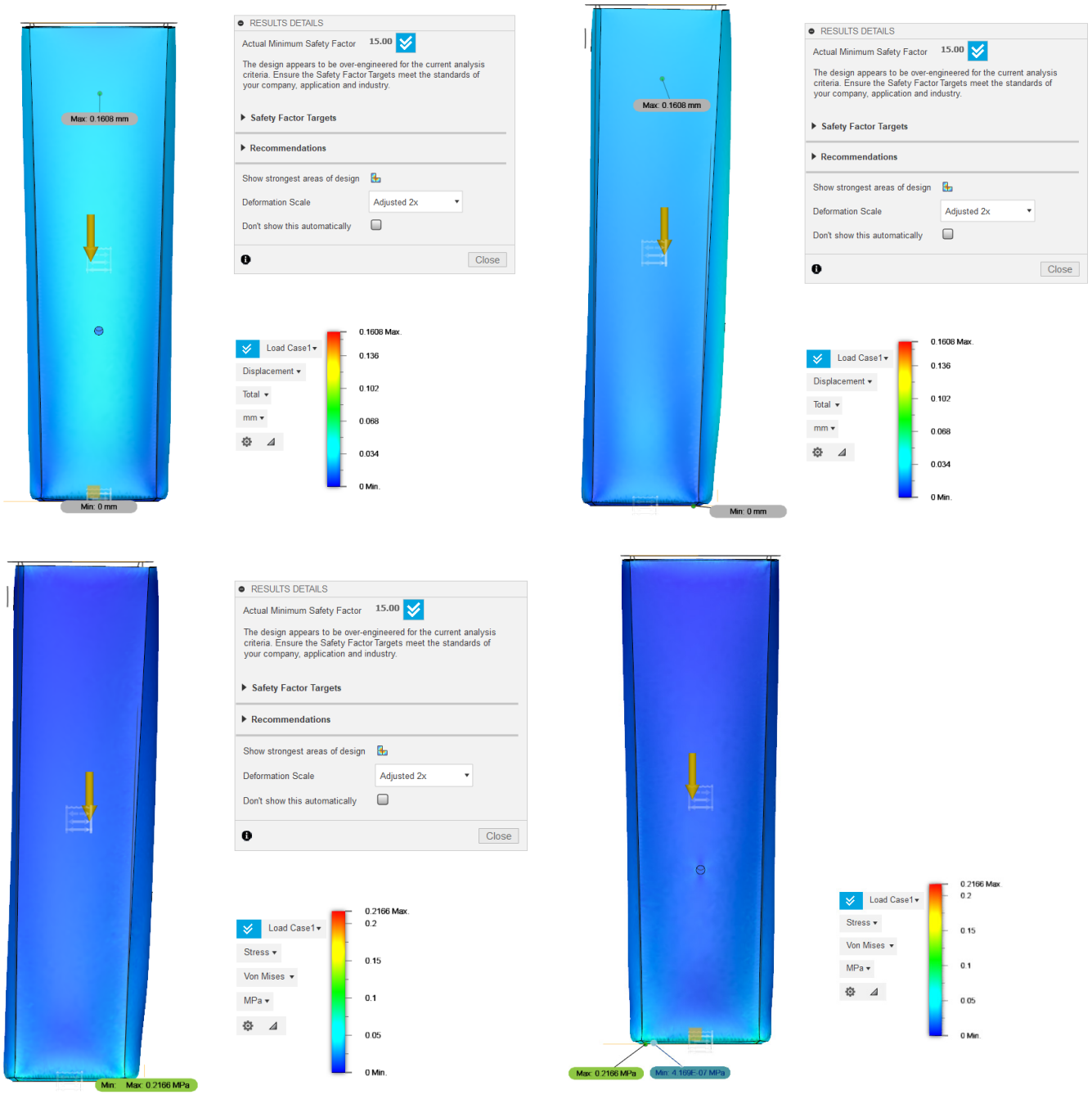


Figure E4.3 Hydrostatic pressure test (5mm), upper two displacement, lower two stress

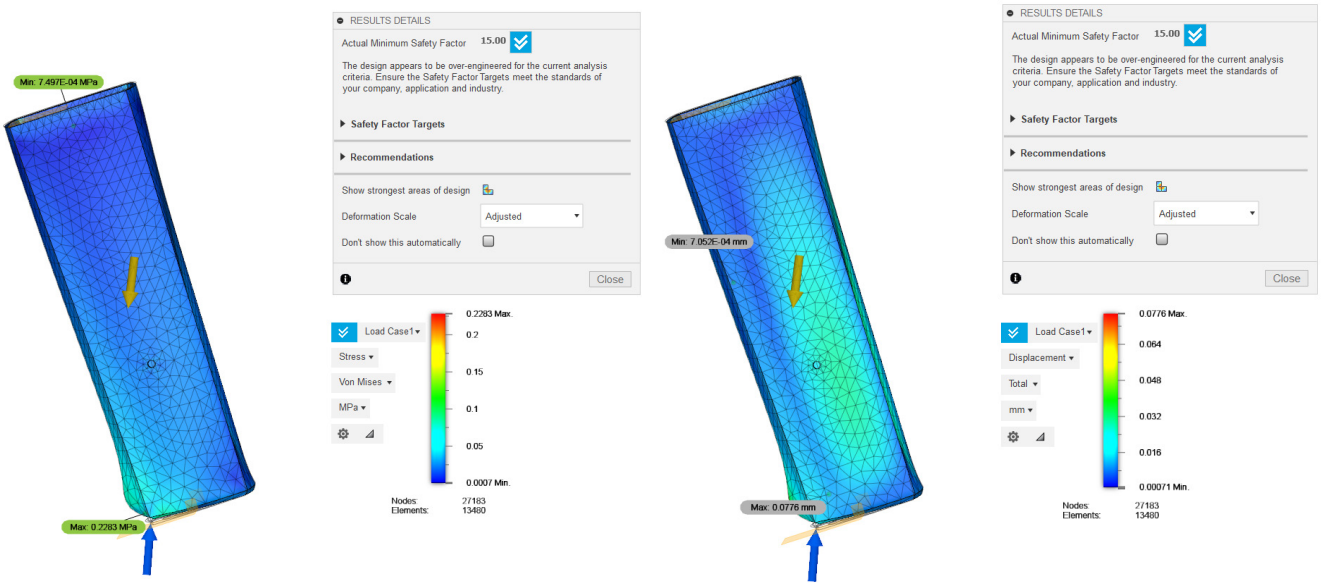


Figure E4.4 Droptest (5mm), left the stress, right the displacement

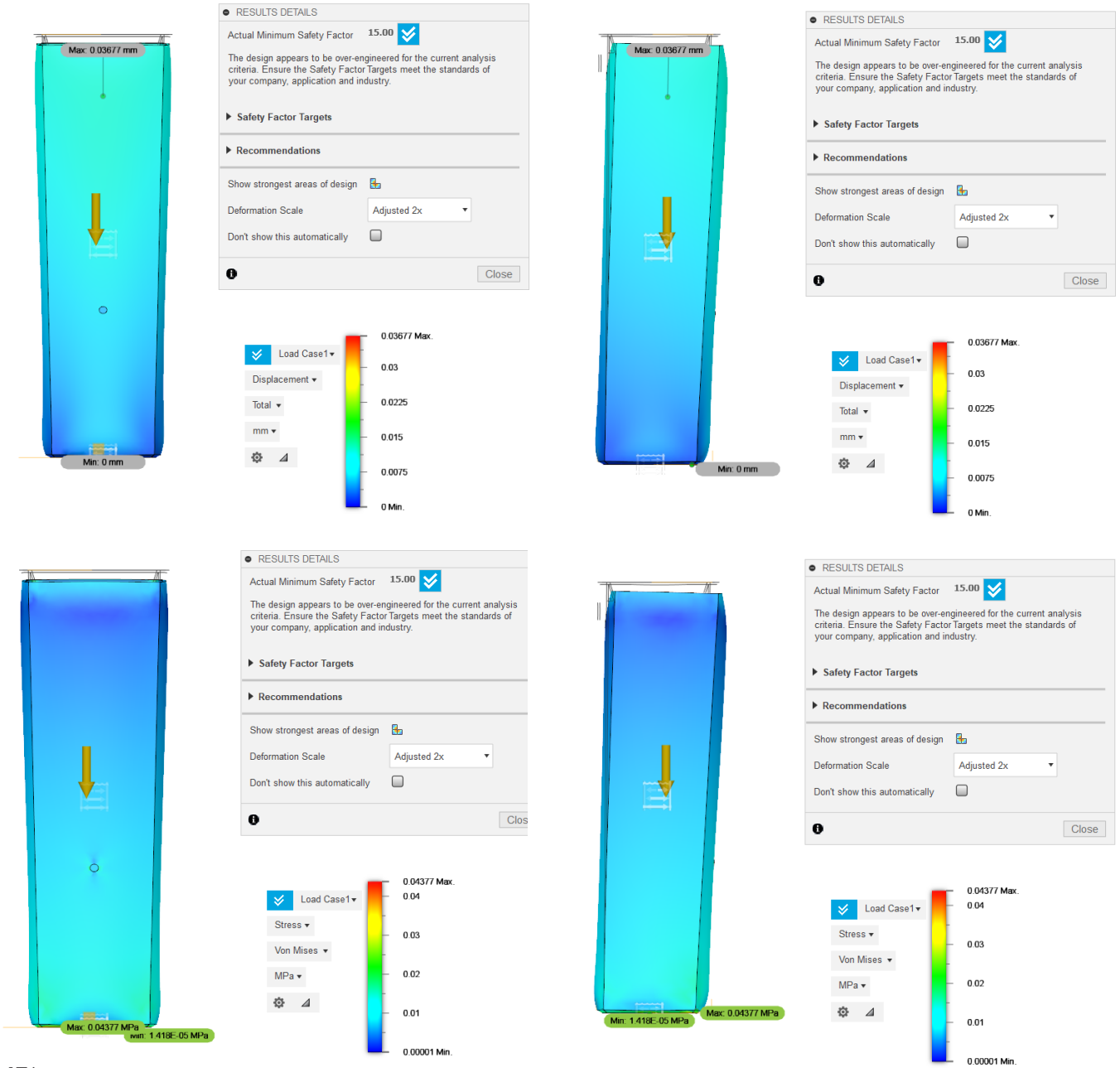


Figure E4.5 Hydrostatic pressure test (5mm), upper two displacement, lower two stress

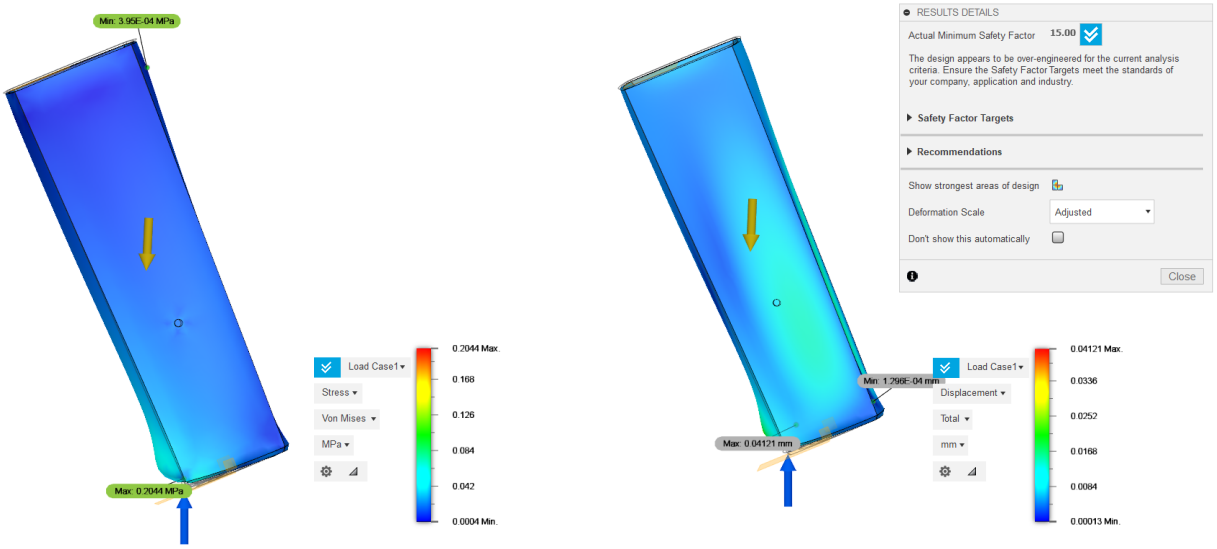


Figure E4.6 Droptest (7mm), left the stress, right the displacement

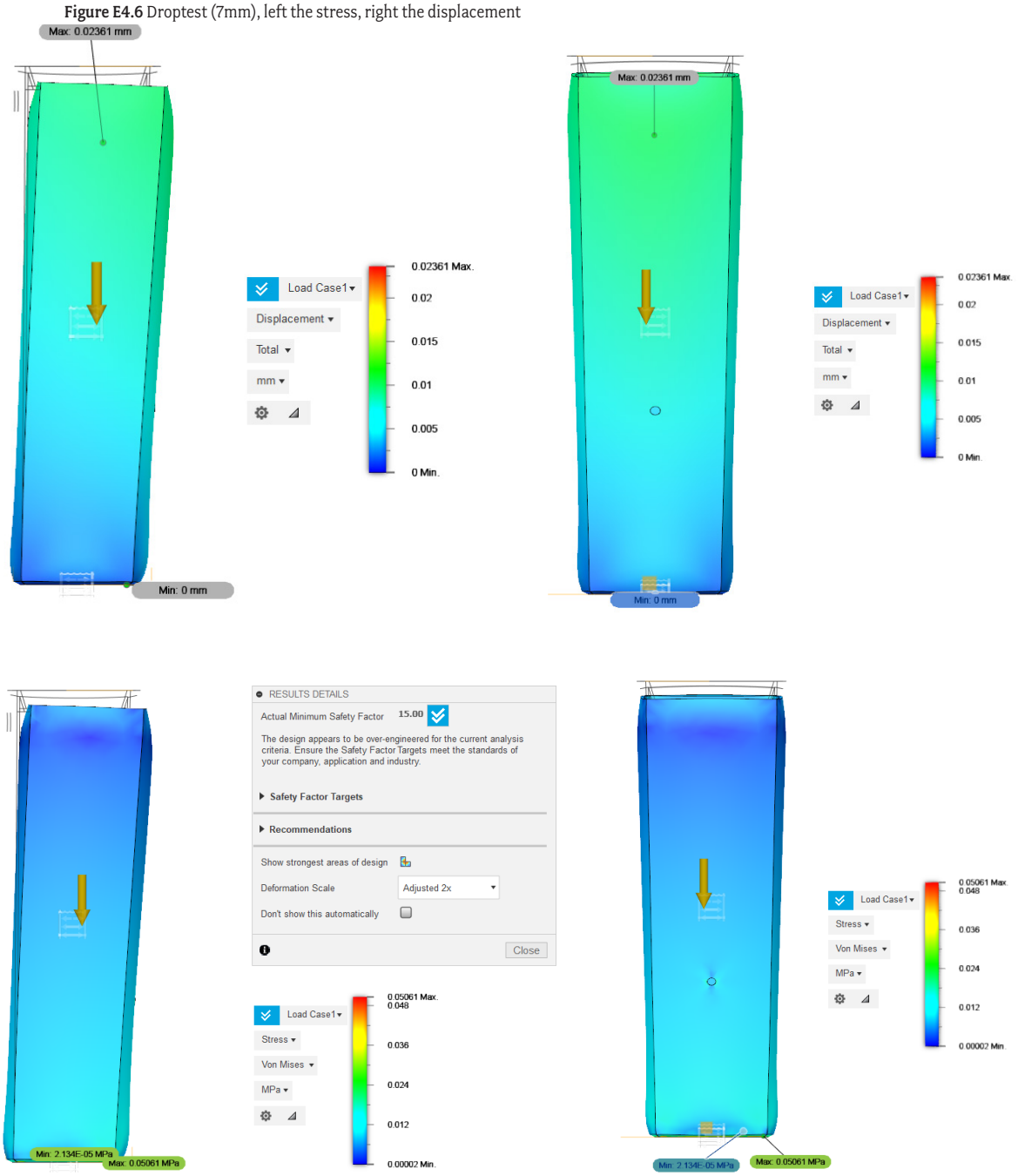


Figure E4.7 Hydrostatic pressure test (7mm), upper two displacement, lower two stress

E5 Cost calculation

Detailing of the cost calculations

E5.1 Costs set-up CirculEm

The costs of the mould are an estimation based on the expertise of Pieter van 't Veer.

Material

Virgin PE powder costs around €2000 per ton. This is based on the expertise of Pieter van 't Veer. Powder is more expensive than pellets or granulate.

Michael Sudhaus from Hubert Eing provided the prices of the agglomerate. The price of PO85 is between €150,- and €180,-. The price of PO95 is between €310,- and €330,-. This price is sigificantly higher, since this material is more purified. According to Van 't Veer, to make powder out of this, €500,- per ton is a good estimation.

Transportation

One truck to transport from Belgium to the Netherlands would cost about €700,-. One truck could transport 40 pallets. One pallet could contain 12 barrels, which means 480 barrels in one truck. This means €1,46 per barrel.

Production costs

For the production costs, Zweva made an estimation for production in the factory of their partnet Plastigi. Plastigi estimated the production costs at €47,- per piece, including man and machine costs, using two moulds. The price for the mould was estimated on €15 000,-.

The retail price could be around €165,-.

Costs first batch 20 000 pieces

Investments					Costs with two moulds
Mould			€ 15.000		€ 1,50
Material	*Weight per product (kg)*	*price per kg granules*		*Powder*	
PO95	4	€0,31 - 0,33		€ 0,50	€ 2,00
Virgin	4			€ 2	€ 8,00
Production	Includes material price				
Total production costs					€ 47,00
Standardized parts		Ex btw		Bulk discount	
Tap	€23,90 per piece incl btw		€ 18,88	50%	€ 9,44
Overflow connection	€18,95 per piece incl btw		€ 14,97	50%	€ 7,49
Insert Thread	€0,40 per piece incl btw		€ 0,32	50%	€ 0,16
	Per truck		*Pieces per truck*	*Per piece*	
Transportation		€ 700	480	€ 1,46	€ 1,46
Total cost price per barrel					€ 67,04
Total cost price incl. VAT					€ 81,12
Retail price	Cost price x2				**€ 162,24**
Subsidy by municpalities		25%			€ 121,68

PACKAGING E6

A VERY FIRST IMPRESSION

E6.1 A POSSIBLE PACKAGING FOR CIRCULEM

The packaging of CirculEm could consist out of two cardboard boxes see figure E6.1. In the box on the top, the tap and the overflow connection could be stored. The boxes are 40*30*15 cm. This makes it possible to fit 8 barrels on a europallet with the dimensions of 120*80 cm.

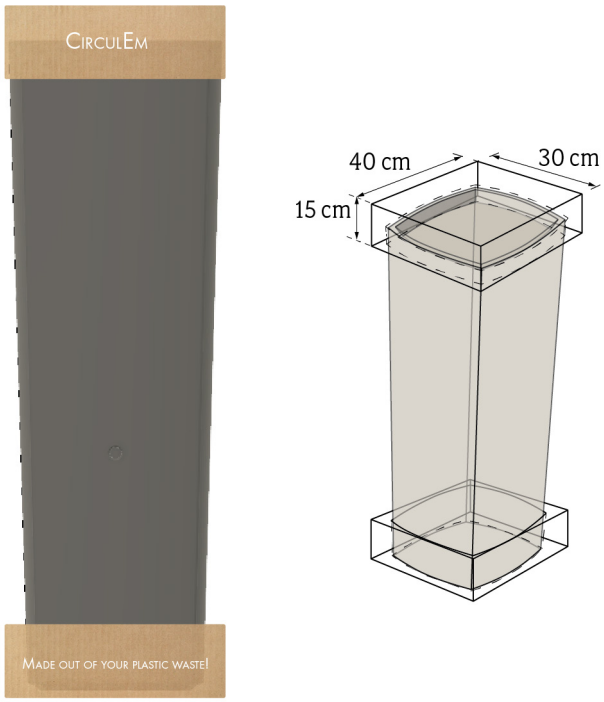


Figure E6.1 The packaging of CirculEm