The Bicycle Carbonator

School of Industrial Design, 2021, Wictor Clifford

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The bicycle carbonator

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Degree Project for Bachelor of Fine Arts in Design

Main field of study: Industrial Design

From Lund University School of Industrial Design, Department of Design Sciences

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Table of content

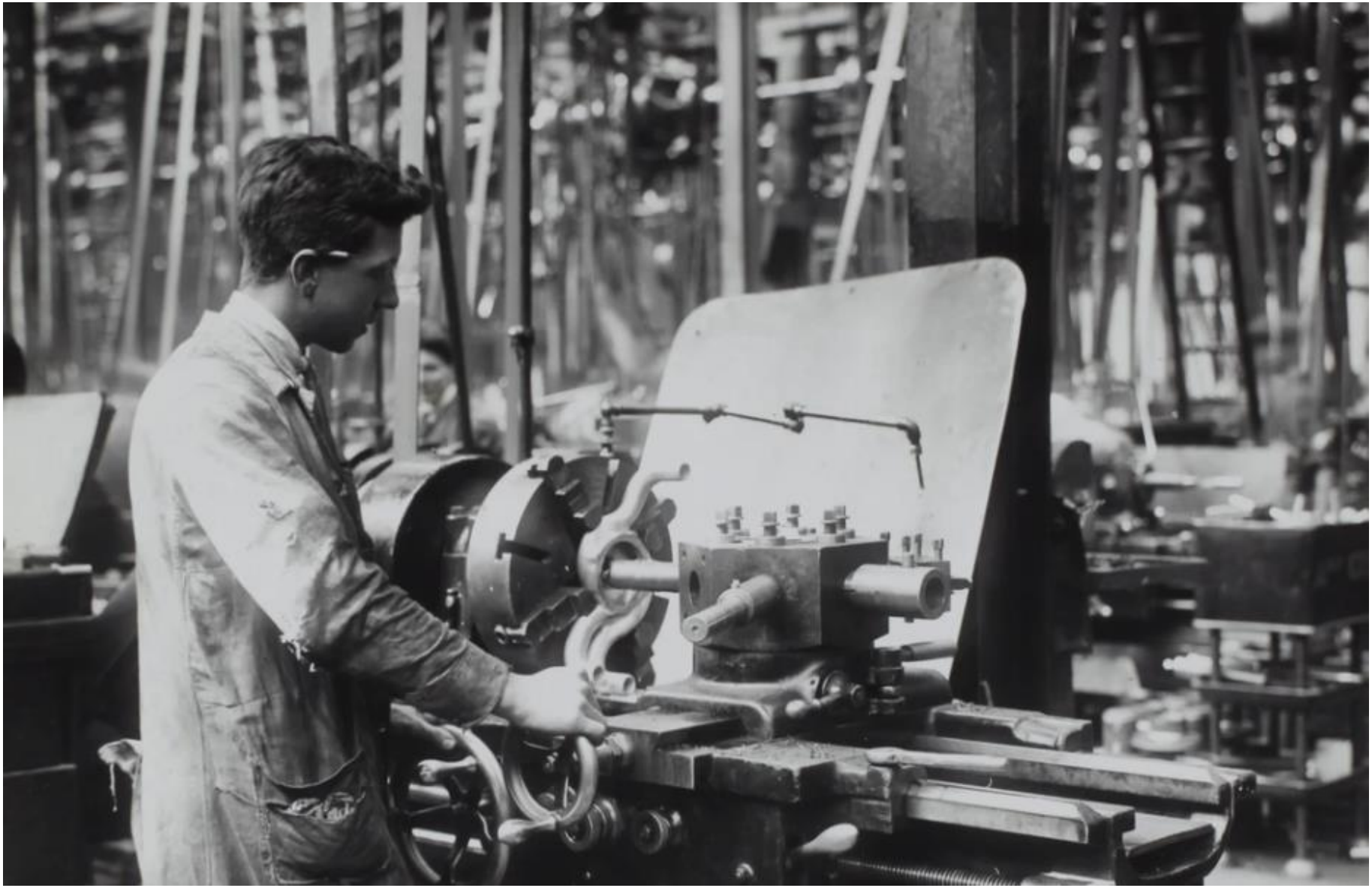
Abstract

The rising levels of carbon dioxide in the atmosphere is one of the most pressing matters right now. Before the industrial revolution, the atmosphere had a concentration of 0,02% which has increased to 0,04% due to human progress. This increase results in melting glaciers, ruined farmland, and more unpleasant consequences.

Counter measures of today involve moving away from fossil fuels and relying on renewable energy sources, such as solar, hydro, and wind power. Smaller contributors to lower carbon emissions happen on an individual level by recycling, choosing different modes of transportation, and consuming food and materials that harm the environment less. Early in this project, I discovered carbon capture, which is supposed to play a big role in lowering carbon emissions and has been in development since the 1970s. Currently, it works on an industrial scale but my intention is to see if the carbon capture process can be miniaturized and made available to the public.

Koldioxidutsläppen av den moderna världen är en av det stora frågorna som påverkar oss globalt. Innan den industriella revolutionen var koncentrationen av koldioxid i atmosfären 0,02%. Den mänskliga utvecklingen har ökat koncentrationen till 0,04% vilket har orsakat smältningen av glaciärer, försämrat skörden och mycket mer.

Dagens medvetenhet om miljökrisen har uppmuntrat företag att skifta till förnybara energikällor så som sol, vind och vattenkraft. Individuella ansvar tas också i form av återvinning, konsumering av resurser som skadar miljön mindre och ändrade transportsvanor. Tidigt i detta projekt upptänkte jag koldioxidinfångning som är tänkt att vara en stor iakttagare emot miljökrisen och har varit i utveckling sedan 1970-talet. I nuläget fungerar det endast på en industriell skala. Med mitt projekt vill jag ta reda på om koldioxidinfångningsprocessen kan förminskas och delas ut till allmänheten i form av en produkt eller tjänst.



A

Introduction

Since the industrial revolution, technological progress has yielded many of the goods today that would be considered luxury a long time ago. The production of electrical power has slowly been more refined over time which allows further advancements in other fields of science, medicine, and society.

Production of power, however, has come at large cost. To provide power, one needs to burn fuel to spin a generator that produces said electricity. The action of burning fuel has been the most effective way to produce power. Oil, gas, and coal is the fuel that is used the most. This is a great concern because the mentioned fuel sources are not only finite in supply, but also damaging to the environment when their fumes enter the atmosphere. The fumes from coal, oil, and gas contain carbon that mixes with the oxygen in the air and creates carbon dioxide (CO_2).

Carbon dioxide is the gas plants need to grow larger, but an overabundance of this gas currently exists. Plants cannot absorb the amount of carbon dioxide emitted from the human activities of today. As a result, people have over the past decades realized that the current state of the environment is in danger of being polluted to the point where many parts of the world will be rendered uninhabitable.

Counter measures do exist in the form of renewable energy sources and a global awareness that motivates people to do what they can to lower the emissions. Unfortunately, renewable energy has a lot of deficiencies in consistent power production and few people are willing to sacrifice everyday luxury to achieve a cleaner environment.

These counter measures are not the only ones that can be put into action. Many more exist and are being used right now. Technological advancements in energy efficient equipment as well as utilization of carbon dioxide is steadily growing. Seeing the carbon dioxide as a resource instead of a biproduct is the premise of carbon capture, which is one of the counter measures that has been under development since the 1970's.

Carbon capture alone cannot reduce carbon emissions but used with every other doable counter measure, it will make a significant contribution to the lowering of carbon emissions.

What is currently happening?

The emissions of carbon dioxide have a wide variety of consequences. Some more severe than others but that does not mean that carbon emissions are not a pressing matter. We have and are witnessing the consequences of continued emissions unfold, which are but are not limited to:[1]

- Longer seasons with high temperatures are more frequent than before. The clearest evidence to this would be glaciers melting away faster which contributes to the rising sea level.
- Droughts and heat waves are becoming more common. Record high temperatures have already taken place around the world. A notable example is in southern Sweden during 2018, where temperatures of 40°C were measured.[2]
- Rainy weather will migrate further up north, turning countries closer to the equator into deserts and savannas.
- Storms and hurricanes are getting stronger and more intense, wreaking more destruction onto cities and towns.

Awareness of our changing climate and the dangers it poses forces people to change the way they live and behave. Methods such as saving water and electricity and buying locally produced food are good ways to reduce the carbon footprint of each person. Coupled with a sparse usage of energy efficient products, every person in an average middleclass household would be able to strongly reduce the amount of carbon dioxide released into the atmosphere.

Without a unified plan, however, these counter measures will not be put into action of noticeable scale. The problem of carbon emissions affects us globally and at this vast scale, it requires a global agreement and an initiative that drives people to do something.

Despite the efforts of the people who are aware of the dangers of a warmer climate, there are still many who either deny the climate change or thinks their efforts make too little difference. Changing the way people see their contribution is an arduous task, but still a doable one if the right type of motivation is found and put into action.

What are we doing already?

Our everyday actions will affect the world around us in different ways and on different scales. One person not recycling properly will not do much damage to the environment, but an entire population will have significant impact if all of them neglects recycling.

Investments and research in renewable energy sources is currently being done with the most successful being hydro, solar, and wind power. The inconsistency of the weather makes these power sources a less appropriate choice as well as their low production capacity during the shifting weather. Nuclear power, however, has a far more consistent power production that outperforms solar, wind and hydro. The long-lasting effect of its waste is one of the dangers which lasts for several generations and has scared people away from using it further.

There are still a lot of places that are being powered by oil, coal, and gas. The introduction and usage of renewable energy sources cannot happen overnight, or it would leave millions of people without electricity. The transition from fossil fuels to renewable energy is slow paced and during that time we need solutions to reduce carbon emissions.

Down on an individual level, there are plenty of things a person could do. Since transportation and energy use is two of the pillars of carbon emissions[3], finding ways to lower the emissions in these parts of one's life is what some people are doing already. By choosing to buy locally produced food and prioritizing the bike or public transportation over the car, one can make a significant impact if kept up long enough.

Encouraging people to change the decisions they make in their lives is where the challenge is. As much as the industry is causing global warming, people are responsible for it as well with the decisions they make. For instance, choosing to buy potatoes from one's own country rather than buying bananas from overseas is an environmentally good choice. Both products satisfy the need for potassium.

What I want to do

I mentioned earlier that one of the ways to reduce carbon emissions was to see it as a resource rather than a bi product. Carbon capture is a new branch of technology that I discovered early in the project. The idea of carbon capture is to prevent the fumes from getting in the air and forming carbon dioxide.

To do this, industrial carbon capture plants must separate the carbon dioxide from the fumes of burning fossil fuels. The carbon dioxide is then pressurized and cooled at around 48 bar and -18°C until it is a liquid.[4] This liquid can then be transported via ship or by pipeline, depending on the distance to the place where the carbon dioxide is used. Lastly, the usage of carbon dioxide varies depending on where it is going. In most cases, the gas is dug deep underground and covered with rocks to prevent the carbon dioxide from escaping into the air. Other usages are within oil recovery and industrial scale greenhouses.[5]

Carbon dioxide can be injected into dried up oil inside the underground reservoirs, making it easier to extract. The gas can also be used within greenhouses to speed up plant growth and food production.

Collecting carbon dioxide from power plants is not the only way to collect the gas. Direct air capture is a way of carbon capture that filters out the excess carbon dioxide from the ambient air and either sends it somewhere else or chemically binds it to something.

On an industrial scale, an average carbon capture plant captures a mean of five million tons of carbon dioxide every year. However, it is argued that the energy cost in relation to the amount of carbon dioxide captured makes it an economically and environmentally unsound plan to keep them running.[6]

This is where my project starts, where I will try to find out if there is a way to make carbon capture energy efficient. Not in terms better machinery, but in terms of taking the idea of carbon capture and applying it elsewhere.

Energy can be extracted from almost anything, albeit in varying amounts and difficulty of extraction. Since most people of today are always on the move, maybe there is a way of bringing carbon capture to them in a manageable package.

Joe

Lily

Thor

Who cares about the environment?

During this project, I asked a couple of people what their thoughts was on the environmental issue. In an additional question that followed, I asked people what they think should be done to reduce carbon emissions.

The answers I got for the first question were almost unanimous. All the people I asked cared for those from the coming generation that would inhabit the world that they are living in right now. Doing whatever they can to lower the emissions, the people I asked would try to make the world more bearable than it is right now.

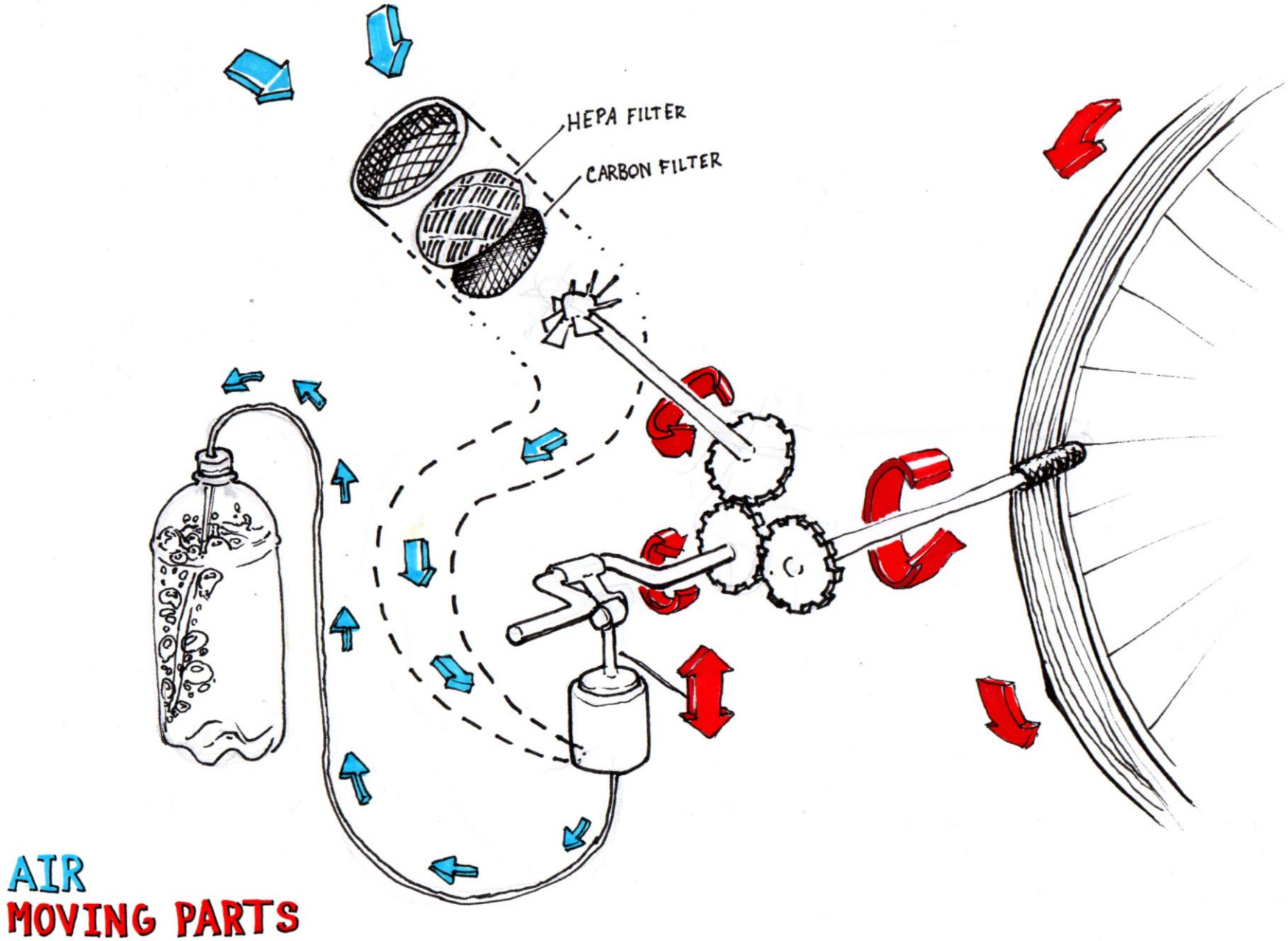
In the second questionnaire, the answers were more scattered. It seemed that everyone had a unique idea to prevent the further release of carbon emissions. What every idea had in common was the desire unify people towards one goal. The methods to achieve the goal of lowering carbon emissions is the difference between each idea.

One of the people I asked was Joe. To him, there needed to be more economic support for renewable energy sources and better opportunities for public transportation.

He also thought that a tax on carbon emissions should be added as well as more international cooperation against further emission.

When I asked Lily, she had a more humanitarian approach. Everyone has a responsibility to consume resources with the environment in mind. On top of that, the access that each person has to the internet is unique for our time which she thought should be used to educate oneself on the matter. If everyone found out that a lot of political questions are related to the environment, it would be more relevant than it is now.

Thor thought a juridical change with politics was better. If more emphasis was put on the question of climate change and taken to the people in the government that debate and decide what laws there should be, new rules will be made in favor of the climate. He also exclaimed that people did not need products that claim to be less harmful to the environment than they are.[7]


HEPA FILTER
CARBON FILTER
AIR
MOVING PARTS

How is this going to work?

With all my questions answered to what people need and what they think should be done, I concluded that a lot of things they thought should be done was beyond individual reach. Most of the actions were decided by organizations of higher societal power such governments.

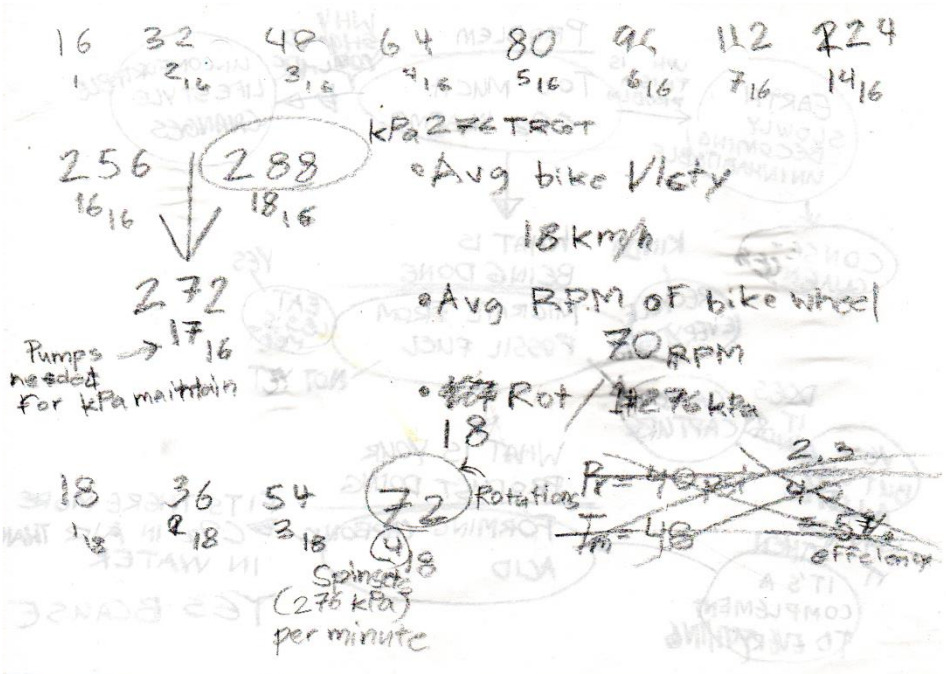
The most likely option would be a movement among a large group of people who all share the same goal. Organizing this would be a difficult task as it would need a lot of commitment from people who are busy doing something else.

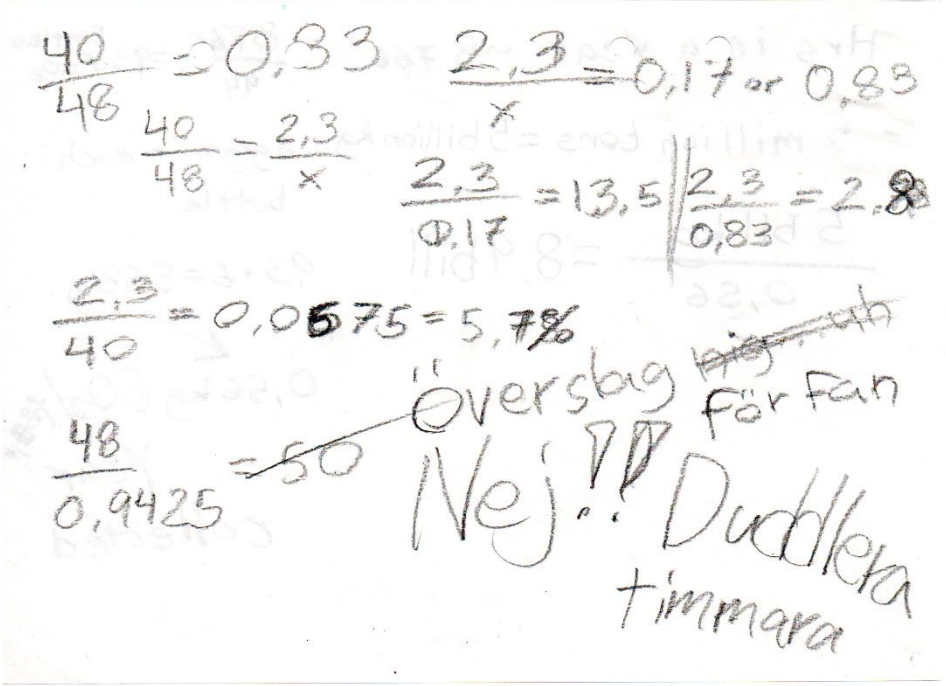
However, I did mention that a lot of people are on the move. Whether it would be by car, bike, walking or public transport, there is energy that can be extracted to power a carbon capture device. Not enough on an industrial scale but enough for a small device. To promote less use of the car, I am focusing on developing an add-on for bikes. This is because a lot of people own a bike, and the wheels produce enough energy to power a bike light which should be enough energy to power the device I have in mind.

Capturing the carbon emissions will happen through carbonation, like infusing water with carbon dioxide to make sparkling water. To do this, I will take the movement from the rear wheel of a bike and mechanically transfer it to the device that houses the mechanics. Cogs inside of the device transfers the movement to important tasks.

The device has air suction that is possible due to a fan which sucks in ambient air through first a HEPA filter and then a carbon filter. The reason why these filters are there is to prevent dust, dirt, and large particles from getting in the mechanics.

Secondly, to push the air into the water bottle the device has a mechanic similar to a crankshaft with a piston that pushes the air through a thin tube. The vastly different dimensions between the piston chamber and the tubing are to achieve a pressure difference like a vacuum cleaner or a pressurized air blower.





$$SA = 2\pi 1 = 12.6cm^2$$

$$P = \frac{F}{A} = \frac{20}{0{,}00126} = 15\,873\ N/m^2$$

$$15\,873\ N/m^2 = 15{,}9\ kPa = 2{,}3\ psi$$

"If you fill it up with room temperature water and let it carbonate at 40 PSI, it will take 24 hours to achieve low but noticeable carbonation, and full 48 hours to get optimum carbonation."

-Tasterofartisan.com, 20/09/2020

$40\ PSI = 48\ hours$

$20\ PSI = 72\ hours$

$10\ PSI = 84\ hours$

$5\ PSI = 90\ hours$

$2{,}3\ PSI = 94\ hours$

$94\ hours\ of\ biking\ to\ carbonate\ 1ltr\ H_2O$

Why should it be used?

In addition to everything that is already done, which includes consuming less resources and choosing different modes of transportation, using a device that will contribute to negative carbon emissions can only be considered a good option. There is only one caveat however, which is the question of scale and efficiency. Because of the smaller dimensions compared to a carbon capture plant of industrial scale, there will be a large decline in efficiency and the amount of carbon dioxide captured.

Despite the inefficiency, however, extracting energy from the bike wheel is far more sustainable than burning fuel to power a carbon capture plant. It can be argued that the carbon capture plant should only consume energy from renewable sources. However, that would be an unnecessary usage of renewable energy since that energy is supposed to be distributed to sources that need it more.

The amount of carbon dioxide captured will be limited by the amount of water used with the device. In this case, a 1-liter bottle of water can store 6-8 grams of said gas in the form of carbonic acid.[8] A hasty calculation shows that it would take a little less than four days of biking to fill up a water bottle with carbon dioxide.

Due to the usage of bikes in cities and towns, attaching this device to the bike frame will most likely communicate to others passing by that the person riding the bike with the device attached are doing what they can to clean up the environment.

Hopefully, this will motivate others to use the device and maybe start a domino effect where more and more people use the device. In fact, if only a hundred people would use the device, they would all collect 0,7 kg of carbon dioxide with merely four days of biking.

The availability of freshwater around the globe is scarce compared to oceanwater. Therefore, the device should be loaded with oceanwater to not strain the freshwater reserves. The difference between the two water types in terms of carbon dioxide absorption is negligible and it is best if ocean water is used. Mostly because of the availability but also because not all impurities can be filtered out during usage of the device, which could result in the drinkable water bring contaminated.

B

C

What exists already?

The idea of a taking carbon capture and reducing it to a smaller scale has been done before, some made into reality. The items that were built however, had varying functionality. It seems that smaller items had less than impressive capturing capabilities compared to those of industrial scale.

Early on, I found a device that were meant to filter out the carbon dioxide from the exhaust pipes of cars. The CO2ube is a contraption that is attached to the tail pipe of a car. The carbon dioxide would be attracted to the chemicals inside of the tube and stick to the chemicals until the device would need to be removed and cleaned.[9]

The project failed because the funding was insufficient and due to the laws of thermodynamics, which made it impossible to capture the amount of carbon dioxide the creators sought out to begin with.

Another concept that exists is meant to collect carbon dioxide directly from the air through thermo siphoning. By using the higher solubility of said gas it would be collected using carbonation and then boiled off with the help of the sun. This device is only at a conceptual stage and has yet to be tried and tested.[10]

On a more industrial scale, a company known as Climeworks has built one of the first carbon capture plants that is not attached to a fossil fuel power plant. This means that the only goal of this plant is to collect carbon dioxide from the ambient air, a.k.a. direct air capture.

Their implementation is a fan that collects all the ambient air and let it pass through a specialized filter where the carbon dioxide gets stuck. The filter, whose material is a trade secret, is heated up to 80-100°C which releases the carbon dioxide.[11]

One way that Climeworks intends to use the carbon dioxide is through reforestation where they send the gas to plantations to boost the growth process. However, much like any other carbon capture plant, Climeworks would rather focus on burying the carbon dioxide deep into rocks and stones. They have teamed up with Carbfix to achieve this, who have specialized in fusing carbon dioxide with porous, basaltic rock. This is because the basalt rock has all the elements needed to form carbonate minerals, preventing the carbon dioxide from escaping into the atmosphere completely.[12]

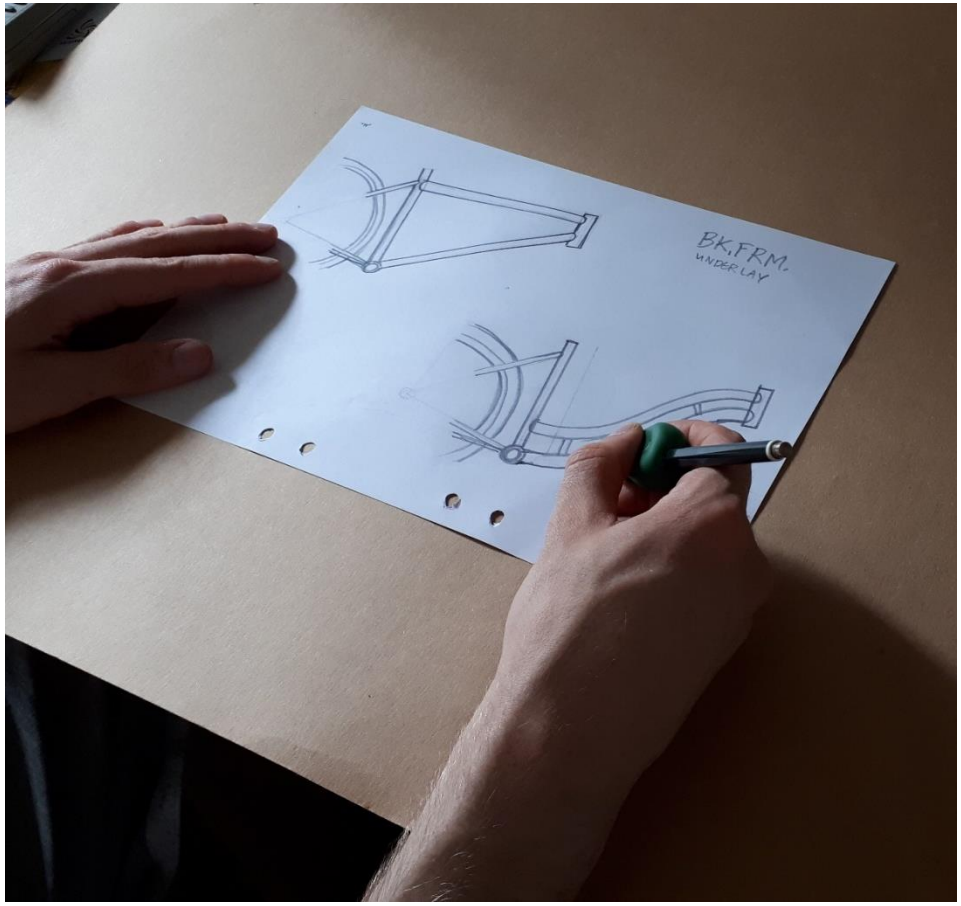
D

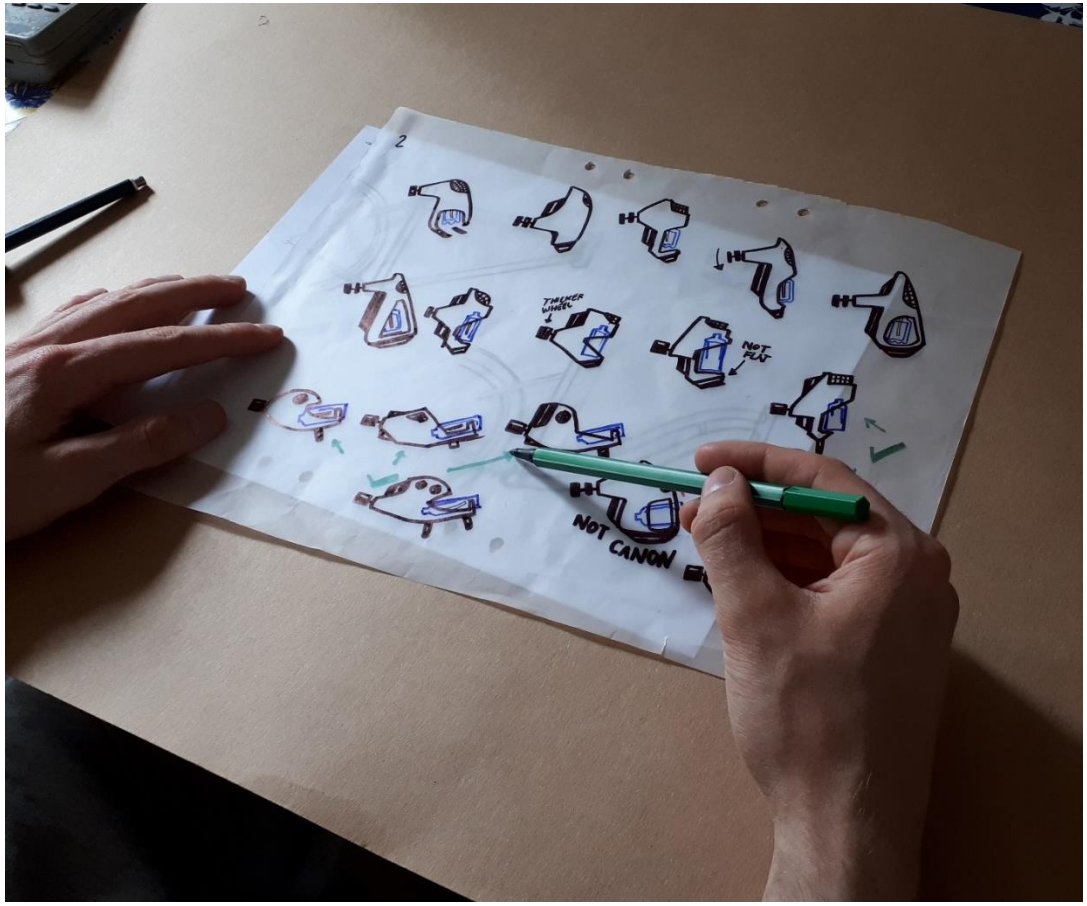
Initial process

In the beginning, there was a model that would do the same thing as the intended device would do. The use case and the development process for that model was never realized, though, which made the prior model incomplete. With that in mind, I renewed the form of the product because not only was the previous model only usable on one type of bike frame, it also had a lot of unexplored aspects that was not covered.

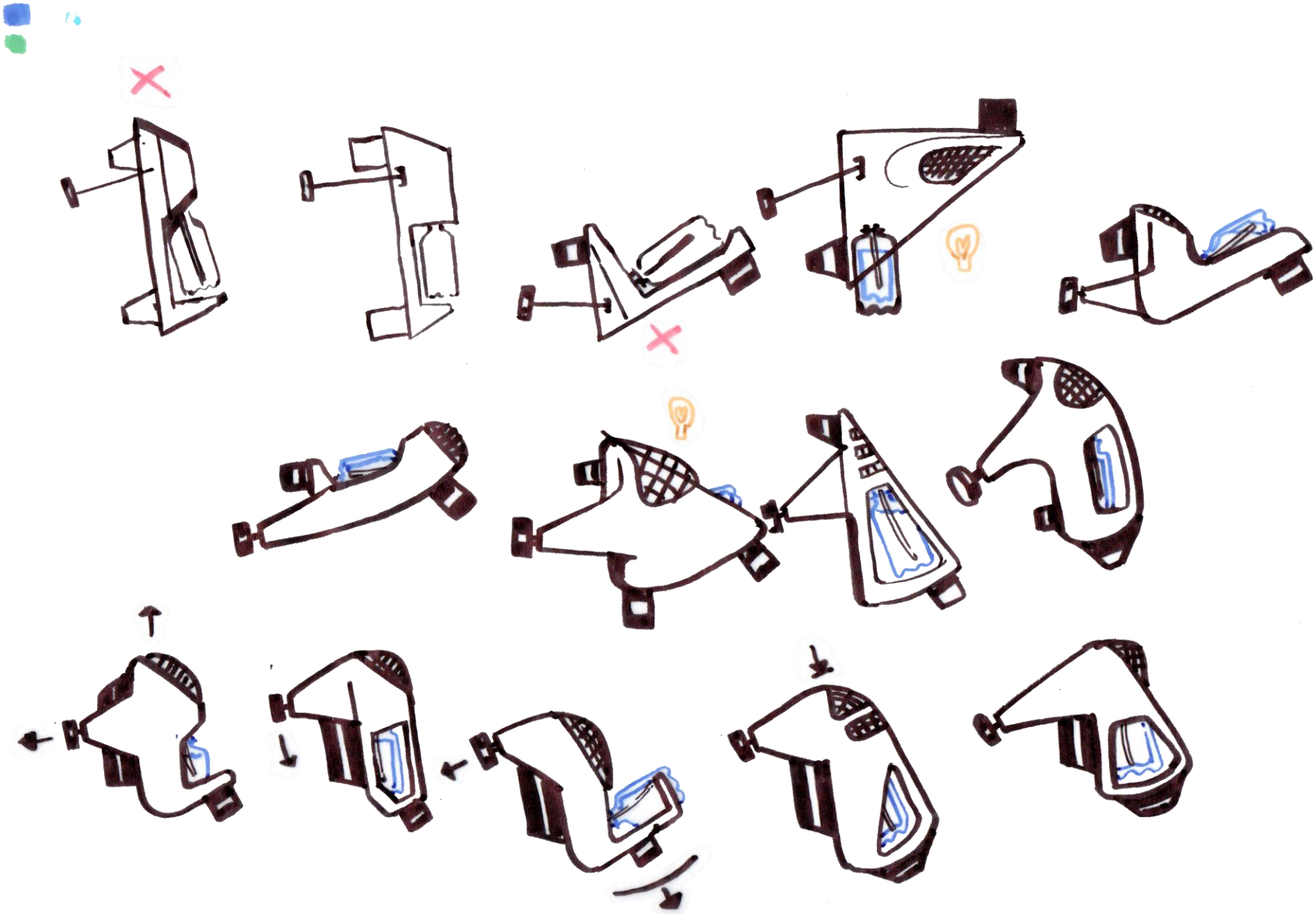
The first thing I did was to collect measurements of different types of bikes. This was to ensure that as many types of bikes was included as possible. I later excluded racing bikes and more technical bikes such as mountain bikes and BMX's, because adding extra weight to those bikes would impair their performance. I found myself catering only to comfort bikes and bikes with a regular triangular frame, since these types of bikes are far more common than the racing-or-technical bikes.

Sketch process

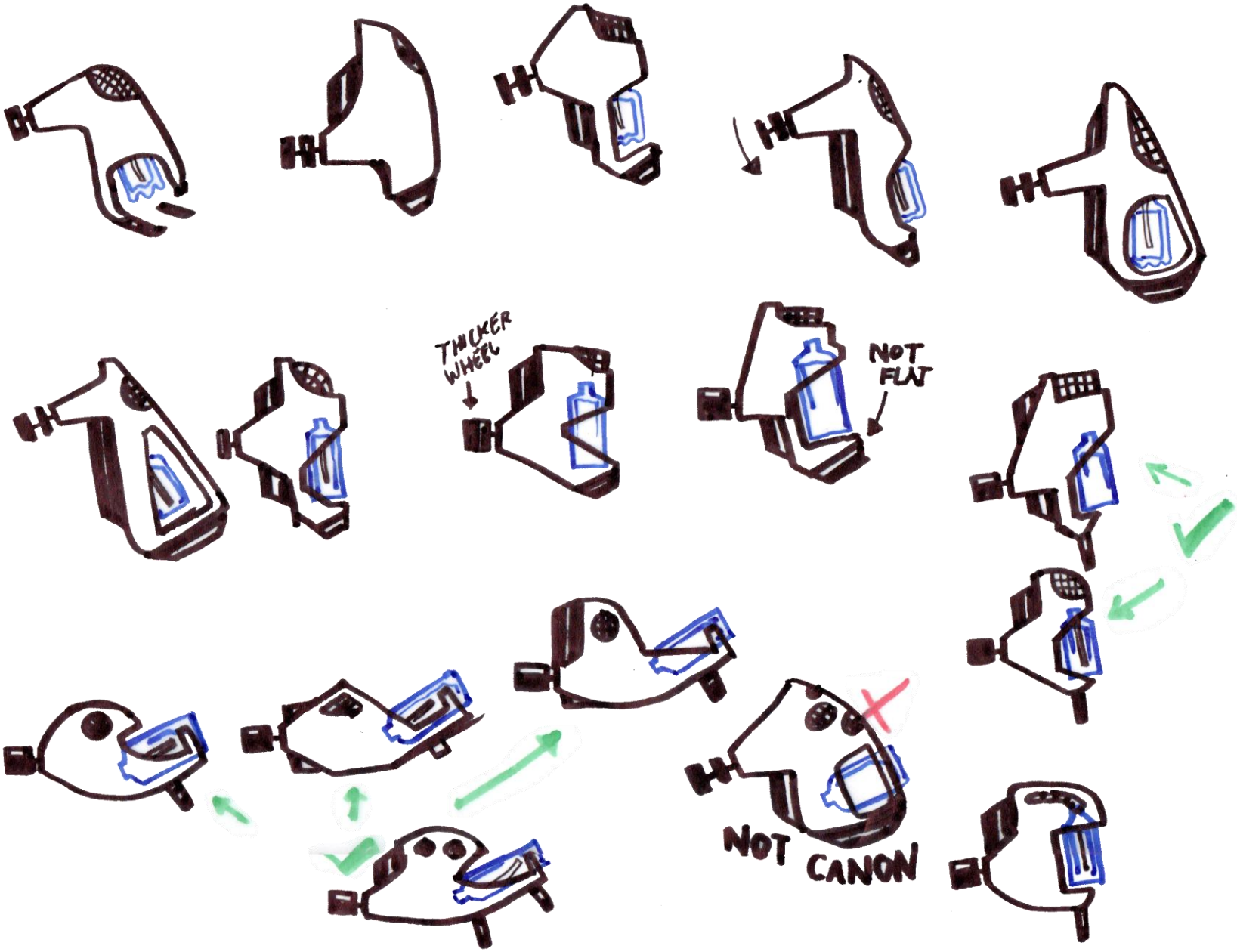




With measurements in place, I drew an underlay drawing that represented the average dimensions of the two frame types of the chosen bikes. I continued to draw side views of different forms the device could have. The goal of drawing these was to find one that could be used universally between the two frame types.



I based my design on the first model (top left) and explored different placements of all the features it had, in relation to the two bike frames.



The continued exploration eventually gave two different results that could fit on both types of bike frames. Interestingly, I found out that I started basing the design of the device itself and later shaping the object after the water bottle and how people expect to place it on a bike.

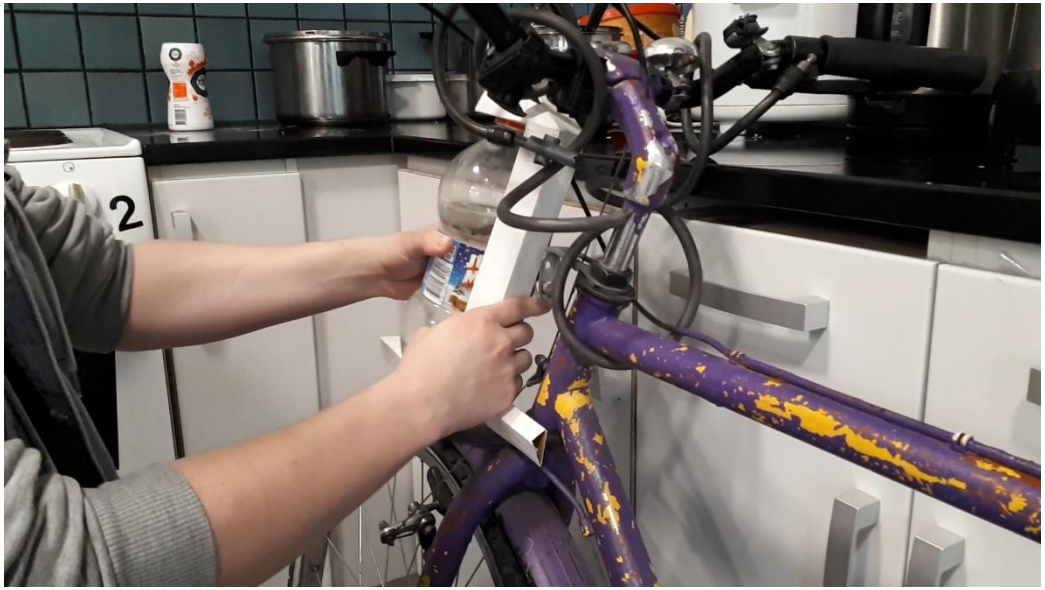
I built a model that represented one of the successful side-view sketches. Before I finished the model, I tested it on a bike and discovered that it is far bigger than I expected. I concluded that I would need to make the new models smaller and leaner, similar to a bottle holder for bikes.

User testing

The two new models were slimmer and more based on the dimensions of the two bike frames. Both models went through interaction tests with one of the frame types. Both participants also got to identify what the models looked like free of any context.




This first model, that I nicknamed “the crab claw”, was seen as the more aesthetically pleasing object. The connection between the water bottle and the claw was obvious for both participants. The placement of this model on the bike was unfortunately not clear since they tried every other possible placement, except for the one I intended.



The second model, that received the nickname “pickaxe”, had much like the crab claw an obvious interaction between the water bottle and the model. Again, much like the crab claw, the placement of this model on the bike was not according to my intended idea of placement.




Wait! Look at the bottom left image of this page! One of the participants figured out my intended placement for this model. This means I am getting closer to how the device is supposed to look like.

After I reviewed the footage, it reminded me of a bottle holder on a bike. The way they wanted to attach the device on the bike was reminiscent of this.

If I were to base the design of my device on the way people usually attach bottles to bikes, I suspect that it would be easier to understand how my product is supposed to be used.

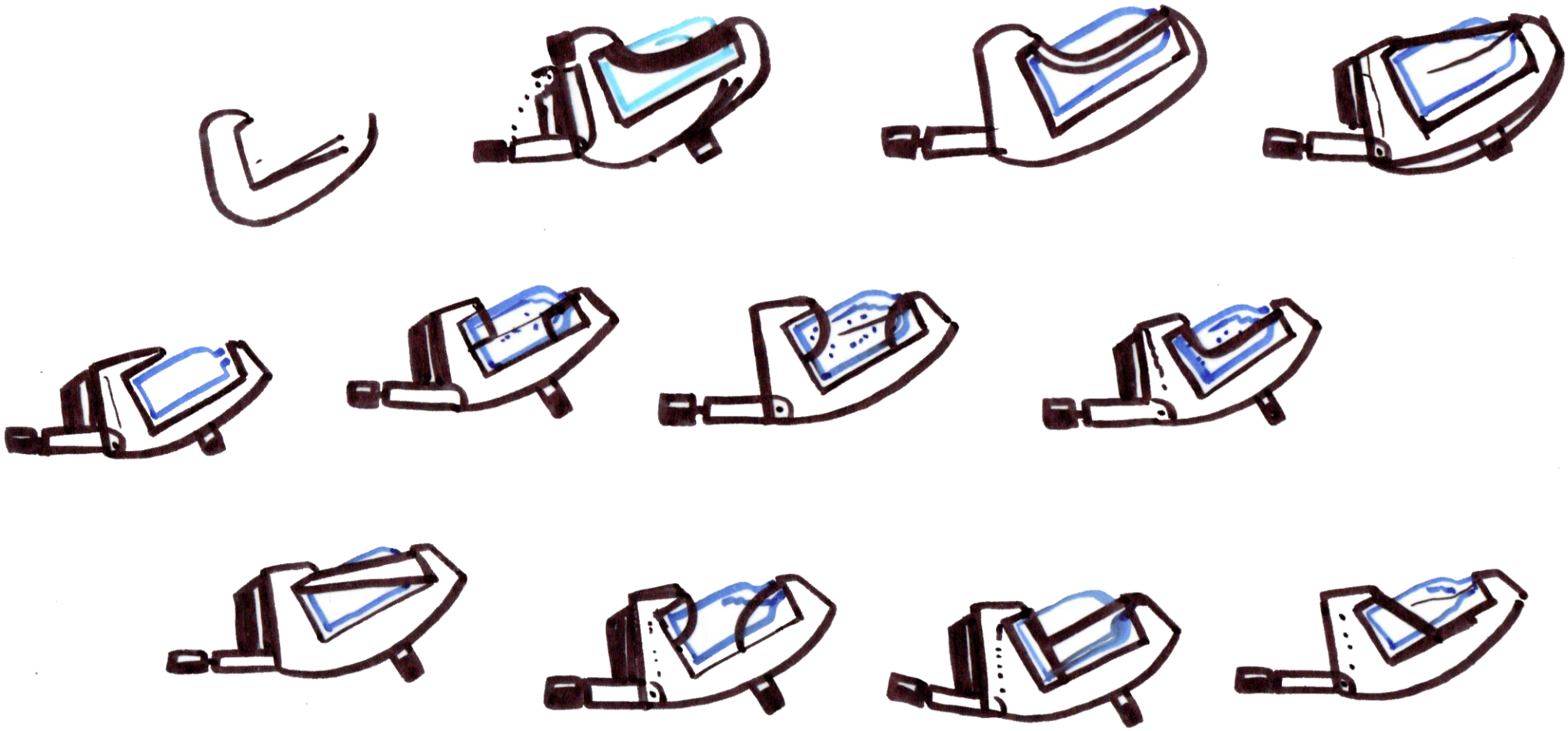
Taking inspiration from a standard bottle holder for bikes, I would take useful features from this item and apply them to the final design of my device.

- Aesthetically pleasing
- Troublesome orientation of bottle on bike

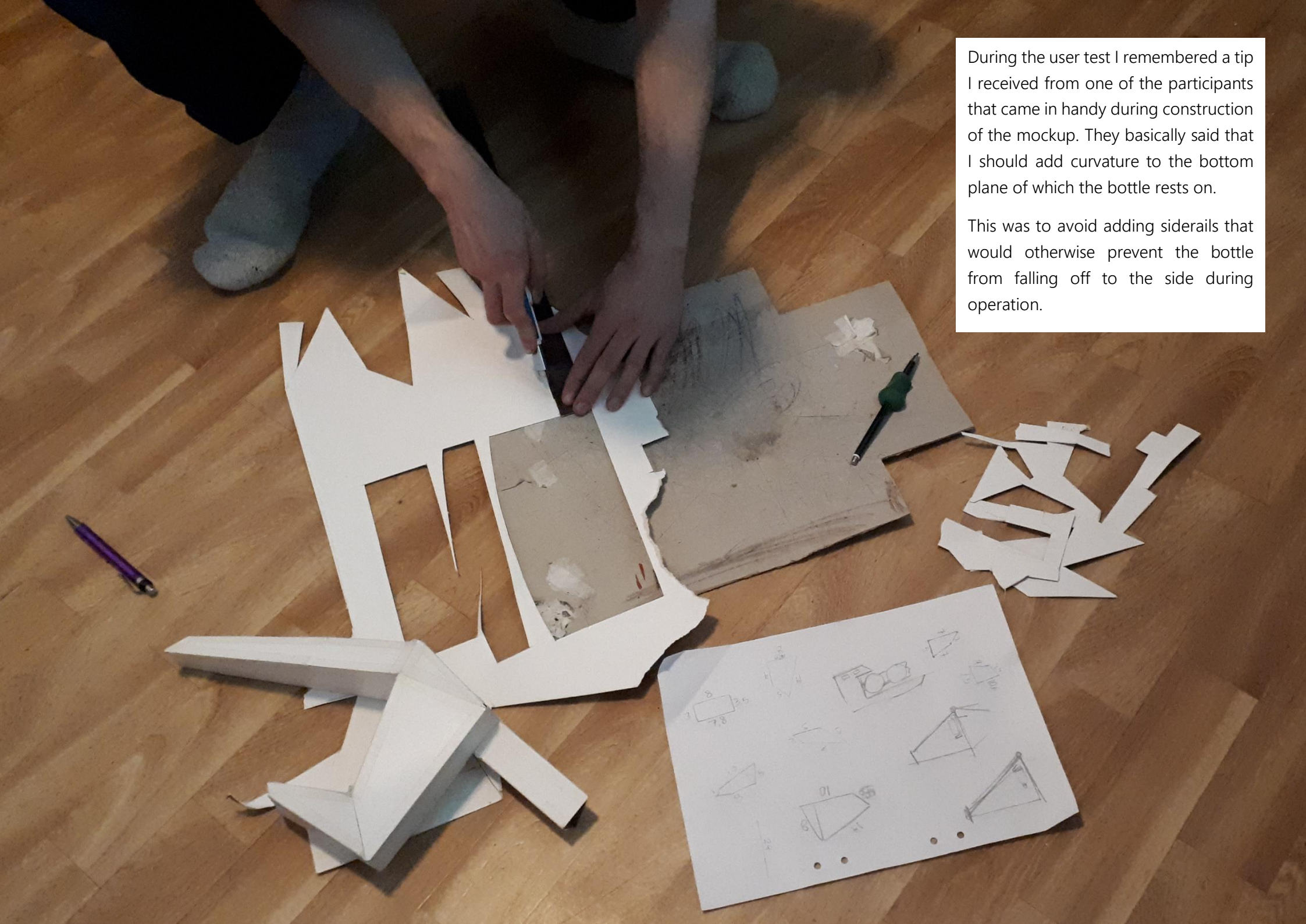
- Easily understood placement on bike
- Less aesthetic than the claw

Based on the feedback I received from the user tests, I compiled a comparative list for each of the two models. They contain the upsides and the drawbacks of each model. My intention here is to combine the pros from both and make the final design easier to use, understand, and nicer to look at.

Second sketch process

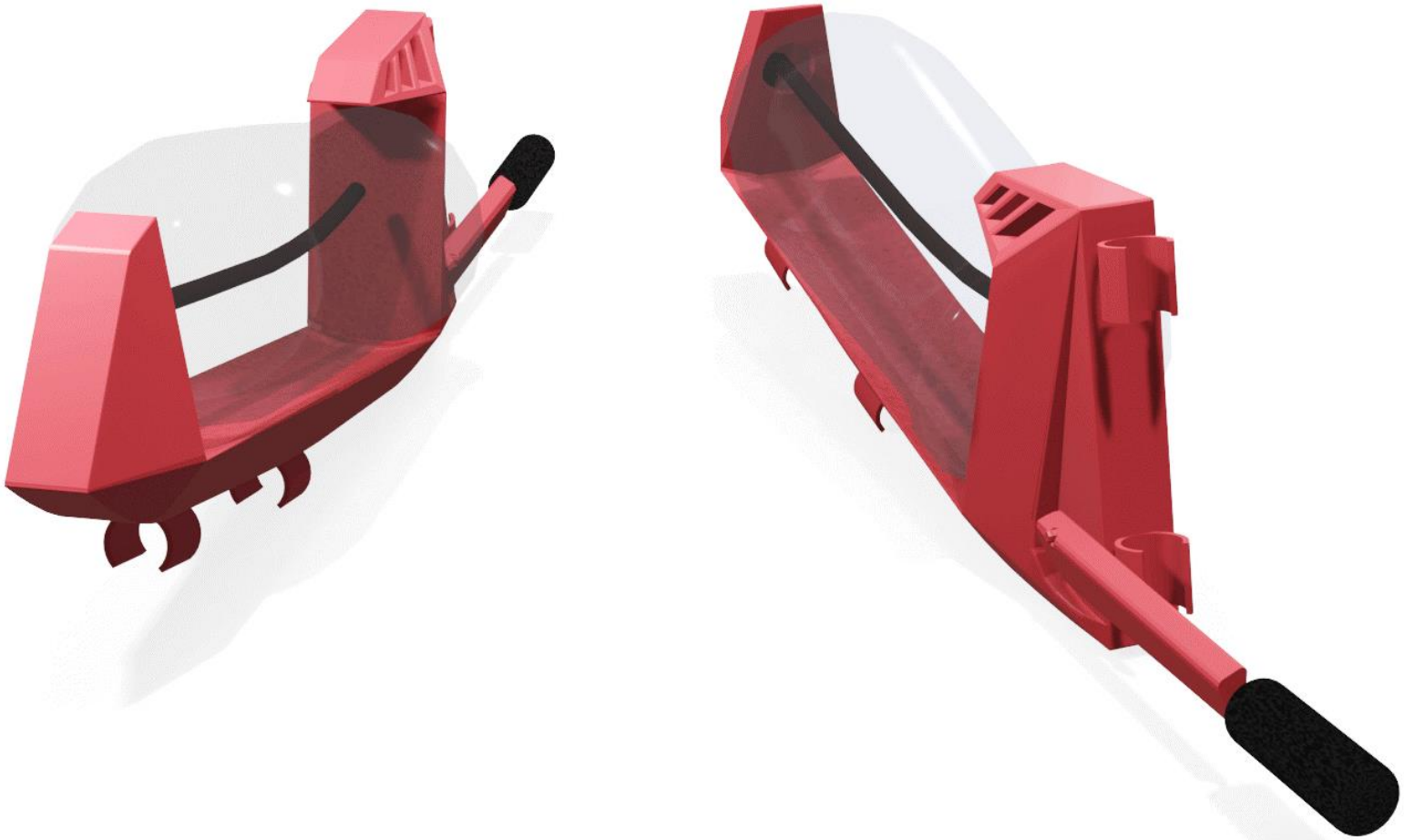


While taking inspiration from the two previous models, as well as from the bottle holder, I went back to the drawing board to experiment with a newer shape. These side-view sketches look similar because I chose an almost horizontal orientation of the bottle. Also, this was to accommodate as much space as possible for the mechanics inside the device while keeping the whole thing small enough to be manageable by one person.

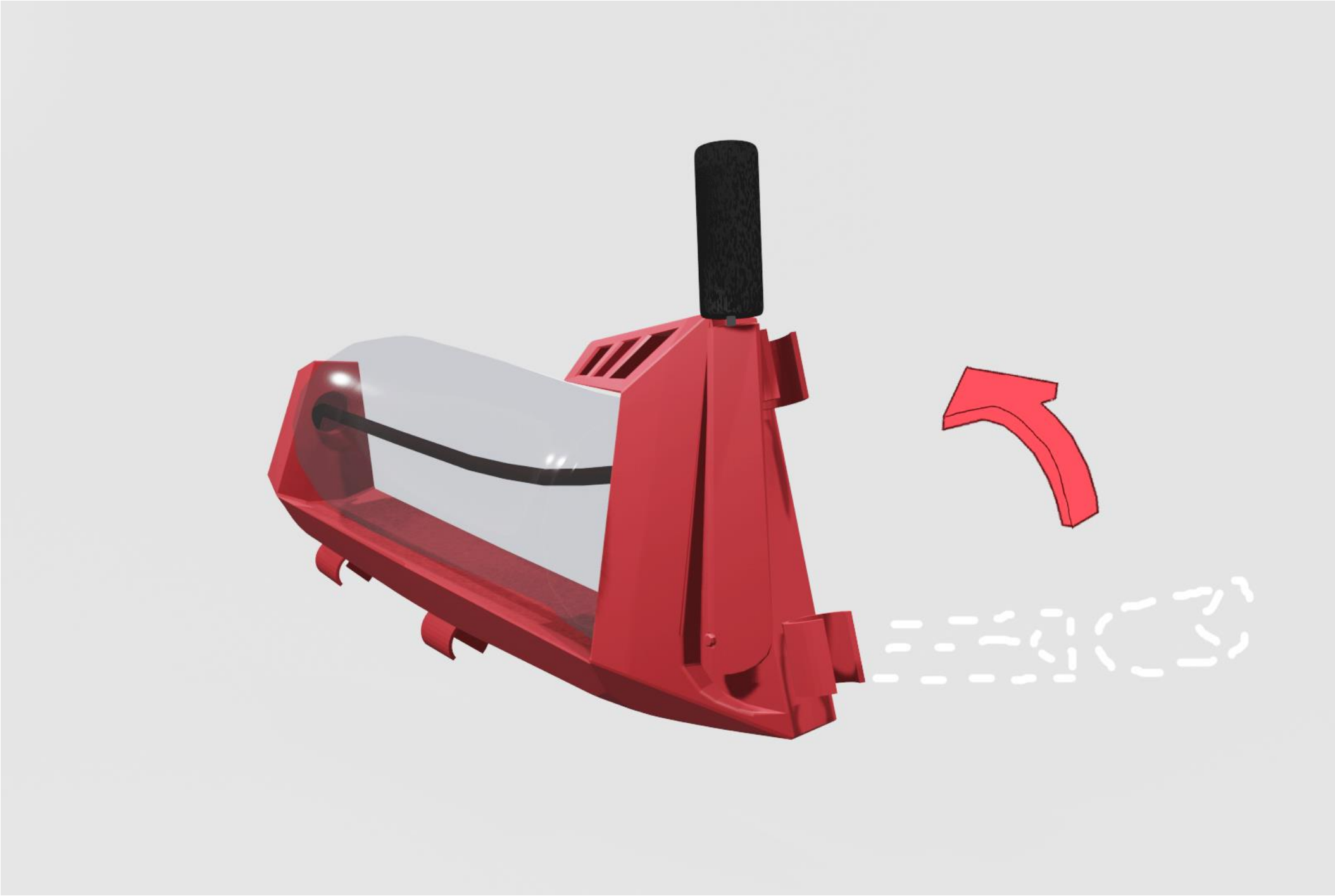


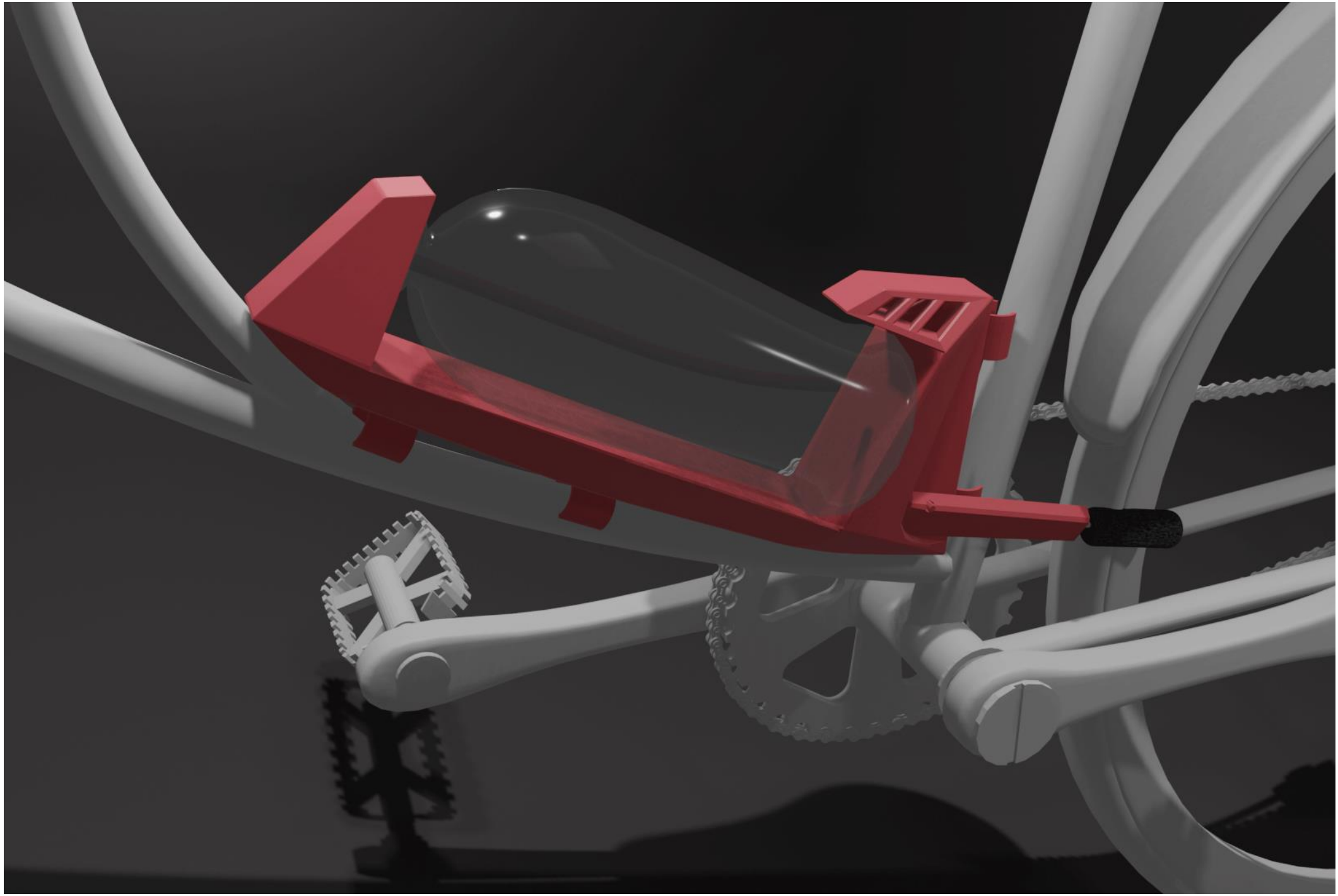
During the user test I remembered a tip I received from one of the participants that came in handy during construction of the mockup. They basically said that I should add curvature to the bottom plane of which the bottle rests on.

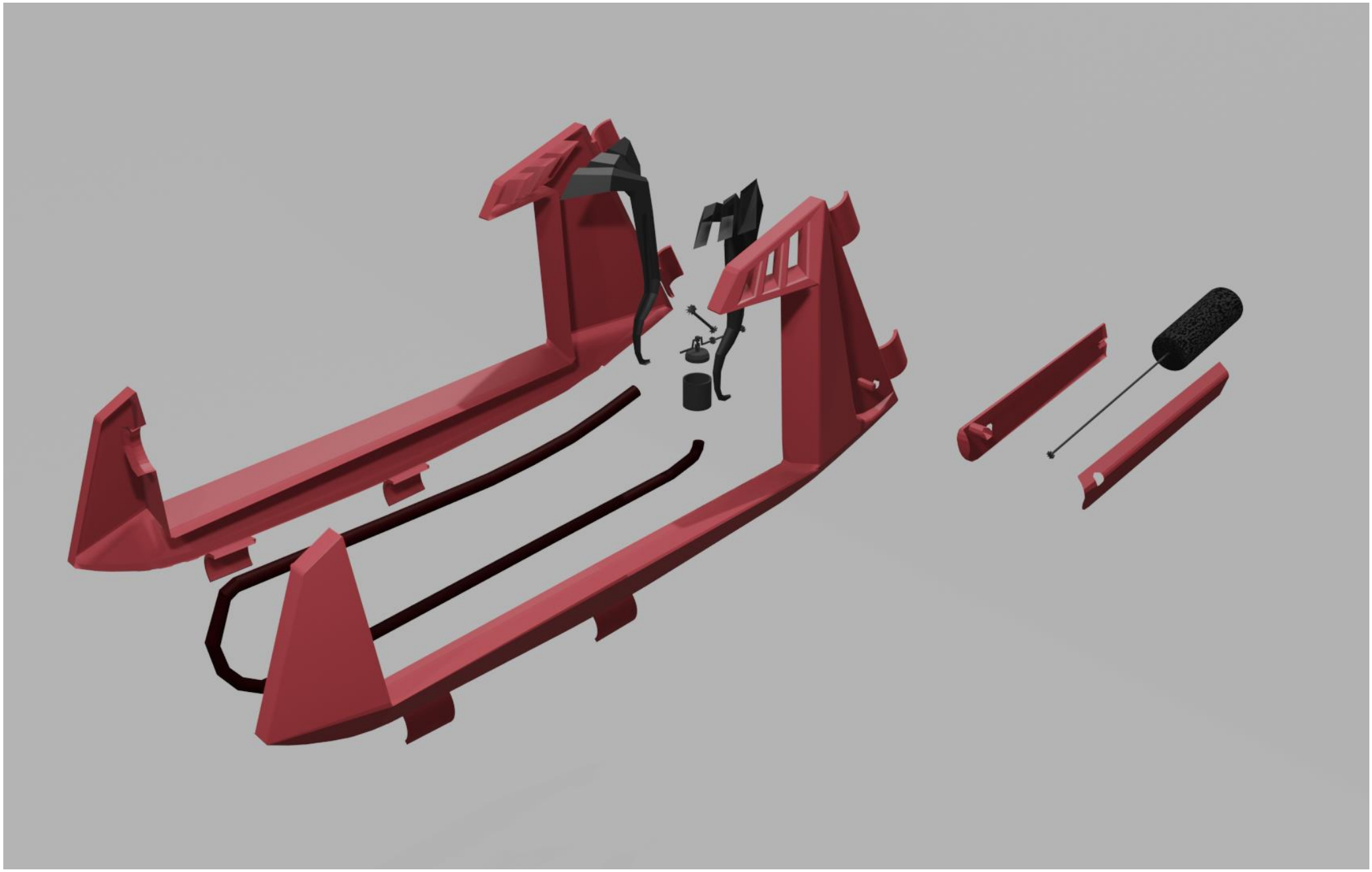
This was to avoid adding siderails that would otherwise prevent the bottle from falling off to the side during operation.

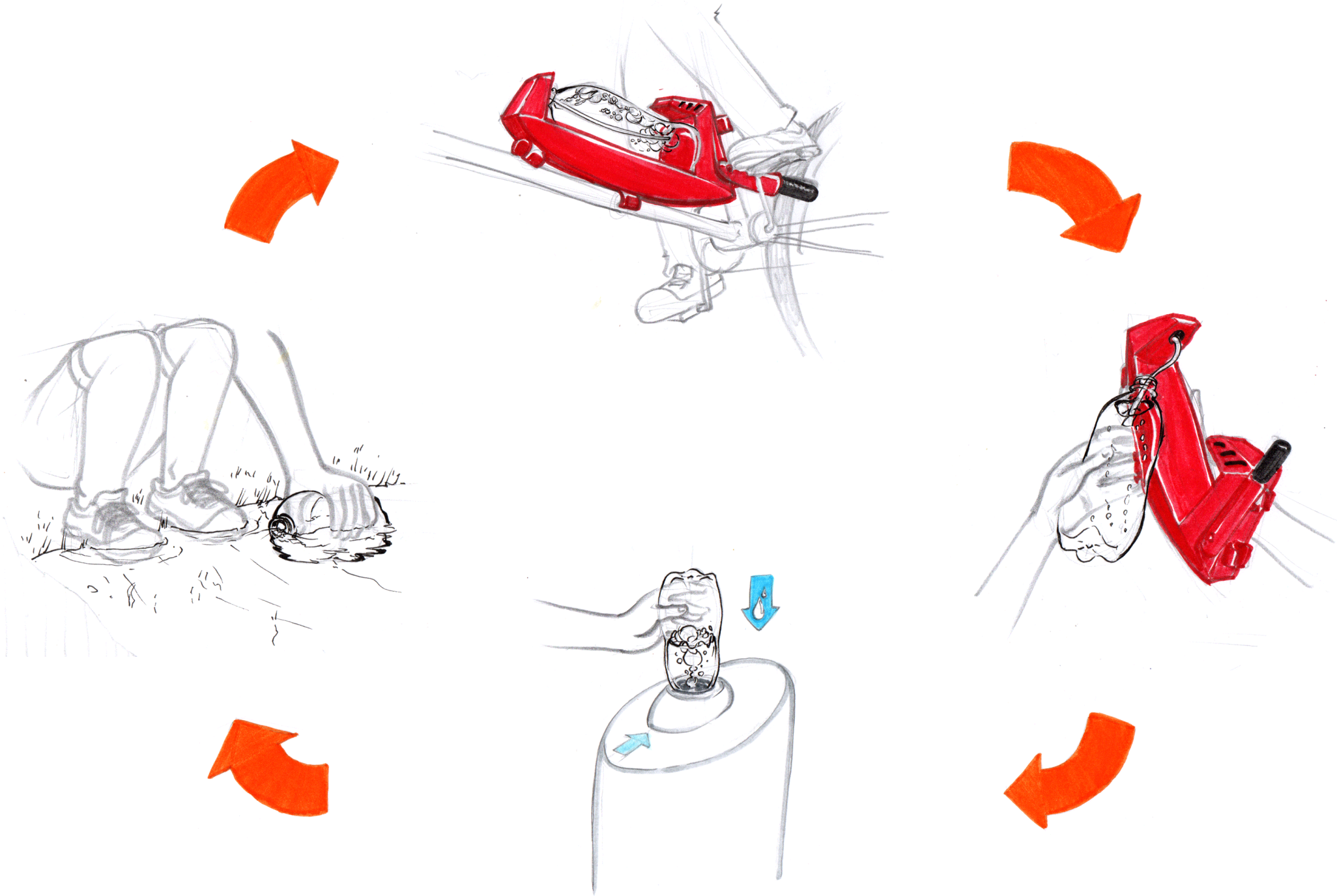


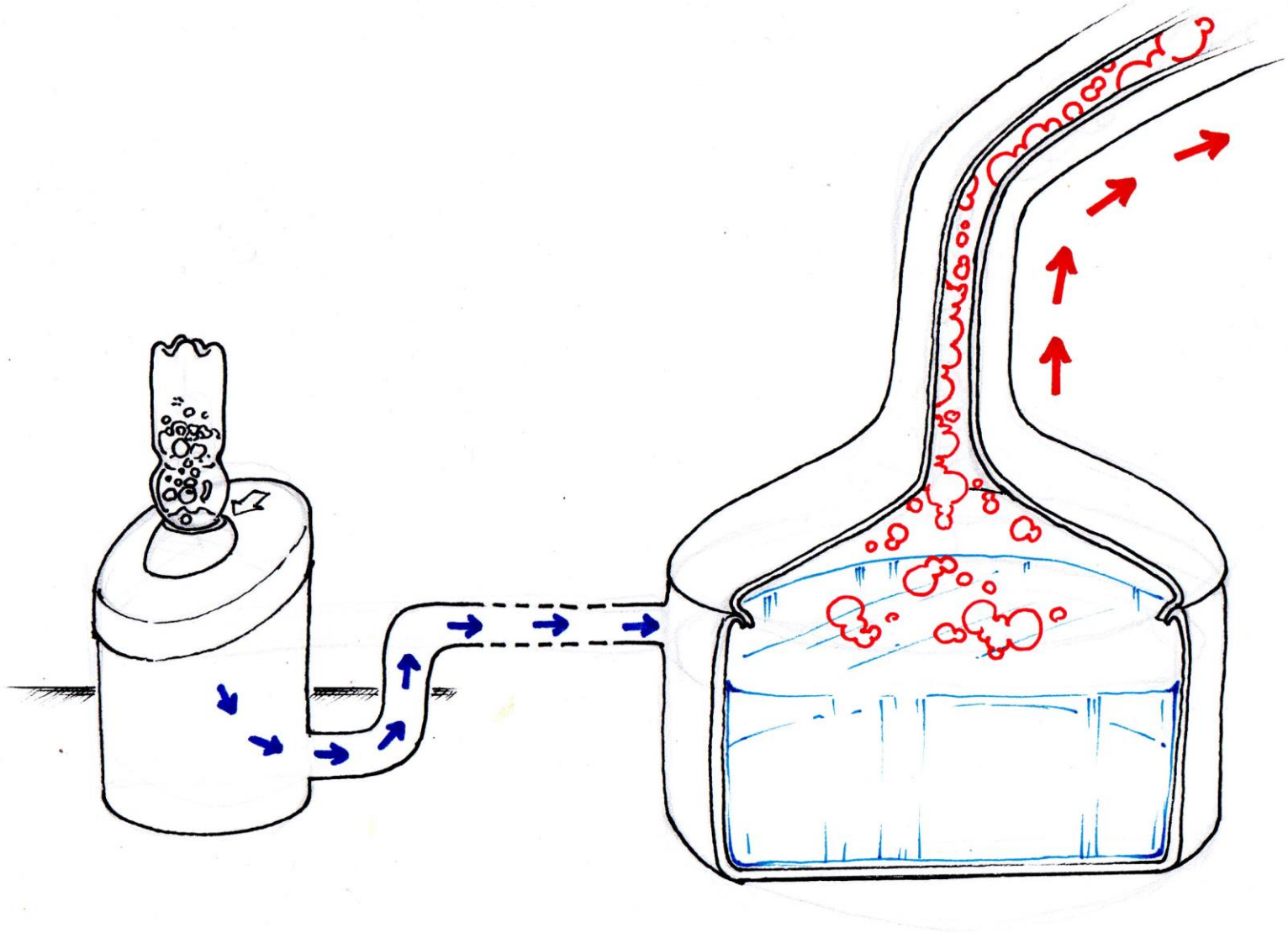
Final product







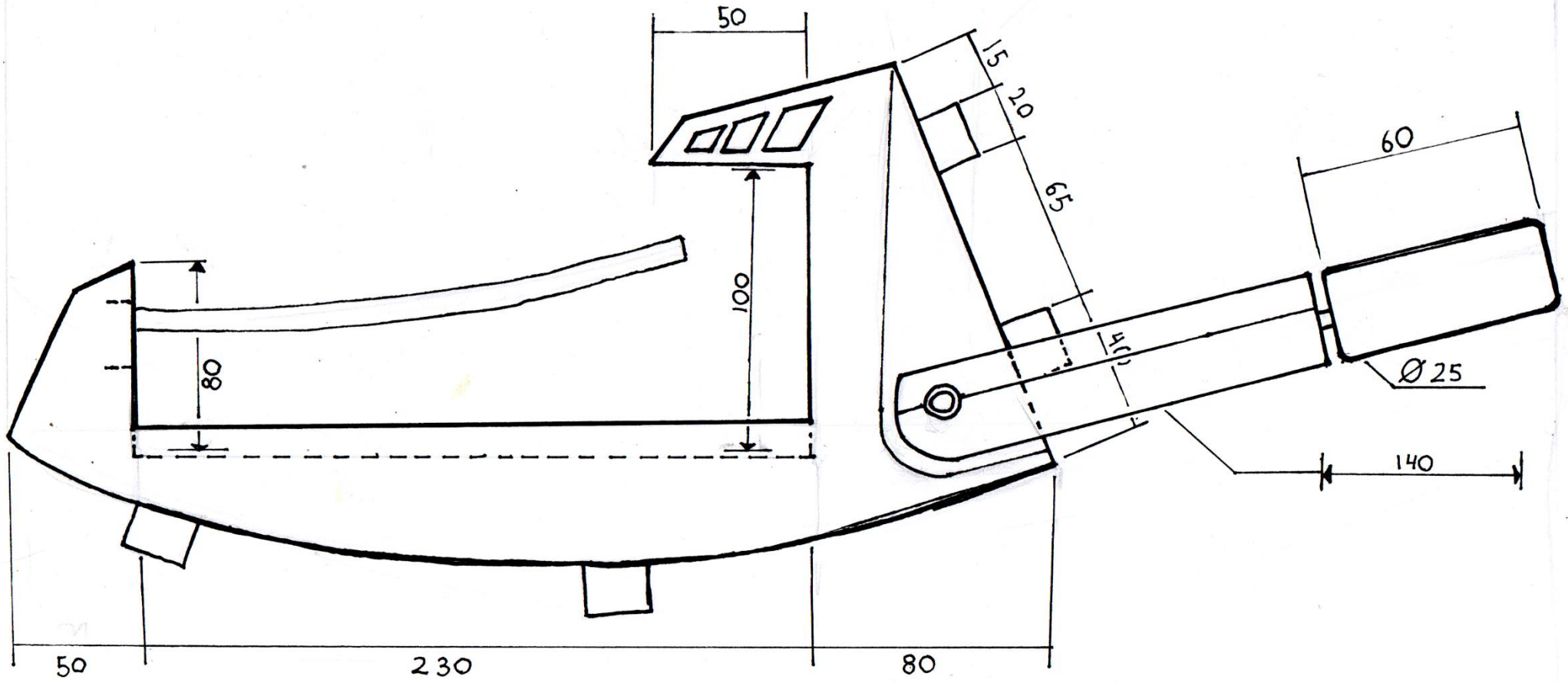




WATER

CO_2

The carbonated water travels to a tub where it is frozen. The action of freezing the water forces the carbon dioxide out of the liquid. The carbon dioxide is then transported to be used in other industries.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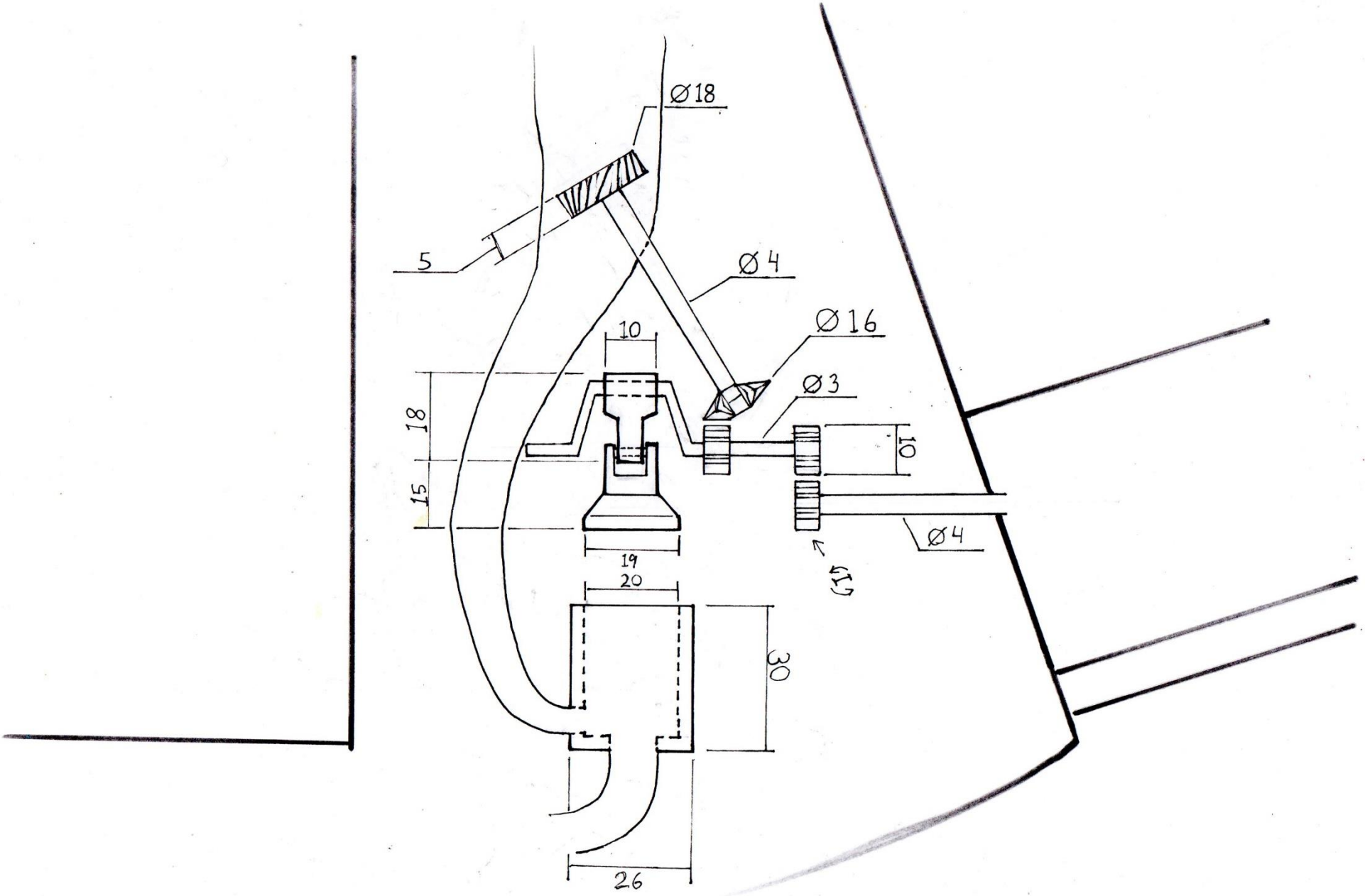
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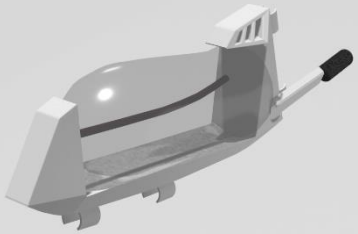
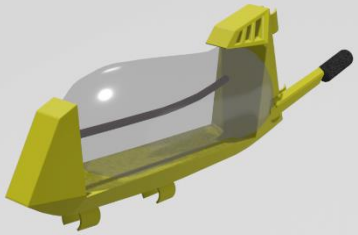
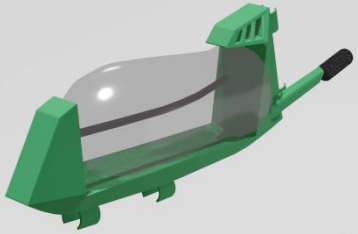
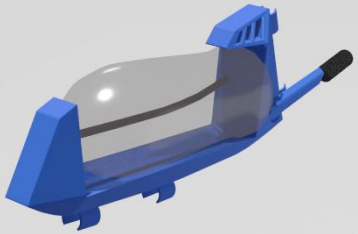
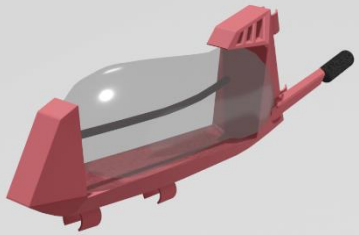
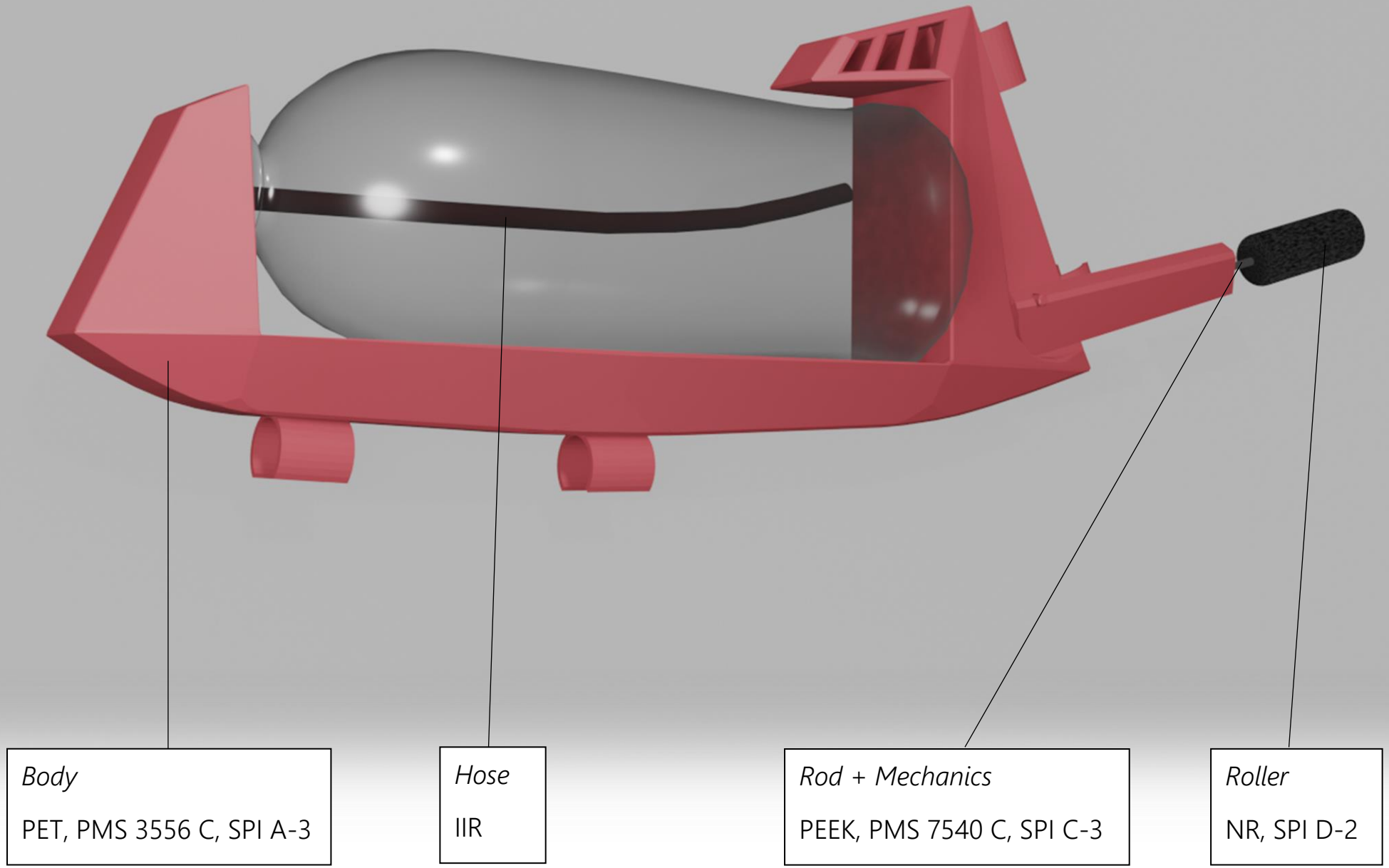
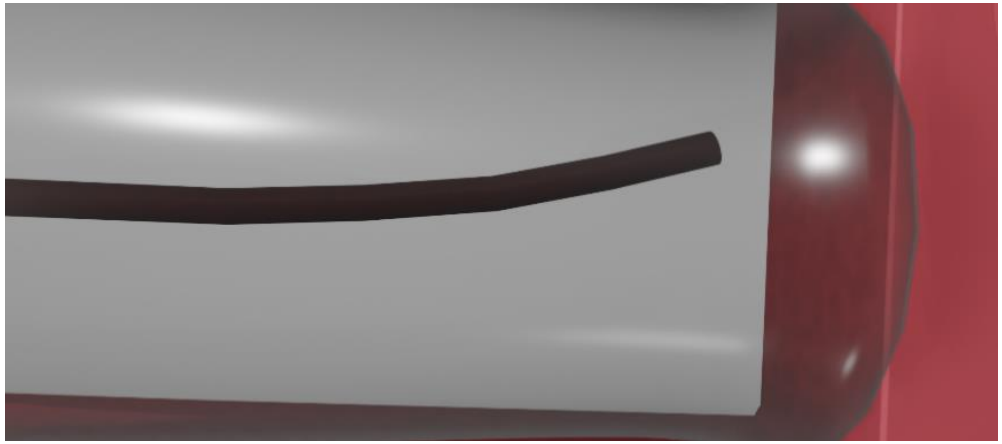
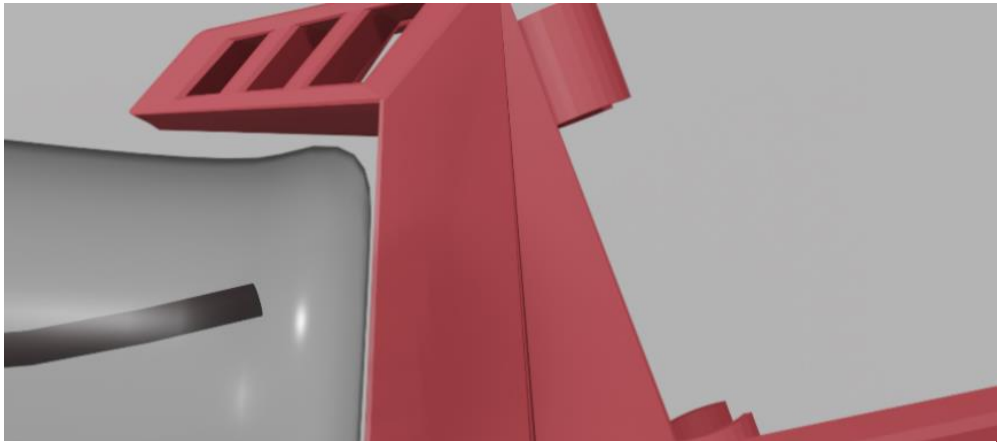
1 What the color communicates	1. Cleanliness 2. Purity 3. Solar reflection		White PANTONE 656 C
	1. Warmth 2. Glee 3. Look intriguing		Yellow PANTONE 604 C
2 The emotion of the color	1. Environment 2. Natural 3. Camouflage		Green PANTONE 7723 C
	1. Stability 2. Calm 3. Spread awareness		Blue PANTONE 2727 C
3 The function of the color	1. Action 2. Aggressive 3. Attract attention		Red PANTONE 3556 C


Body
PET, PMS 3556 C, SPI A-3
Hose
IIR
Rod + Mechanics
PEEK, PMS 7540 C, SPI C-3
Roller
NR, SPI D-2



Hose

IIR: Butyl rubber. Soft and elastic rubber ideal for tubing.

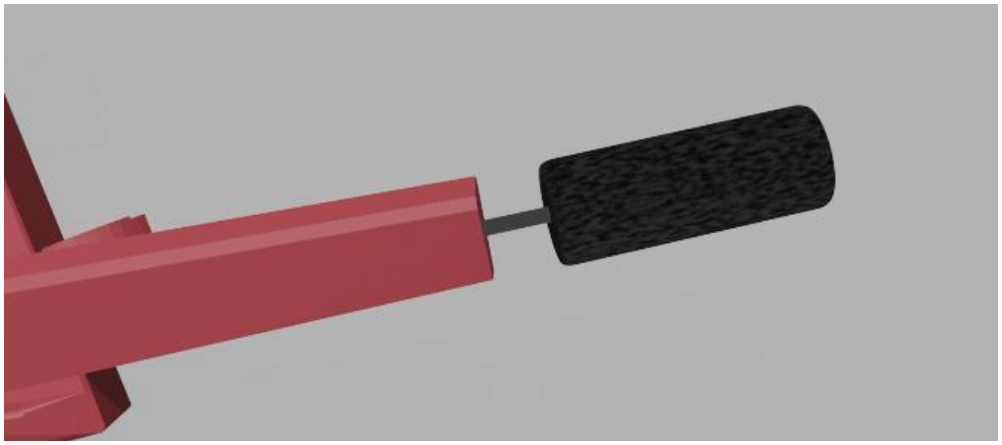


Body

PET: Plastic from discarded PET bottles. Lightweight and easily recyclable.

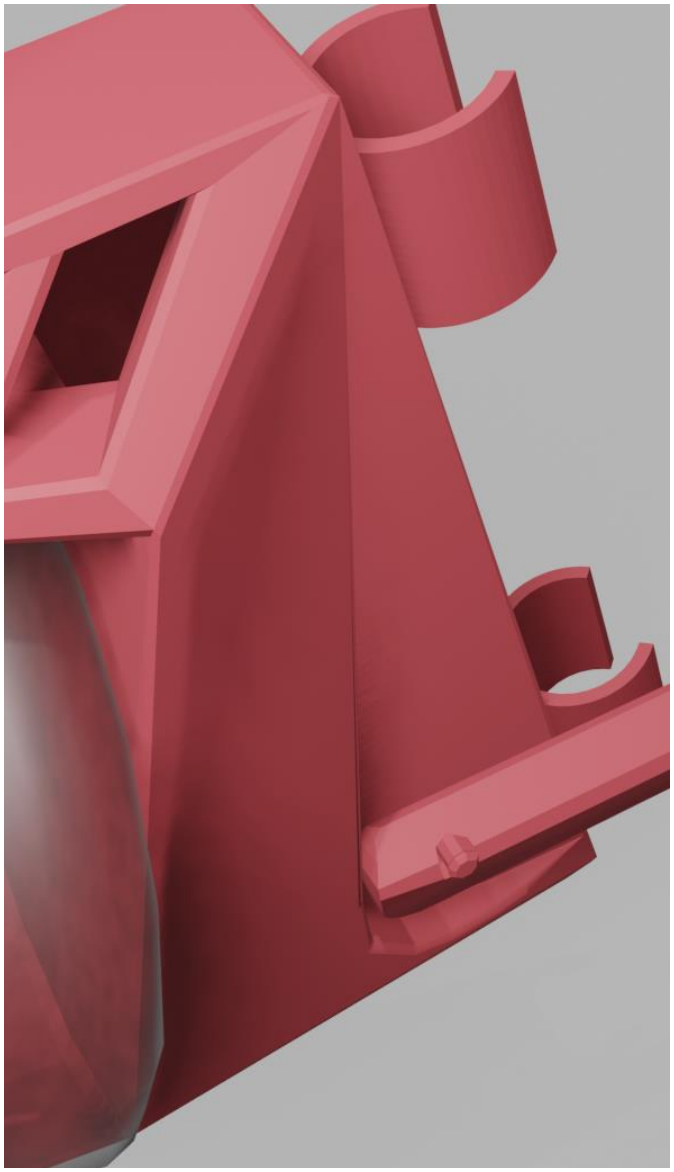
Rod + Mechanics

PEEK: Polyether ether ketone. A rigid and strong material ideal for mechanics.



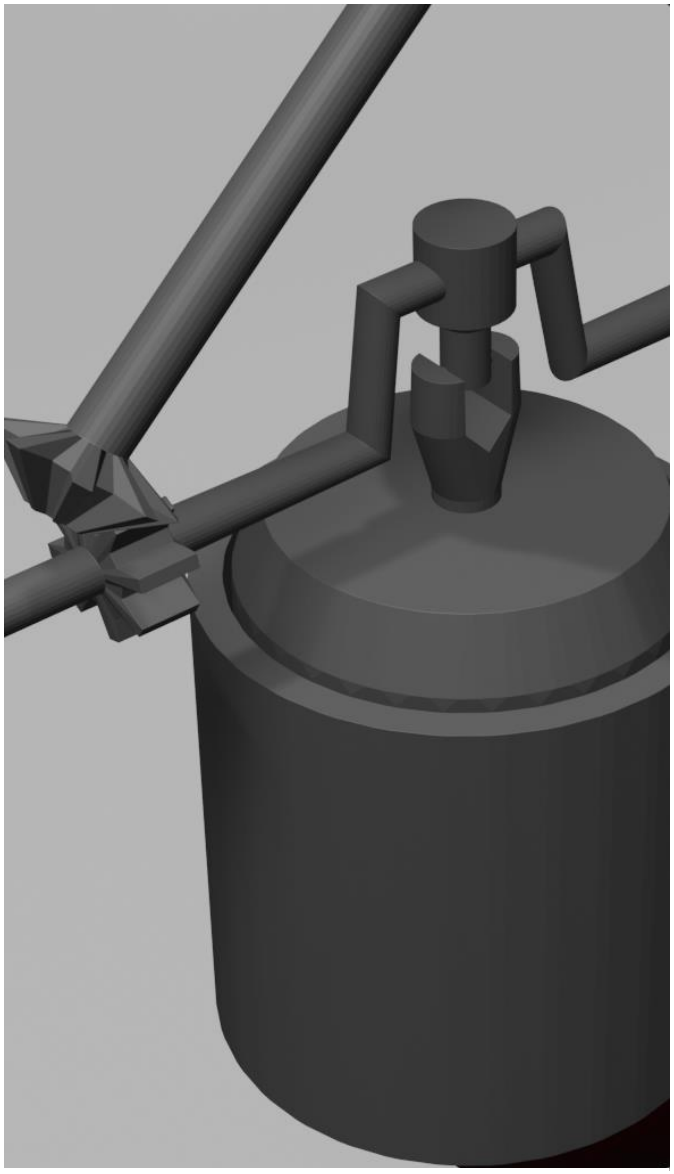
Roller

NR: Natural rubber recycled from old tires. Good friction when in contact with a bike tire.



SPI A-3

The surface of the body has a glossy finish. This is to achieve a clean exterior for aesthetic cleanliness.



SPI C-3

Since the mechanics are rarely seen but need to run smoothly, a low polish is all that is needed.

SPI D-2

To gain more friction from the bike tire, the roller has been given a dull finish.

Evaluation

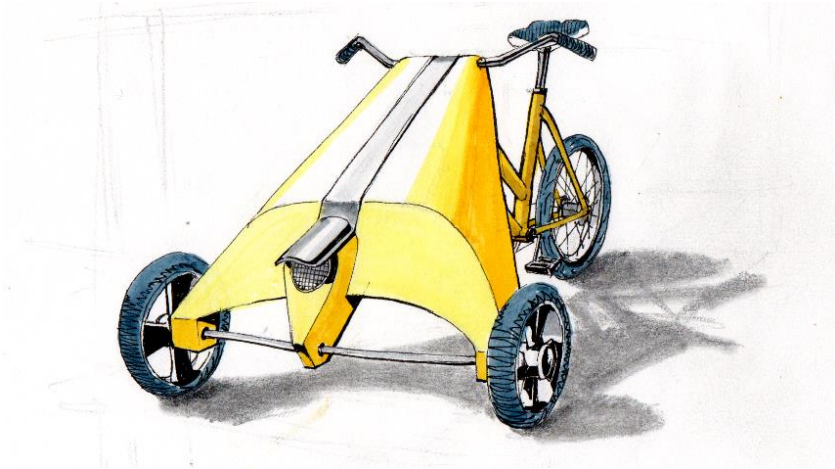
At the start of the project, which took place in late January, I began with presenting my idea for this bachelor project and what I wanted to do. The very next thing I did was to collect as much information on carbon capture as possible. What I recovered was mostly explanations on how the technology worked and what it was being used for. History of the technology and information on stakeholders within carbon capture were more difficult to find.

Without me knowing, each new topic found on the subject quickly turned into a rabbit hole that led elsewhere. Most topics led me to read up on chemical engineering and, oddly enough, CO_2 filtering for aquariums. Other topics led me to NASA's official webpage on the basics of climate change which I based a lot of my motivations on.

The research was unexpectedly expansive to me, so much so that I started to sketch out and try different ideas of how my prototype product would work and be used. The goal at the time, which was in late February, was to apply what I have read on the internet to the prototype and see if it worked. Due to the lack of proper equipment and materials however, I was not able to physically test out any of the prior ideas I had in mind.

My intention to build a functional prototype started to become a main goal of sorts, where I would jump back and forth to my research to find new ways to theoretically realize my idea. This way of working lasted until somewhere in the middle of April where I had already received feedback on my work on numerous occasions. My intended idea went from a stationary object on rooftops, to a carbon capture bike, and finally to a miniature carbon capture device that is mounted on a bike.

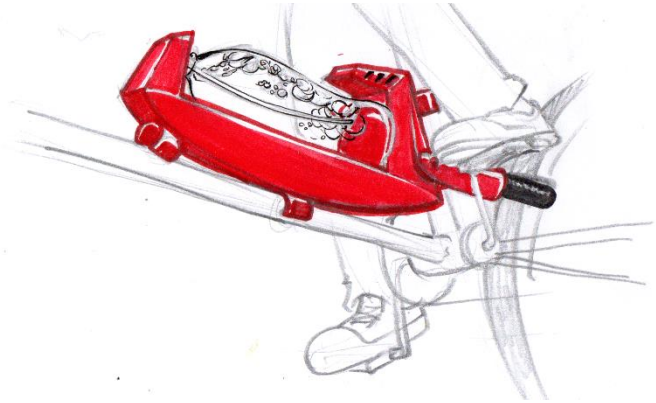
At the final presentation, I showed more of my research than a developmental process of the device itself. That was because the testing of the final device, both with and without potential users, was simply missing. At that time, I was forced to present an idea of how it might be used without ever having consulted with actual users before.



Around the beginning of May, I received some feedback on my documentation which stated that it was more of an engineering report than a document of design. I was told that the design element of this project was missing. This forced me to rewrite and rethink my entire project from the ground up. What ensued after that feedback session was a two-week design process that only pertained to finding a more appropriate shape for my device before it was time for the final exhibition in the beginning of June.

Within the two-week time frame, I managed to develop two new models that were ready for user testing. The result of said tests gave me useful advice and information on how my product should evolve into a graspable product.

The shape of the final product is the result of a mix between shape exploration, feedback from user tests and input from inspirational sources, such as the bottle holder from bikes.



Evaluation – Errors in the process

Going over the project from a bird's-eye view, the process from January to June was not ideal. That becomes clear already in February where I went directly from research to prototyping. The research itself was inconclusive since it was limited to internet searches only.

The lack of user tests during the project made any prototypes, models, and ideas built during this time difficult to validate. Without proper feedback on the things I have built, it is impossible to know if my choices in design are going in the right direction.

Jumping back and forth between research and prototyping was also a grave mistake. Even if new insight is valuable, an excess of information in this case only made it difficult to realize my goal for this project. A lack of convergence in the research made it difficult to construct a mental model of carbon capture as a whole and how it connects to everything related to it.

Lastly, the lack of testing on the device showed in the "initial process" chapter of this document, resulted in a product that was difficult to understand and put into a realistic scenario.

Evaluation – Improvements for next time

This project carries mixed experiences for me. For starters, I am glad that I had the opportunity to make a mistake of this scale during my bachelor education, for I suspect that I would not be able to recover so easily if I did the same mistake out in the work field. At the same time, I missed an opportunity to make the best work of my education due to strange values I adopted early in this project.

With that said, I will first address the improper research process. The better way to conduct research in this case would be to reach out to carbon capture companies via e-mail or phone and talk to local chemists to quicker find out if carbonation is a good option for carbon capture. All this questioning should have been done in addition to both internet searches as well as visits to local libraries to find literature about and related to carbon capture.

The involvement of users should have occurred sooner. Some quick cardboard mockups like the crab claw and the pickaxe would suffice in user tests to early on give me an idea of how people would interact with my device. Questionnaires would also be a useful tool to find out if what I am making is something that people would be interested in using. Preferably sent out before building anything.

Due to the situation with the pandemic at the time, the workshops closed which made it impossible to build prototypes. Still, I had tools and materials to build the prototypes, albeit in lower quality. What prevented me from building a prototype was pretty much everything that came before it. Without the right research, user tests, and usage scenario to back up the project, the is no reason to build a prototype.

During the final presentation, the amount of research presented outweighed the presentation of the design process. This is not ideal because the process is necessary to understand the outcome of the project. At the time, I believed that the evolution of my theoretical ideas counted as a design process. It did not count as a design process because it was not based on research or on user preferences.

After the final presentation, I had a feedback session which prompted me to redo the design process completely within two weeks. I can say in hindsight that the design process showed in this document is far better than the one I did before. The final note I can take from this experience is that the process showed here is what should have been done at the start.

References

1. https://climate.nasa.gov/effects/
2. https://www.smhi.se/forskning/forskningsnyheter/varmebolja-i-maj-2018-det-var-ovanligt-varmt-till-och-med-exceptionellt-1.136806
3. https://ourworldindata.org/ghg-emissions-by-sector
4. https://www.ascoco2.com/en/co2-production-and-co2-recovery-plants/general-information-about-co2
5. https://www.rff.org/publications/explainers/carbon-capture-and-storage-101/
6. https://news.stanford.edu/2019/10/25/study-casts-doubt-carbon-capture/
7. The identity of each person I asked has been altered, but their opinions remain the same.
8. https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/carbonation
9. https://www.kickstarter.com/projects/105742033/co2ube-the-worlds-first-carbon-dioxide-filtration
10. https://www.instructables.com/Solar-powered-CO2-Scrubber/
11. https://climeworks.com/co2-removal
12. https://www.carbfix.com/how-it-works

Image references

A. https://unsplash.com/photos/-7Xb4TmVTN8
B. https://www.kickstarter.com/projects/105742033/co2ube-the-worlds-first-carbon-dioxide-filtration
C. https://climeworks.com/co2-removal
D. https://pixabay.com/sv/photos/mannen-cykel-rida-cykeltur-manliga-731492/