# A VISIT TO THE PAST

## CAST ALUMINIUM HOUSE CLEANING TOOLS

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# Summary

Unsustainable use of natural resources has been the basis for economic growth since the industrial revolution. The linear model of extraction, processing, consumption and disposal has brought significant environmental consequences such as resource scarcity, pollution, biodiversity loss and climate change. The use of plastics is one example of unsustainable human behaviour. The use of them has offered an answer to many challenges related to modern economies but not without a cost. The global plastics production has risen dramatically since the 1950s. In European Union, we now use 100 kg of plastics per person per year. Plastics make up a large and growing share of solid waste around the world. Every piece of plastic ever made still exists, in some form on Earth. They are in the air we breathe and in the water we drink.

With this project, I aim to find solutions to reduce our environmentally harmful plastic waste generation. This report consists of theory part and productive part. In the theory part I go through the principles of circular economy and forms and patterns in nature. I compare recyclability of plastics and aluminium and the environmental impacts of their production. In the first part I also go through the important steps of designing cast products. In the productive part I am applying the insights from the first part in the context of useful everyday objects. I use qualitative and visual research methods to identify products that everyone needs focusing on plastic made objects. I further conduct form studies by sketching and prototyping with cardboard and CAD models.

The outcome of this project is a collection of cast aluminium household cleaning supplies. The result successfully highlights circularity by simplicity, material selection and easy separation of materials. The product family also approaches the activities related to the household care from a more resource efficient and less environmentally harmful angle. Also, in addition to their purpose as useful everyday products, the carefully crafted objects are designed to inspire and nudge people to replace plastics.

# Acknowledgements

This project and the outcome would not have reached this level without the guidance of senior lecturer Olof Kolte. I am especially grateful to him for challenging me and for being an inspiration. I would also like to thank professor Jasjit Singh for his insights during the project and Max van der Mars for finding time between his studies to help me out with the 3D prints.

Overall, concerning the master studies, I want to thank the whole staff including the workshop crew, service group, lecturers and management at the University. The master's programme allowed us to develop as industrial designers and the well-structured programme also gave us a good opportunity to show our skills at international trade fairs and in collaborations with companies. Valuable feedbacks have been exchanged with colleagues and new connections have been made. It has been an exciting journey.

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# Background

## Climate Neutrality

Climate change challenges our society to change. In 2015, the Paris Agreement brought all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects. The goal of the Paris Agreement is to limit global warming to well below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels. To achieve this long-term temperature goal, countries aim to reach global peaking of greenhouse gas emissions as soon as possible to achieve a climate neutral world by mid-century.

Scientists, engineers, artists and people in general are able to do almost anything imaginable. We just need to be provided with a right type of challenges. Instead, or in parallel of telling people of all the negative impacts of climate change, we could show them the future in harmony with nature and try to find ways to nudge people to change their behaviour. Is it possible? We want to inspire and create a vision. Let's make sustainable future look so fascinating that people and nations are willing to compete to reach that vision.

## Casting Project

This degree project is a lot about summing up the insights, experiences and things I have learned during the master's education. I would like to mention our first project that was held under supervision of senior lecturer Olof Kolte because it had a significant effect on this project. We were challenged to identify linear systems and then to come up with replacing circular systems. The outcome of the course was an object manufactured by casting to support your chosen circular system. Among many of my colleagues, I chose sand casting as a method and aluminium as a material for my object.

I immediately felt that this combination of material and manufacturing method was something that I had been looking for, but I just had not noticed before. Metals are perceived as cold and hard materials. By sand casting, the liquid metal can be guided into forms that can also be warm and soft. The material is not

forced to its shape, it just naturally flows into its shape with the help of gravity. It is a gentle method, and I think, that is how things should go in life in general. Not by forcing, but by natural flow.

I did my bachelor's studies in Lahti University of Applied Sciences, where I studied applied arts in four-year programme. Our class was divided into two focus areas: jewellery design and object design. I started with jewellery design, but eventually I started to feel limited with scale and usage scenarios while doing jewellery. Therefore, I switched to object design during the second year. Despite the switch, I enjoy sculpting and shaping the metal. It is also, fascinating to see how some skilled craftsmen can reach unbelievable precision with their work.


*We did a field trip around Scania as a part of introduction to master studies. On the trip, we visited several companies and museums. Here I am fascinated by the foundry area at the old factory museum Ebbamåla Bruk.*

"Supply chains can be disrupted by extreme weather events, such as drought interrupting waterways and heat interrupting rail traffic."

Europe

"Species loss is significant throughout the continent."

Africa

"In coastal cities such as New York, the likelihood of flooding is increasing significantly, forcing societies to prepare for flood prevention and damage mitigation."

North America

"The physical effects of climate change are manifesting themselves in the Arctic faster than they can adapt. The impact on the health of indigenous peoples in the region in particular is significant."

Arctic regions

"Asia's coastal ecosystems' capacity to provide people with food and jobs by 2050 will be significantly reduced."

Asia

"Extreme drought and wildfires are highly likely to occur, particularly in the southwestern United States and north western Mexico by 2050, threatening locally whole ecosystems."

North America

"The availability of logistically important winter and frost paths is decreasing. On the other hand, the availability of waterways, especially near land areas, is improving."

Arctic regions

"Himalayan glaciers are projected to decline by about 40 percent by the middle of the century."

Asia

"Ice fluctuations and melting of permafrost cause damage to the structures of important infrastructure such as bridges, pipelines, oil wells and hydropower."

Arctic regions

"Many species of animals and plants are most likely to disappear completely along all warming paths, as many species of animals and plants are already living above their temperature tolerance."

Asia

"Farming in southern Europe is becoming more difficult, and periodic droughts can also dampen growth conditions in the north."

Europe

"With population growth and increasing drought, pressure on groundwater infrastructure is increasing and problems of access to clean water are increasing."

Africa

"The rise in temperatures threatens whole species of organisms and contributes to the spread of various diseases and pest species to ever larger areas."

Australasia

"There is huge potential for solar energy in the region, but there are currently about 5 gigawatts of solar energy in Africa, which is only one 1 % of global production capacity."

Africa

"Climate change will have a particular impact on food security in the region, forcing economies to invest in key infrastructure routes and in securing resource reserves."

Asia

# Motivation

**Possible Future Scenarios**

The master's programme gave us a good opportunity to work on a variety of fascinating scenarios. The NASA project held by Per Liljeqvist & Pia Jonsson was eye opening because resource efficiency cannot be separated from designing for space missions, they go hand in hand. It was also good to be reminded that things on Earth can have a new meaning in space or on another planet.

Design Management course held by Carl Lidgard brought us closer to business world. We tried to predict how the clients' business area would be in some specific time in the future in order to grow the competitiveness of our clients' business. By trying to understand the future this way we can prepare ourselves to those conditions in the future. It is good to prepare ourselves for at least few different future scenarios. The scenarios are always imaginary as we can't forecast the future, but we can always aim to create as realistic future scenario as possible. On the other hand, the scenarios could also be highly imaginary.

As a designer I like to play with scenarios because it is a good way to enhance your creativity. It makes you to look at things from different perspectives. The altered reality leads to altered results of thinking. In other words, we can come up with new innovative concepts and ideas which can be relevant not only to the future scenarios, but also to the current time. With this in mind I tried to identify challenges within industries in the context of their adaptability to the future affected by climate change. To get the overall understanding on the subject I read Deloitte report to the Confederation of Finnish Industries on impact of climate change on Finnish business.

By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters.

By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination.

By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes.

By 2030, achieve universal and equitable access to safe and affordable drinking water for all.

By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally.

By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity.

By 2030, increase substantially the share of renewable energy in the global energy mix.

By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally.

By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature.

By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution.

Strengthen efforts to protect and safeguard the world's cultural and natural heritage.

By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities.

By 2030, achieve the sustainable management and efficient use of natural resources.

By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse.

Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle.

**Context**

It was a bit hard for me to come up with a clear focus and context. I wanted to find a challenge that would be deep enough to put me out of my comfort zone but also important to solve from the standpoints of nature and human well-being. United Nations have sustainable development goals under 17 categories on their web page. I went through them in order to identify targets that would also be meaningful for myself to reach. The chosen targets can be found under the goal 12 *ensure sustainable consumption and production patterns*. Education plays an important role to reduce our waste generation and therefore, the targets go well hand in hand.

*"By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature."*

*"By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse."*

*UN SDG 12*

**Plastic Waste**

The global plastics production has risen dramatically since the 1950s. In European Union, we now use 100 kg of plastics per person per year. Even though, the use of plastics has offered an answer to many challenges related to modern economies, the use of them has also its downsides.

Plastics make up a large and growing share of solid waste around the world. Every piece of plastic ever made still exists, in some form on Earth. Plastics are in the air we breathe and in the water we drink. According to WWF (2020) an estimated 8 million metric tons of plastic enter our oceans each year – the equivalent to a truckload of plastic every minute. Once in the water, plastic waste breaks apart into microplastics and is then ingested by marine animals, thus polluting the entire food chain. In addition, the growing plastics use will be a major contributor to CO2 emissions.

The global growth of plastics consumption is set to continue, as developing economies begin using plastics in a range of applications and consumer goods. Material Economics (2018) estimates that global plastics production would double from 320 million tonnes in 2015 to over 800 million tonnes per year by 2050. If produced with today's fossil feedstock, the global plastics production would then require 900 Mt of oil per year. That would exceed the amount European Union uses today, and equal to 23% of total global oil use in a 2 °C scenario.

Even though most plastics are recyclable, the recycling rates in European Union are very low. PE (polyethylene) is the most commonly used plastic type of the more than 30 types in common use. It is widely used in packaging sector which equals 40% of European plastic use, followed by buildings and construction 20%, automobiles 9% and electronics 6%. Five big plastics types account for more than 70% of use, and all of them can be recycled mechanically.

According to studies done by Material Economics (2018), there are three main factors preventing the production of high-quality secondary plastics from technical perspective. First, the material flows are often mixed and contaminated. High-quality recycling requires that plastics are separated into streams of single plastic types. Currently, the separation can be difficult or even impossible because of product design and collection systems, which mix or fuse different types of plastics. Second, plastics often contain additives such as: colourants, stabilisers or flame retardants. Additives are difficult to remove and they can make the material unsafe or impossible to use in new products. Third, plastics may also be contaminated by the substances they held. Contaminants such as medical waste for example, require plastics to be incinerated. Other fundamental reasons are related to policy and market features. For example, the prices of the primary plastics are so cheap that the used plastic has low value (Material Economics 2018).

**Unsustainable human behaviour**

Pollution

Biodiversity loss

Resource scarcity

Climate change

Living conditions getting worse

**Solution?**

# Inspiration

**Circular Economy**

Unsustainable use of natural resources has been the basis for economic growth since the industrial revolution. The linear model of extraction, processing, consumption and disposal has brought significant environmental consequences such as resource scarcity, pollution, biodiversity loss and climate change.

The rapid industrialization of emerging economies and continuous high consumption in industrialized countries have pushed global demand for resources to unprecedented levels. The weight of materials consumed worldwide grew from 27 billion tonnes (Gt) in 1970 to 89 billion tonnes in 2017. This will increase further with continued population growth and economic development. In the absence of new policies, the Organisation for Economic Co-operation and Development (OECD) projects that the global material use will rise from 89 Gt in 2017 to 167 Gt in 2060.

These challenges have forced governments and policymakers to look at alternative models such as the circular economy to secure a more sustainable economic growth path. The European Commission has adopted a circular economy policy package in 2015, which was followed by a new package in 2020. This package of legislative and non-legislative initiatives, known as the European Circular Economy Action Plan (CEAP), has put Europe on a transition towards a carbon neutral, resource efficient and competitive economy. The Action Plan announces initiatives along the entire life cycle of products, targeting for example their design, promoting circular economy processes and fostering sustainable consumption. Several countries have followed and established their own national strategies and circular economy roadmaps.

Regardless of the Circular Economy Action Plan and the national roadmaps, there is no commonly agreed definition of the term “circular economy”. The Ellen MacArthur Foundation defines circular economy as “an economy that provides multiple value-creation mechanisms which are decoupled from the consumption of finite resources” (Ellen MacArthur Foundation & McKinsey, 2015, p. 23). The Finnish Innovation Fund Sitra defines it as “an economic model which does not

focus on producing more and more goods, but instead promotes consumption based on using services - sharing, renting, and recycling - instead of owning. Materials are ultimately not destroyed but are used to make new products over and over again" (Sitra, 2020). Both approaches have emphasis on resource efficiency. Different definitions usually share the basic concept of decoupling of natural resource extraction and use from economic output (Sitra & IISD, 2020).

There are three main reasons often highlighted for promoting a circular economy transition according to McCarthy et al. (2018). First, the more efficient use of resources could represent an important tool for achieving climate and other environmental goals. Second, reduced reliance on critical resource and material imports. Resource efficiency is a crucial factor in order to mitigate the risks associated with future geopolitical shocks. Third, the activities related to circular economy transition could also become significant drivers of job creation and economic growth. Secondary material production, repair and remanufacture, the services sector and the sharing economy are among the sectors where the new opportunities will rise (McCarthy et al., 2018).

*"An economy that provides multiple value-creation mechanisms which are decoupled from the consumption of finite resources."*

*Ellen MacArthur Foundation*

**Nature**

Biophilia hypothesis suggests that we have an innate tendency to seek connections with nature and other forms of life. Throughout our human evolution, we have developed in direct connection with nature. From this perspective, large scale constructed environments are still something new to us. In order for us to function and develop well, we need some form of connection to nature. Nature and forest environments have been found to have a positive impact especially on our mental wellbeing and they are also connected with creativity.

I would call myself as a nature admirer. I have always been inspired by nature, but its connection to my design work has probably been related only to subconscious preference to form aesthetics present in nordic landscapes. During the ice age, the moving ice masses and the gravel beneath them have been grinding the bedrock. As a result, all the sharp edges have been worn away and only the most durable forms are left. My intention with this project was to come up with sustainable and life supporting ways to shape our future. Perhaps understanding of nature's principles, systems, forms and patterns could guide me to better solutions. To deepen my understanding on the subject, I dived into the world of biomimetics.

Nature provides an unlimited inspirational source of structures, procedures and evolutionary principles we can apply to our own design. However, to understand nature's structures and processes can be challenging and implementing them can be even more challenging as nature delivers no blueprints. We can still study nature's models and discover the principles they are based on, but we should not slavishly attempt to rebuild every detail. As Nachtigall (2015) points out: "Tapping into these reservoirs cannot be uncritical, nor by merely copying nature — that would be pure charlatanism. Rather one should critically comb through the tremendous potential of "nature's discoveries", research them and implement them technically, thus making them useful for humanity."

Nature follows clear rules and laws. Forms are developed to be energy efficient, which applies both to the growth, and to the care of living beings. This energetic efficiency of growth is apparent in nature because it is a matter of survival. Nature is seeking the optimum form. In the long run, a life form that is not functioning properly is not able to survive. A good example of efficient use of material and energy is an eggshell. Thinnest possible shell that fulfils the purpose being strong enough while the egg is being laid but weak enough for a hatching chick to be able break out.

Mathematicians have proved a century ago, that the most efficient way to pack circles together on the plane is the honeycomb. Stewart (2015) explains: "If you take a lot of identical circles — coins, say — lay them on a table, and jiggle them around until they are squashed as tightly as possible, then they form themselves into a honeycomb." The principle is that six circles fit exactly around another

circle of the same size, and the honeycomb repeats this pattern around every circle. According to Stewart's observations, systematic large-scale patterns can be created by following simple, local rules. In a beehive, the honeycomb pattern is formed by perfect hexagons, where each hexagon is a tiny chamber capable of holding a grub or honey. Bees, as individuals are not smart enough to make these structures, but they arise because in principle the universe obeys simple rules. The Belgian physicist Joseph A.F Plateau (1801 – 1883) Did experimental observations with soap bubbles and used them as means of expressing physical laws. Plateau had wire loops of different shapes that he dipped into a soap solution. With his method he was able to find a minimal surface for each wire loop boundary because the soap film will always form a minimal surface because of its surface tension.

Kaplinsky (2006) argues that over idolization of nature seeks to cut humanity and human achievement down to size. He is concerned that environmentally conscious way of thinking might be in conflict with the human-centred outlook that is associated with the Enlightenment. He further points out that humanity is condemned for relying on the unsustainable use of fossil fuels, while nature is idolised as a careful and efficient recycler that breaks down waste and makes use of all available resources. The claim that we would avoid the problems of resource depletion and pollution by learning from nature is false in his opinion. As he puts it: "...the fossil fuels that supply our energy are, after all, nothing but waste products of nature that escaped its supposedly miraculous recycling process." Kaplinsky also argues that the claim that nature always optimise is not completely true. Nature optimises incrementally, as evolution proceeds by small steps. It can never start from scratch like human imagination which can make leaps and set to work on a radically new set of design principles.

Nature can be a valuable source of inspiration for designers on projects involving for example: mechanics, functionality and aesthetics. Cyclic principles are also present in nature in many ways. Observing and understanding them can beneficial when we are designing systems. Functional design seems to be something that is common in the living world and in the fields of design. Form construction has to cover multiple demands in both environments. Especially nowadays when the design aspirations are becoming increasingly ecological. Nature can be our guide when we create forms and shapes. Instead of just drawing lines and dimensions, we can create relationships between them, thus making them more harmonious and appealing to human eye.


**Aluminium**

The use of aluminium has many advantages which are related to its material properties and which can benefit today's society from the environmental perspective. Aluminium is almost everywhere around us. It is present in the large amount of applications and also in the soil. After oxygen and silicon, it is the third most abundant element in the Earth's crust.

Aluminium is light and relatively strong metal. It can easily be processed in several ways – both in a cold and hot condition. It will melt when temperatures exceed 660 °C, without releasing any gases. Its specific weight of 2.7 g/cm3 is one third of that of steel. The low weight is especially beneficial in relation to transportation, as it reduces energy consumption, and therefore also emissions of greenhouse gases. It has an innate ability to form a protective oxide coating itself which is highly corrosion resistant. This property prolongs the useful life of aluminium in its applications, thus reducing the need of replacement and maintenance. Corrosion resistance can be even further improved by various types of surface treatments. In addition, aluminium is also a good conductor of heat and electricity (Hydro 2012).

The primary production of aluminium is highly energy consuming. The smelting of aluminium uses 13–15 MWh per tonne of metal produced. When that is multiplied by the 60 million tonnes of aluminium that is produced now around the world, the electricity usage amounts to 5% of global electricity consumption. CO2 and greenhouse gas emissions also arise from the production of alumina and from the production of electricity when the electricity is produced by using fossil fuels. The major factor related to emissions from aluminium production is electricity and how the electricity is produced. Globally, 60% of aluminium today is produced using coal-fired electricity. The emissions per tonne of aluminium produced this way arise to 18 tonnes CO2. For comparison, this is more than seven times the emissions related to producing one tonne of primary steel.

Emissions from the aluminium production can be significantly reduced by using low-carbon power. Majority of aluminium produced in Europe is relatively low-carbon because of the use of hydro- and nuclear power. By using low-carbon electricity supply, the emissions from the primary aluminium production are reduced to 3 tonnes CO2 per tonne. Recycling of aluminium can even further lower the emissions as re-melting requires only 5% of the energy of primary production (Material Economics 2018).

It is estimated that 75% of the nearly one billion tons of aluminium that is ever produced is still in use, some of it having been through countless recycle loops through its lifecycle. Aluminium recycling industry includes both refiners and remelters. Refiners produce alloys to customer's specifications from a range of scrap sources by using more sophisticated processes. Remelters mainly use clean and sorted wrought alloy scrap and make products of the same type as the scrap sources. Collectors, dismantlers, metal merchants and scrap processors which deal with the collection and treatment of scrap are also involved in the industry.

Most of the aluminium produced is used for long-life products such as vehicles and building products. Approximately 25% of aluminium produced every year goes to the transportation sector. At the end of a car's useful life some of its aluminium parts, such as wheels and cylinder heads, are removed and the remaining body is fed into a shredder. After the shredder, the aluminium fraction is separated by using various technologies. Mixed alloy aluminium scrap collected this way is usually processed into casting alloys for the production of engine blocks and gearboxes. The use of wrought alloys in car bodies has increased and the volume of such scrap is anticipated to grow. Therefore, it is likely that separate collection of specific alloys from cars is becoming economically viable in the future. In Europe, 95% of the aluminium scrap from cars is currently being recycled. The numbers are similar in building and construction sector (Hydro 2012).


**Casting**

The casting process is used to make complex shapes by pouring molten metal into a mold made of refractory material. The mold has a cavity of a desired shape, where the metal solidifies into the desired shape. Castings are often made of recycled metal and in this way the casting process can take a waste product and turn it into new high value components, unendingly. The following chapters partly summarize Honkavaara's (2014) guide for designing cast products, where he goes through the important steps leading to a successful casting. The summary helps to understand the limitations and possibilities of the manufacturing method. It also partly answers to the question, where the forms come from?

Casting processes can be divided in two main categories. In one, the mold is destroyed as a part of the process and in the other, the mold can be reused. The choice of the process is determined by the shape of the object, the size of the series and the metal alloy to be cast. In sand casting the mold is made of bonded sand using a pattern made of wood, metal or plastic. The pattern is in the shape of the part to be made and it is removed before the molten metal is poured into the cavity. Once the metal has solidified, the sand mold is removed, and it cannot be used again. The pattern can be reused, and the sand can generally be recycled. In die casting, the mold is made of metal and it is called a tool or a die. These molds can be very complex and include separate pull-out cores. The molten metal is introduced into the die by gravity or by low or high pressure. The

die can be reused up to thousands of times to produce thousands of castings. Other variations of casting processes include investment casting, centrifugal casting, continuous casting and processes in which a semi-solid metal billet is squeezed into the mold or a die.

Each cast product has a parting line, which is the contact surface between the mold parts. The parting line is the basis for the design of castings. Straight parting line is ideal in terms of costs and manufacturability. It would be good for the designer to consider that the parting line leaves a visible shape in the final product. Designer should also keep in mind that at from some point the material must go into the cavity. Metal shrinks when it solidifies from molten state into a solid. While designing a product, the designer can already consider that the part solidifies from the thinnest points towards the mass concentrations that are fed with feeders. Mass concentrations should be kept to a minimum.

Each material has its own properties. The properties required of the material to be casted are mainly determined by the requirements set by the intended use of the product. There is no single right material for casting. The challenge is to find the most cost-effective alternative that meets the requirements of the product. The choice of material is an important part of the product design process because it affects the product's properties, sustainability, manufacturability and price. The material options should be compared already at the design stage, because at a later stage, changing the material will affect the construction of the part.

The creation of forms is a technical performance where the functions are connected with necessary shapes, considering the factors that limit the design. In order for the cast product or the pattern to be released from the mold, it has to be drafted. Draft angle is an angle or amount of slope that is incorporated into the walls perpendicular to the parting line. Purpose is to make the cavity opening wider than its base. Draft angle varies a bit depending on the casting process, but it is usually at least 3 degrees. Smooth forms make it easier for the metal to flow into the cavity and they also help the casting to solidify as evenly as possible. It is good for the designer to remember that unnecessarily thick spots should be avoided, and the wall thickness should be as even as possible to avoid porosity. It is advisable to round sharp edges because they are subjected to high stress. Otherwise, they can lead to fractures and variations in material properties.

Flawless casting does not exist. Casting defects are quality features and structural defects which can be caused by e.g., design, tools or work steps related to casting process. It is therefore necessary to determine which defects and to what extent are detrimental to the functioning of the product (Honkavaara, 2014).

**Art**

To get inspired, I also familiarized myself with the work of several interesting persons. The art of Donald Judd and the writings of Max Bill had the biggest impact on me. Both of them were formerly unknown to me. Donad Judd is one of the most significant artists of the twentieth century associated with minimalism. He is well known of his sculptures which are often based on rectangular cube. For the viewer, the sense of perception is often open between what is solid, what is present and what is absent. He already enjoyed a successful career in New York in 1970's when he decided to move to an empty town Marfa in a remote area of west Texas. The vast open space and his bases in Marfa impacted his sense of scale and the cubes started to get big variation in scale. However, one perceives each individual cube, despite the scale, as part of a whole. To me, this was inspiring.

Especially his installations of pure aluminium cubes at the artillery sheds (Chinati Foundation) were fascinating. I tried to imitate those cubes in smaller scale with the leftover aluminium sheets I had from the previous project. It was interesting to see how the perception of the objects and the space around them changed

depending on the distance and angle they were looked at. It was also interesting to see how light and reflections behaved on the surfaces. For example, some cubes looked like they were lit up from the inside. Without an actual light source inside, it seemed interestingly illusive.

There was also one particularly interesting comment Judd made in the first episode of Inspired (Issa & Barra, 2020) on shapes that I haven't considered before. The context is a bit unclear because of the editing, but he describes how he had to distance himself from the organic sort of shape or line because it always refers to something else. He adds that "the geometric shapes don't refer to anything else".

Max Bill was a Swiss architect, artist and designer. He studied at Bauhaus in 1927 – 1928 and later co-founded the Ulm School of Design thus contributed to upholding the Bauhaus philosophy. His multi-dimensional background made his writings fascinating to read and I often found myself from the position where my thoughts and conceptions were brought up and challenged.

If I would need to describe the meaning of design to me in one word, I would say it is about discovery. With every project I dive into a new world that can be sometimes completely unknown to me. Perhaps previously it has been more important for me to find something that has not been found before. In many cases, the emphasis has been on finding something new rather than on fulfilling the functions of the object. Bill (2010) remarks that: "It is this character of the object, its purpose, that I'd like to see expressed, rather than the personality of the designer, with his more or less perishable plays on form." On the other hand, Bill says: "artists represent the vision of the future, their duty is to direct the common interest towards this goal." I think, as designers we have the ability to influence on peoples' behaviour and we have the duty to show the way and inspire them. Sometimes these visions of the future can be still very abstract on the contrary to the practical, application-oriented design.

# Concept Development

**COVID 19**

Since its onset on March 2020, the COVID-19 pandemic has spread to almost all countries of the world. Social and physical distancing measures, lockdowns of businesses, schools and overall social life, have become commonplace to prevent the disease from spreading. The virus has affected all of us but most detrimental it has been to people in most vulnerable situations, including people living in poverty, older people and people with disabilities.

The outbreak of COVID-19 forced me to make decisions on finding a context and a clear focus for my project. As we started to work from home and I no longer had access to workshops, I started to consider what kind of project I could carry on under those circumstances. I started to consider the physical size of the project outcome and I was also thinking that I should be able to do the sketch models and prototypes at my student accommodation with a very limited set of tools and material.

As a consequence of spending more time indoors, the squeegee that I use for drying the floor after a shower started to take more space in my thoughts. The squeegee was interesting because they are usually made of plastics. It is also a useful tool as it makes cleaning and drying faster and easier. I assumed that most of us use it at least few times a year when the windows are cleaned, which is the primary function of the object.

It was clear that it was a useful everyday product that everyone needs, and it could be improved at least from the standpoints of material selection, form and beauty. I talked about my thoughts with my supervisor Olof Kolte and he suggested that I should perhaps do a series of useful everyday objects that fall under a theme of keeping your house clean for example. He explained that if I would present a series of simple objects casted in aluminium, the discussion would fall more onto the ´replacing plastics´ rather than onto the object itself which would be the case if I presented a single object. This was an interesting insight from Olof and I also thought that designing a series of objects would be an interesting challenge because, previously I had only designed single objects.

## MAKING FOOD

Dishbrush (plastic)
Measuring cups
Organizing kitchen

## LISTENING TO MUSIC

Headphones stand
Physical record storage

## PLAYING MUSIC

Instrument parts
Organizing cables
Guitar stand

## CLEANING

Brushes
Dustpan
Brooms
Squeegee (plastic)

## SHOPPING

Shopping basket (plastic)
Food containers (plastic)

## GYM

Gymnastics rings
Ab wheel (plastic)
Foam roller (plastic)

## SKATEBOARDING

Where to put your phone, wallet, keys & water while on spot & while changing the spot?

## RUNNING

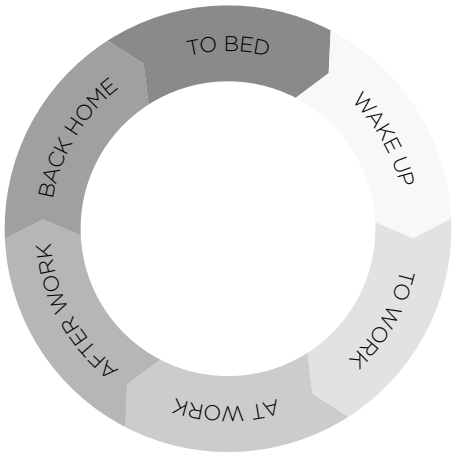
Head light
Reflector

## FRIENDS & FAMILY

Socializing
Tableware
Games
Concerts
Playing music

## READING

Reading light
Night stand
Alarm clock
Bed and legs




## LUNCH & COFFEE

Tableware
Lunch box
Cooling & heating
Fridge parts (plastic)
Eggholder
Tables & chairs

## TASKS

Laptop & (mouse (plastic))
Storing & organizing
Tables & (chairs (plastic))
Privacy
Space
Lighting
Tools

## CLEANING UP

Shower head (plastic)
Floor wiper
Toilet brush (plastic)
Bathroom cabinet
Tooth brush

## DRESSING UP

Garment storing
Hangers (plastic)
Boxes (plastic)

## BREAKFAST

Storing food
Storing dishes
Lunch box
Coffee maker
Table and chairs

## WALKING

Observing
Listening to music
Carrying things you need during the day

## CYCLING

Bike parts
Light (plastic)
Reflector (plastic)
Helmet (plastic)

## PUBLIC TRANSPORT

Sitting and observing
Large surface areas
Impact between the air and the vehicle

**Ideation**

After the discussion with Olof, it was time for ideation. Before I got started, I framed my objectives for myself as: ´Come up with useful everyday objects suitable for sand casting that everyone needs. Focus on identifying products that are made of plastic.´ I had two methods that I used to find and identify those objects.

With the first method, I went through my basic everyday activities by splitting the day in six sections. Then, section by section, I tried to come up with useful things related to these activities. The result of my conclusions of using this method was to focus on morning routines and activities related to keeping your house clean. I understood that these activities are universal and most of us share similar habits and behaviours related to these activities. I excluded profession, free-time and hobby related activities because of the variation. There are so many different professions and free-time activities that it would have been difficult for me to come up with objects that everyone needs which was one of my main objectives.

*´Come up with useful everyday objects suitable for sand casting that everyone needs. Focus on identifying products that are made of plastics.´*

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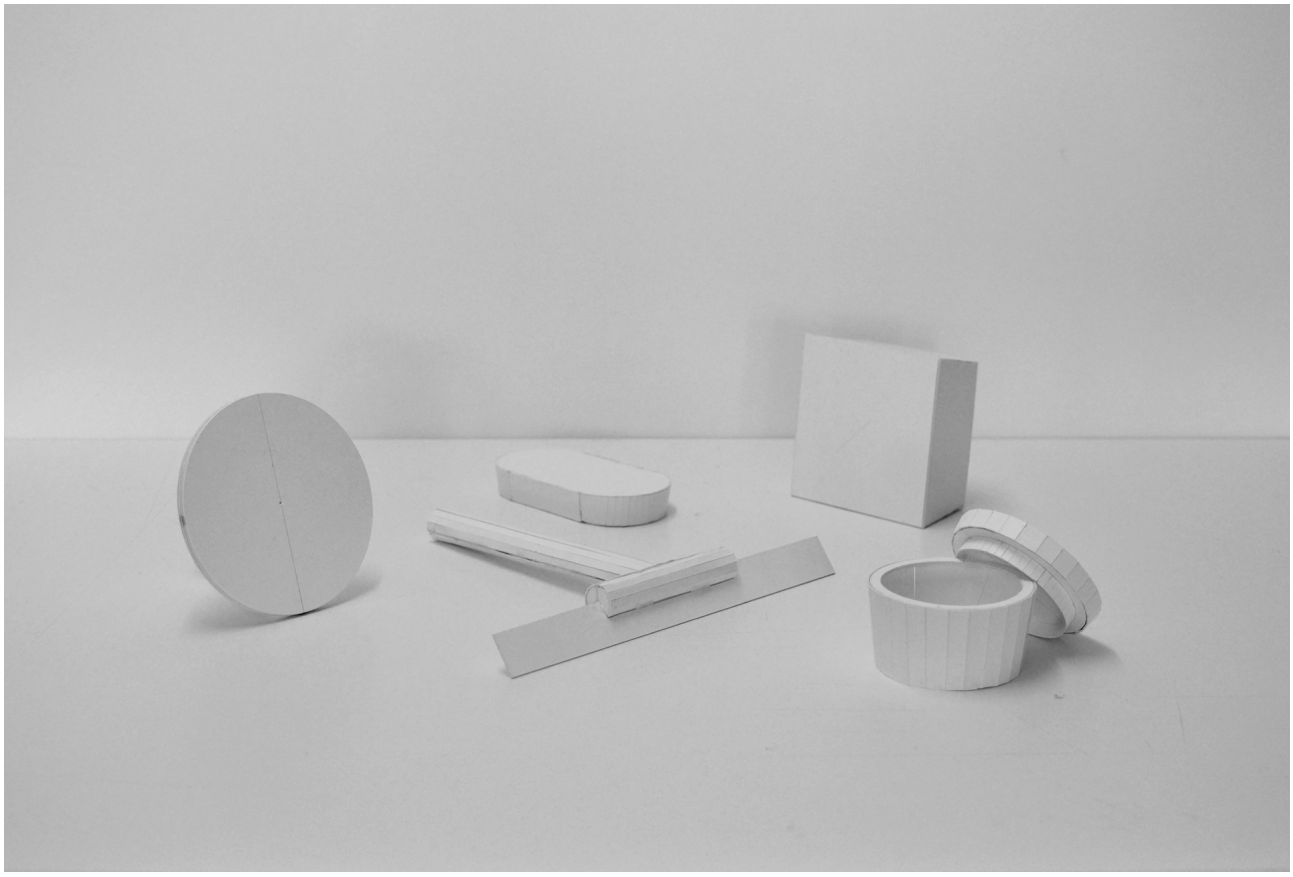
Image sources: page 57



**Everyday Objects From The Past**

When the focus was clear, I wanted to get inspired by everyday objects from the past. For this purpose, I used Finna digital search service, which provides access to material from Finnish museums, libraries and archives. I was interested to learn from the pre-industrial objects because, first of all, our mindset was different. Societies usually strived for a standard of living that keeps people alive. Most people produced just as much as they consumed. Secondly, the objects were made from natural materials. One had to use materials that were available and the tools to work the material were not as sophisticated as nowadays. These limitations led sometimes to insightful solutions.

I started to generate ideas under the themes of: ´mourning routines´ and ´keeping your house clean´. Sketching has been part of the process all the time as I have put ideas down on paper when something has popped into my mind. At this point of the process, I put more concentrated efforts on sketching to generate ideas. Simultaneously I was doing physical sketch models out of cardboard to get understanding on proportions, usability and ergonomics.


SINI
MONITOIMIMOPPISETTI


TOLU
Cif
POWER & SHINE
AJAX
TARJOUS
Mulieres

**Design Challenge - Reduce Environmentally Harmful Plastic Waste Generation**

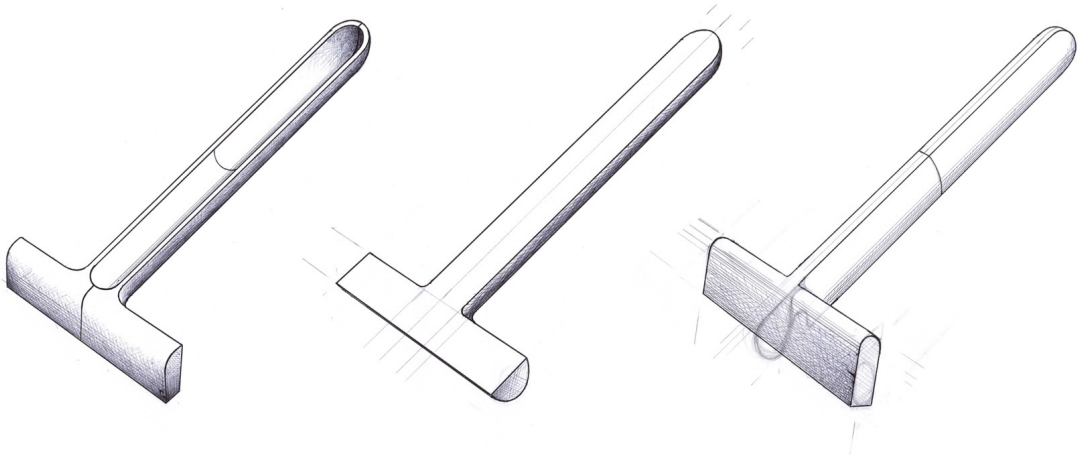
I want to inspire people and industries to replace plastics by redefining useful everyday products that everyone needs. Emphasis is going to be on the products that are usually made of plastics. I am happy when people start asking these products in alternative sustainable materials. I also feel satisfaction when the value of these products is increased to the level where people don't want to hide them into the cabinets when they are not in use. I expect the products to be manufactured locally under socially responsible conditions.

SUSTAINABLE - I want to use aluminium as a material for these objects. The sourcing by mining is energy consuming, but when aluminium is in use, it circulates well in the industry. It is relatively cheap material, thus making it an alternative for plastics. It is an inorganic natural material that does not end up in the environment to create harm to living organisms.

INSPIRING - I am aiming for insightful and harmonious result that would increase the appreciation of relatively cheap products.

SIMPLE - I want to use local sand-casting as a method for manufacturing. Objects are going to be simple in order to reduce unnecessary processes and to keep the costs low.

I am especially trying to identify products that everyone needs. I want to raise awareness of living in harmony with nature within the groups of people who are perhaps not that environmentally conscious.



**Series Of Simple Objects Under The Theme Of ‘Keeping Your House Clean’**

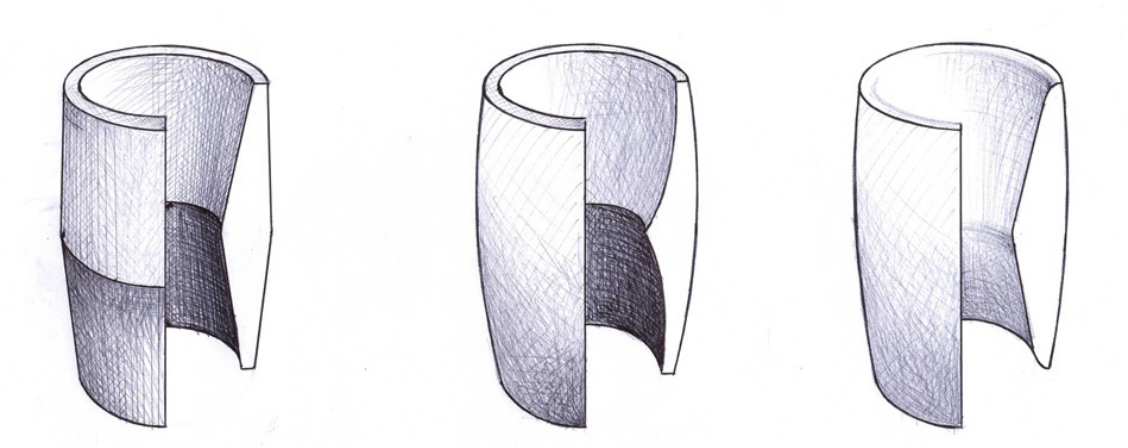
I got more ideas suitable for sand casting out the theme ´keeping your house clean´. This led to a decision to focus on that theme. I decided to begin with five objects, because then I would have some room to drop one or two of them if needed and I would still have a series of objects. Squeegee was the first object I was thinking of, thus making it a starting point for the series of household cleaning products. Eventually it was the object I had to drop off because I couldn’t find a way to do it in the nature of how the other objects are done. One of the main objectives was to design simple objects that are basically almost ready when you take them out of the sand. With the squeegee, I couldn’t find a way to attach the natural rubber blade to the body without machining or using additional parts to do it. I feel that it would break the consistency of the series if I used the help of additional parts.

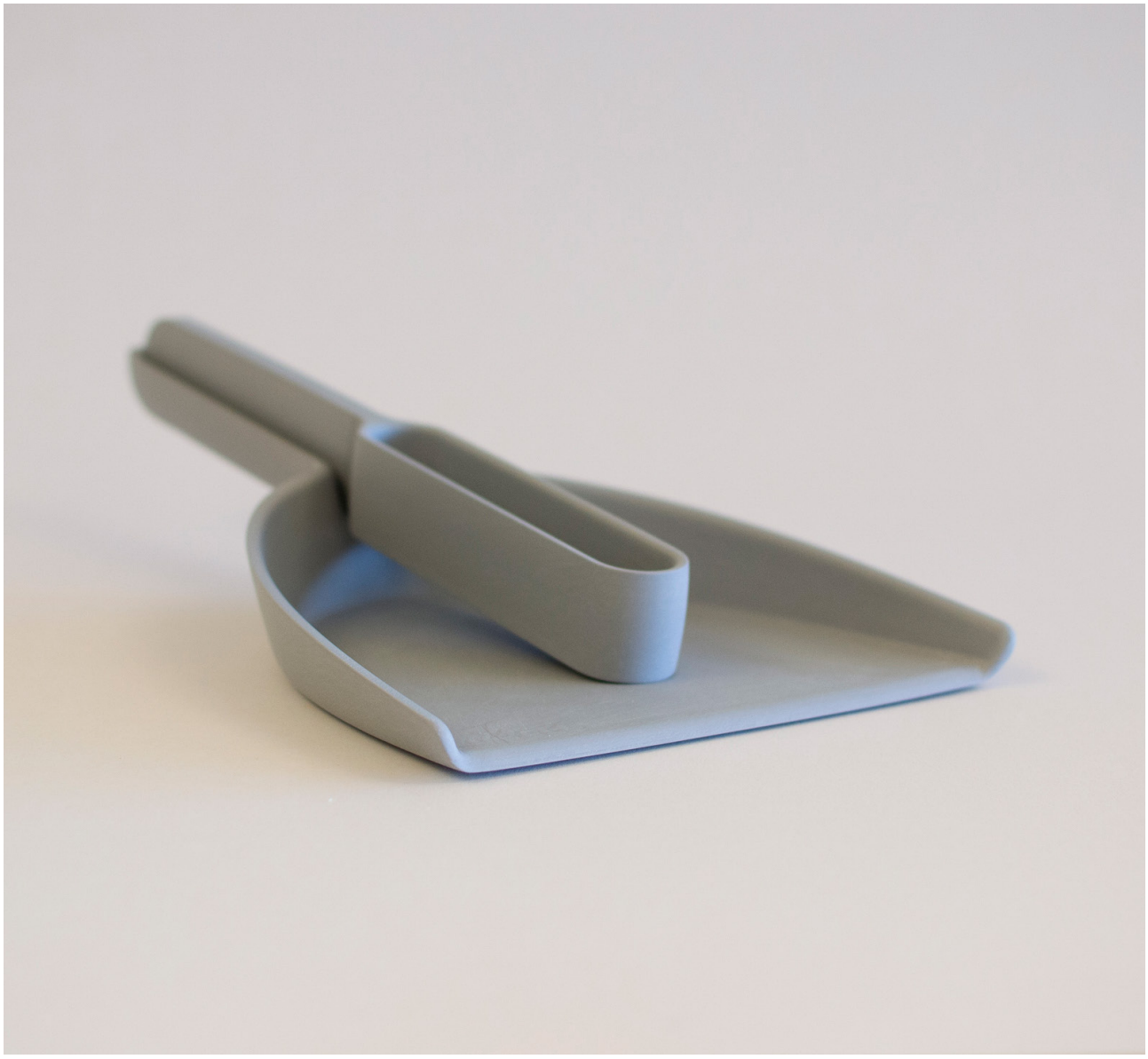
I also found few interesting brushes when I was going through older pre-industrial objects. There was one wooden nailbrush with pig hair bristles that caught my attention. I got an impression when looking at the image that the bristles went through the holes which were drilled through the wooden block. It looked like the bristles go through narrow holes and then at both ends, the packs of bristles get more volume which makes them stick to the block. By following this principle, I would be able to make simple brushes without using glue or additional parts to bind bristles to the body of a brush. This would be good because I wouldn’t need to use any environmentally harmful chemicals to bind the bristles. It would also make the manufacturing process smoother and perhaps cheaper because there wouldn’t be a need to produce or purchase unnecessary additional parts. And when thinking about the end of the object’s useful life, this would make the

separation of materials easier. All of these principles add to a more sustainable product. I put my focus on developing a brush to wash the utensils and on a brush – dustpan combination.

All of these forementioned objects are nowadays often made of plastics. They are being used all over the world by most of us humans. Together, at the end of their useful life, they form a large amount of plastic waste. When you go to your local supermarket to search for cleaning supplies and you find the right shelves, you can see that they are full of plastic things. I assume that we perceive cleaning supplies as plastic made nowadays. If we present these objects in a uniform aluminium material finish, I assume it would make people to look and think what this project is about. If the objects are beautifully crafted, perhaps it could have an influence on consumer behaviour. Perhaps it would make people to want and ask for these products in alternative sustainable materials.

The use of plastics is not the only problem related to cleaning supplies. Cleaners and detergents that contain mostly water, are sold in disposable plastic packages. Cleaners for different purposes differ mainly in their colour and scent. In addition to forementioned purposes, chemicals must be added for preservation. These chemicals are often irritating to skin and may cause allergies. They can be dangerous if inhaled or exposed and they add unnecessary chemical load on nature. To address this problem, I also wanted to design a measuring cup to promote the activity of mixing your own ecological detergent.





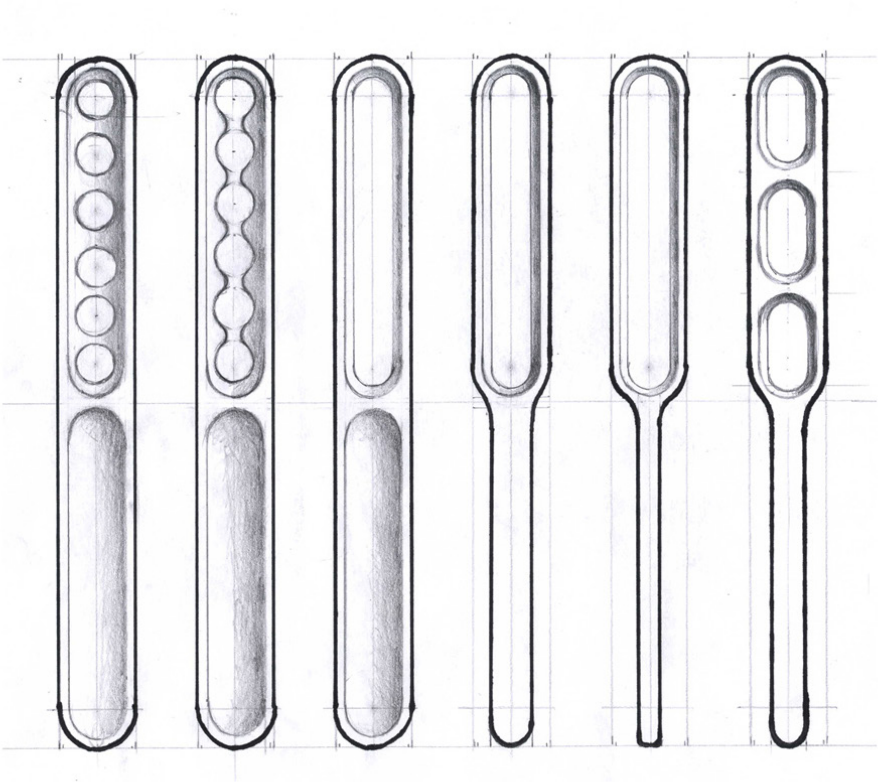
**Refined 3D Printed Sketch Models**

The first set of refined 3d printed sketch models were printed at the University. In addition to the critique session with the project supervisor Olof Kolte and examiner Jasjit Singh, the models helped me to understand the design defects of the objects and thus showed me the areas, I still needed to work on. After the critique, we decided to do improvements on the objects as none of us were satisfied with the outcome.

A handle containing a hole for hanging was added to the measuring cup and to the brush for utensils. This change was necessary to improve the functionality of the objects and to better utilize the manufacturing method. The objects are now easier to store when they are not in use. The handle also indicates that the cup is for measuring. In the beginning, I was thinking more of a universal cup for storing and measuring and therefore, I didn't have a handle included. In hindsight, the handle made the cup a better fit to my context.

I realized that the opening for the bristles has to be circular. When you put a pack of bristles through a narrow hole, the pack wants to swell up. When the walls around the pack are in the shape of a circle, they resist the swelling force equally from all directions thus making the attachment tight. The wide opening resulted a loose attachment in the middle. I ended up using four circular openings to attach the bristles to the body. More rigid bristles such as rice root bristles can be just pushed through the opening if the opening forms a conical cavity. Thinner and more flexible bristles need to be pulled through the opening with the help of a strong string.

The brush dustpan combination was the most difficult to get right. I had troubles in finding the right orientation for the brush in relation to the pan. The orientation affects significantly to the shape of the body. I had to keep the design simple and try to find a shape that is ideal for the manufacturing method. In addition, I had to consider where to place the parting line. If the parting line is in the wrong place, it increases the amount of post-processing work. If the excess material has to be removed from difficult places, the work can damage the geometry of the object. I did several iterations of the brush with Rhino 3D. Off all the objects, the pan is the most dependant on the shape of the brush. Because of this, I constructed the pan again few times. Same goes more or less with the other objects. If I did a major change to the brush, it broke the consistency of the product family and I had to construct all of them again. It is more challenging to control the consistency of the design in a product family environment than in the single object environment.



**Softening Of The Edges**

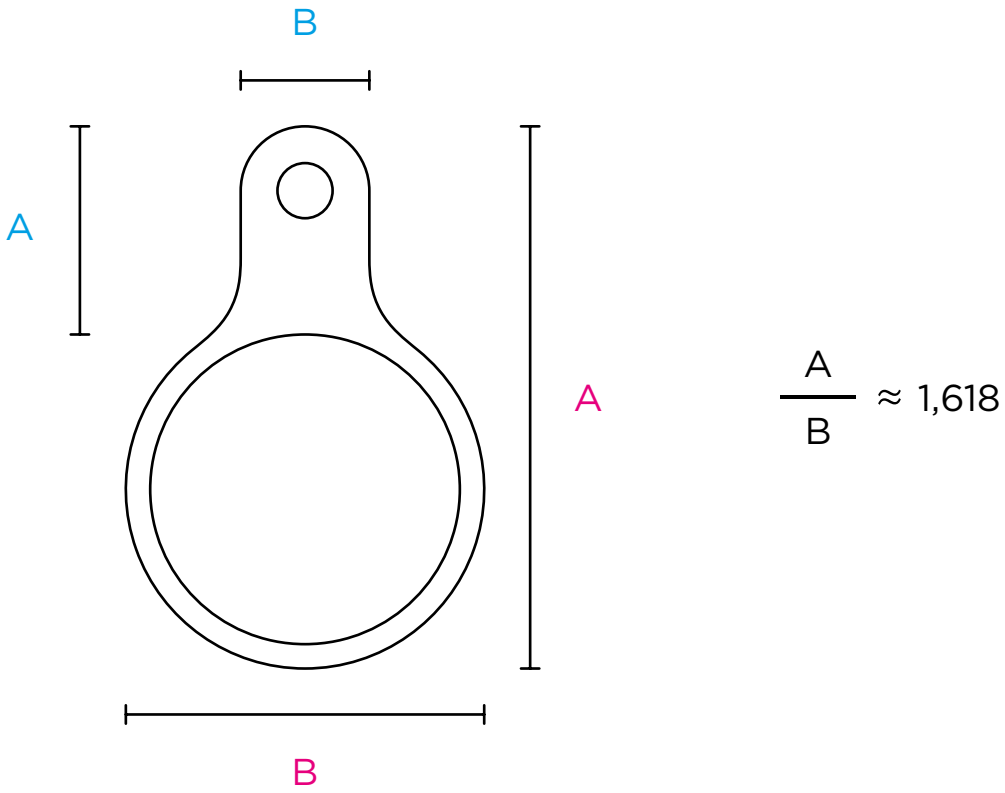
Recommended wall thickness for aluminium sand casting is 4-5 mm and on some occasions this is not ideal. It increases the material volume, thus making the object heavier, which can decrease the usability of the object. Thick wall thickness can also be seen as a negative feature from the aesthetic standpoint. I did my first sand casted object during our first master project in Lund. It was a bath scoop with a 6.5 mm wall thickness. I added quite a bit of safety margin as it was my first try. I also wanted to make sure that the casting works so that I would be ready to our first exhibition.

I started to add softening to the inner edge of the bowl part to make the pouring of water smoother. In the end, I decided to make the softening go around the whole object. The softening made the flowing of water smoother, but it also made the appearance of walls thinner than they actually are. I applied this principle also to this project because of the advantages mentioned but also because I felt that this feature would play a part in binding the objects together. It is a feature that makes the individual object part of the family.

# Result

The outcome of this project is a collection of cast aluminium household cleaning supplies. I think that the result successfully highlights circularity by simplicity, material selection and easy separation of materials. The product family also approaches the activities related to the household care from a more resource efficient and less environmentally harmful angle. Also, in addition to their purpose as useful everyday products, the carefully crafted objects are designed to inspire and nudge people to replace plastics.

Since my bachelor studies, I have been using golden ratio to help me to make decisions concerning the form giving. In the beginning I didn't have much experience but I was capable to produce ideas and shapes. Sometimes it felt difficult to compose the masses when you had a lot of alternatives. Eventually I found out that I can get harmonious and practical results when I let the golden ratio to do some of the work. This insight can make the design process more efficient by reducing the time used or freeing up time for something else. It is the harmony that I am always trying to reach with the result and there is a detail related to the playing of an instrument that can be used to describe the pursuit for harmony. When you tune guitar by ear, you get one string in tune from an external reference point or just decide that one string is close enough. When the low E-string is in tune, you play the fifth fret (A) of the string to get the reference to tune the next A-string. You play both strings at the same time and if the A-string is out of tune, the sound is waving. The more out of tune the string is, the higher the waves are. When the string is in tune the waves disappear and the sound is still. When I start to refine the shapes, I often do quick CAD renderings with realistic materials to identify any distractive elements. I do corrections and repeat as long as my eyes can rest on the image. I don't know why it is the harmony I am seeking. One explanation could be that our constructed world is full of distractive stimuli and mind can easily get fatigued because of them. Everyone can understand when they are in front of true beauty and it is rare that this beauty is created by human. The mind feels relaxed when viewing a natural scenery because all our senses are being fed more delicately.




*Golden ratio can be a practical tool for composing masses.*

Making the CAD models was not easy for me and the project showed some limitations with my modelling skills. Therefore I had to explore and study a bit. The objects are simple but all of them consist of wireframe of curvatures created with thought and consideration. I had few occasions when I was in trouble when building the surfaces for the sweeping transitions between the main functions of the objects. The transitions were important not only for the manufacturing method but also for reaching harmonious unity between the functions. The objects are also a result of some compromises. For example, with the hand broom, I would have wanted the handle to be more spherical on top. Spherical shape was problematic because of the opening that was placed at the end of the handle for hanging purpose. If you drill a relatively wide hole through a pole, it removes a chunk of material from it. This is more visible from the side view and in my case that would have destroyed the geometry of the broom. I was able to reduce this effect by making the top of the handle more flat. In hindsight, it was probably the right decision because with the cup, you don't need to have depth in the handle. It is more reasonable to have a short flat handle in the cup.

Concerning the material selection, it is of course debatable how sustainable choice aluminium is for these products. The main raw material for primary aluminium production is bauxite. Due to its location close to the surface and relatively shallow thickness, bauxite mining involves disturbance of relatively large land areas and negative environmental impacts do occur. Vegetation has to be

removed in order to access the bauxite. Removal of vegetation and mining will cause significant negative change of landscape. Noise, dust and disturbance of water ecosystems are also involved in the mining operations. Circularity plays a crucial role in reducing these kinds of negative environmental impacts. The recycling processes need to be developed and refined so that the materials can be kept in use more efficiently. These objects could be made of wood but they would need to be reshaped. Otherwise, milling would probably be the only option and I am not sure if it is the most practical way to do serial production in this case. Aluminium is more durable and it can always be locally melted and used for other applications. Therefore, I think aluminium is a better choice. Bio based castable materials are in the market but they also need the right conditions to decay. Compared to the other castable metals, aluminium is very light and corrosion resistant. It is also a lot easier to work with and do the post processing work. New sustainable materials are however developed all the time and I might find some interesting alternative for the aluminium in the future.

# Reflections

At the very beginning of this project, I framed three personal key objectives for myself. First, I wanted to learn from nature's systems and phenomena in order to better utilize sustainability when tackling through my future challenges. Second, I wanted to make use of nature's principles in some clever way and third, I wanted to become better at modelling organic sweeping surfaces.

I think that during the research phase, I only scratched the surface of the world of nature's systems and phenomena. However, I think I got a good base to start discovering the area. I got an overview of various useful methods that I can study further and I identified some important researchers on the field with whose work I could familiarize myself with. The second objective is perhaps a bit vague as everything is somehow related to natures principles. However, I think that the way how I attached the bristles to the brushes is convenient as I don't need to add anything to the product to make the attachment. The short CAD course we had under the supervision of senior lecturer Andreas Hopf was really useful in relation to the third objective. Among other things, Hopf showed us how to approach the modelling tasks and shared his expertise in constructing high quality surfaces. The course was held in the beginning of the master studies and eventually, the degree work gave me an opportunity to apply the insights from the course. The ability to construct efficient forms and smooth transitions between the functionalities of the object is useful especially when designing cast products.

**Conclusion**

The problems related to the recycling of aluminium are quite similar to the recycling of plastics. In both cases, the recyclability of the material can be significantly improved by better design and refined separation processes. Because the recycling system is not sophisticated enough, there is an increasing amount of aluminium that has been reused so many times in various consumer products, that it no longer has so many suitable applications because it is so mixed with other metals. Engine blocks and gear boxes have been applications where it does not matter if the used aluminium has been mixed with other metals. At the moment transportation industry is shifting towards using renewable energy sources. Therefore, world will need fewer engine blocks for cars with

internal combustion engines in the future. I would say that this kind of mixed aluminium “scrap” can be used to manufacture everyday products to keep your house clean. Of course, among other things that have been produced of plastics during the past decades. Brush or squeegee does not need to be manufactured from pure alloys.

Basic plastic made brush dustpan set costs about 10 euros. Locally produced, sand casted aluminium set would cost 10-15 times more. The price is then closer to sets from the well-known design brands which are also made of natural materials such as wood and steel. Therefore, I can’t say that my set would be a direct replacement for the plastic alternatives. On the other hand, the pricing of plastic products can be described as unhealthy which is one reason why they end up into the environment and landfills at some point of their product lives. Sooner or later, we will pay the “missing” price of the plastic products. The main objective of this project is to inspire people and industries to replace plastics. At the moment, it is impossible to evaluate whether the project has been successful in that. What would be the indicator of success? Even if all the plastic made cleaning supplies were replaced by more sustainable alternatives, I could not say it is because of this project. However, If I could turn this concept into a profitable practice, could it be an indicator of some sort of success? I have tried my best to utilize the manufacturing method while considering the sustainability aspect. I have also put significant effort on crafting the objects in a manner where the form and function can meet in harmony.

Our planet is more or less a closed system with finite resources where life has organized itself around circular principles. When we zoom in, we can see that humans have organized themselves as nations, communities, groups and households. If we play a bit and think that our households were closed systems, then it would be perhaps relevant to ask: “where would you like to place your landfill?” We need to continue to seek ways to reduce our waste generation. There has to be people who can visualize our future and for that purpose we need artists. These are exciting times to be alive. The path ahead is fascinating as we need to change our behaviour. I think we need to come up with novel ideas and innovations, but also look into the past, if we want to keep our freedom.

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**Images**

1. The Maritime Museum of Finland - Collections of the Maritime Museum
2. The National Museum of Finland - Finno-Ugric collections
3. Lusto - The Finnish Forest Museum
4. The National Museum of Finland - Ethnological collections
5. The National Museum of Finland - Finno-Ugric collections
6. Lusto - The Finnish Forest Museum