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Project Realisation

The Bascut

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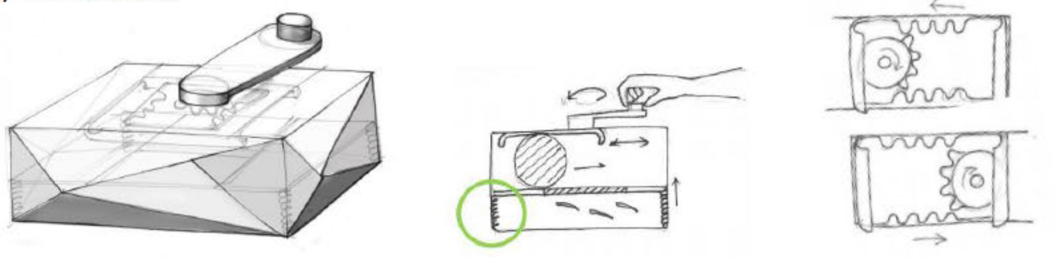
INTRODUCTION

In Module 2 Project ideation has finished and 3 product concepts per person have been defined. In this third Module project, the development of 1 of the product concept continues. Based on the chosen concept, a prototype has to be developed. The goal of this prototype is to evaluate some of the choices made for the product. To do so, the prototype should resemble the product to a high degree. However, the prototype is made in the Workplace and not every material and process is available. This has effect on the prototype and therefore it will be different from when it was a mass product. During this project the chosen concept of project Ideation will also be further developed into a mass produced consumer product. We will redesign the concept to fit the demands for mass production. Furthermore, we try to maintain the main characteristics of the product in both the prototype and mass product the same as much as possible. There are also 5 assignments from production that deal directly with the development of the prototype and mass product. These results are in the Appendix.

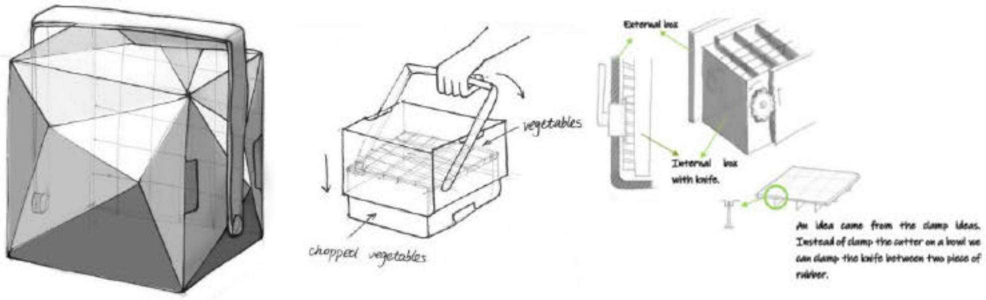
Choosing 1 of the concepts

We had to choose between 21 different concepts. We made a top 3 of the products we liked most and looked at the pros and cons. These are the 3 concepts we liked the most and looked the most feasible.

1) The Boxturn

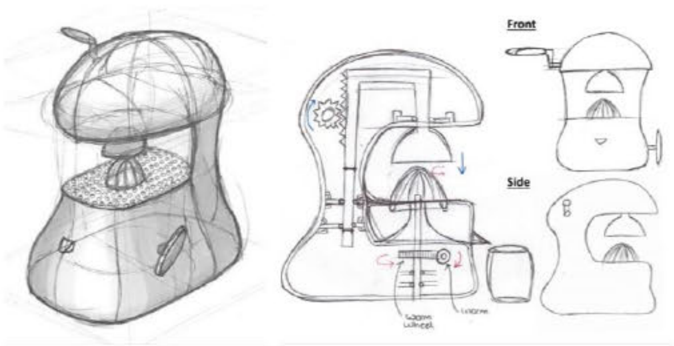


2) The Bascut



3) Combination between two concepts

The Rotator



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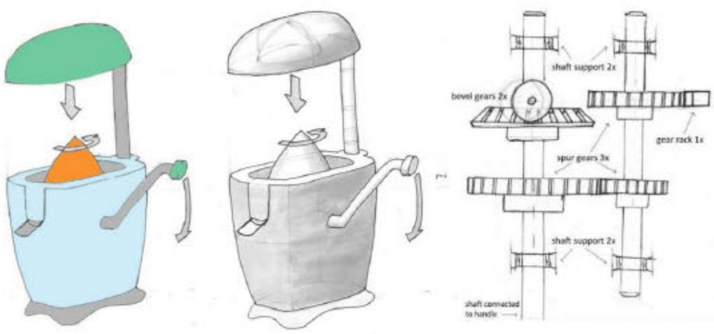


Looking at all the different concepts we choose concept 2) The Bascut, a vegetable cutter. We like this concept because of the fact that you can bring it with you as a box.

We want to choose a concept that has already an extra feature compared to the already existing products. We think that the other concepts were quite basic and not very different from the current market.

The target group

Our target group for the Bascut is Students. We want to make this box mainly for students who go to college and want to have a healthy meal, but don't want to do much effort by themselves. For more insight about the target group see the appendix: Report Module 2 Vegetable cutter. Students are really busy, so they want to have a quick and healthy meal. They should be able to bring the box as lunchbox with them to college. This is what we take into an account for the design.

Style

The style of our vegetable cutter is angular forms. We don't want to put the main focus on this style in the prototype. We want to use this style as an extra feature to make the appearance of the vegetable cutter more stylish and fancy. For more insight about Angular forms See the appendix: Report Module 2 Vegetable cutter.

PROTOTYPE

When designing a product you need a very clear description of requirements. The product is a vegetable cutter and therefore it is obvious that the product needs to have enough force to cut vegetables. For this assignment the product also needs to function mechanically and be operated manually. We also want that the user doesn't have to deliver an enormous force, but a comfortable force to cut the vegetables. Have a power transmission that makes the cutting as easy as possible. Safety is also very important requirement. The vegetable cutter should be able to cut the vegetables in a safe and easy way in order to fit the students who want to cook quick and healthy. You should not only be able to cut with this vegetable cutter, but also have space to storage your vegetables. Because you want to take the box with you as a lunchbox for example. Therefore the lunchbox should also be portable and we can accomplish this by giving the box a handle and not making the product too large and making the product as light as possible. Furthermore we will give the box an angular style look. The list of requirements is also based on the list of requirements from the project in the second module see the appendix: Report Module 2 Vegetable cutter.

LIST OF REQUIREMENTS:

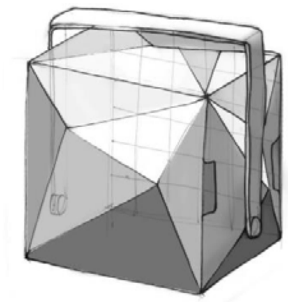
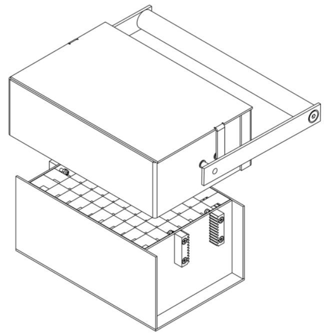
CONSTRAINTS

- Enough force to cut vegetables (like unions and carrots)
- User doesn't have to exert more than 300 N to cut vegetables
- Safety for the user when both cutting and washing
- Function mechanically
- Operated manually
- Space to storage the vegetables
- If we make a 180 degree movement with the handle, the top part must go down 32 mm
- Portable:
  - carry the product by the handle (like a suitcase)
  - Dimensions of closed box up to 150*60*200 mm

OBJECTIVES

- Power transmission that makes the cutting as easy as possible
- Angular style look
- Easy to clean
- Portable:
  - as light as possible

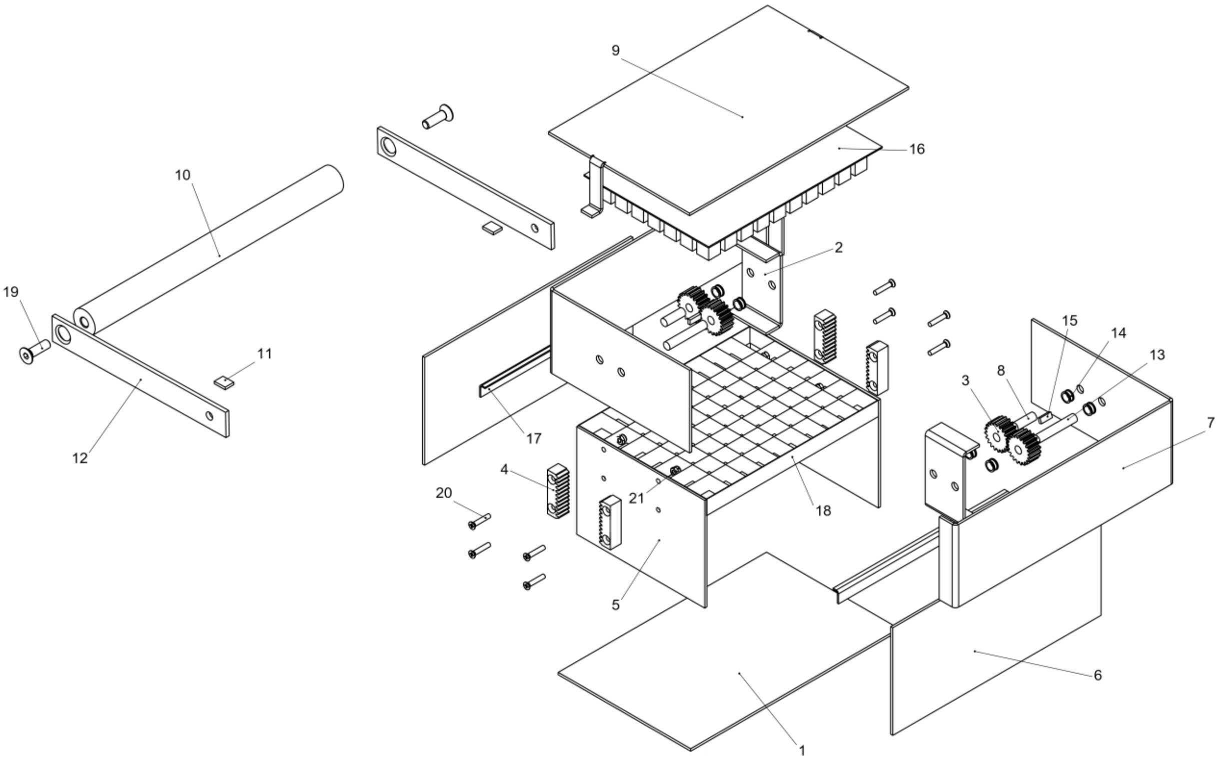
DESCRIPTION OF THE PROTOTYPE

Before	After
	

HOW TO USE THE BASCUT?

1. In the start position the outer box is in the highest position and the handle is precisely horizontal. You can open the top lid and put your vegetables in.
2. To cut the vegetables, you need to close the top lid and rotate the handle 180 degrees to the other side.
3. Now you want to open the top lid to get your vegetables, but that is not possible, because the top lid is locked (to prevent the customers from hurting themselves to the knives).
4. To get the sliced vegetables, you need to turn the Bascut 180 degrees. In that way the Bascut is now upside down.
5. Now you can open the bottom lid to get you vegetables.
6. Enjoy!

SOLIDWORKS MODEL 3D EXPLODED VIEW



Number	Name	Amount
1	bottom lid	1
2	C-part	2
3	gear	4
4	gear rack	4
5	part of inner box	2
6	part of inner box	2
7	part of outer box	2
8	(receiving) shaft	2
9	top lid	1
10	grip handle	1
11	(coolbox) locking system lips	2
12	Handle side	2
13	drive shaft	2
14	sleeve	8
15	key	2
16	raster	1
17	L-bracket	2
18	knives	1
19	tapered screw (M6)	2
20	tapered screw (M3)	8
21	locknut (M3)	8
--	C-rings	4
--	(make) keyhole	2
--	Angular forms handle	2
--	Angular forms top lid	1
--	Angular forms bottom lid	1
--	Angular lines outer box	1

MEASUREMENTS OF THE MAIN PARTS

For all the parts, see the appendix: Technical Drawings.

	length (mm)	height (mm)	width (mm)	used material
Inner box				Sheet metal
Outer box				
Top lid (without (coolbox) locking system lips)				
Bottom lid				
C-part				
Raster				
Knives				
L-bracket				
Grip handle				
Handle side				
Angular forms handle				
Angular forms top lid				
Angular forms bottom lid				

IMPROVING MECHANISM AND INSIDE DESIGN

We had to improve and make changes to the chosen concept from module 2, because it wasn't fully defined yet and we could make it handier and easier.

ORIGINAL IDEA

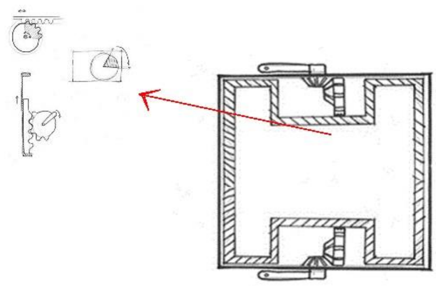


FIGURE 1, MECHANISM 1

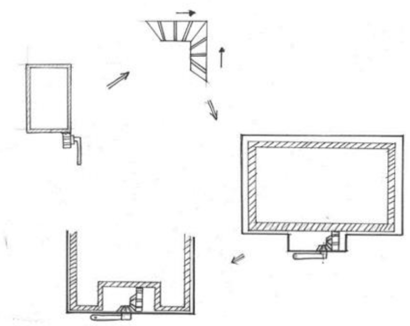


FIGURE 2, MECHANISM 2

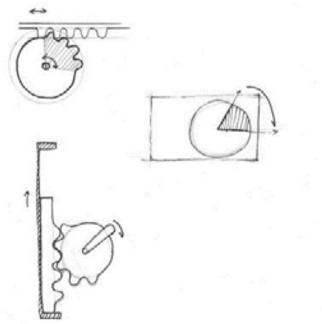


FIGURE 3, GEAR RACK

The original idea was a mechanism with 2 bevel gears with a spur gear attached to one bevel gear. In that way the spur gear can rotate over a gear rack.

FIGURE 4, BEVEL GEARS

FIGURE 5, SPUR GEAR ON GEAR RACK

Mechanism 1: In Figure 1 you can see that we used a bevel gear at the starting point, followed by another bevel gear and on that bevel gear, a spur gear is attached. This spur gears transmits the force onto the gear rack. This happens on both sides. Both sides need to be aligned with each other.

Mechanism 2: In Figure 2 you can see that only one side is used to move the box up and down with the gear racks. That is way more fragile than mechanism 1, because in this mechanism only one side is supported with a gear.

IMPROVED IDEA

We want to make the mechanism more sturdy. In the original idea there was only one gear on one gear rack that took all the forces on both sides. We want to have 2 gear racks on 2 sides of the box that take all the forces together. So in total 4 gear racks. See Figure 6, 4 gear racks and housing.

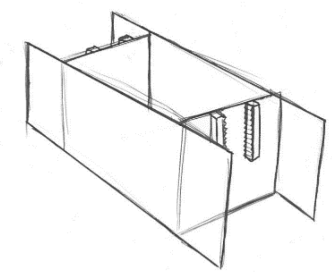


FIGURE 6, 4 GEAR RACKS AND HOUSING

Now we can think of the gear system we want to have in between these gear racks. We came up with 3 different types of mechanisms between these 2 gear racks.

DIFFERENT TYPES OF MECHANISMS

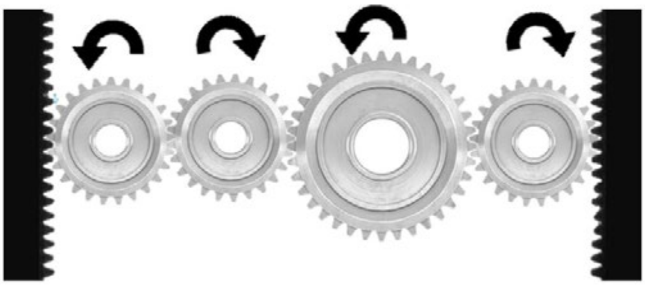


FIGURE 7, IDEA 1

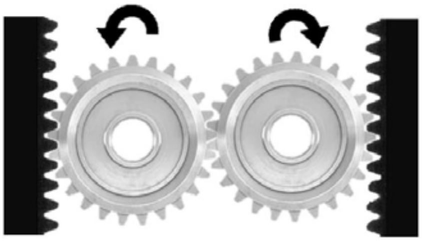


FIGURE 8, IDEA 2

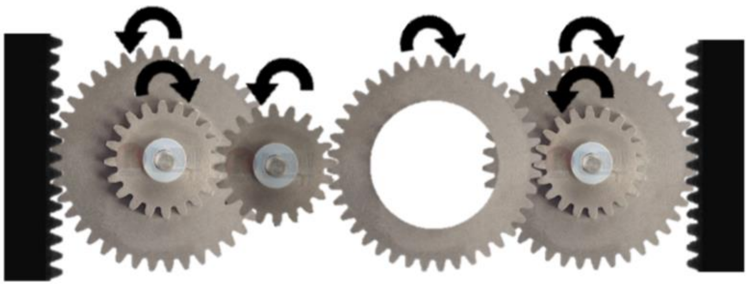


FIGURE 9, IDEA 3

On all the ideas there is a gear rack on both sides.

Figure 7, idea 1: The largest gear is where the transmission starts. This idea is very handy if you have a large space to bridge. But it is very important that the first two gears are the exact same size as the last gear. Otherwise the gears are not aligned and they don't rotate in the same speed.

Figure 8, idea 2: This is a very simple mechanism. If you have a small space for gears, this mechanism is perfect. Both gears need to be in exact the same size. Then they will stay good aligned and rotate at the same speed.

Figure 9, idea 3: The gear with the large hole inside is where the transmission starts. This idea is very handy if you want a increase in speed in the gears. With this mechanism the gears will rotate faster than the speed you give them. There is also a transmission ratio and therefore it takes less effort to cut vegetables. This is handy if you do not want to give a lot of force and you want a fast rotation. This mechanism is also quite big in depth if you look from the top.

CONCLUSION

For our project we need a feasible mechanism for a small space. We don't need gears that rotates faster than the force you give them, so our finial mechanism is idea 2 for our Bascut. We have this mechanism on 2 sides of the box.

FORCES WHILE CUTTING

vegetable	tomato	cucumber	celery	chinese cabbage	lettuce	onion	carrot
Force (kg)	1.3	1.2	3.4	4.3	3.7	5.3	3.4

TABLE 1, FORCES WHILE CUTTING WITH A SINGLE KNIVE

In Table 1 you can see that the onion takes the most forces while cutting it. This means that we take this force for our maximum value.

We now want to see how the forces are if we use a different type of knife pattern. We directly chose for the pattern we want to use for the actual prototype.

The pattern we use in our prototype is shown in Figure 10.

FIGURE 10, KNIVES AND RASTER

To cut a large onion, it took around 25 kilograms (about 250 N). We tested it several times. To insure that the gears won't break while cutting a small onion and some other vegetables, we decided that we calculate with the maximum force that the gears need to take is 30 kilograms (about 300 N).

Gear System calculations

So on both sides of the box we have the following system:

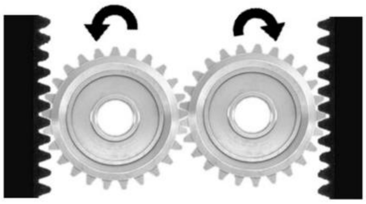


FIGURE 11, MECHANISM ON BOTH SIDES

We measured the force it takes to press an union through the 1cm*1cm knives mesh: 250 N
Suppose you cut a little union and some other vegetables, so we calculate with 300 Newton.
Upper part volume (200 * 60 * 4 + 130* 60 * 2 + 200 * 130) * 2 = 179200 mm^3 = 179,2 cm^3
Density stainless steel 7,7 g/cm^3
Weight upper part = 179,2*7,7 = 1380 g ≈ 1,4 kg
Force on gears from upper part ≈ 14 N
Total max tangential force on gears = W_t = 300 N + 14 N = 314 N
We have 2 gears on each side so the tangential force on gears = W_t = 314N/2= 157 Newton

Our gears have:
Teeth = z = 20
modulus = m = 1
D = pitch diameter = z*m = 20 mm
Radius = 10 mm

Length calculation

Tangential force $W_t = (2*T)/D \rightarrow$ Torque $T = (W_t*D)/2 = (157*0{,}02)/2 \approx 1{,}57$ Nm
So a Torque of 1,57 Nm is required to cut an union and some vegetables.

It is still comfortable to press with a force of 30 Newton (feels like lifting up 3 kg).
Now we can calculate the minimum length of the handle. We have the following system at 2 sides see Figure 12, free body diagram, so each side gets 15 Newton.

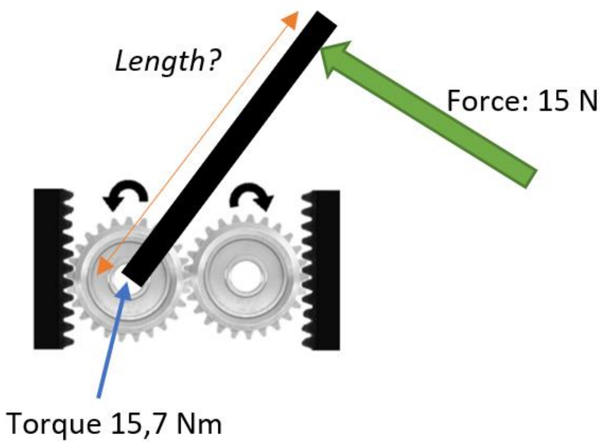


FIGURE 12, FREE BODY DIAGRAM

Length * Force = Max Torque on gears
So the Length of our handle needs to be at least:
Max Torque on gears / Pressing force = 1,57 Nm /15 N ≈ 0,10 m ≈ 10 cm

Therefore we made the handle in our Prototype larger namely 16 cm, this length is sufficient.

The center distance between the holes where the handle is attached is 13,5 cm.
The maximum Force we need to exert on the handle in this case is:
1,57 / 0,135 = 11,6 Newton on each side, so exert a force of approximately 23 Newton on the handle.

Safety factor Calculation

In order to know whether the teeth will break when there is an tangential force of 157 Newton, we have to calculate the bending stress safety factor.
F_t = 157 N
Our gears are from Plastic so $\sigma_{f\,lim}$ = 28 N/mm^2
Gear width b = 10 mm
$Y_{Fa\,(Delrin)}$ = 2,9 (read from table DIN3990)
K_A = 1,0 (uniform load)
Maximum force the teeth can resist is;
Bending stress = σ = (F_t*Y_{FA}) / (b*m) = (157*2,9)/(10*1,0) = 45,53 N/mm
So our Bending stress Safety factor S_f = 2* σ_{flim} / σ * K_A = 2*28 / 45,53*1,0 = 1,23
This is not a very large Safety factor but it is sufficient. However, First our plan was to have gears from stainless steel.
In that case $\sigma_{flim\,(C45N)}$ = 210 N/mm^2
The safety factor would have been: S_f = 2* σ_{flim} / σ * K_A = 2*210 / 45,53*1,0 = 9,23
Which will never cause problems, but is quite a large margin.

Distance upper part goes down when rotating the handle 180 degrees

A constraint for the prototype was that the upper part, and therefore the gears, goes down 3,2 cm when we rotate the handle 180 degrees.
We have gears with 20 teeth and modules 1.
Modules 1 means that the distance between each teeth is Pi ≈ 3,14 mm.
If we rotate the handle this means that the gears roll 10 teeth over the gear racks and therefore the upper part goes 3,14 mm *10 = 31,4 mm = 3,14 cm down. So this is correct.

Choosing the colors

We want the colors to look fresh, because you're going to eat out of the Bascut. Therefore we choose to make the box a certain green. We drew a few color combinations to see which one works best and looked best on the box.

Ideas

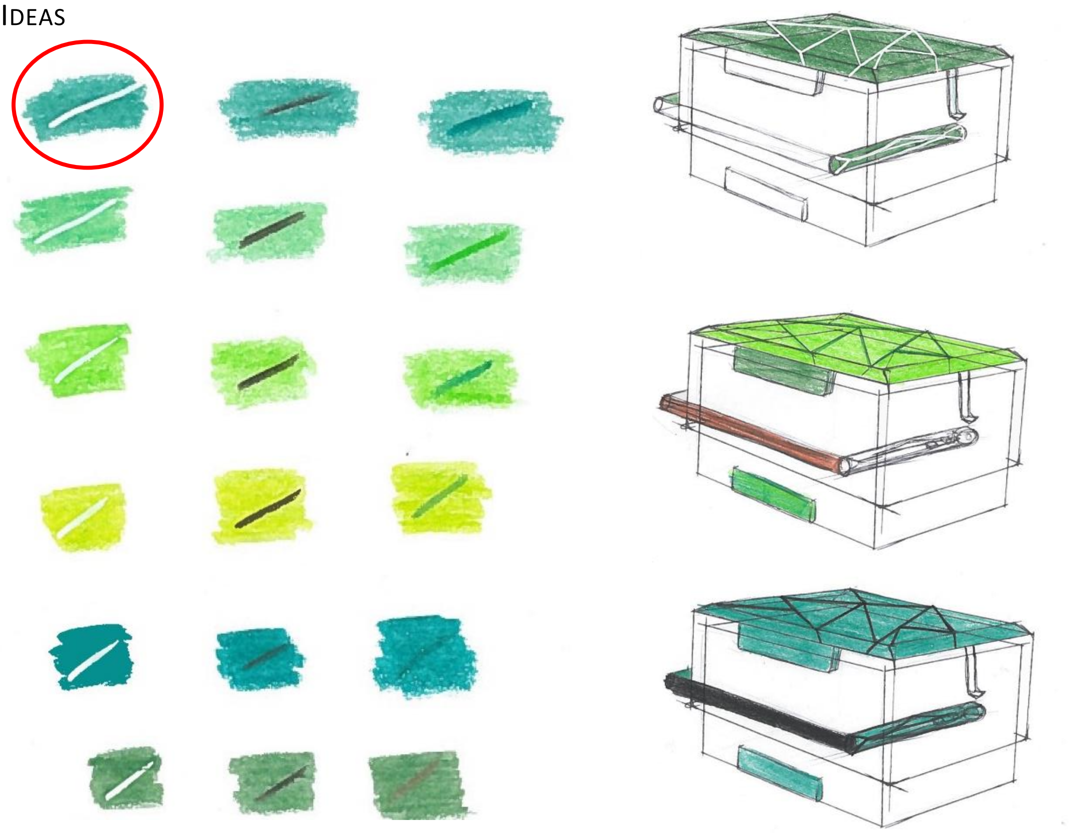


FIGURE 13, TESTING COLOR COMBINATIONS

In the end we choose this darker green with white stripes see Figure 14 and the box itself white with the darker green stripes. We choose this color because we thought it looked most fresh and outstanding.

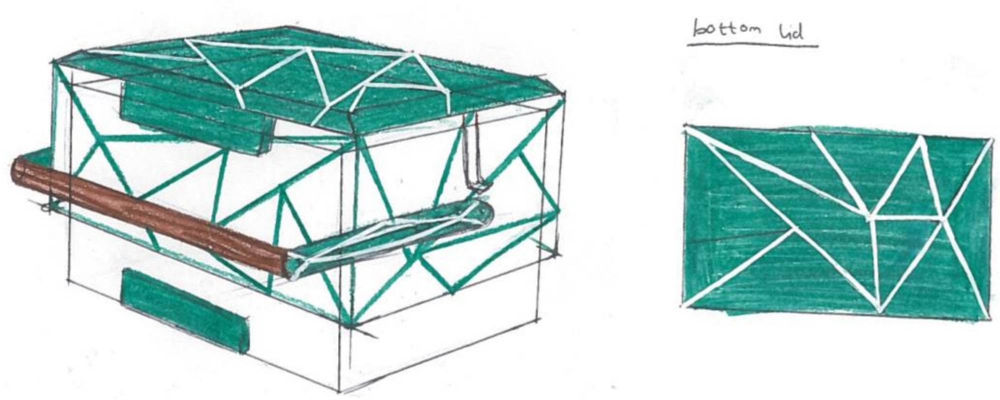
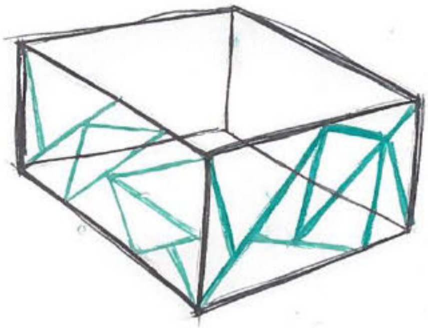


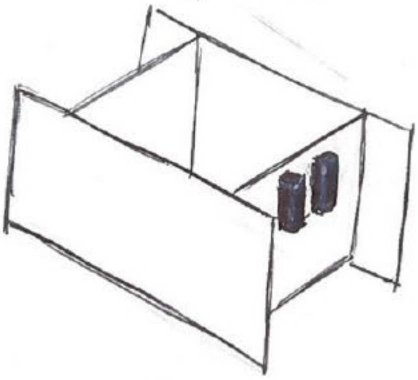
FIGURE 14, FINAL COLOR COMBINATION

PLAN OF ACTION FOR PAINTING



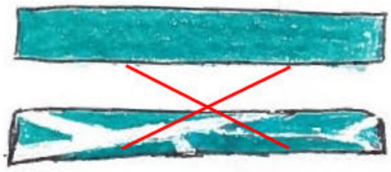
white spray paint for the hole outer box

green acrylic paint for the lines



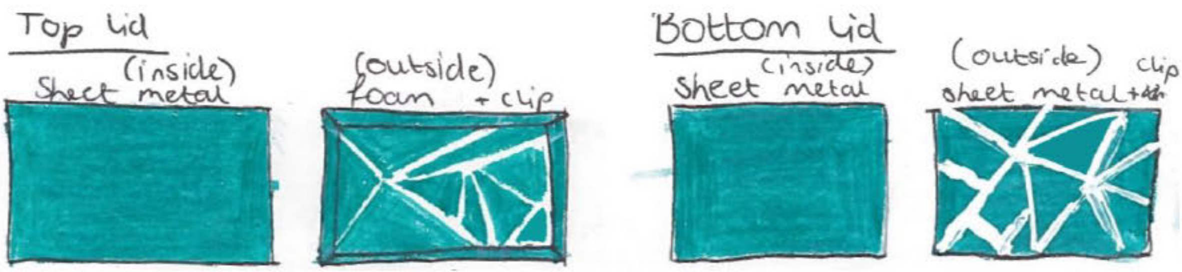
- white spray paint for the hole inner box

- white spray paint (when already assembled to the outer box)



- green acrylic paint for the in- and outside of the handle side

Our initial idea was to draw white lines on the outside of the handle side, but later we decided to keep the outer part of the handle green as well, to emphasize that the handles are angular thickness and that the other parts are angular by engraving.

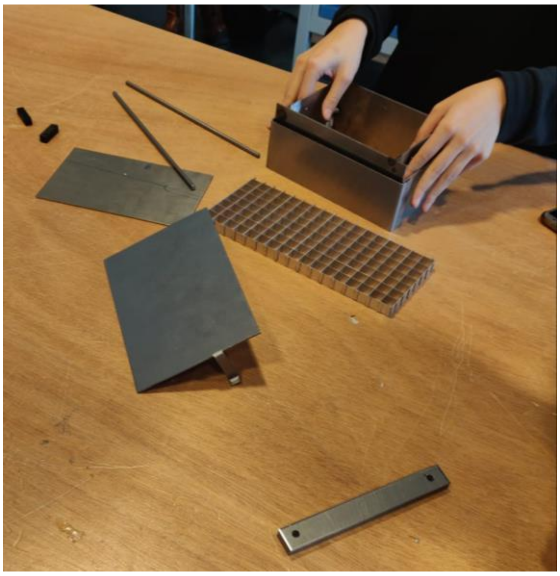


WORKSHOP IN PROGRESS

WORKSHOP SESSION 1

In the first workshop session the following things have been accomplished

- The inner box have been finished
- The C-parts are not finished yet, but work on it has been done
- The outer box is ready, but not spot welded yet, but work on it has been done
- The upper and under lid are finished
- The handles are not done yet, but work on it has been done



WORKSHOP SESSION 2

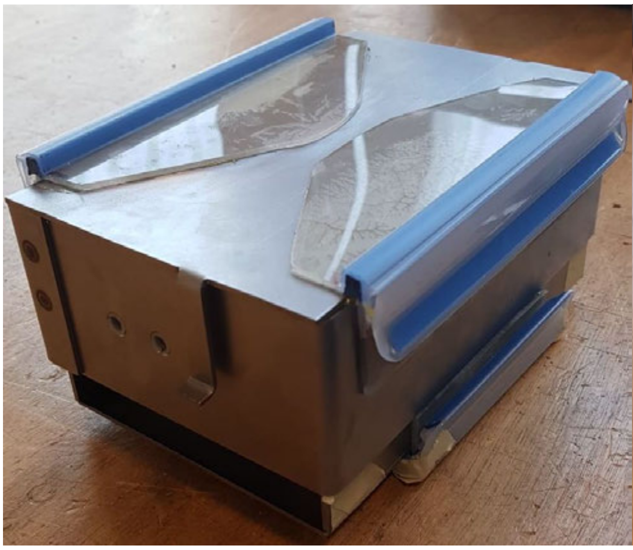
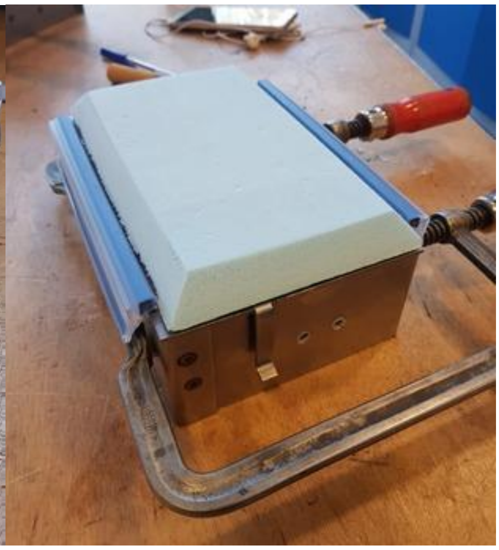
In the second workshop session the following things have been accomplished

- The C-parts have been finished
- The handles are not finished yet, but work on it has been done
- The outer box has been finished
- The shafts are not finished yet, but work on it has been done
- The knives are finished

WORKSHOP SESSION 3

In the third workshop session the following things have been accomplished

- The gear rack have not been finished yet, but work on it has been done
- The box closing mechanism has not been finished yet, but work on it has been done
- The shaft has not been finished yet, , but work on it has been done
- The L- brackets are finished
- The angular forms are not finished yet, but work on it has been done

Workshop session 4

In the fourth workshop session the following things have been accomplished

- The box closing mechanism have been finished
- The angular forms have been finished
- The shaft has been finished
- The gear rack has been finished
- The key has been finished
- The knifes got glued on the L-brackets
- The closing mechanism has been glued on the box

After the 4 workshops we finished all parts. We only had to assemble the whole box and finish the painting. Although there were a few setbacks..

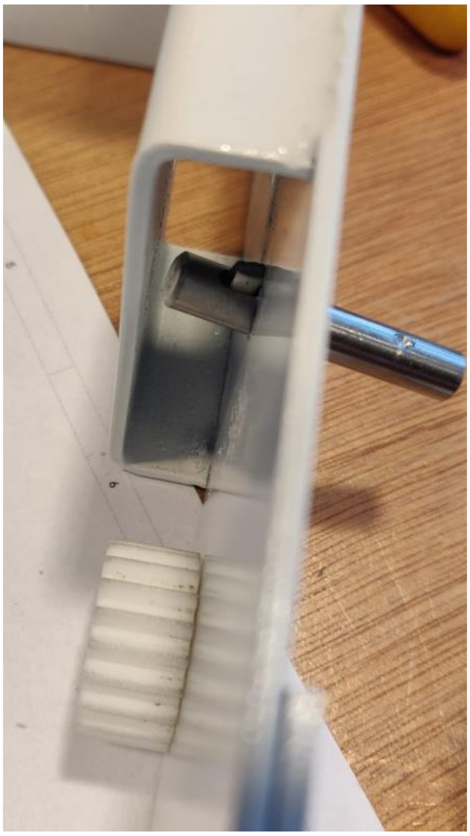
REFLECTION WORKSHOP SESSIONS

We had quite some setbacks in making our prototype: In lesson 2 of the workshop we already needed the gears, but we also had a plan B for the workshop. Before lesson 3 of the workshop we got a mail that the gears and gear rack were arrived. We found out that we only received one gear instead of 4 gears. We directly contacted Tom Vaneker to find a solution.

We couldn't order any other gears because the one we needed was out of stock till June and the other gears were too thick.

It was possible to print them in 3D, so we modeled the gears we needed in Solidworks and sent the file to Tom Vaneker.

On the half of lesson 4 of the workshop we got the gears. We then found out that the holes in the middle were to small (it was modeled right in Solidworks), so we needed to adjust this.



Because of all this extra work we had during the workshops, we had kind of a delay. In a rush some member of our group decided to already weld the C-parts to the outer box, as a result, we cannot put the gears on the shaft because of the keys. (see picture)

Then we had an idea to cut the parts off again and weld it when al the gears are assembled. But that wasn't possible.

Because of the fact that the gears would melt, caused by the heat generated by the welding process, we already needed to weld the C-part to the outer box. (This solution would be possible if we had the gears from Maedler)

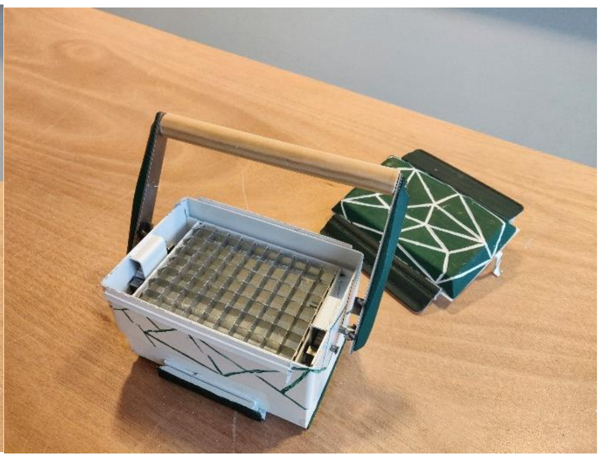
Our two solutions:

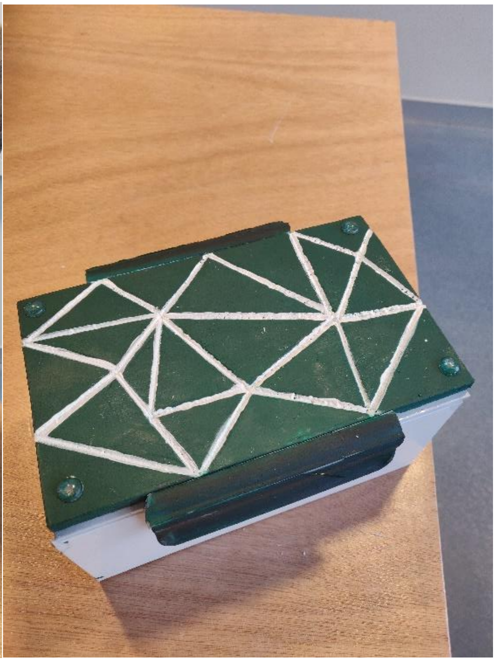
1) to make the keyseat longer till the end on the shaft and already put the key in the gear. Then put the gear between the C-part and the outer box and slide the shaft through the hole.
2) To make a little hole on top of the hole in the outer box. The key can already be attached to the shaft. Then you can put the gear in place and put the shaft with the key through the gear

We wanted the most fast solution to solve our problem, so we chose option 2. We drilled a little hole on top of the hole in the outer box, so the key with fit through it.

Eventually after a lot of work we got all the gears in place and the prototype worked!


END RESULT



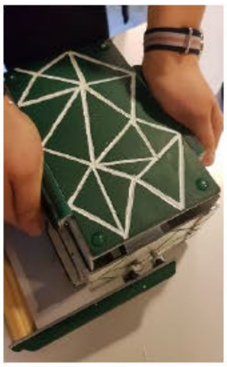
TESTING THE PROTOTYPE

TEST 1 CUTTING


Starting position


Rotating the handle


Handle rotated 180 degress → the top lid is locked


Total box is rotated 180 degrees


Result

DISCUSSION

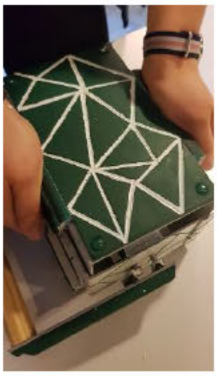
Our first test was with a little piece of cucumber. It was very easy to rotate the handle. It did not take a lot of force.

TEST 2 CUTTING


Starting position


Rotating the handle


Handle rotated 180 degress → the top lid is locked


Total box is rotated 180 degrees


Result

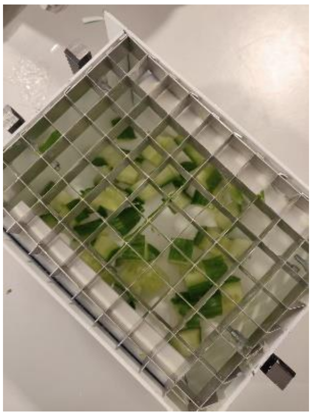
DISCUSSION

We already cut the cucumber in half because there is not enough height to put a whole cucumber in it. To rotate the handle took quite some force and you have to support the box from lifting it up when the handle goes up. But the result was very nice. The cumcumber was cut in even parts and it was not crushed.

If we would turn the cumcumber on the back, than it would take less force, because then the area that needs to be cut, starts smaller and increases quite evenly. So the input force is way lower than when the cumcumber is positioned like test 2.

Another aspect is that the knives in our aren't really sharp. They are less sharper than real knives. If we could make them sharper, than the input force is way lower. This is the main reason why it took quite some force.

This is the top view of the Bascut when the cumcumber is cut. The user normally cannot see this situation because the top lid is locked when the knives are on top.



TEST 3 CLEANING

We saw that, while cleaning, not all the cumcumber pieces came off. That is mainly because the knives are not that sharp and not smooth. That is why the cumcumber would not come off that easy.

REDESIGN FOR THE MASS PRODUCT

Demands: The product has to be designed that 100.000 products can be manufactured at a competitive price.

LIST OF REQUIREMENTS:

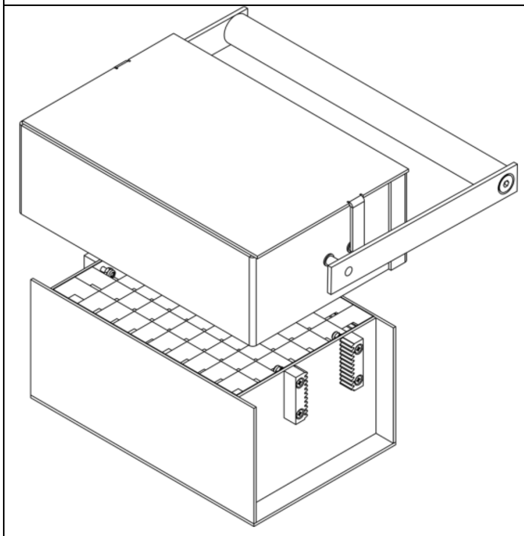
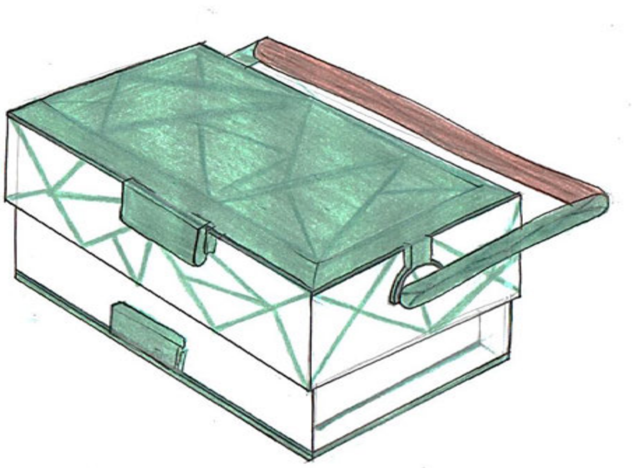
CONSTRAINTS

- Enough force to cut vegetables (like unions and carrots)
- User doesn't have to exert more than 300 Newtons to cut vegetables
- Safety for the user when both cutting and washing
- Knives squared mesh to cut vegetables in squares
- Material water and acid resistant
- Space to storage vegetables (for 2 times cutting)
- Function mechanically
- Operated manually
- Angular style look
- Portable:
    - Dimensions of closed box up to 150*60*200 mm
    - Weight less than 2 kg
    - Carry the product by the handle (like a suitcase)

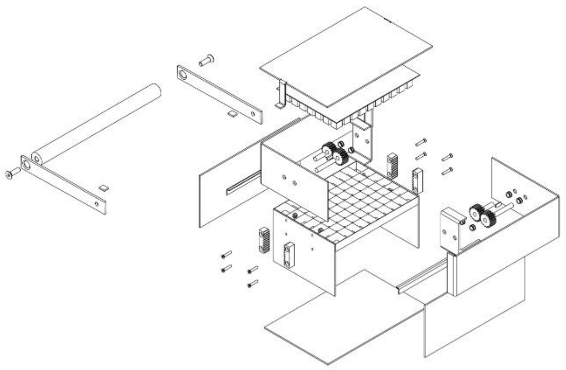
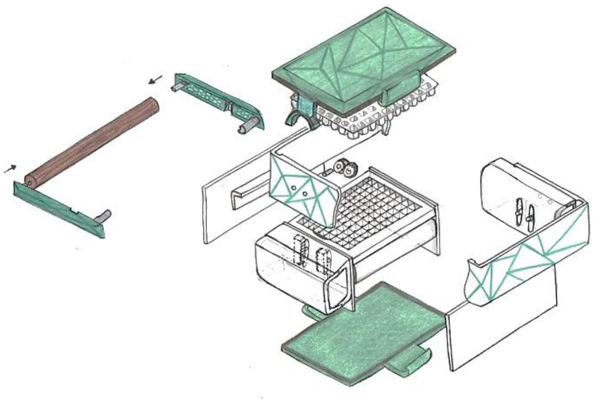
OBJECTIVES

- Power transmission that makes the cutting as easy as possible
- Easy to clean
- Best portability as possible
    - Weight less than 1 kg
- Can be used quickly
- Make the product as aesthetic pleasing as possible

Isometric view

Before	After
	

Exploded view

Before	After
	

Number of Components

The Components of the mass product are separated into **three categories**, namely the main components, the sub-components and the basic components. At the production facility, colour codes would also be provided to these three component categories to prevent confusion and improve the different usage and roles the components categories play.

MAIN COMPONENTS are components that mainly make up the product and resemble it, these components are also large in size in comparison to the basic and sub components. Examples of main components are the outer and inner box.

Colour Code: Red

Main Components

- 1x Inner Box
- 1x Outer Box
- 1x Top Lid, clips and cool box mechanism lock (With 3D Angular Forms)
- 1x Bottom Lid with clips
- 1x Grip of the Handle
- 2x Handle sides with shaft
- 1x Knives without outer lining

Total Number of Main Components: **8**

SUB-COMPONENTS are part of the main-component, but due to limitations in the processing method, they would be made separately to the main component and be connected to the main components afterwards. They would be attached often using means like ultrasonic welding. Examples of such components are like the raster, which would be ultrasonic welded to the top lid, and C-parts which would be ultrasonic welded to the outer box.

Colour Code: Green

- Sub Components
- 4x Clip Locks
- 2x L-brackets (Locking system for knives)
- 1x Outer lining of knives
- 2x C-Parts
- 1x Raster

Total Number of Sub Components: 10

BASIC COMPONENTS are small but important components that make up the product. These components would often not be seen at first sight, but play an important role in joining and holding the product together, as well as allowing the mechanism to work. Examples of basic components are gears, screws, fasteners, bolts and nuts. Basic components would be ordered in bulk from suppliers, and would always be in abundance in the production facility.

Colour Code: Blue

Basic Components

- 4x Shaft (4 of these would be connected with the handle)
- 4x Gear Rack
- 2x Spur Gears with key
- 2x Spur Gears without key

Total Number of Basic Components: 12

Total Number of Components

In total our mass product would have 30 components. This is equivalent to a Level 2 for a model building set from Revell. (This level is for novice hobby-kit modelers)

Total Number of Components: 30

This is a significant reduction of the amount of components required to produce the product in comparison to the prototype which had up to 65 components. The reduction of components in the mass product has been made to simplify the process of making the product itself, making it easier to produce the product itself. This would in the end save us time as well as money in the long term, as more components would directly result in us having to buy more different equipment and or suppliers for us to obtain the components.

Processes Used for the mass product

Production Stages

Stage 0: Pre-shaping
Stage 1: Shaping
Stage 2: Machining
Stage 3: Joining
Stage 4: Surface Treatment

Post-Production Stages

Stage 5: Functionality and Safety Testing
Stage 6: Packaging

Production stages mainly focus on turning the material the product is made out of into the product itself. However not to the point that it is ready to be shipped off to the stores, that is the primary focus of post-production stages.

Stage 0: Pre-shaping

Level of Automation: High

This stage would be done prior to stage 1, where punching would be used to produce the knives. Doing so the knives would be ready at the moment stage 1 begins, and could directly have their outerlinings injection moulded.

Processes in this stage:

- punching

Punching

Punching would be used to create the knives. We would create the knives instead of buying them as the knives we need require a specific geometry in order for them to fit inside the box. The knives would be created from a sharp piece of sheet metal, this would make the knives sharp immediately after punching. Once punching is finished the knives would go to an injection moulding machine where the outer linings of the knives with the magnets would be installed.

Geometric Specifications:

- Thickness of Sheet Metal: 0.3 mm
- Size of punch: 10 mm x 10 mm

Technical Specifications:

- Supply: 5000 tons/ month
- Thickness range: 0.8 - 2.1 mm
- Output power: 15 kW

Components made using this production method:

- Knives (without outerlining)

Stage 1: Shaping

Level of Automation: High

Stage one focuses on shaping processes like injection moulding and extrusion. All components except for the ones bought from stock would go through this stage. Three processes would be used to produce our components, which are extrusion, injection moulding, and vacuum forming. In general extrusion, injection moulding, and vacuum forming are used in favor of other production methods, as they allow us to produce the components in a short amount of time, with low energy, and inexpensively.

Extrusion

Components that have constant cross sectional areas and require straight walls like the inner and outer boxes would be extruded, and then cut once extruded to the right dimensions. Since this process only requires the for the material to be extruded and then cut, it is a relatively simple and easy process, it also requires minimal time and effort. Due to its simplicity tooling costs would be low for this process. Extrusion would be used for components with constant cross sectional area. Therefore components like the inner and outer box would use this process. A mandrel would also be used for the extrusion of the main components since they are hollow from the inside. For the sub components this is not required, as they are not hollow from the inside. Due to us using plastics for the extrusion method, a sealed bath of water is carefully acted upon by a carefully controlled vacuum to prevent the component from melting and collapsing.

Geometric Specifications:

- Geometry of mould for extrusion is based on the component that would be extruded, in general extruded components have constant cross sectional area, with no sharp corners, and are often symmetrical in shape.

Technical Specifications:

- Output Power: 315 kW
- Screw diameter: 120 mm
- L/D Ratio: 38:1
- Output rate: 1300 Kg/h

NOTE: Values for the Technical Specifications are taken from: KPM 120/38p

Components made using this production method

Main Components

- Grip of the Handle
- Inner Box
- Outer Box

Sub Components

- Clip Locks (to attach to box)

Injection Moulding

Components with non-constant cross sectional areas and have a more complex geometry would be injection moulded. Injection moulding is used as it is relatively fast, allowing us to make the components in high volumes in a short amount of time. Through this stage some components are also joined, like the handles sides with the shafts, which allows the shafts to fit more tightly to the handle sides resulting in more effective force transmissions and prevents them from slipping. Some components also undergo two stages of injection moulding like the top and bottom lids, where the component is injection moulded first with ABS plastic, forming the component, and then Silicone is injection moulded in the second stage for the sealing. Components made with this method would have injector markers from the injector pins.

GEOMETRIC SPECIFICATIONS:

- Draft angle: 0.5-1 degree (components larger than 50mm would use a draft angle larger than/equal to 1).
- No-constant cross section
- Wall thickness must be equal or larger than 1 mm.

TECHNICAL SPECIFICATIONS:

- Output Power: 26 kW
- Power demand for machine: medium
- Flow rate: high

COMPONENTS MADE USING THIS PRODUCTION METHOD:

<u>Main Components</u>

- Handle sides, would be injection moulded with the angular forms around the shaft
- Top Lid, 2k Injection Moulding (first to create the bottom lid, than to inject the silicone to the sides of the lid, silicone would be added to make the lid water locked)
- Bottom Lid, 2k Injection Moulding (first to create the bottom lid, than to inject the silicone to the sides of the lid, silicone would be added to make the lid water locked)

<u>Sub Components</u>

- Outer lining of knives (injection moulded around the knives)
- L-brackets (Knife locking system)
- C-Parts

VACUUM FORMING

Vacuum forming would also be used for the raster as that has a similar geometry like plastic boxes, and therefore can be made using that method. The reason why we would use vacuum forming instead of injection moulding for this component is because for injection moulding the wall thickness must be smaller than 3 mm. This would not be the case for the raster, where the boxes have a thickness of 4 - 5 mm.

GEOMETRIC SPECIFICATIONS

- Box shaped, with minimum draft angle of 3 degrees.
- Shrinkage rate: 0.3 - 0.8 %
- Wall thickness and cooling time
    - 1 mm → 40 seconds
    - 1.5 mm → 60 seconds
    - 2 mm → 80 seconds
    - 3 mm → 120 seconds
    - 4 mm → 160 seconds

TECHNICAL SPECIFICATIONS

- Since ABS is hygroscopic it must be pre-dried at 80 degrees Celsius before vacuum formed, 1 hour per 1 mm thickness.
- Output power: 22.25 kW/sqm
- Preparation time before operations can begin: 10 - 15 minutes
- Glass transition temperature: 88 -120 degrees Celsius
- Mould temperature: 82 degrees temperature
- Forming temperature: 150 - 180 degrees Celsius
- Drying temperature: 80 degrees Celsius

NOTE: For values for the Technical Specifications see Appendix

Components made using this production method

Sub Components

- Raster

Stage 2: Surface Treatment

Level of Automation: High

Stage two focuses on surface treatment processes like attaching the sticker of the angular forms to the outer box. Unlike the top and bottom lid where the angular forms are made directly with the injection moulding, another method should be used to create the angular forms on the outer box as the outer box would be extruded. Therefore the method used for adding the angular forms to the outer box is through adding a sticker to the surface and then attaching it using ultrasonic welding. Since the sticker is made out of another material then the surface of the outer box, a melt film is used to attach both parts. More on this would be described in the full description of ultrasonic welding in stage 3.

Processes in this stage:

- Ultrasonic Welding
- Components to be welded:
- Angular forms sticker to outer box.

Stage 3: Machining

Level of Automation: High

Human worker would drill the holes. Automation would also make this process very fast.

Ultrasonic welding

Ultrasonic welding would be the main method we would use for connecting components in our product. Components that would be connected using this method are the subcomponents to main components, as well as connecting some basic components like the gear racks to the outside of the inner box. The reason why we choose ultrasonic welding as our main method for creating connection is because it is safer, cost efficient and faster than other welding methods and fastener types.

It is safer because ultrasonic welding does not require any use of flammable gases or noxious solvents like in conventional welding and soldering. Instead it would use high frequency sounds, which could damage the ear of a worker when exposed directly, but could be avoided by using safety equipment or when placed in a safety box. Ultrasonic welding is more cost efficient than most connection methods, as it requires much less energy to reach the necessary weld temperatures than conventional welding. Lastly, ultrasonic welding is much faster than other connection methods like conventional welding and glue as the cool time for the ultrasonic welding only takes a split second, while glueing can take about more than a minute to cool and harden.

Aside from those three factors ultrasonic welding is very suitable for the materials that require the connections, which are ABS (for most components) and Delrin (for Gear Racks), as both materials are thermoplastics. Thermoplastics are suitable for ultrasonic welding due to their low levels of crystallinity, as crystal structures would absorb the vibrations, making it harder to weld, as the vibrations are required to heat the plastic and make the weld. Although ultrasonic welding can be seen as a 'holy grail' for connecting components,

Geometrical Specifications

- Weld height: 0.2 - 1.0 mm
- Weld depth: < 1.0 mm
- Weld size: 0.4 - 2.0 mm

Joint types used:

- Butt Joint

Butt joints are the only type of joints we would use for connecting the components with ultrasonic welding. The main feature of this mould is a 60 to 90 degree triangular shaped ridge moulded into one of the mating surfaces. This ridge plays an important part for the weld to happen, as it would be the plastic that would melted and flow throughout the joint area bonding the parts together. This ridge would be located at the centre of the mating surface, as this allows the plastic to flow easier to all parts of the surface from the melted ridge. The ridges would be placed on the sub-components like the c-parts or clip locks, as this would be easier to manufacture, considering that the components these sub components should stick on like the inner box are extruded, making it hard to put ridges everywhere. For the Gear Rack since it is made out of a different material than the outer box a film melt would be put between the two surfaces. The machine would then weld this film melt with two stages having two different forces, allowing the film to melt and the materials to stick to one another. Then a third stage the weld is finished with a slightly higher force to harden the connection.

Technical Specifications

- Input Power: 3 kW
- Output frequency: 20 kHz
- Max Force: 3000 N
- Max Amplitude: 100%
- Stroke length 100 mm

Components to be welded

- C-Parts to Outerbox (ABS with ABS)
- Clip Locks to Outerbox (ABS with ABS)
- Raster to Top Lid (ABS with ABS)
- L-brackets (Knife locking system to inner box (ABS with ABS)
- Gear Rack to Inner Box (Delrin with ABS)

NOTE: Values for the Technical Specifications are taken from the USP 3000-3000 ultrasonic welding machine see appendix

Drilling

Drilling would be used for creating the holes for the shafts to be placed in from the handle. Drilling would be done using a specific plastic drill which would use a spur point bit. Drilling at low speeds of 100-300 rpm it would prevent the plastic from forming any crack or deform from heating caused by the drilling. Drill speeds would be at a lowest when exiting the material, as this is when it could most likely break the material when at high speeds. Drilled components would be clamped to ensure a steady drill, and drills would be lubricated to dissipate the heat and to efficiently remove debris .

Geometrical Specifications

- Hole size: M6
- Shaft Size: 6mm diameter
- Drill size depth M6

Technical Specifications

- Drill Speed: 250 rpm
- Output Power: 600-800 W

NOTE: For Values for the Technical Specifications see appendix

Components to be drilled

- Outerbox (drill holes for the shaft)

Stage 4: Assembly

Level of Automation: High

Stage four focuses on the assembly of the entire product. At this stage all components would have to be complete, with the only thing being left to do is to assemble the Bascut. Since all components are done at this stage to an extent that nothing else needs to be attached, the assembly of the box could be seen as how an IKEA product would be assembled but without the requirement of any screws or fasteners. Robotic assembly would be used for assembling the entire product, as this would be faster and more accurate then human assembly, and in the long term be more cost efficient. The robotic assembly would be done with 4 6D robotic arms, where 1 robotic arm holds the component, while the other three insert and assemble the other components into that component. For example, one robot arm holds the inner box, while the other places the knives into it. Another example would be assembling the mechanism, where one robot arm would hold the outer box, another would hold the gear, and another would insert the handle side with the shaft into the outer box through the gear, assembling the mechanism.

Processes in stage

- Robotic Assembly
- Using 4x 6D robotic arms.

Post-production stages are concerned with the final touches the product would undergo before it is shipped off to the stores.

Stage 5: Functionality and Safety Testing

Level of Automation: Medium

Since product functionality and safety are of our primary concern, both factors would be checked thoroughly for the entire product to see if everything works and is safe to use. Through this stage we can see if there are any defects products, and separate them before the products are packaged and sent off to the stores. In this stage human workers are required for the checking of each component, they would do this with mechanical aid. The human workers task is to see if all data recorded by the testing equipment matches the required specifications.

Stage 6: Packaging

Level of Automation: Low-Medium

Once finished products have passed the testing stage they would be packaged, and sent of to the stores. Packaging would consist out of a box to house the entire product and soft materials like styrofoam (not preferable though since it isn't eco-friendly) to cover and protect fragile components like the mechanisms. Soft material is also used to prevent the product to receive any scratches or break when being shipped to the stores. Human labour would also be used for the shipping and transferring of completed products.

Note: A flow chart on when each process would take place is in the appendix, see: Flow Chart of mass production stages. This includes everything up to stage 4, since the main focus is emphasized on the production staged of the product.

Redesign

Introduction

Since the mass product is often a more simplified and improved version of the prototype, as well as that very different manufacturing methods would be required to produce it, a redesign of the entire product is required to meet these new requirements. Below is a list of the components that are redesigned, supported with justifications afterwards.

Redesigned Components

1. Gears
2. Gear Rack
3. The Boxes
4. Inner Box
5. Outer Box
6. Grip of the Handle and Handle sides
7. Top Lid
8. Bottom Lid
9. Cool Box Lock Mechanism
10. Knives
11. L-Brackets (Knife locking system)
12. Raster
13. C-Parts
14. Locking Clips

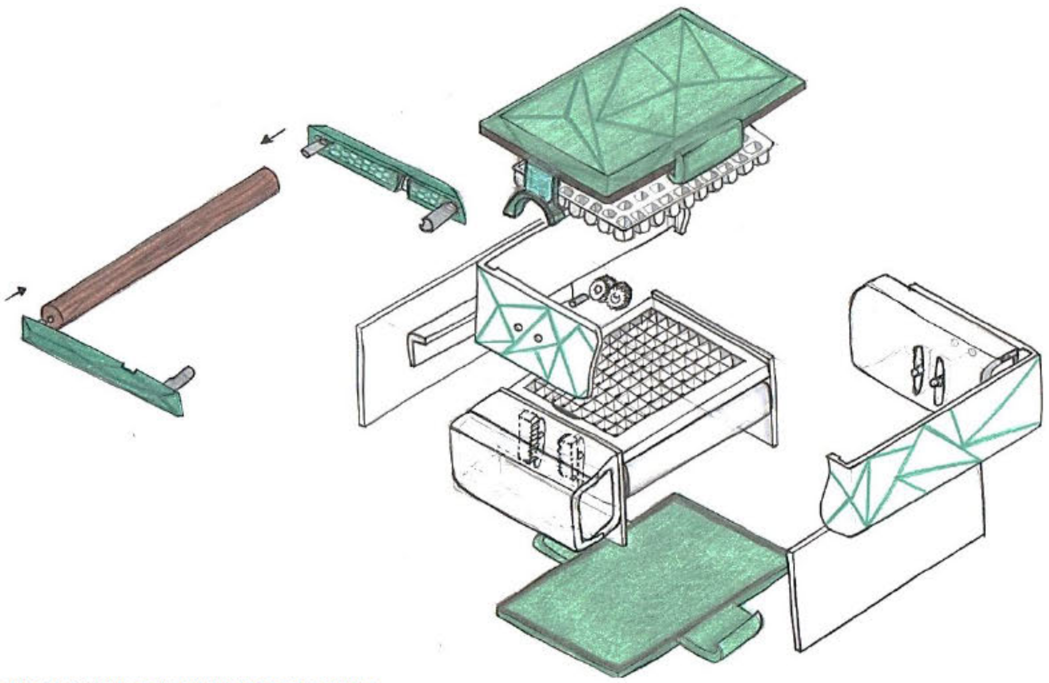


FIGURE 15, EXPLODED VIEW MASS PRODUCT

1. Redesign for the Gears

Unlike the prototype, where all the gears had a keyhole, only two would have them in the mass product, and instead of the key being in the shaft they would be in the gear itself. Before discussing the re-design, keys and keyholes were used so that force from the rotating shaft could be transferred to the gear through a key in the shaft. Since there were two rotating shafts in the prototype, both shafts had keys, and therefore both gears required a keyhole. This isn't the case anymore for the redesigned gear system, where there would only be one rotating shaft, which is the shaft connected to the handle, this can be seen in (figure RD.1). Since this shaft would be the one that is required to transfer the tangential force created by the movement from the handle to the gear, it has a small hole milled out hole, and therefore the gear would also have a key. On the other hand, the other gear would not require a key, as it is connected to a non-moving fixed shaft, which is injection moulded along with the C-part (more on this at the Redesign for C-part). Since the shaft isn't moving no forces are required to be transferred, and therefore no key is required for this gear. The gear would rotate due to the tangential force exerted on it by the other gear with the key.

For the mass product, since the gear is a basic component, it would be bought instead of being made. The gears that would be bought per product would be 2 gears with a key, and two gears without a key.

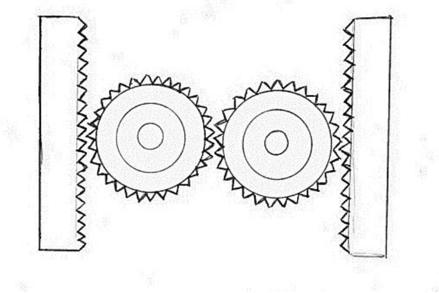


FIGURE 16, SIDE VIEW GEAR SYSTEM BEFORE REDESIGN

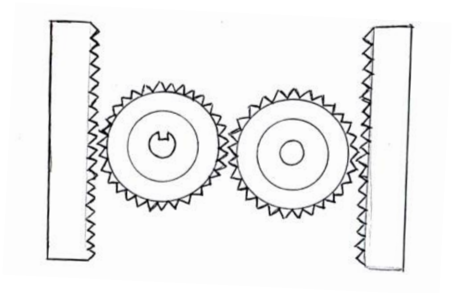


FIGURE 17, SIDE VIEW GEAR SYSTEM AFTER REDESIGN

2. Redesign for the Gear Rack

Like the gears, we would prefer to by the gear racks instead of making them ourselves, as gear racks production is outside our field of expertise.

For the redesign of the mass product, we would use Delrin gears instead of regular steel gears as in the prototype. As mentioned before these Delrin gears would be bought, and not produced. The reason why we changed the material of the gears is because Delrin itself is still strong having a safety factor of 3, allowing it to handle quite some stress before it breaks. Delrin itself is also lighter than steel, adding less weight to the product. Although steel is stronger than Delrin, having a safety factor of 9, this safety factor is much too high, resulting in overall re-design of the products mechanism. Steel itself is heavy, and more expensive to acquire, not that we want to produce stuff the cheapest way, but that we try to avoid over-designing our products and making them too heavy.

Also unlike the prototype where the gear racks were fastened to the inner box with screws, nuts, and bolts, the mass product makes use of ultrasonic welding. Although the gear rack which is made out of Delrin isn't made out of the same material as the inner box which is made out of ABS. Both could still be ultrasonic welded with the use of melt film that acts as a third party material combining both the Delrin and ABS to stick to one another.

If we would by chance produce the gear rack by our own means, we would have done it through injection moulding. Due to gear racks requiring straight outer walls and teeth, the draft angle would be placed on the inside, and be a have a minimum draft angle of 0.5. This is similar method used in the production of LEGO bricks. Due to the draft angle being on the inside of the gear rack, the inside like a lego brick is sort of hollow, instead of filled.

The gear racks need to be attached to the inner box using ultrasonic welding, as indicated in Figure 19**.** The gears will have a centain distance form the inner box. The reason why will be explained in the 'Redesigned Components: C-parts'.

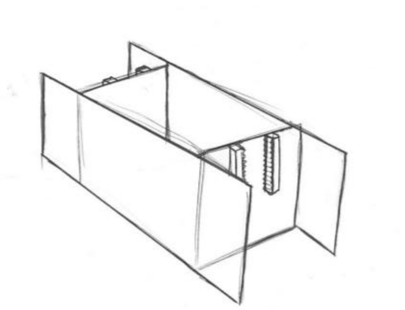


FIGURE 18, PLACE OF THE GEAR RACKS ON INNER BOX BEFORE REDESIGN

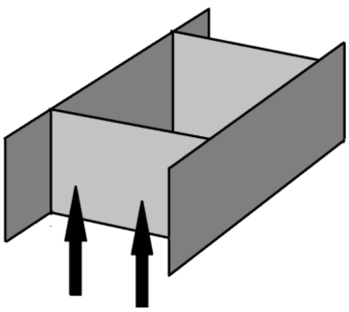


FIGURE 19, PLACE OF GEAR RACKS ON INNER BOX BEFORE REDESIGN

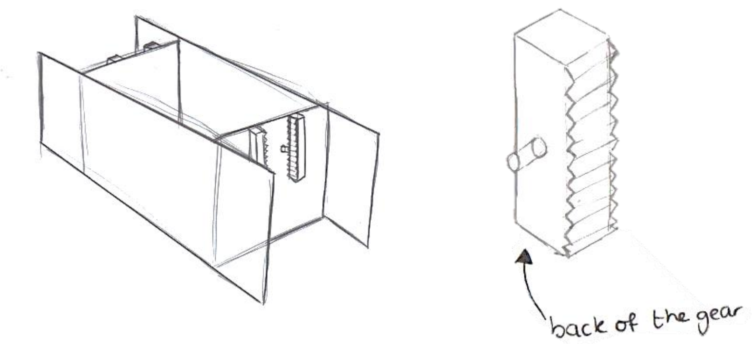


FIGURE 20, CONNECTION OF THE GEARS ON THE INNER BOX

3. Redesign for the Boxes

A. Inner Box

Unlike in the workshop were the inner box was made out of sheet metal, which was first cut then bent, extrusion would be used for the inner box in the mass product. This is due to the inner box having constant cross sectional area. Extrusion was used as unlike a regular injection moulded box which has a top or bottom part, ours had nothing at the top and bottom part of the box. Also we wanted to boxes to have completely straight walls, which isn't possible with injection moulding, as it requires a draft angle. Although it would geometrically same to its prototype counterpart, the redesigned inner box would more easily slide and stay aligned with the outer box, due to its corners being fitted in small notches in the outer box.

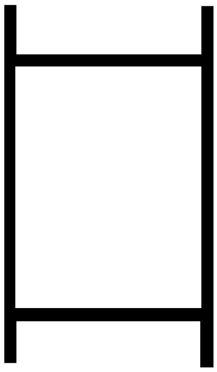


FIGURE 21, TOP VIEW INNER BOX

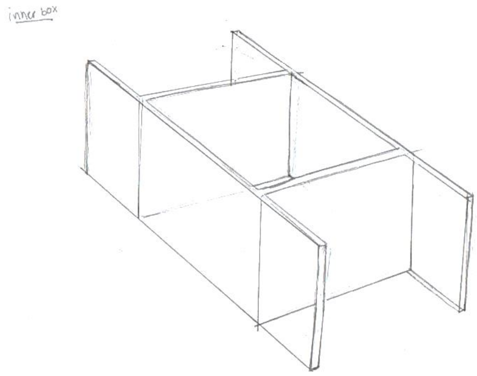


FIGURE 22, 3D VIEW INNER BOX

B. Outer Box

Just like the inner box, the outer box has constant cross sectional area, allowing it to be made using extrusion. The inside of the outer box is hollow. Extrusion was used as unlike a regular injection moulded box which has a top or bottom part, ours had nothing at the top and bottom part of the box. Although similar to its prototype predecessor, the redesigned outer box would include notches that act like rails where the inner box' outer edges would slide through, allowing the inner box to more stable and smoothly sink into the outer box, as seen in Figure 25. This would prevent the inner box to sink unevenly and shake. Two holes need to be drilled in the outer box, the holes would be drilled at both the short end of the box (the wide part not the long part). This hole would be drilled so that the shaft of the handle could go through.

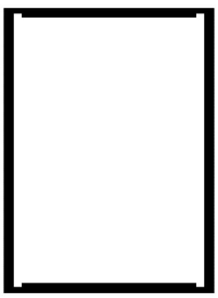


FIGURE 23, TOP VIEW OUTER BOX

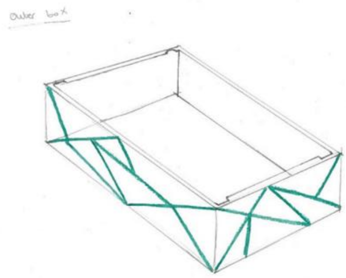


FIGURE 24, 3D VIEW OUTER BOX

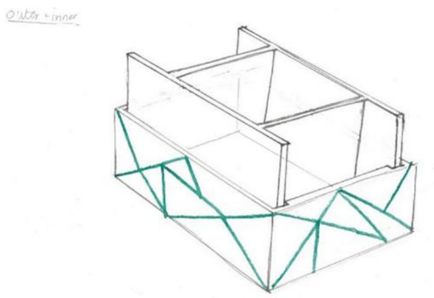


FIGURE 25, ASSEMBLY INNER AND OUTER BOX

4. Redesign for the Grip of the Handle and Handle sides

The Grip of the handle has gone through two redesigns throughout the course of this project. The first redesign is presented in figure 8, while the second is presented in figure …..

First Redesign of the Grip of the Handle and Handle Sides

The handle will be shaped like a cylinder. Due to having a constant cross section, it can be extruded, and cut when in the right length. Once extruded to the right length, the extruded cylinder would be bent to nearly shape of a handle, the handle sides would still be a bit slanted so that it can still fit on the box itself. Once on the box, the sides are pressed to the box, and the handle becomes like the shape in Figure 26. At the same time two holes would be drilled on the sides of the handle so that a shaft could fit through. This shaft is made out of metal, and would form fitted into the hole of the handle. This form fit is done by pressing the ends of the shafts, making them ellipse, and then force fitting them through the circular hole of the handle. The gears would in this case be attached the same way.

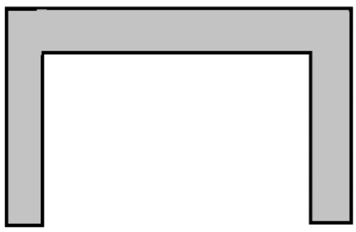


FIGURE 26, THE HANDLE

Second Redesign of the Grip of the Handle and the Handle sides

However, after doing some evaluations on the first redesign of the handle, we found out that it wasn't the most practical solution, as it is nearly impossible to press the shaft from a circle to an ellipse. How hard we would try, it would not fit through the hole in the outer box. Also since the handle with the handle bars are extruded, it would be hard to attach and make a locking mechanism on it like in the cool box system. This locking mechanism would have to be made separately and be attached in a later stage of production. Therefore we began with the second redesign of the handle.

Handle sides

For the original prototype, the handle sides we made out of a cut out piece of sheet metal, with two holes drilled inside it, one for a shaft which would be connected to a mechanism, and one for a screw which would hold the grip of the handle. Then angular forms were attached by using glue.

In the second redesign two shafts would first be cut into the right length. One shaft would be pressed from a circle to an ellipse cross section on both ends, while the other is only stamped on one end. The one stamped only at one end is also brought to a milling machine, where a small piece is milled away for the key of the gear to fit in. Both shafts are then brought to an injection mould machine where the handle sides would be made around the shaft, resulting in a very tight fit for the metal in the plastic. The plastic is also injection moulded in such a way that the handle would be shaped like an angular forms.

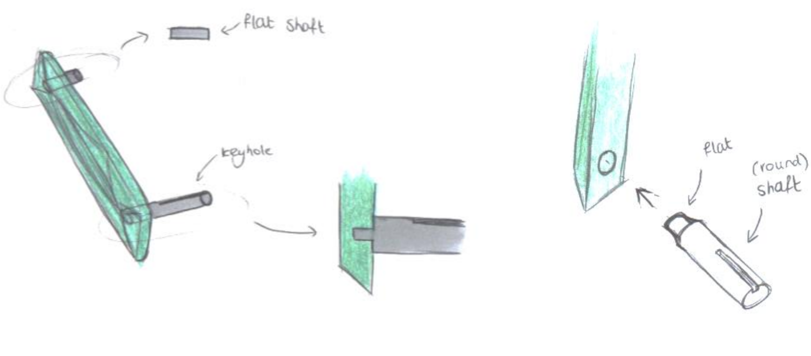


FIGURE 27, ASSEMBLY SHAFT INTO HANDLE SIDE

Because of the altered cool box mechanism, as you can read in 'Redesign Components: Cool box lock mechanism', the handle side needs to be adapted to.

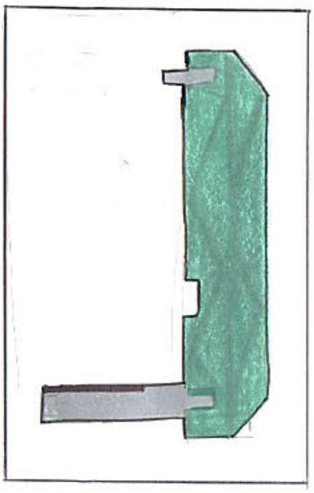


FIGURE 28, SIDE VIEW HANDLE

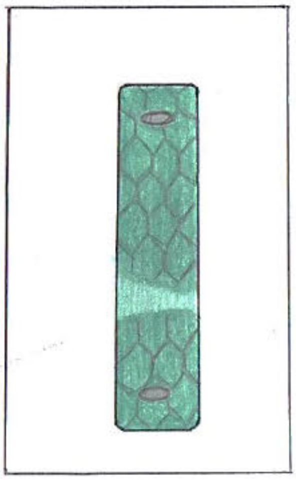


FIGURE 30, INNER SIDE HANDLE SIDE

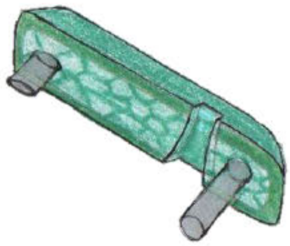


FIGURE 29, 3D VIEW HANDLE

Grip of the Handle

In the prototype the grip of the handle is technically a single piece of wood, which is attached to the handle sides using screws.

In the second redesign the grip of the handle would be made using extrusion, with the hollow cross section as seen in Figure 33. Once extruded a sticker would be placed around it to give it a wooden look. The shaft stamped two times, having the elliptical end, and not the milled end would then be force fitted into the grip of the handle. This ensures a strong and tight fit. At the same time the lower milled shaft goes through the drilled hole of the outer box and attaches itself with one of the gears.

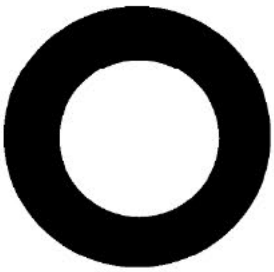


FIGURE 33, CROSS SECTION HANDLE

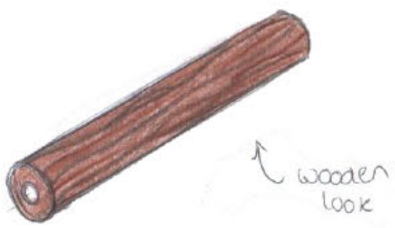


FIGURE 32, HANDLE WITH WOODEN LOOK

FIGURE 31, STICKER WITH WOODEN LOOK

5. Redesign for the Top Lid

The top lid has gone through two redesigns throughout the course of this project. The second redesign is the eventual redesign we choose to implement in our mass product.

First Redesign of the Top Lid

Using the clip lock mechanism as in a regular lunchbox, the top lid is able to be attached and locked on the outer box. Since it is the top lid it would include two important features for the box, namely the raster and the angular forms. Due to this we would use 2k injection moulding to make the component. The first injection moulding stage results in the creation of the top lid itself with angular forms and the clips, while the second stage would result in the creation of the raster. Due to the component using injection moulding, it would have a minimum draft angle of 1 degree.

Second Redesign of the Top Lid

This would however not work, because when using injection moulding the wall thickness should be constant. So the new idea of making the top lid is by making the angular forms with a thickness of 3mm and the trench depth of the angular forms will be 0,5mm. This thickness will make the angular forms obvious and is thin so that dirt will not get stuck that much in between. The lines on top will have a different surface structure then the rest of the angular forms, to create more contrast between those two. We first wanted the lines to be white and the rest of the lid green, but this will be really hard and expensive to make, with for example 2k injection moulding.

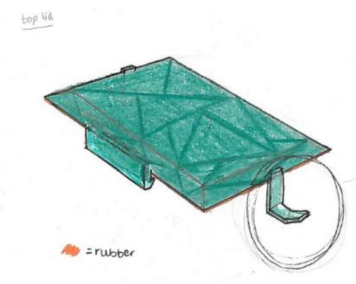


FIGURE 34, TOP LID

To still have a flat bottom there will come an injection moulded honey grid under the angular forms. The honey grid would make the piece very strong. Unlike the first redesign, where the raster is made along with the top lid, the raster would be made in a separate process for the second redesign. This would make the process a bit simpler and easier.

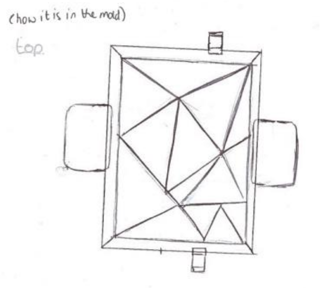


FIGURE 36, TOP LID TOP VIEW

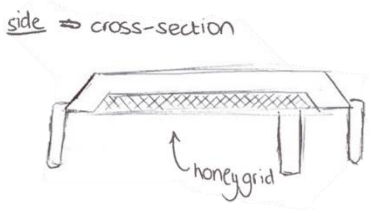


FIGURE 35, TOP LID SIDE VIEW

2k injection moulding is still used in the second re-design, and it would be used for injecting the silicone sealing into the sides of the top lid. Hence in the 2k injection moulding, the top lid would be injection moulded first with the clips and cool box lock mechanism, and then the silicone would be injected in the small trenches on the sides of the top lid. Silicone would be injected to provide for a watertight sealing, that would prevent liquids from the inside of the box to leak out of the box, and liquids from outside of the box to enter the box.

6. Redesign for the Bottom Lid

The bottom lid is similar to the top lid, but without the raster and the 3d angular forms. Therefore due to its more simple shape it can be produced using the regular injection moulding technique. Due to the component using injection moulding, it would have a minimum draft angle of 1 degrees. The angular forms will be realised by having a trench depth of 0,5mm.

Like the top lid, silicone sealing would also be added to the sides of the bottom lid, to make it watertight. Doing so liquids inside the box would not drip out, and liquids outside of the box could not go in. Through making a small trench, at the edge of the lid, silicone sealing could be injection moulded into it after the bottom lid has been injection moulded using 2k injection moulding.

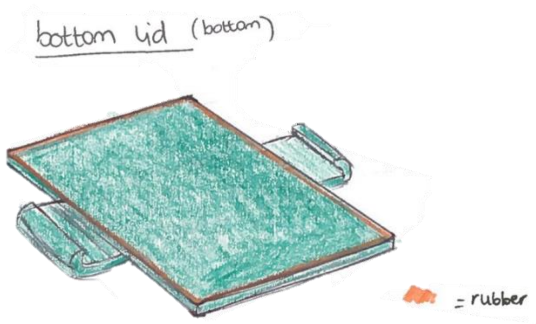


FIGURE 37, BOTTOM LID BOTTOM SIDE

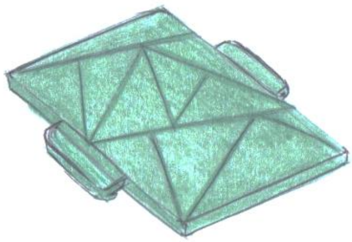


FIGURE 38, BOTTOM LID TOP SIDE

7. Redesign for the Cool Box Lock Mechanism

The Grip of the handle has gone through three redesigns throughout the course of this project. The third redesign is the eventual redesign we choose to implement in our mass product.

FIGURE 39, COOL BOX MECHANISM

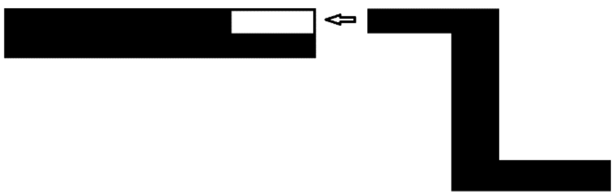


FIGURE 40, UPPER LID AND COOL BOX MECHANISM

First Redesign of the Top Lid

To prevent the upper lid from opening after the handle has been turned, a cool box mechanism will be added to the upper lid. This mechanism makes sure the lid cannot open after the handle has been turned 180 degrees. Therefore there will be a part attached to the outer box. The part will have a side view like Figure 39. This part will be extruded as well.

To attach this mechanism to the outer box, there must come a little insert in the top of the top lid. As clarified in Figure 40. The left part is the upper lid and the right part the ice box mechanism. It can again be attached onto each other using the ultrasonic welding.

This is however not the most practical solution. Due to having to make an insert in the top lid, which would require cutting, that can make the top lid pretty ugly.

Second Redesign of the Top Lid

The cool box mechanism would be used, to be able to click and hold the handle in place after it has been turned 180 degrees. Since the handle is made using angular forms, we will make these forms in such a way that at the bottom there is a part that sticks out. This form will click in the cool box mechanism attached to the top lid, so that the handle does not fall back. With a bit of force the handle can get loose. The cool box mechanism will therefore look like Figure 42.

Unlike the first redesign, it would not be an additional part, and will be injection moulded along with the rest of the top lid at once.

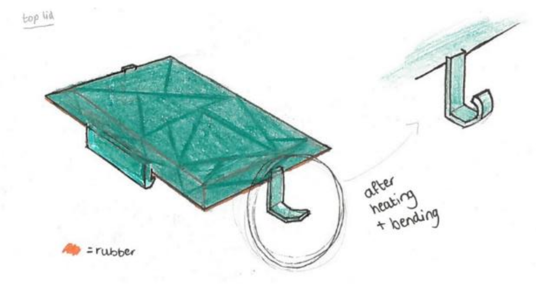


FIGURE 41, MOULD

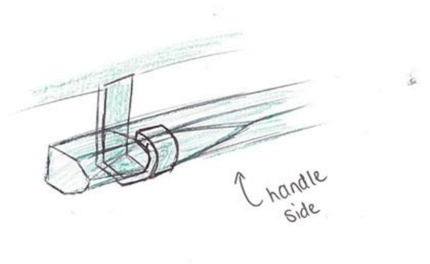


FIGURE 42, COOL BOX MECHANISM

The top lid will be injection moulded as shown in Figure 41. We need to bend the part that sticks out partly with a hot wire. If the part that sticks out already was bend entirely in the mould, then we could not get it out.

This closing mechanism is not located in the middle of the box, and isn't part of the box. Bending would be a nice solution, but isn't practical for mass production, as it requires a lot of time to be executed.

Third Redesign of the Top Lid

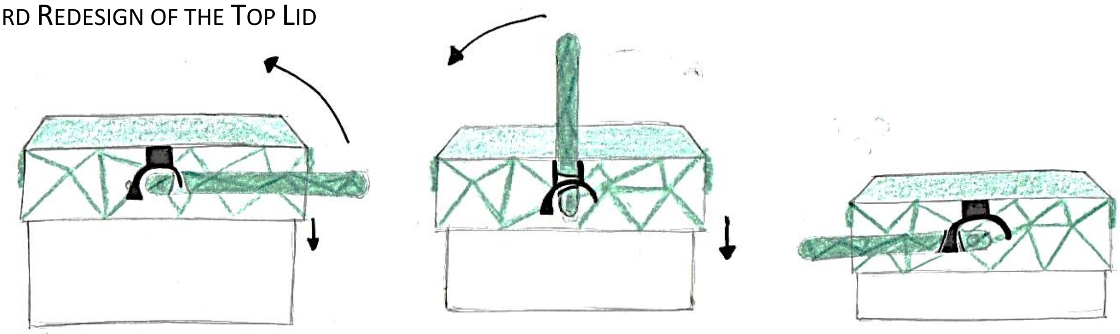


FIGURE 43, CLOSE UP FINAL MECHANISM

The new closing mechanism will be symmetrical, but it cannot be entirely symmetrical, because the lid must be open when the handle is on one end and the lid must be closed when the handle is on the other end after the 180 degree turn. The top lid will now have an extension at the short sides with a form shown in Figure 44 . This will make sure that in one position the lid can open and in the other position it will stay locked, which is the position when the handle has been turned.

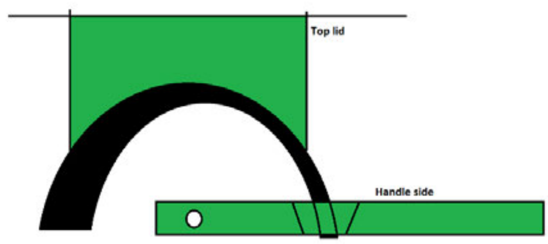


FIGURE 44, FINAL MECHANISM

FIGURE 45, SIDE VIEW HANDLE

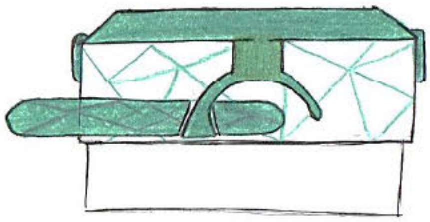


FIGURE 46, DRAWING SIDE VIEW COOL BOX LOCKING MECHANISM

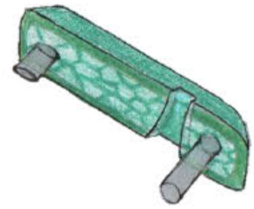


FIGURE 47, DRAWING ISOMETRIC VIEW HANDLE SIDE

8. Redesign for the Knives

The knives will be made using a punching machine with sheet metal having a thickness of 0,3mm. This sheet metal is already sharp and does not need to be sharpened. The sheet metal is already very thin. How thinner the material, how earlier it becomes blunt. That is why we want to keep it straight in the end.

To make the slits in the sheet metal, we need to punch them. All the knives will be punched with the same slit in the same way. After this, the knives fit into each other. See Figure 48.

FIGURE 48, PUNCHED SHEET METAL

Once the knives have been punched, they would be assembled in a mould, where plastic would be injection moulded around the sides of the knives. Before the plastic is injection moulded, 4 neodymium magnets would be placed on the long side of the knives as seen in Figure 49. Once in place the plastic is injection moulded around the sides of the knives, and would coat and cover the magnets. The magnets should be covered by the plastic to prevent corroding from happening. Since the magnets have a very strong magnetic field, covering them with a thin layer of plastic from water wouldn't make the magnetic field interaction weaker with other metals. The injection moulding would be done in such a way that there is a large hole at the width side of the knives, where one can put in their finger and lift the knife safely and easily, as seen in Figure 49. Removing the knives easily allows the user to easily switch the types of knives they want to use, and replace them with newer knives if the older knives are blunt. These magnets are also added so that the knives do not fall off in one direction, as when the user turns the box, without turning the handle, gravity would act upon the knives resulting in them to fall out of their place.

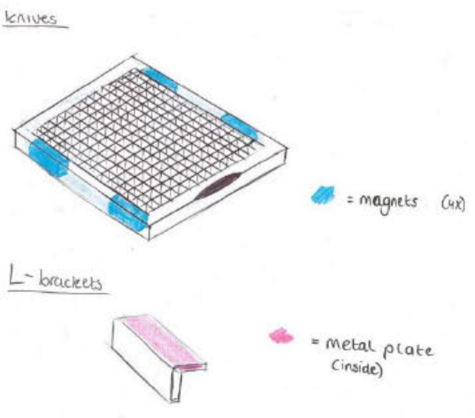


FIGURE 49, KNIVES WITH L-BRACKET BOX

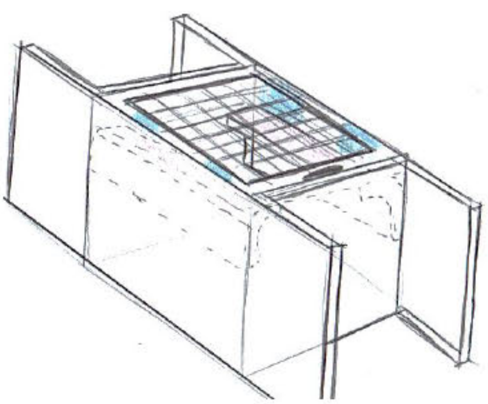


FIGURE 50, KNIVES ASSEMBLED INSIDE INNER BOX

9. Redesign for the L-brackets (Knife lock system)

In the prototype we used L-brackets for the knives to rest on. These L-brackets were simply bent pieces of sheet metal welded onto the inner part of the inner box. The knives were also glued to the L-bracket in the prototype, not allowing for them to be detached. In the mass product however, L-brackets would be much smaller and lighter than that of the prototype. They would be smaller in size, so that they don't cover too much of the knife, and only hold it, and lighter because instead of being made out of sheet metal, these L-brackets are made out of injected moulded ABS plastics. The mass product L-brackets also have a metal plate, to act as a piece where the magnets from the knives could attach onto. We would use magnetic plates that are ferromagnetic instead of another magnet, as magnets are expensive, and metal plates that are ferromagnetic would also attract strongly to a magnet. Hence this would be a smart alternative to magnets. A layer of ABS plastic would be inject moulded around the metal piece to coat it and protect it from water that could corrode it. However due to the thin coating of plastic, it would still allow the magnet to be attracted to the metal piece, allowing the knives to attach onto the L-bracket. What is also nice with this system is that knives could be changed to different types or to newer ones when blunt.

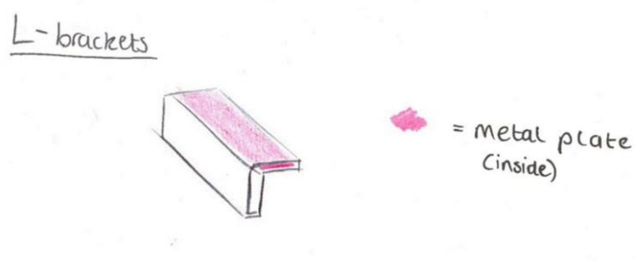


FIGURE 52, THE L-BRACKETS

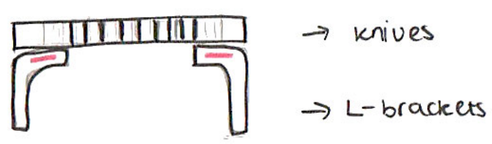


FIGURE 51, SIDE VIEW OF THE ATTACHMENT

10. REDESIGN FOR THE RASTER

The raster itself would not be change a lot in the redesign, only that it is produced using a different process, and made out of a different material. In the prototype, the raster was made out of 3d printed plastic, in the mass product it would be made using vacuum forming and out of ABS plastics. The reason why vacuum forming was used for the raster is because of its inconsistent wall thickness that didn't allow it to be made using injection moulding. The raster itself is made out of ABS plastics, so that it is made out of the same materials as the top lid, which allow the raster to be easily attached to the top lid using ultrasonic welding. The raster itself would be used as a place for the knives to sink in, so that once the vegetables are cut, one cannot see the knives or touch them when putting their finger in the box. The raster would have some flat outline as seen in Figure 54 for it to be easily welded using ultrasonic welding.

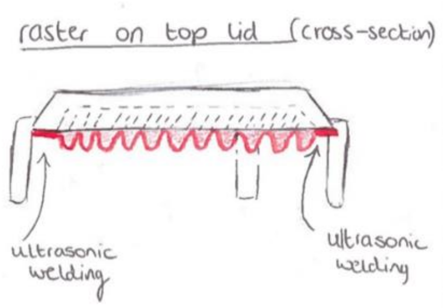


FIGURE 54, RASTER SIDE VIEW

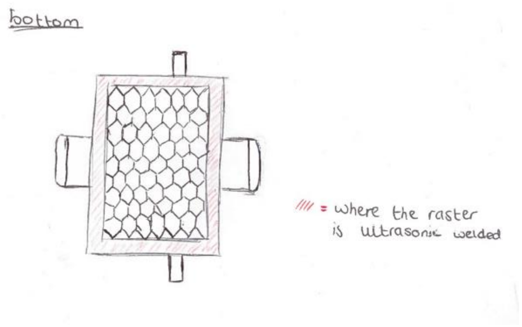


FIGURE 53, RASTER TOP VIEW

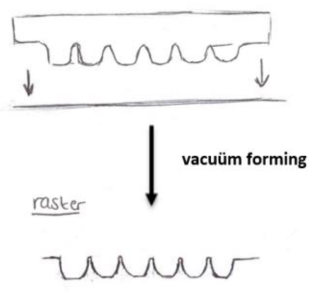


FIGURE 55, HOW THE RASTER IS MADE

11. REDESIGN FOR THE C-PART

In order to keep the gears in one place, and hold the shaft steady and not misalign, a C-part was created. Doing so the gear racks can easily roll around the gears inside the C-parts.

For the C-parts of the mass product we thought of making each C-part box of two parts.
In Figure 56 you can see a drawn top view cross section of how the C-part will look like. At the top there are two round parts sticking out, one small round part at the left, and a bigger one on the right. A plastic shaft with a small end would fit inside the hole of the big round as seen in the figure, while the other big end would cover the smaller circle on the left side. Doing so a form fit would be ensured. Through assembly though, the gear would be first attached to the shaft and then placed in the C-part. Since the shaft doesn't rotate, no key is required for the gear, so the gear without key would be put on this shaft.
At the bottom part of the same figure, a ring can be seen on the right side. Once the shaft from the handle side goes in from the outside through the hole on the left, the shaft would end and fit in the ring seen on the right. Both the ring and the hole ensure that the shaft is hold in such a way that it would stay aligned and wouldn't slip. there will come a ring in which a shaft can fit and at the other end there will be a hole, through which the shaft can fit. Then both shafts are supported at both sides. Since this shaft does rotate, this would also be the shaft where the gear with the key would go.

The two c-parts can be put together using the same principles like a click mechanism. Once the click is heard the parts are firmly together. This also ensures that both parts stay together.

These two parts will be injection moulded, therefore there must be a draft angle of at least 0,5 degrees. For assembly, the gears and shafts would already have to be inside the C-parts before both the halves of the C-parts are clicked together, once this is done the C-part can be welded onto the outer box through ultrasonic welding.
Ultrasonic welding would be done at the open parts of the C-part.

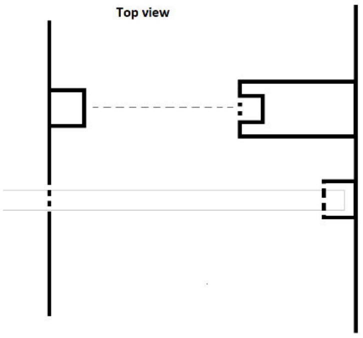


FIGURE 56, C-PART TOP VIEW

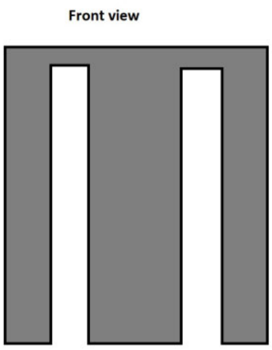


FIGURE 58, C-PART FRONT VIEW

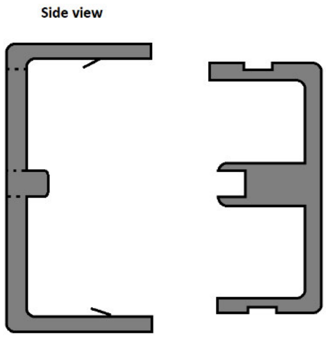


FIGURE 57, SIDE VIEW C-PART

Another issue that needs to be solved when compared to the prototype, are the open spaces next to the C-parts when the box is opened. This open space could lead to a problem as food can get in, which could get into the mechanism and jam the entire system. This is because in this space there are the gear racks and the C-part with the gears in it. Aside from having the chance for vegetables to clog and break the mechanism, seeing the mechanism isn't always nice for the user. Hence our goal was to cover this using a bigger C-part. This bigger C-part would cover than entire empty space and mechanism, covering it for the user. The only problem was that if we extend the C-part in both length and width, the gear racks can at some point no longer pass from the inner box. Therefore to achieve this, we planned on having the gear racks attached on top of 2 plastic cylinders that have thickness of about 3 mm. If we do this the C-part can go behind the gear racks. For assembly we would ultrasonic weld the cylinder to the outer box, and the gear rack to the cylinder, all made from the same material which is ABS. This allows the ultrasonic welding to be done effectively.

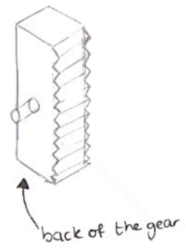


FIGURE 59, GEAR WITH TUBE

The C-part will be just as high as the outer box, but on the bottom the c-part will be bigger than the outer box. That is why we need to make the outer box slightly higher, to get the C-part at the same height. The width of the C-part is as big as the width of the inner box.
Slits would be made in the C-part, so that the cylinders of the gear racks can fit.
The slits will make sure the gear rack can move freely up and down, but it makes sure the gear rack can not go higher than the slits allow. This makes sure that the handle stops at 180 degrees.

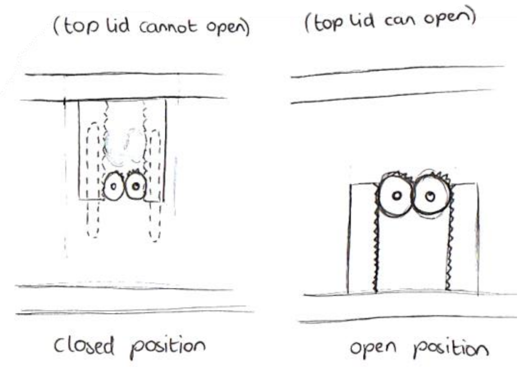


FIGURE 60, FRONT VIEW OF PREVENTING THE BOX FROM FALLING APART

The only problem not solved yet is the problem of the gears going out of the gear rack, when the outer box goes up so much that it can be lifted of the inner box. To overcome this, some sort of system should be developed so that it stops. This problem can be solved by ultrasonic welding a piece of plastic under the C-part. This would result in the new front view of the C-part as seen in Figure 61. The plastic must be the bottom part of the C-part and therefore it must contain a clicking system and a corner. Due to its more complex geometry, the part would be injection moulded.

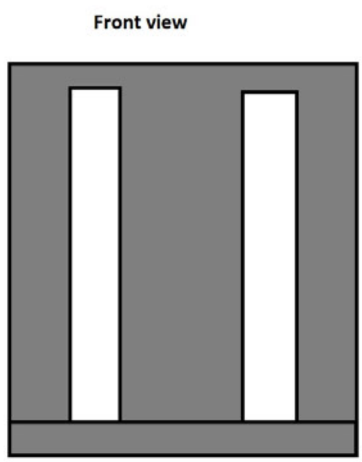


FIGURE 61, FRONT VIEW (WITH THE SLITS FOR THE GEARS)

This can only be connected to the c-part when the gear racks are already in between the slits, otherwise it is really hard to assemble the gear racks in between the slits.

Eventually the parts will look like this:

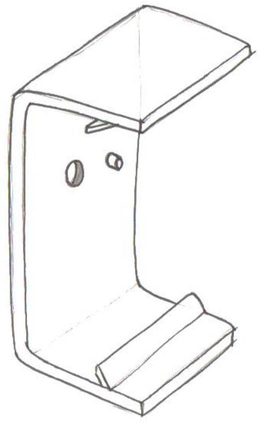


FIGURE 62, C-PART (GETS WELDED ON OUTER BOX)

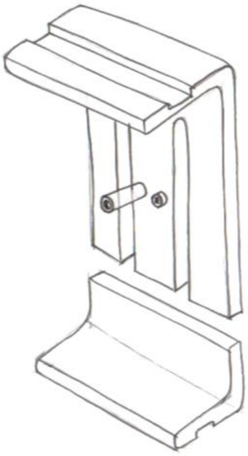


FIGURE 63, C-PART WITH SLITS FOR GEARS

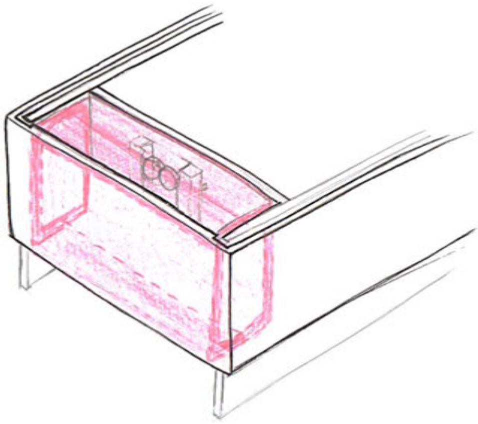


FIGURE 64, BOTH C-PARTS ASSEMBLED

12. Redesign for the Locking Clips

To ensure that clips on the lid would stay closed on the boxes, a locking clip (Figure 4.17) would be sticked on the two long sides of the boxes. The clip and locking clip work exactly the same way as in a regular lunch box (Figure 4.16). Since the inner box is extruded, the locking clip would have to be made separately. This would be done with extrusion as well as the locking clip has a constant cross section. Once both components are ready, they would be attached to one another using ultrasonic welding. Unlike the gear racks (Delrin) which were made out of a different materials than the outer box (ABS). The locking clips are also made out of ABS, making it very easy to ultrasonic weld, and doing so without the help of a melt film. A robot arm would be used as this would allow the robot to easily reach the location for the weld to happen.

The closing mechanism will work just like it is shown in Figure 65. The approximation of the side view of the closing mechanism is shown in Figure 66.

FIGURE 65, LUNCH BOX USING LOCK CLIPS

FIGURE 66, LOCK CLIP SIDE VIEW

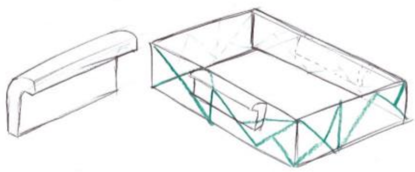


FIGURE 67, ISOMETRIC VIEW

EXTRA FEATURES

During the course of the re-designing for the mass product, there were also additional features that came into our mind. These features couldn't be added at the time as they made the process more difficult, and more complex, either because they were made out of a different material or required a very different process. However if more development on this product would ever come to play, then these features would certainly be added.

RUBBER IN RASTER

The knives are really sharp and the rubber prevents the knife from cutting the plastic raster.

FIGURE 68, RUBBER IN RASTER

MULTIPLE KNIVES

To keep the price as low as possible, but the product still attractive, we add some extra features to make it possible to have a more luxurious feeling to the product.

3 different cut options for small blocks:

- 08x08mm
- 10x10mm
- 12x12mm

FIGURE 69, 3 DIFFERENT KNIVES

It would cost too much if we add a feature that has two different sizes of knives in one casing. Because then you need to make different casings, so the process need to be adjusted.
Only the inside can be changed.

We are using ultrasonic welding to attach the plastic parts onto each other.

MATERIALS USED FOR THE COMPONENTS

ABS PLASTICS

PROPERTIES (FROM CES)

- Low Price (2.60 - 2.63 Euro/kg)
- Thermoplastic
- Tough
- Dishwashable
- Hygroscopic (requires drying before thermoforming
- Stiffest of all thermoplastics
- Can be damaged by machining oils
- Highest impact resistance of all polymers
- Resilient
- Easily Moldable
- Non-Toxic
- Recyclable
- UV stabilizers required for the plastic to go well with outside environment.
- Sunlight can damage and weaken the material when no protective coating like UV stabilizers are used.
- Accepts colour well
- Excellent resistance to acids, alkalis, salts, and many more solvents
- Can be extruded, compression moulded, and formed to sheet for thermoforming
- Can be joined with ultrasonic of hot plate welding
- Can be bonded with polyester, epoxy, isocyanate and nitrile-phenolic adhesives.
- Two sub groups
    - ASA
        - Can be coloured
        - High gloss
        - Chemical and Temperature Resistant
        - High impact resistance at low temperatures
    - SAN
        - Can be processed easily like polystyrene but with higher toughness, stiffness, strength, chemical and heat resistance.
        - Glass fiber can improve rigidity significantly

COMPONENTS MADE FROM THIS MATERIAL:

- Top Lid
- Bottom Lid
- Handle sides
- Grip of the handle
- Inner Box
- Outer Box
- Raster
- Outer Lining of Knives
- Clip Locks
- L-bracket
- C-Part

Reason component uses this specific Material

A majority of the big components like the lids, inner and outer boxes are made out of ABS plastics. One of the main reasons for using this material for these components is because ABS plastics are easily moldable and made using existing injection moulding machines. This makes it much easier to produce the components, which would reduce factors like the amount of time to produce the components, and the overall cost of producing the component. ABS plastics are also used as they come at a low price, which would overall reduce the cost of the product itself as most large components are made using this material. Aside from that ABS plastics are also very tough and strong making them impact resilient which would be a good characteristic for the material to have, as products like vegetable cutters would on certain occasions fall or be dropped accidently by the user. Since the boxes would be made out of this material, the components would be able to withstand such scenarios and not break. ABS plastics are also dishwasher safe, like all the other materials of the product, making it easier for the user to clean the product after usage. Therefore because of these factors, we chose ABS plastics for these components.

300 Series, Stainless Steel

Properties (From CES):

- High price 5.04 - 5.28 Euro/kg
- Does not rust
- Does not become brittle in places below room temperature
- Remains ductile to the lowest of temperatures
- Recyclable
- Dishwashable
- High Strength
- Economic Design = Thin, Rolled Gauge, Simple Sections, Concealed welds to avoid refinishing, and grades suitable for manufacturing when machining is required.
- Difficult to bend, draw, and cut
- Available in sheet, strip, plate, bar, wire, tubing, and pipe
- Can be readily soldered and braised.
- Surface finish can be controlled by rolling, blasting and polishing
- Welding is possible as long as the filler material maintains a equivalent composition to ensure that the stainless steel remains corrosion resistant.
- Welding is more preferable with the 300 series type of stainless steel.

Components Made from this Material

- Knives
- Shafts

Reason component uses this specific Material

Stainless steel would be used for most metallic components of the product like the knives, and screws, since these components require a material with high strength. Most metals would have a high strength, but what made stainless steel preferable choice was its inability to rust due to containing 10% chromium which creates a protective film around the metal to prevent rusting. Stainless steels ability to stay stainless and not rust is important for metallic components in a food appliances as the absence of rust would prevent food poisoning, and that's the main reason why stainless steel has been chosen as the material for our metallic components. Since stainless steel does come at a high price, only a few components are made out of this material to reduce the overall cost of the product itself. These components are also generally small in size, reducing the need of the material.

Polyoxymethylene (Delrin)

Properties (From CES):

- Low price (2.68 - 2.82 Euro/kg)
- High price relative to other mass polymers
- Thermoplastic
- Stiffer and better water resistant than nylon and other polymers of similar class
- Worse abrasion and impact resistance than nylon
- Fatigue resistant
- Dishwashable
- Low coefficient of friction
- Good moldability
- Recyclable
- Easy to mold by blow molding, sheet molding and injection molding.
- Minimum required wall thickness for injection moulding = 0.1 mm
- Can be coloured
- Can be extruded for components like fibres and pipes.
- High crystallinity leads to increased shrinkage when cooling.
- Processing temperature = 190 - 230 °C.
- May require drying before forming as it is hygroscopic. (tends to absorb moisture from the air)
- Can be joined with welding through welding methods that use high energy and long ultrasonic exposure.
- Adhesive bonding can also be used for joining, and is the more commonly used method.
- Without coPolymerization or Blocking groups Delrin can easily degrade.

Components Made from this Material

- Spur Gears with key
- Spur Gears without key
- Gear Rack
- Used for metal insert in L-bracket

Reason component uses this specific Material

Delrin would be used for the gears, racks and sleeve bearings as it is strong, lightweight and also comes at a low price. Although stainless steel could have also been used, as it is stronger than Delrin, it is also more heavier and pricier. Stainless steel would have also led to an over design of the product itself, as when using stainless steel the safety factor of the gears would be much too high, which isn't necessary if reducing it could be more beneficial. Delrin on the other hand had a safety factor that was reasonably high as well, but not as high as that of stainless steel. Delrin also had characteristics like that of stainless steel, such as that it is non-toxic, and could is dishwashable. However what Delrin also had, was its lower price and weight, and with a more reasonable safety factor than stainless steel, it eventually became the material for the gears, racks and sleeve bearings.

Silicone

Properties

- Moderate price (3.57 - 5.29 Euro/kg)
- Thermoset
- Low strength
- Can be used from -100 to 300 degrees Celsius
- Chemically very stable
- Used often for water sealing and food applications
- High heat resistance
- Not recyclable
- Non-Toxic

Components Made from this Material

- Used at the raster to prevent the knives to cut the plastic from the lid
- Used for sealing in the lids

Reason component uses this specific Material

Silicone would be used behind the raster, at the handle, and in the lids as a seal for the lids to make the product watertight. The reason why we choose Silicone was mainly due to its elastic and low strength properties. These properties serve very well with the usage of the material in our product, as for in the case for the knives the elastic material would rather deform with the knives when force is applied rather than hold the knives back which could cause scratching.

Neodymium

Properties

- Expensive: 68.69 Euro/kg
- Made from an alloy of Iron, Boron, and Neodymium.
- Rare-earth magnet
- Can corrode very easily, therefore requires coating to prevent it to come in contact with water.
- Zinc, gold, tin, and nickel, as well as polymers can be used for coating.
- One of the strongest magnets available
- BHmax
  - BHmax = Magnetic Energy Product, or the strength of the magnet, where 0 is lowest strength.
  - 8 times stronger than a Alnico magnet

Components Made from this Material

- Magnets for knives

Reason component uses this specific Material

Neodymium would be used in the form of magnets in our products. We choose Neodymium since it is one of the strongest magnets available coming at a good price for its strength than other magnets which are more expensive but weaker. Although Neodymium is the most expensive material we would use in the product, its use is limited, and only for the knives so they can attach to the L-brackets. In terms of strength to price rating, Neodymium rates very well having a rating of 0.78 Euro per BHmax, while other magnets like AlNiCo have a rating of 3.56 Euro per BHmax, and only a BH max rating of 5. The only problem Neodymium magnets have is that they tend to easily corrode due to their high iron content, because of this we would add plastic (ABS) sealing to the magnet which would be injection moulded around the magnets when the outlining of the knives is injection moulded to the knives.

Bought or Produced?

Main components like the inner and outer boxes are mainly produced due to their unique geometry and specifications. Knives, although common in the market would be made, as there are no knives with the required dimensions we require, therefore it is easier for us to produce them ourselves. Basic components like the gears, gear racks and shafts are bought from stock in bulk as it is much easier and inexpensive to buy these components rather than produce them ourselves. Component like gears also need require very accurate and precise tooling for their creation, something that would be too costly for us to have, and outside our field of expertise.

Components to be Made

1. Inner Box
2. Outer Box
3. Top Lid with clips and 3D angular forms
4. Raster (With Angular Forms)
5. Bottom Lid with clips
6. Handle handgrip
7. Handle sides with shaft
8. Clip Locks
9. L-brackets (Locking system for knives)
10. C-parts
11. Knives
12. Outer lining for knives

Components to be bought from stock

1. Shaft
2. Gear with key
3. Gear without key
4. Gear rack

Assembly Time

It cannot be guaranteed that this is the most accurate time required for creating the product, as a lot of estimations and assumptions are made, similar to the cost estimation. However this is a the most closest we can get to hypothesizing the assembly time of our product.

A process and stage is complete, when all the components being produced or involved in that process are completed. Therefore the total time for each process is taken from the part that takes the longest to be produced, same goes for the stage itself. For example in injection moulding the longest time to produce a part is 14 seconds, therefore the total time for the process to take would be 14 seconds. Another example would be for the stages, for stage one to finish it would take 35 seconds, as 35 seconds is the longest time it takes for a process in that stage to produce a component. The total time for the process and stages are determined in this way, as once at the longest time has been reached, so after 35 seconds, we would be sure that all components are completed in stage 1, hence the stage is complete and we can move on to the next one.

Time required to transfer to next stage, is the amount of time it would require to transfer from one machine to the next. The specified time, 30 seconds is a hypothetical time, as we do not know the actual distances from the machines.

Stage 0: Pre-Shaping

Punching

Amount of punching machines used: 1
Parts to be punched: 1
Time required to punch the knives out of sheet metal: 6 seconds

Total time for stage to complete: 6 seconds

Time required to transfer to next stage: 15 seconds

Stage I: Shaping

Injection Moulding

Amount of Injection moulding machines used: 4
Parts to be injection moulded: 4
Time required to injection mould C-parts: 6 seconds
Time required to injection mould Outerlining of knives: 14 seconds
Time required to injection mould L-brackets: 2 seconds
Time required to injection mould Handle sides: 6 seconds

Total time for process: 14 seconds

2k Injection moulding

Amount of 2k Injection moulding machines used: 1
Time to injection mould top lid: 39 seconds
Time to injection mould bottom lid: 14 second

Total time for process: 39 seconds

Extrusion

Amount of extrusion machines used: 4
Parts to be extruded: 4

Time to extrude Outer box: 15 seconds
Time to extrude Inner box: 15 seconds
Time to extrude clips: 15 seconds
Time to extrude Grip of the handle: 15 seconds

Total time required for process: 15 seconds

Vacuum Forming

Amount of vacuum forming machines used: 1
Parts to be vacuum formed: 1
Time required to vacuum form raster: 35 seconds

Total time required for process: 35 seconds

Since all these stages would be done simultaneously, the longest time would be taken for the time required for this stage to finnish. Since 35 seconds is the longest time, this stage would take 35 seconds.

Total time for Stage to complete: 35 seconds

Time required to transfer to next stage: 15 seconds

Stage II: Surface Treatment

Attaching of Angular forms stickers to Outer Box through Ultrasonic Welding

Per side: 3 Seconds
Time required to move from one side to other side: 2 seconds
Average time to attach angular forms stickers to side of outer box: 18 seconds

Total time for Stage to complete: 18 seconds

Time required to transfer to next stage: 15 seconds

Stage III: Machining

Ultrasonic Welding

Average time for ultrasonic welding per part: 2 seconds
Time required for machine to change from one welding location to the other: 3 seconds
Parts to be welded: 5
Total time to welding: 22 seconds

Drilling

Average time for drilling one hole: 3.5 seconds
Average time for drill to move from one hole to the next: 3 seconds
Number of holes to be drilled: 2
Total time for drilling: 10 seconds

Since in this stage the process wouldn't be done simultaneously, instead after one another, the total assembly time would be the sum of time required for both processes. Therefore the total amount of time for this stage is 35 seconds.

Time for stage to complete: 35 seconds

Time required to transfer to next stage: 15 seconds

Stage IV: Assembly

Robotic Assembly of Entire Product with 4 Robot Arms
Time required: 210 seconds

Human Aid for Assembly
Time required: 58 seconds

Since in this stage the process wouldn't be done simulatoeously, instead after one another, the total assembly time would be the sum of time required for both processes. Therefore the total amount of time for this stage is 268 seconds.

Total time for stage to complete: 268 seconds

Time required to transfer to next stage: 15 seconds

Stage V: Testing

Testing of Product
Time required: 115 seconds

Total time for stage to complete: 115 seconds

Time required to transfer to next stage: 15 seconds

Stage VI: Packaging

Packaging
Time required: 299 seconds

Total time for stage to complete: 299 seconds

Total time for process

from Stage 0 to IV (Production)
434 seconds

7 minutes and 14 seconds

from Stage 0 to Stage VI (Production with Testing and Packaging)
863 seconds

14 minutes and 23 seconds

Cost estimation

In order to get a first idea in how far our design is suited for the market, it is important to do a cost estimation. This cost estimation allows us to get a rough idea of the price range our product will fall in. By knowing the price category of our product, we can make a more informed decision on whether or not our product is suited to be brought to the market.

It should be noted that although a cost estimation can give a rough idea of the sales price for a certain item, it should not be considered as a final price. There are many elements that influence production costs.

In the case of our product, we arrived at a final selling price, including taxes of 60.80 Dollar if we were to produce a 100’000 vegetable cutters. This number has been obtained by making a few assumptions that are explained in a more detailed manner in the appendix:

Assignment 3 Cost Estimation.

The final selling price of our product would thus be 54.09 Euros in the Netherlands.

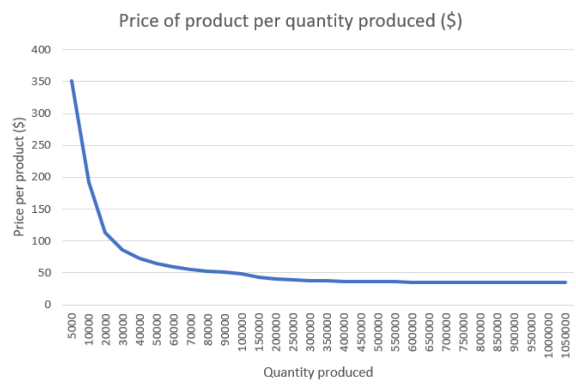


CHART 1, PRICE OF PRODUCT AND QUANTITY

It is also very important to note that, production quantity has a very big impact on sales price. As can be seen in chart 1, price of product and quantity, the quantity of produced products has a very big impact on the cost price when producing small quantities.

However, in the case of our product, around 250'000 products, the price begins to become more constant. This is of course a simplification as it does not take into account the life of a mould or other products that produce the high "One-off" costs. In reality this chart would have spikes every now and then.

	One-off Costs ($)	Costs per product ($)	Type		Extra percentages	
Injection Moulding	135632.2028	1.356322028	One-off Costs		Margin for forgotten elements	0.05
		5.177555785	Produced parts Costs		Overhead	0.8
Plastic Extrusion	500846.7218	5.008467218	One-off Costs		Warranty	0.05
		3.415794293	Produced parts Costs		Profit	0.1
Punching		0.3	Produced parts Costs		Amount of products produced	100000
Vacuum Forming		0.2	Produced parts Costs			
Bought Parts		2.464	Produced parts Costs		BTW.	0.21
Assembly	91000	0.91	One-off Costs			
Labor		4.18724208	Produced parts Costs			
Total		23.0193814				
Total with margin		24.17035047				
Total with Overhead		43.50663085				
Total with Warranty		45.6819624				
Total with Profit		50.25015864				
Sales Price incl. BTW.		**60.80269195**				

APPENDIX

Target group

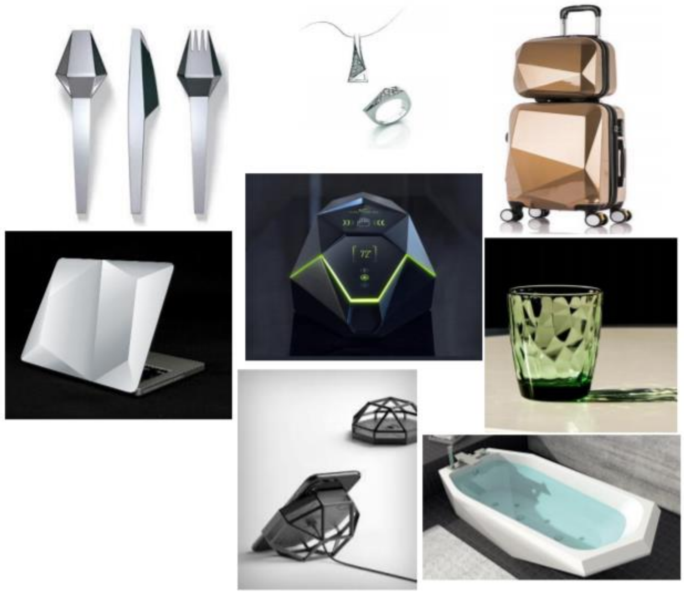
The target group is the university students which might not good at cooking. They need healthy food but do not have a lot of time. They might have a university students live around three years. So they need a vegetable cutter to help them cook better and faster. They always cook for themselves but also need to make a meal for several people when they have a party.

4

Style

Angular forms

This from is usually made by plastic, metal, glass and ceramics. All kinds of color can be used. The angular forms usually have the sharp lines and smooth surface. The vegetable cutter will use the angular forms to show the sharp feeling. Another reason for using the angular forms is to adapt to the preferences of young people. The smooth and shining surface and the polyhedral form can give them a modern feeling.



6

Requirement list

The requirement list is based on all the analysis above. The safety is the most important requirement. The vegetable cutter should able to cut the vegetables in a safety and easy way in order to fit the students who are not good at cooking. In addition, in order to make be suitable for the university students which are usually live along also in order to save space the size of the vegetable should not be too big.

- **Safety**
- **Easy function (easy to understand and easy to use)**
- **Suitable for people live along**

Save space

Suitable size

More important

8

TECHNICAL DRAWINGS

Whole Box number: 100

Outer Box Assembly 100-01

Outer box part with holes 100-01-01

Inner Box Assembly 100-02

Innerbox part 1 (short)

Inner box part 2 (Long)

Handle Assembly 100-03

Handle cylinder 100-03-01

Handle lip (2x) 100-03-02

Handle Side (2x) 100-03-03

Top Lid 100-04

Raster 100-05

Bottom Lid 100-06

C part (2x) 100-07

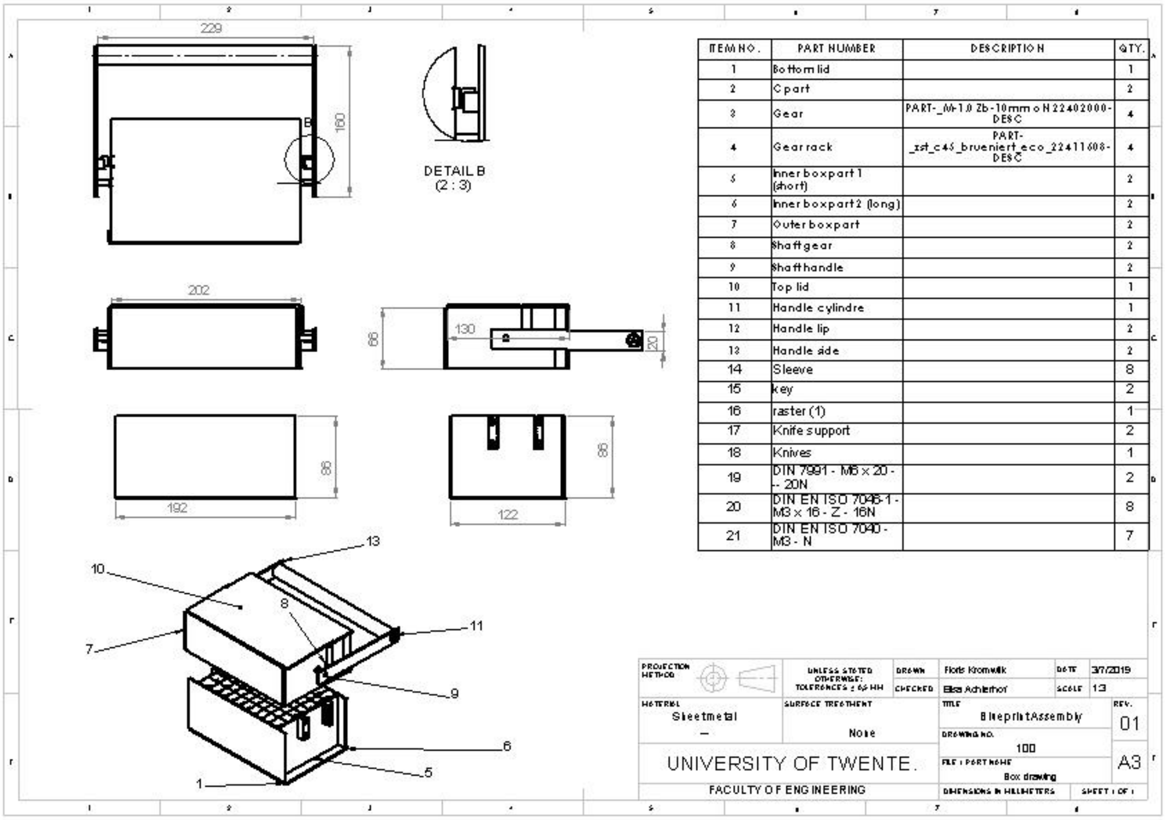
Knives 100-08

Shaft gear (2x) 100-09

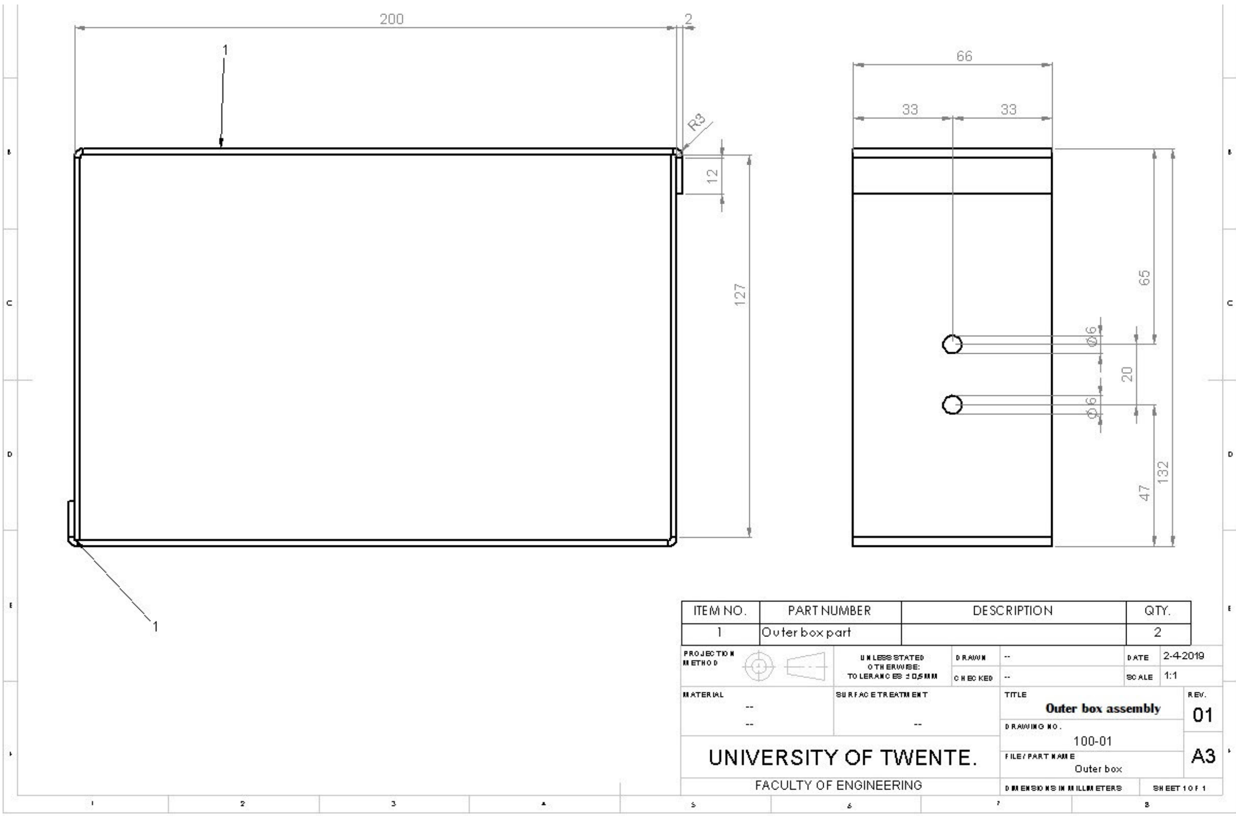
Shaft handle (2x) 100-10

Gears (4x) 100-11

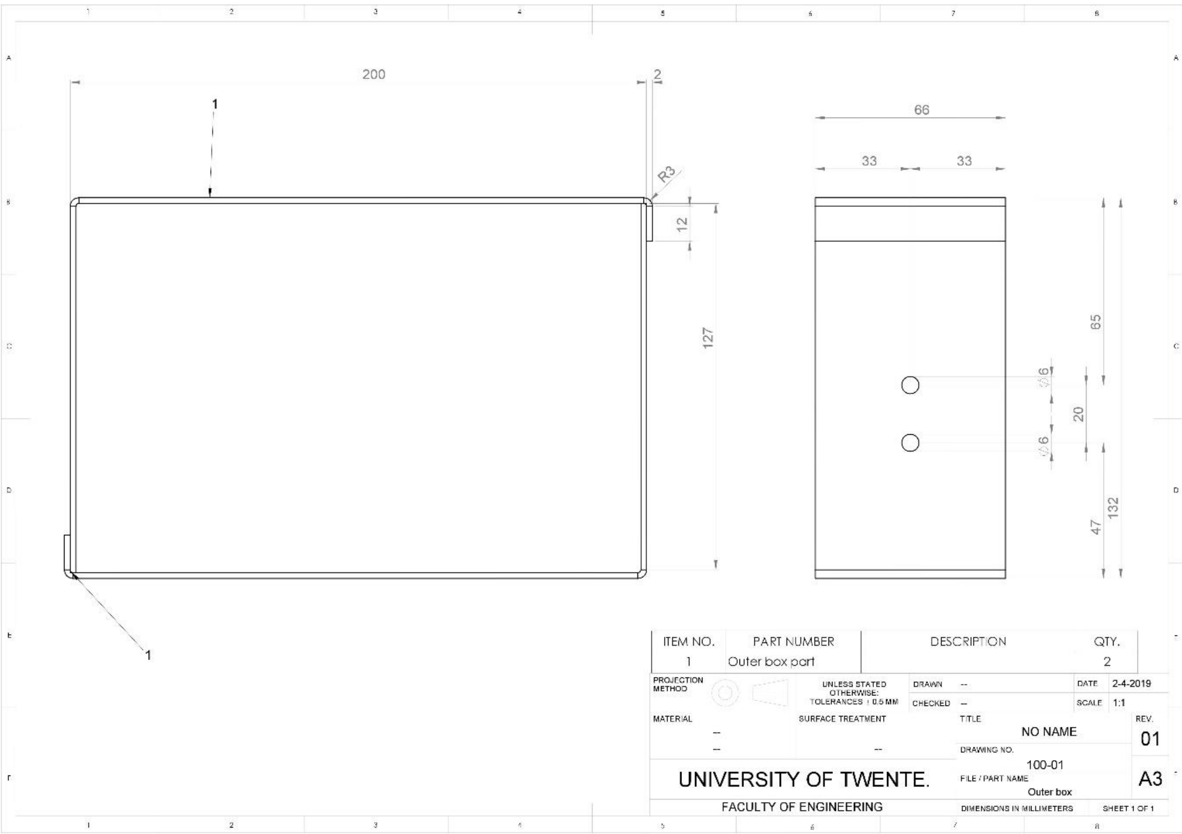
Gear rack (4x) 100-12

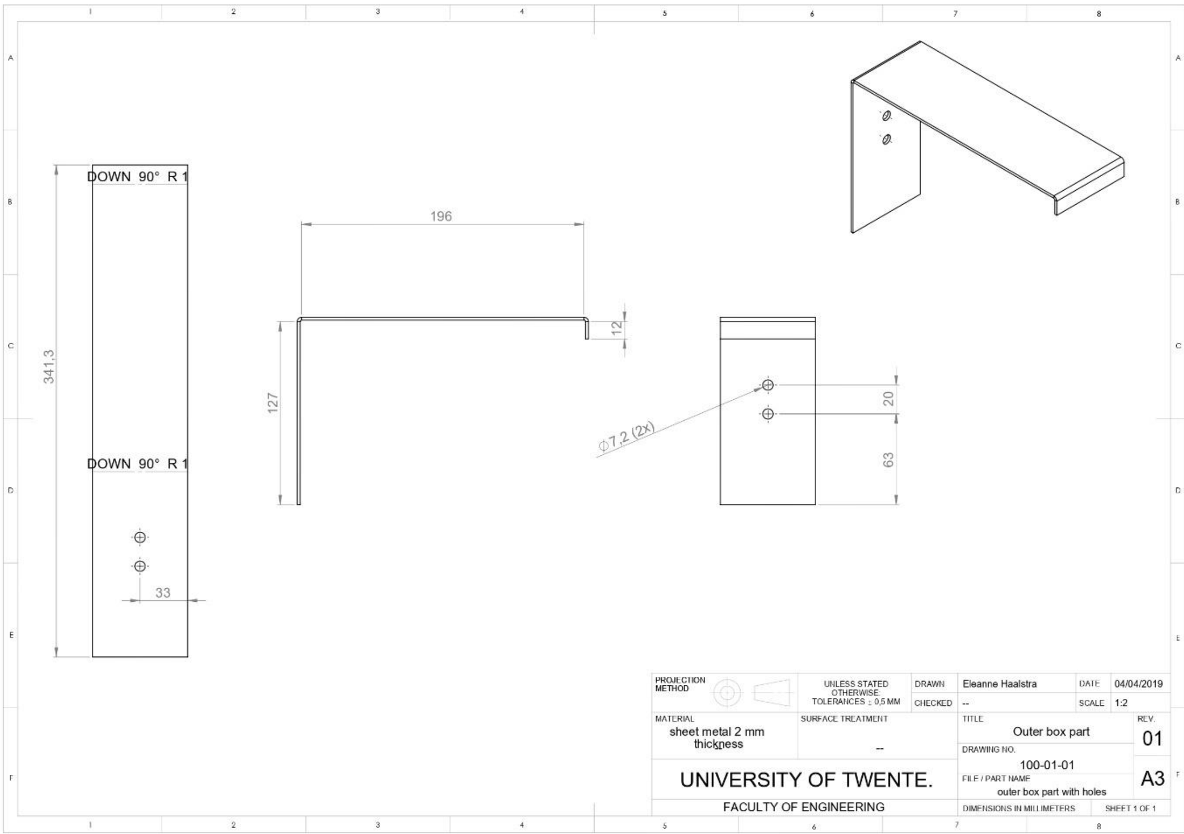


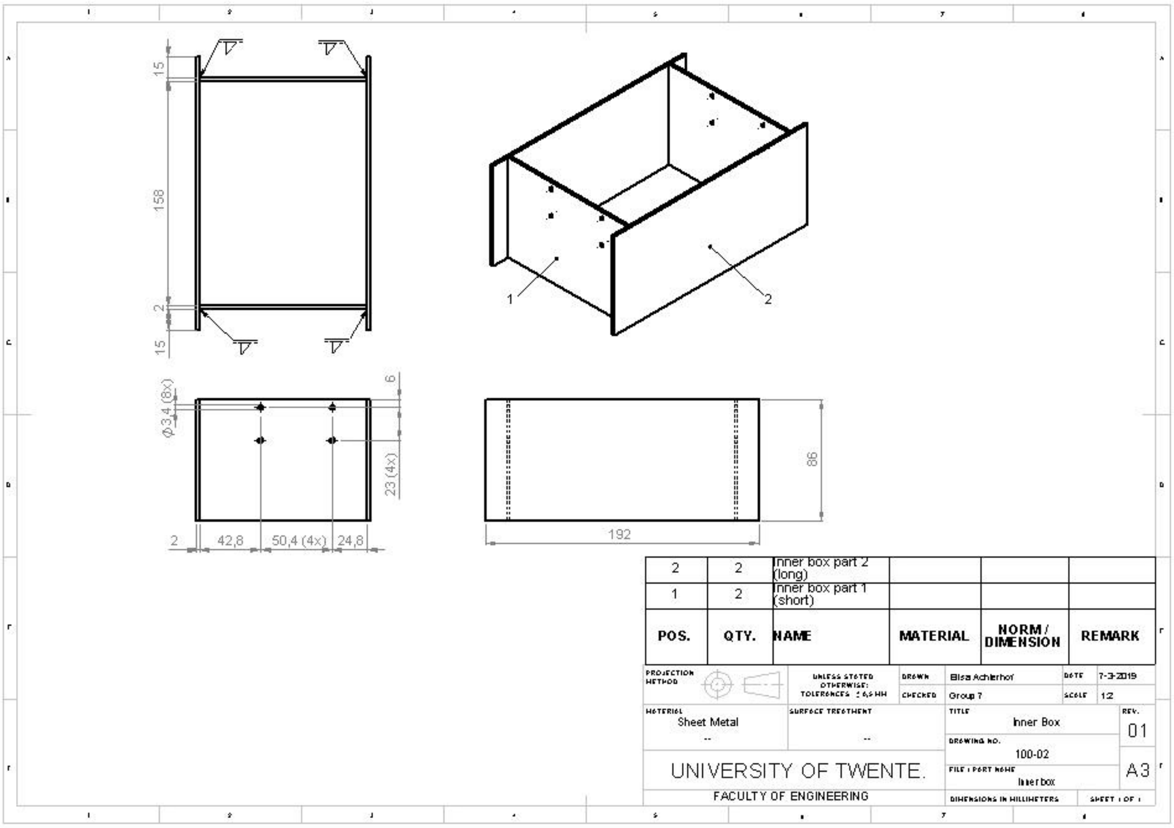
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Bottom lid		1
2	C part		2
3	Gear	PART-_M-1.0 Zb-10mm o N 22402000-DESC	4
4	Gear rack	PART-_zst_c45_brueniert_eco_22411608-DESC	4
5	Inner boxpart 1 (short)		2
6	Inner boxpart 2 (long)		2
7	Outer boxpart		2
8	Shaft gear		2
9	Shaft handle		2
10	Top lid		1
11	Handle cylindre		1
12	Handle lip		2
13	Handle side		2
14	Sleeve		8
15	key		2
16	raster (1)		1
17	Knife support		2
18	Knives		1
19	DIN 7991 - M6 x 20 -- 20N		2
20	DIN EN ISO 7046-1 - M3 x 16 - Z - 16N		8
21	DIN EN ISO 7040 - M3 - N		7

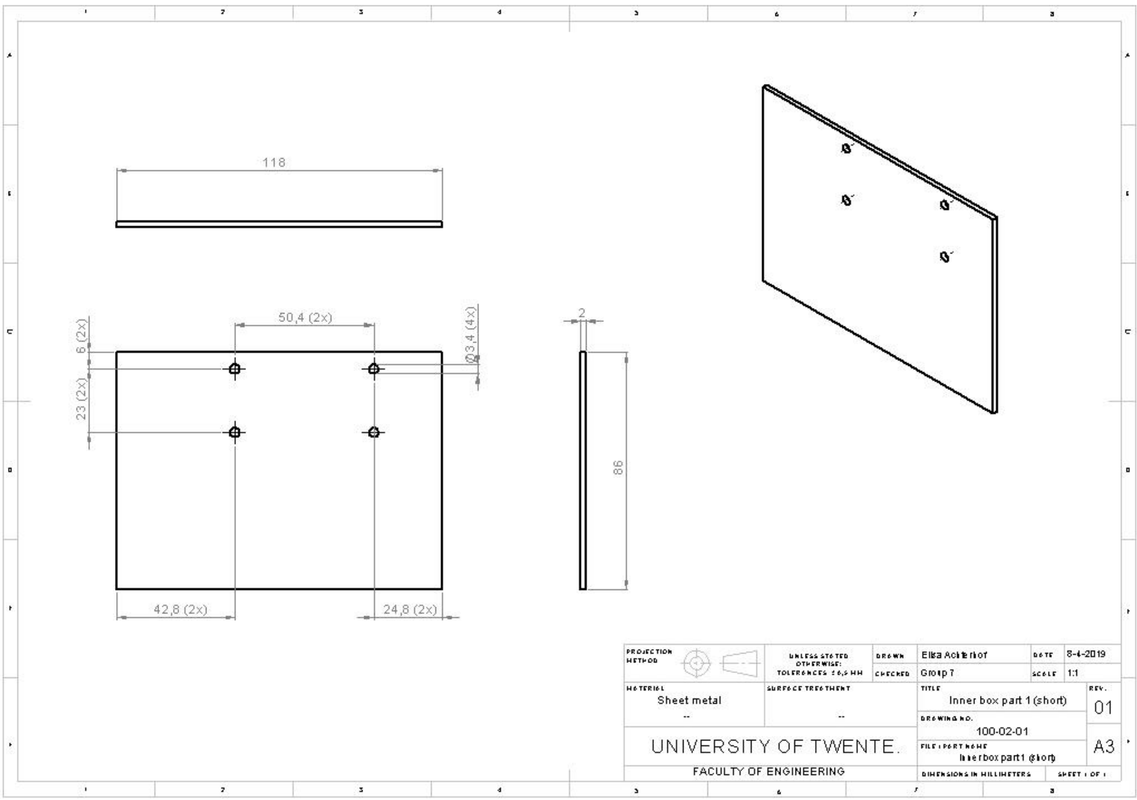


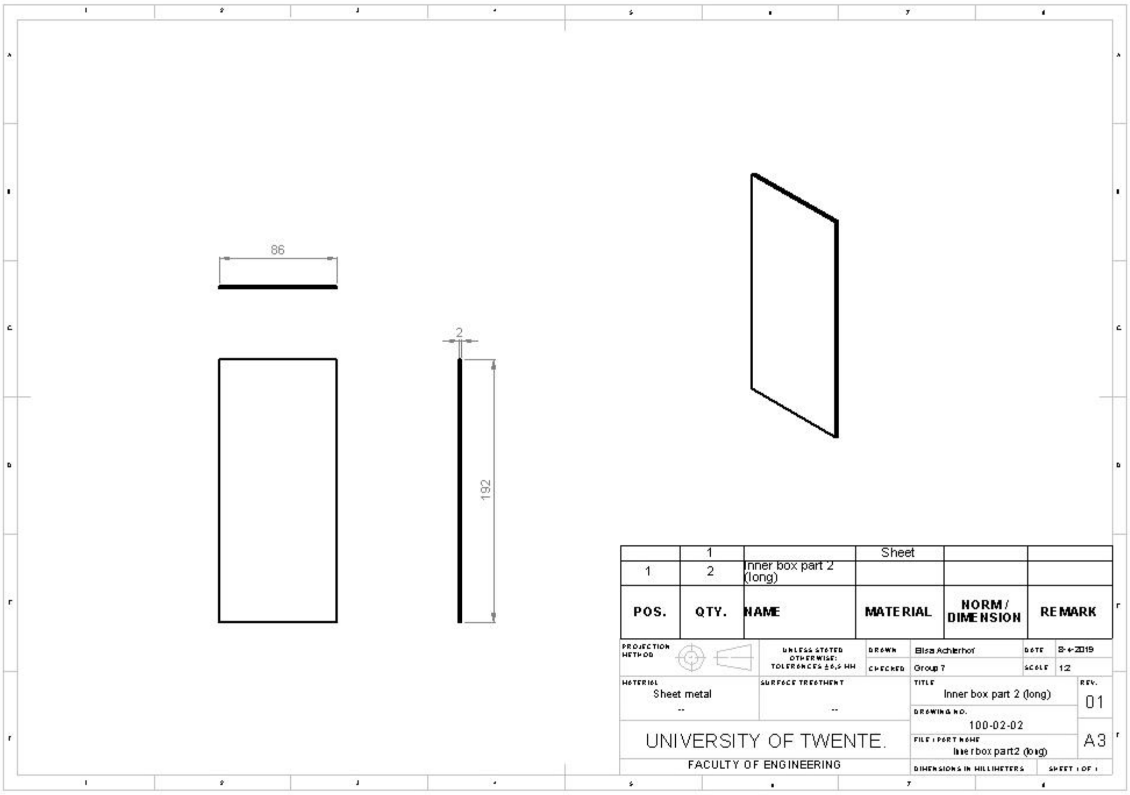
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Outer box part		2

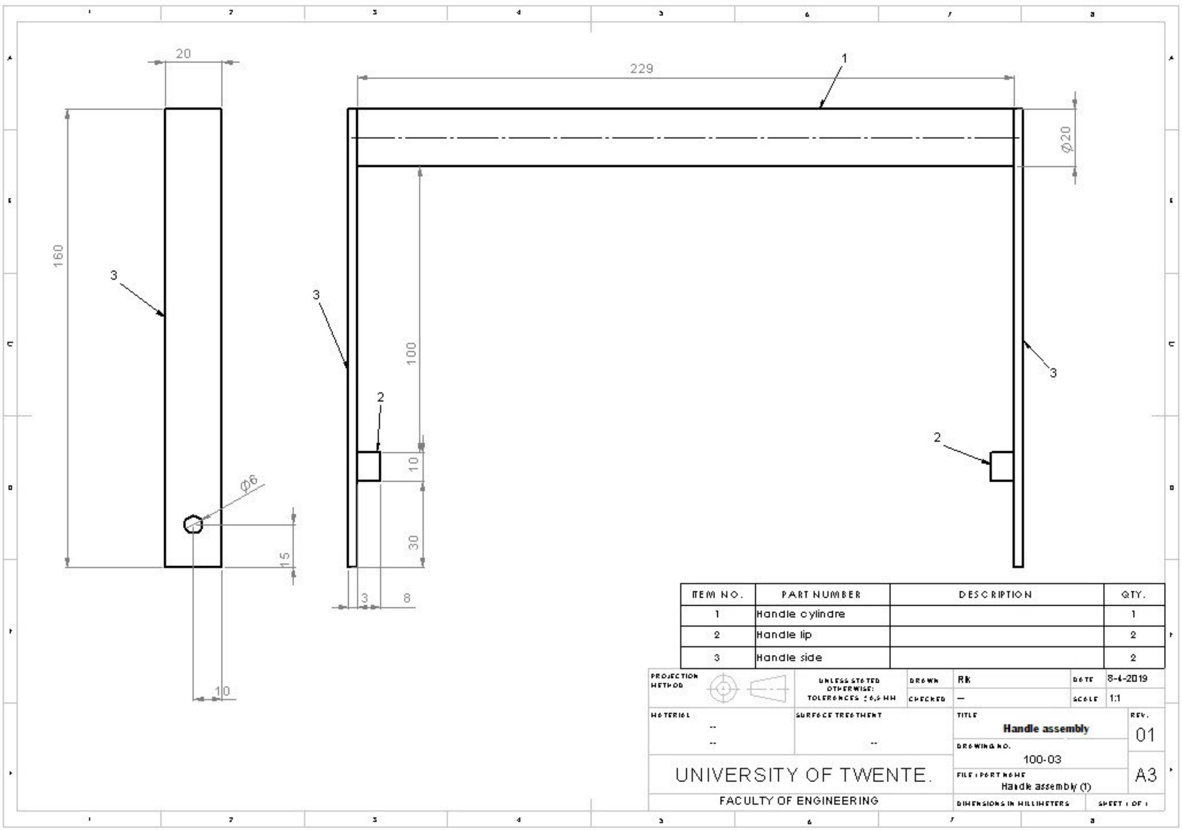

200
2
1
R3
12
127
66
33
33
65
⌀6
20
⌀6
47
132
1
ITEM NO.
PART NUMBER
DESCRIPTION
QTY.
1
Outer box part
2
PROJECTION METHOD
UNLESS STATED OTHERWISE: TOLERANCES ± 0.5 MM
DRAWN --
CHECKED --
DATE 2-4-2019
SCALE 1:1
MATERIAL --
SURFACE TREATMENT --
TITLE NO NAME
REV. 01
DRAWING NO. 100-01
FILE / PART NAME Outer box
A3
UNIVERSITY OF TWENTE.
FACULTY OF ENGINEERING
DIMENSIONS IN MILLIMETERS
SHEET 1 OF 1

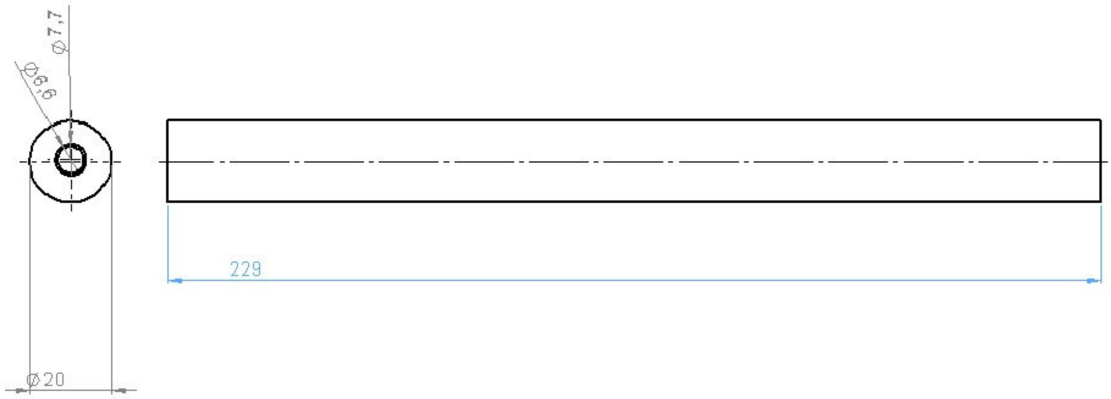

DOWN 90° R 1
DOWN 90° R 1
341,3
33
196
12
127
⌀7,2 (2x)
20
63
PROJECTION METHOD
UNLESS STATED OTHERWISE: TOLERANCES ± 0,5 MM
DRAWN Eleanne Haalstra
CHECKED --
DATE 04/04/2019
SCALE 1:2
MATERIAL sheet metal 2 mm thickness
SURFACE TREATMENT --
TITLE Outer box part
REV. 01
DRAWING NO. 100-01-01
FILE / PART NAME outer box part with holes
A3
UNIVERSITY OF TWENTE.
FACULTY OF ENGINEERING
DIMENSIONS IN MILLIMETERS
SHEET 1 OF 1


15
158
2
15
Φ3,4 (8x)
6
23 (4x)
2
42,8
50,4 (4x)
24,8
86
192
1
2
2 | 2 | Inner box part 2 (long)
1 | 2 | Inner box part 1 (short)
POS. | QTY. | NAME | MATERIAL | NORM / DIMENSION | REMARK
PROJECTION METHOD
UNLESS STATED OTHERWISE: TOLERANCES ±0,5 MM
DRAWN Elisa Achterhof
DATE 7-3-2019
CHECKED Group 7
SCALE 1:2
MATERIAL Sheet Metal
--
SURFACE TREATMENT
--
TITLE Inner Box
REV. 01
DRAWING NO. 100-02
UNIVERSITY OF TWENTE.
FILE / PART NAME Inner box
A3
FACULTY OF ENGINEERING
DIMENSIONS IN MILLIMETERS
SHEET 1 OF 1

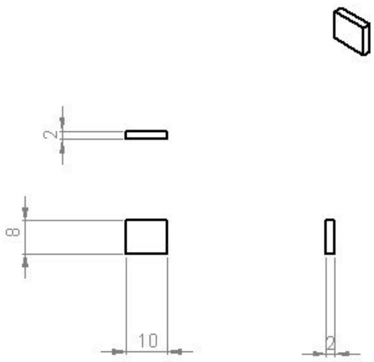

118
50,4 (2x)
6 (2x)
23 (2x)
Φ3,4 (4x)
2
86
42,8 (2x)
24,8 (2x)
PROJECTION METHOD
UNLESS STATED OTHERWISE: TOLERANCES ±0,5 MM
DRAWN Elisa Achterhof
DATE 8-4-2019
CHECKED Group 7
SCALE 1:1
MATERIAL Sheet metal
--
SURFACE TREATMENT
--
TITLE Inner box part 1 (short)
REV. 01
DRAWING NO. 100-02-01
UNIVERSITY OF TWENTE.
FILE / PART NAME Inner box part 1 (short)
A3
FACULTY OF ENGINEERING
DIMENSIONS IN MILLIMETERS
SHEET 1 OF 1


86
2
192
1
Sheet
1
2
Inner box part 2 (long)
POS.
QTY.
NAME
MATERIAL
NORM / DIMENSION
REMARK
PROJECTION METHOD
UNLESS STATED OTHERWISE: TOLERANCES ±0,5 MM
DRAWN
Elisa Achterhof
DATE
8-4-2019
CHECKED
Group 7
SCALE
1:2
MATERIAL
Sheet metal
--
SURFACE TREATMENT
--
TITLE
Inner box part 2 (long)
REV.
01
DRAWING NO.
100-02-02
UNIVERSITY OF TWENTE.
FILE / PART NAME
Inner box part2 (long)
A3
FACULTY OF ENGINEERING
DIMENSIONS IN MILLIMETERS
SHEET 1 OF 1

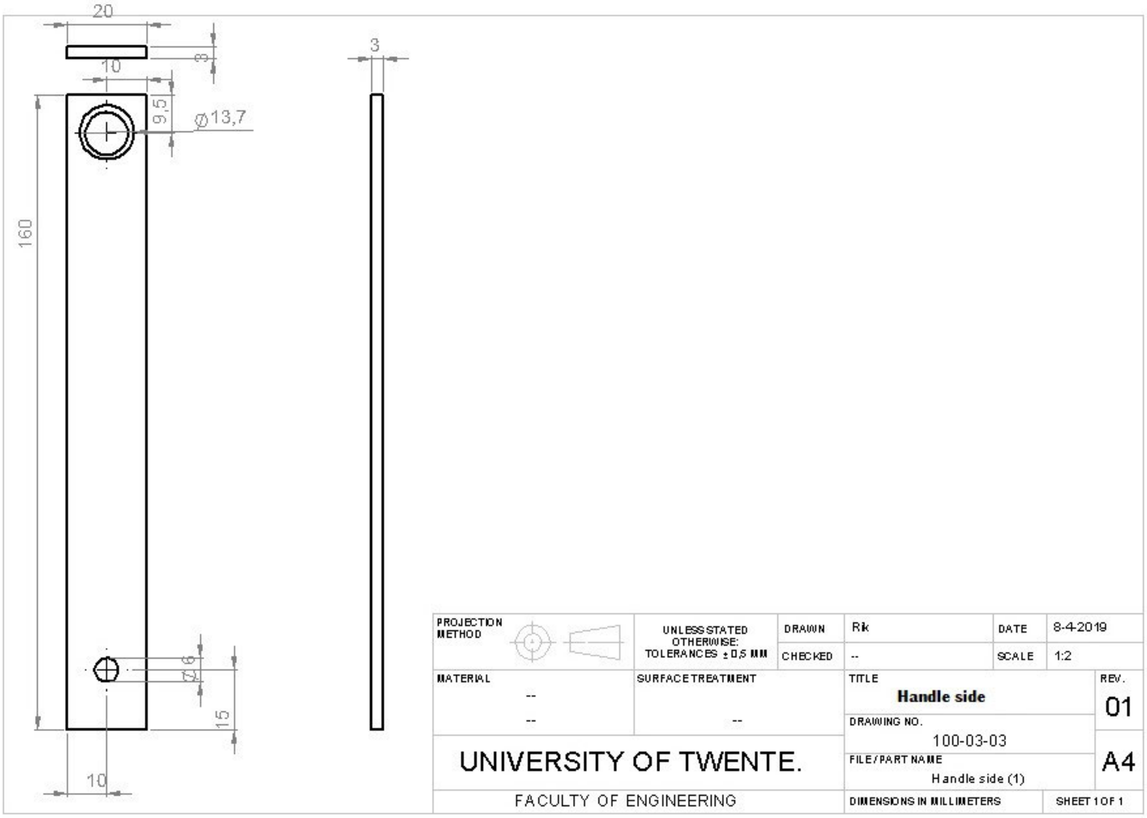

20
229
1
Ø20
160
3
3
100
3
2
2
10
Ø6
30
15
3
8
10
ITEM NO.
PART NUMBER
DESCRIPTION
QTY.
1
Handle cylindre
1
2
Handle lip
2
3
Handle side
2
PROJECTION METHOD
UNLESS STATED OTHERWISE: TOLERANCES ±0,5 MM
DRAWN
Rik
DATE
8-4-2019
CHECKED
--
SCALE
1:1
MATERIAL
--
--
SURFACE TREATMENT
--
TITLE
Handle assembly
REV.
01
DRAWING NO.
100-03
UNIVERSITY OF TWENTE.
FILE / PART NAME
Handle assembly (1)
A3
FACULTY OF ENGINEERING
DIMENSIONS IN MILLIMETERS
SHEET 1 OF 1

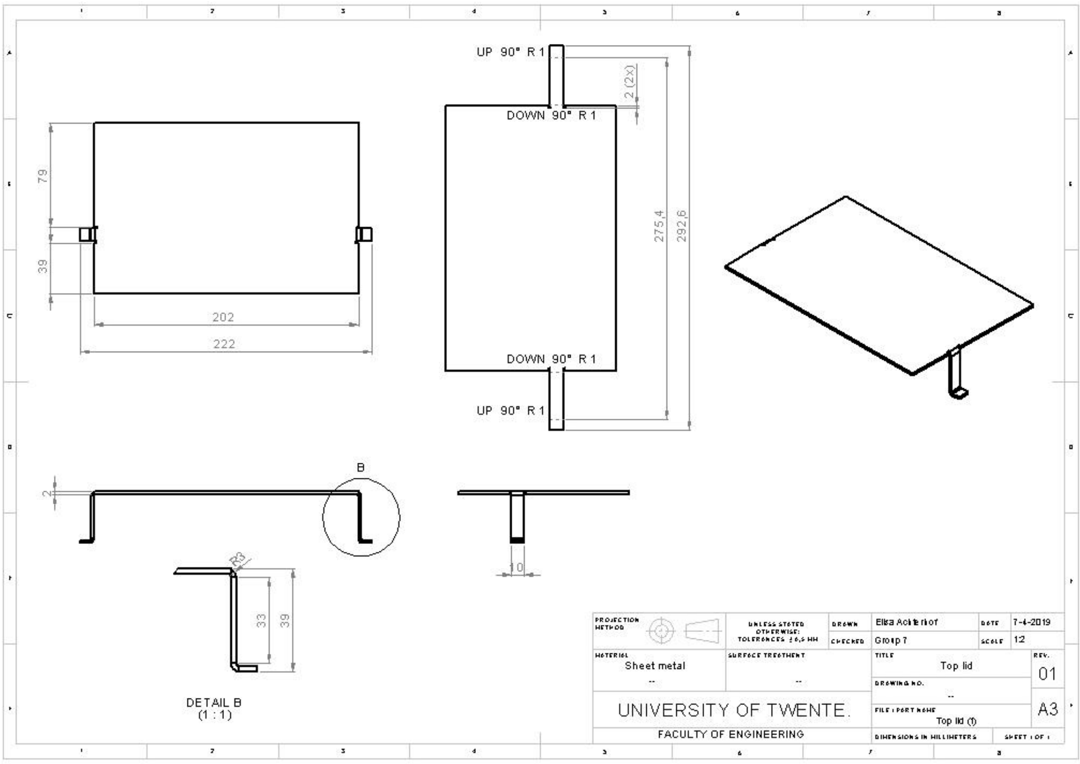


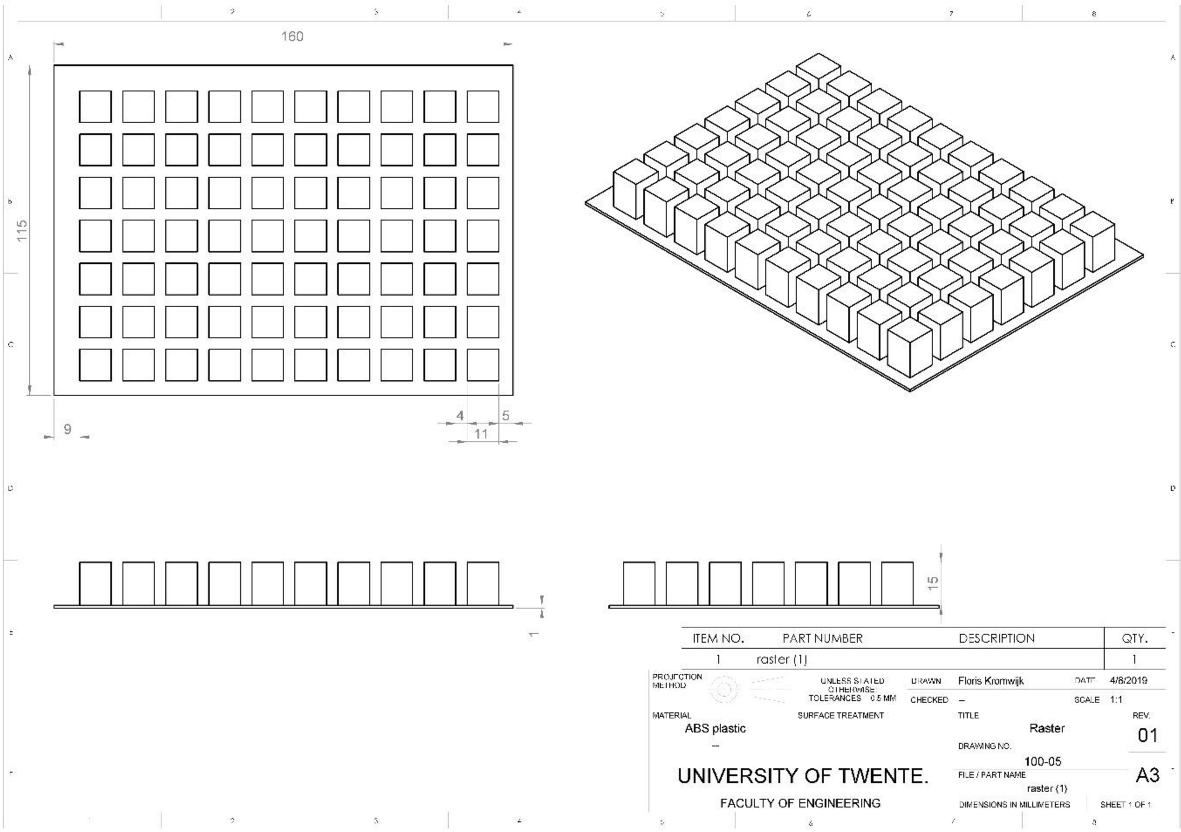
PROJECTION METHOD		UNLESS STATED OTHERWISE: TOLERANCES ±0,5 mm	DRAWN	Rik	DATE	8-4-2019
			CHECKED	--	SCALE	1:5
MATERIAL -- --	SURFACE TREATMENT --		TITLE **Handle cylinder**		REV. 01	
UNIVERSITY OF TWENTE.			DRAWING NO. 100-03-01		A4	
			FILE / PART NAME Handle cylindre (1)			
FACULTY OF ENGINEERING			DIMENSIONS IN MILLIMETERS		SHEET 1 OF 1	

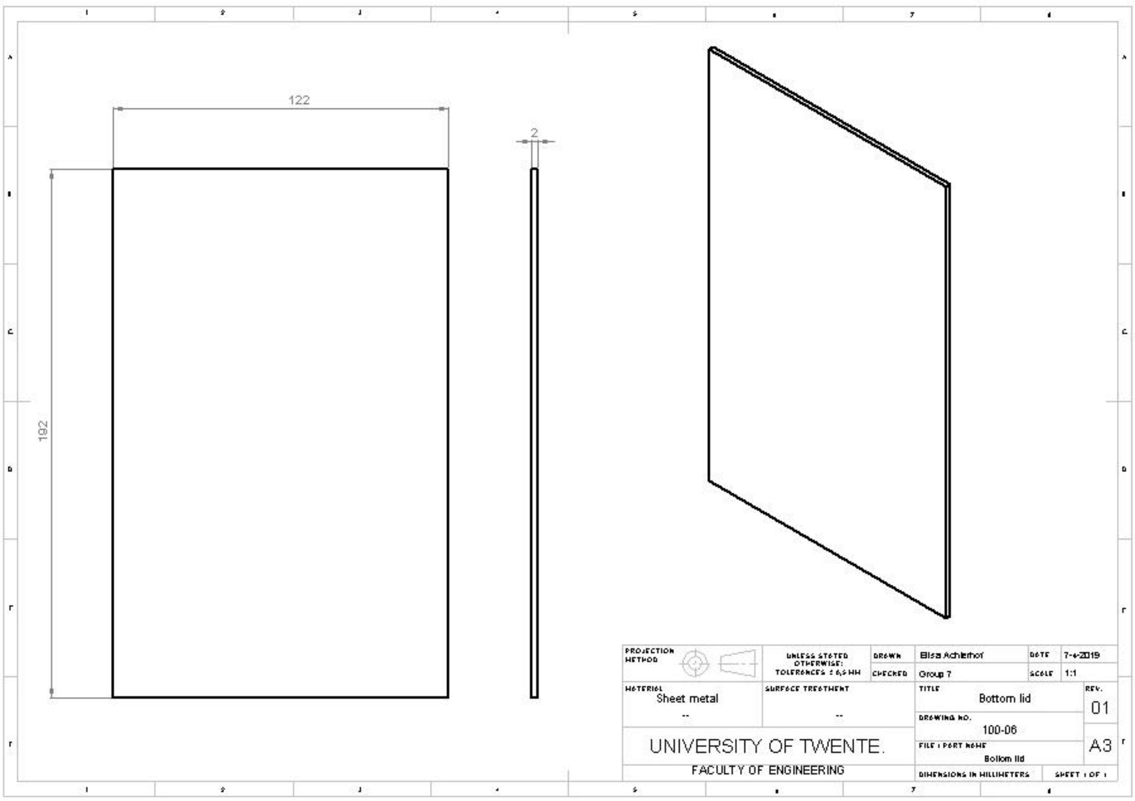


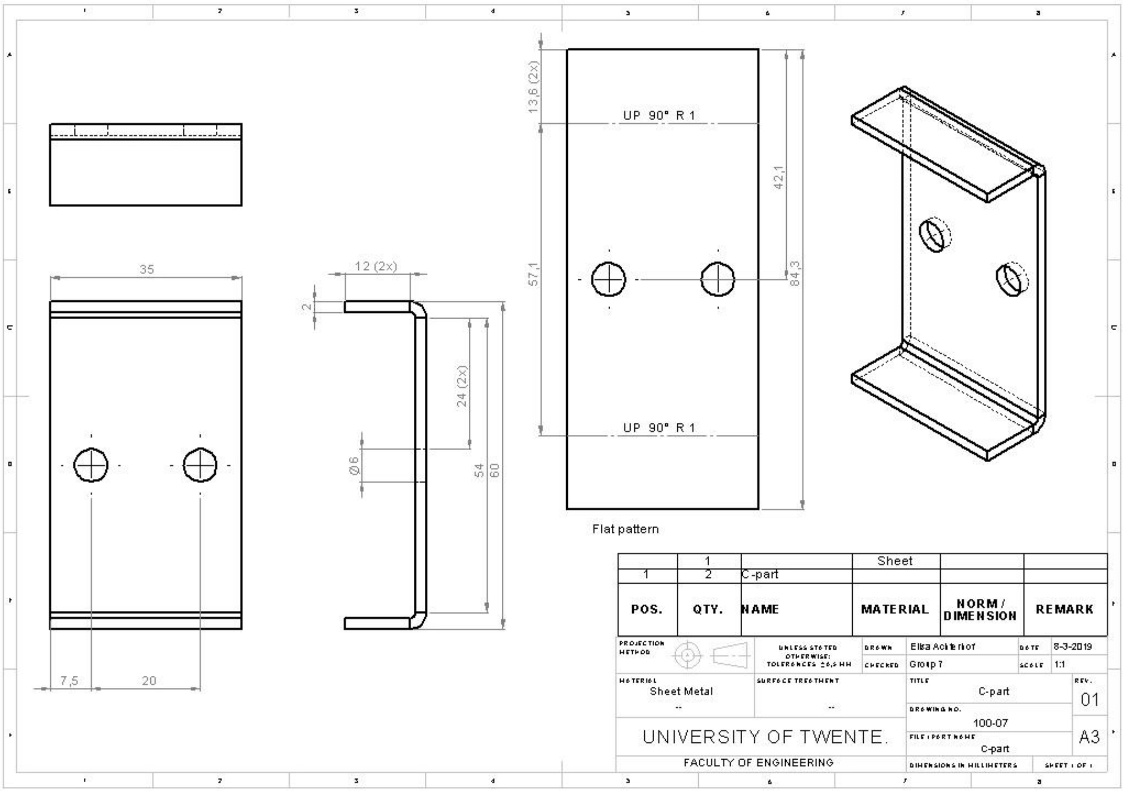
PROJECTION METHOD		UNLESS STATED OTHERWISE: TOLERANCES ±0,5 mm	DRAWN	Rik	DATE	8-4-2019
			CHECKED	--	SCALE	1:1
MATERIAL -- --	SURFACE TREATMENT --		TITLE **Handle lip**		REV. 01	
UNIVERSITY OF TWENTE.			DRAWING NO. 100-03-02		A4	
			FILE / PART NAME Handle lip (1)			
FACULTY OF ENGINEERING			DIMENSIONS IN MILLIMETERS		SHEET 1 OF 1	

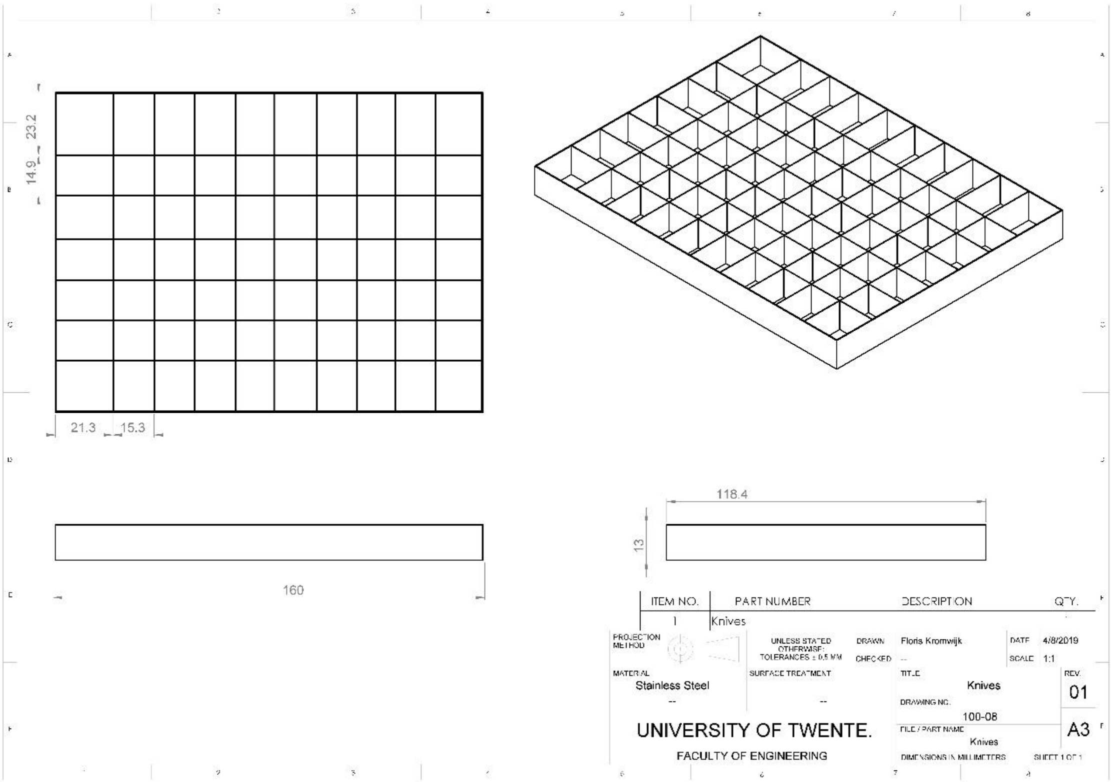

20
3
10
9,5
Ø13,7
3
160
Ø6
15
10
PROJECTION METHOD
UNLESS STATED OTHERWISE: TOLERANCES ±0,5 MM
DRAWN
Rik
DATE
8-4-2019
CHECKED
--
SCALE
1:2
MATERIAL
--
--
SURFACE TREATMENT
--
TITLE
Handle side
REV.
01
DRAWING NO.
100-03-03
UNIVERSITY OF TWENTE.
FILE/PART NAME
Handle side (1)
A4
FACULTY OF ENGINEERING
DIMENSIONS IN MILLIMETERS
SHEET 1 OF 1


UP 90° R 1
DOWN 90° R 1
2 (2x)
79
39
202
222
275,4
292,6
DOWN 90° R 1
UP 90° R 1
B
2
10
R3
33
39
DETAIL B
(1 : 1)
PROJECTION METHOD
UNLESS STATED OTHERWISE: TOLERANCES ±0,5 MM
DRAWN
Elisa Achterhof
DATE
7-4-2019
CHECKED
Group 7
SCALE
12
MATERIAL
Sheet metal
--
SURFACE TREATMENT
--
TITLE
Top lid
REV.
01
DRAWING NO.
--
UNIVERSITY OF TWENTE.
FILE/PART NAME
Top lid (1)
A3
FACULTY OF ENGINEERING
DIMENSIONS IN MILLIMETERS

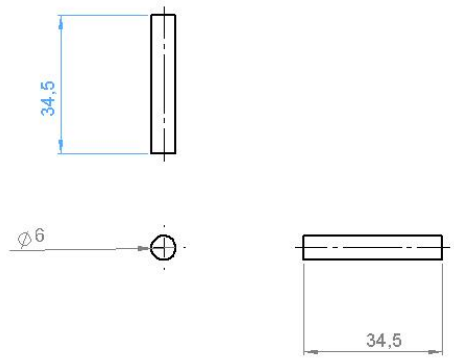

160
115
4
5
9
11
15
1
ITEM NO.
PART NUMBER
DESCRIPTION
QTY.
1
raster (1)
1
PROJECTION METHOD
UNLESS STATED OTHERWISE: TOLERANCES 0.5 MM
DRAWN
Floris Kromwijk
DATE
4/8/2019
CHECKED
--
SCALE
1:1
MATERIAL
ABS plastic
--
SURFACE TREATMENT
TITLE
Raster
REV.
01
DRAWING NO.
100-05
UNIVERSITY OF TWENTE.
FILE / PART NAME
raster (1)
A3
FACULTY OF ENGINEERING
DIMENSIONS IN MILLIMETERS
SHEET 1 OF 1


122
2
192
PROJECTION METHOD
UNLESS STATED OTHERWISE: TOLERANCES ±0,5 MM
DRAWN
Elisa Achterhof
DATE
7-4-2019
CHECKED
Group 7
SCALE
1:1
MATERIAL
Sheet metal
--
SURFACE TREATMENT
--
TITLE
Bottom lid
REV.
01
DRAWING NO.
100-06
UNIVERSITY OF TWENTE.
FILE / PART NAME
Bottom lid
A3
FACULTY OF ENGINEERING
DIMENSIONS IN MILLIMETERS
SHEET 1 OF 1

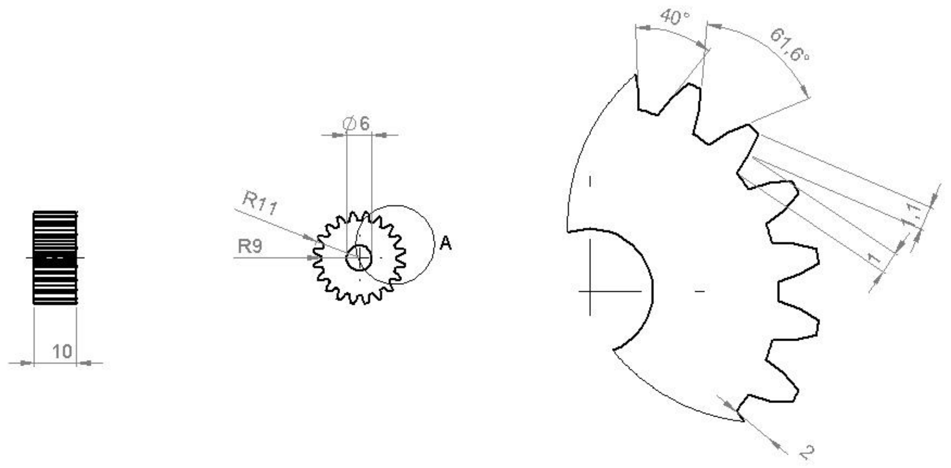

35
12 (2x)
2
24 (2x)
Ø6
54
60
7,5
20
13,6 (2x)
UP 90° R 1
42,1
57,1
84,3
UP 90° R 1
Flat pattern
1
Sheet
1
2
C-part
POS.
QTY.
NAME
MATERIAL
NORM / DIMENSION
REMARK
Elisa Achterhof
8-3-2019
Group 7
1:1
Sheet Metal
C-part
01
100-07
UNIVERSITY OF TWENTE.
A3
C-part
FACULTY OF ENGINEERING


14.9
23.2
21.3
15.3
118.4
13
160
ITEM NO.
PART NUMBER
DESCRIPTION
QTY.
1
Knives
PROJECTION METHOD
UNLESS STATED OTHERWISE: TOLERANCES ± 0.5 MM
DRAWN
Floris Kromwijk
DATE
4/8/2019
SCALE
1:1
MATERIAL
Stainless Steel
SURFACE TREATMENT
TITLE
Knives
REV.
01
DRAWING NO.
100-08
UNIVERSITY OF TWENTE.
FILE / PART NAME
Knives
A3
FACULTY OF ENGINEERING
DIMENSIONS IN MILLIMETERS

PROJECTION METHOD	UNLESS STATED OTHERWISE: TOLERANCES ± 0,5 MM	DRAWN	Rik	DATE	8-4-2019	
		CHECKED	--	SCALE	1:1	
MATERIAL -- --	SURFACE TREATMENT --	TITLE	Shaft gear			REV. 01
		DRAWING NO.	100-09			
UNIVERSITY OF TWENTE.		FILE / PART NAME	Shaft gear			A4
FACULTY OF ENGINEERING		DIMENSIONS IN MILLIMETERS		SHEET 1 OF 1		

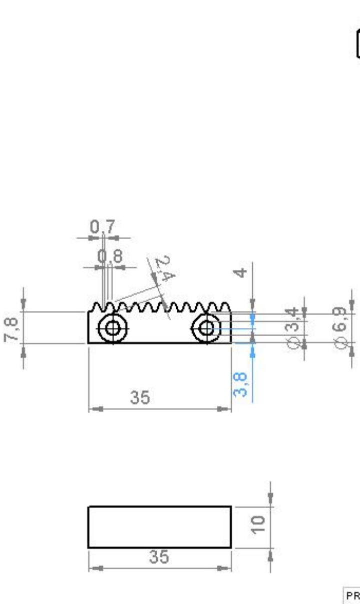


PROJECTION METHOD	UNLESS STATED OTHERWISE: TOLERANCES ± 0,5 MM	DRAWN	Rik	DATE	8-4-2019	
		CHECKED	--	SCALE	1:1	
MATERIAL -- --	SURFACE TREATMENT --	TITLE	Shaft handle			REV. 01
		DRAWING NO.	100-10			
UNIVERSITY OF TWENTE.		FILE / PART NAME	Shaft handle			A4
FACULTY OF ENGINEERING		DIMENSIONS IN MILLIMETERS		SHEET 1 OF 1		



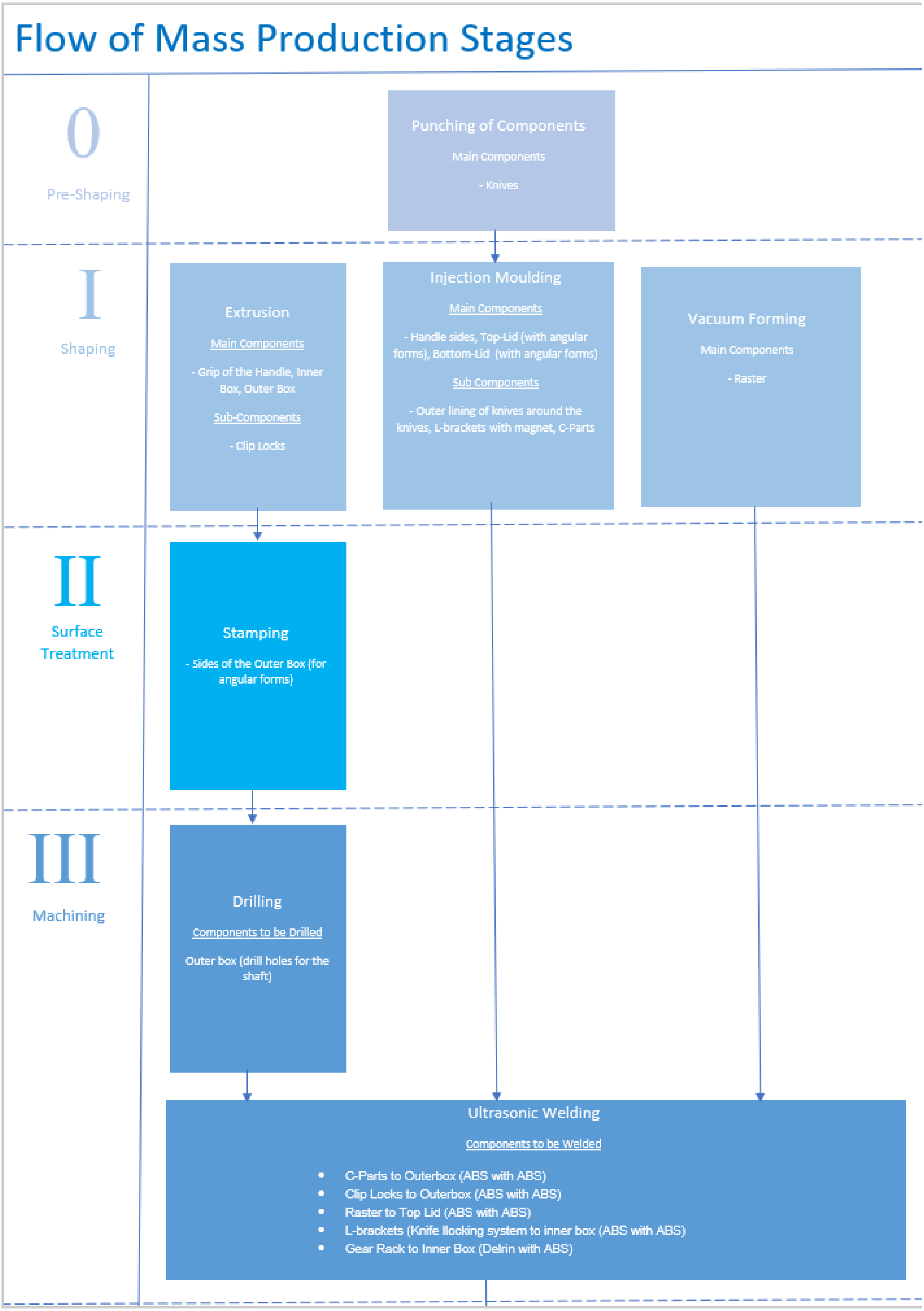
DETAIL A
(5 : 1)

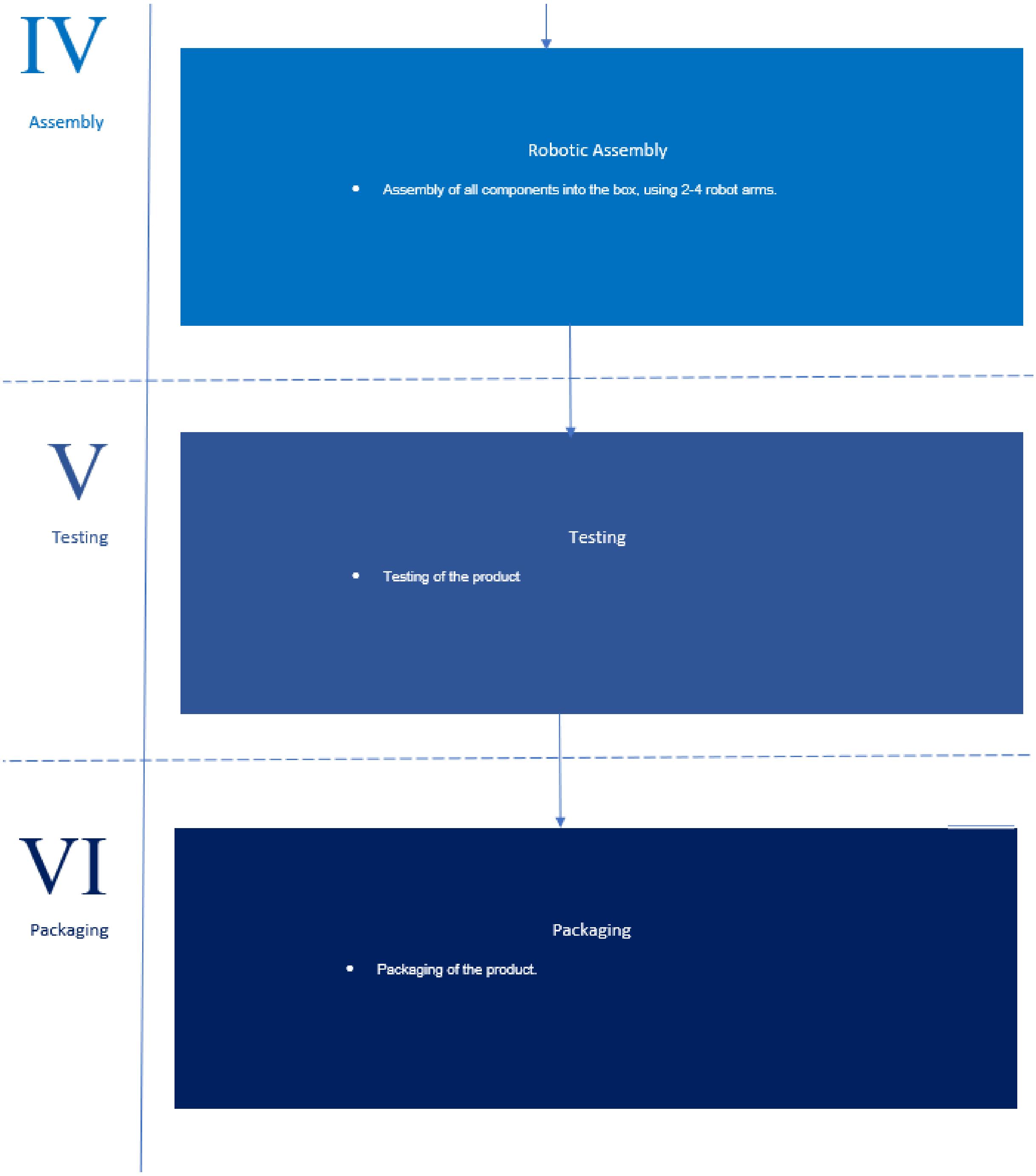
PROJECTION METHOD		UNLESS STATED OTHERWISE: TOLERANCES ± 0,5 MM	DRAWN	Rik	DATE	8-4-2019
			CHECKED	--	SCALE	1:1
MATERIAL -- --	SURFACE TREATMENT --		TITLE	Gear		REV. 01
			DRAWING NO.	100-11		
UNIVERSITY OF TWENTE.			FILE / PART NAME	Gear		A4
FACULTY OF ENGINEERING			DIMENSIONS IN MILLIMETERS		SHEET 1 OF 1	



PROJECTION METHOD		UNLESS STATED OTHERWISE: TOLERANCES ± 0,5 MM	DRAWN	--	DATE	8-4-2019
			CHECKED	--	SCALE	1:1
MATERIAL -- --	SURFACE TREATMENT --		TITLE	Gear rack		REV. 01
			DRAWING NO.	100-12		
UNIVERSITY OF TWENTE.			FILE / PART NAME	Gear rack (1)		A4
FACULTY OF ENGINEERING			DIMENSIONS IN MILLIMETERS		SHEET 1 OF 1	

FLOW CHART OF MASS PRODUCTION STAGES




IV
Assembly
Robotic Assembly
Assembly of all components into the box, using 2-4 robot arms.
V
Testing
Testing
Testing of the product
VI
Packaging
Packaging
Packaging of the product.

Assignment 1: Product Quality Assignment

List of Requirements

For this project, two list of requirements exist, one is that for the prototype, and the other is that for the mass product. The list of requirement used would be that for the prototype, since the Kano Model and House of Quality can serve as useful tools to translate the current list of requirements into development goals for the development of the prototype. For the Mass Product, further development would be done based on the prototype using FMEA. In where the FMEA would be used as a tool to turn the prototype into a mass product model based on the result of the testing and research.

List of requirements Prototype

Constraints

- Enough force to cut vegetables (like unions and carrots)
- Doesn’t take more than 300 N to cut vegetables
- Safety for the user when both cutting and washing
- Function mechanically
- Operated manually
- Space to storage the vegetables
- Portable:
    - carry the product by the handle (like a suitcase)
    - Dimensions of closed box up to 150*60*200 mm

- If we make a 180 degree movement with the handle, the top part must go down 32 mm

Objectives

- Power transmission that makes the cutting as easy as possible
- Angular style look
- Easy to clean
- Portable:
    - as light as possible

List of requirements Mass Product

Constraints

- Enough force to cut vegetables (like unions and carrots)
- User doesn’t have to exert more than 500 Newtons to cut vegetables
- Safety for the user when both cutting and washing
- Knives squared mesh to cut vegetables in squares
- Material water and acid resistant
- Space to storage vegetables (for 2 times cutting)
- Function mechanically
- Operated manually
- Angular style look
- Portable:
    - Dimensions of closed box up to 150*60*200 mm
    - Weight less than 2 kg
    - Carry the product by the handle (like a suitcase)

Objectives

- Power transmission that makes the cutting as easy as possible

- Easy to clean
- Portable:
    - as light as possible
- Can be used fast
- Make the product as aesthetic pleasing as possible

- weight less than 1 kg

KANO MODEL

From the list of requirement from the prototype, the constraints and objectives are filtered out into the 6 quality aspects of the Kano Model. Later on we use these performance factors for the house of quality.

QUALITY ASPECTS

Must-Be/ Must Have

Must-Be/ Must Have qualities are basic qualities that are necessary for the product to have. Although often ignored by the customer at first sight, the absence of these factors could lead to the customer to very quickly and for a long term perceive the product with low quality, and could lead them to not trust the product itself.

- Must cut vegetables is a basic quality, as it is the basic requirement of the product. If the product fails to meet this requirement the user would immediately perceive the product with a bad quality. This is because this requirement is the reason they bought the product in the first place. Therefore it is a minimal requirement for the product to cut vegetables, so the basic needs of the customer are met.
- Functions mechanically is a basic quality, as it is a basic requirement of the product. If the product isn't able to function mechanically, it technically means it is broken. This would result in the customer not perceiving the product with a lot of quality. Therefore it is a minimal requirement for the product to function, so that the basic needs of the customer are met.
- Safe usage is a basic quality, as it is a basic necessity for the product. Not having it would make the product have a low quality and ergonomic perception. Customers wouldn't like to buy unsafe products, as they might perceive them as untrustworthy orr threats to their environments. Therefore it is a necessity for the product to operate safely.
- Manual operation of the product is a basic quality, as based on the task given the product may not be operated with use of electronics or motors. Customers would also need to be able to operate the product without the need of any mechanical assistance, as if mechanical assistance would be required, usage would become much more complex which would impact the customer negatively. Therefore it is necessary for the product to be operated manually.

Performance

Performance qualities are function type of qualities, which increase the customers perception when more of the certain aspect is present, and decrease when it becomes more absent. Performance factors can also be seen as wishes the customer has for the product, in which the product would be perceived more positively the closer the product is in achieving their wish. Performance qualities also play key in the Kano Model, as they are used for further working in the House of Quality.

- The amount of force required by the user to cut the vegetables is a performance quality, as the less force is required the better the product is perceived by the customer. This is because customers prefer to use the product easily and with minimal difficulty, which is influenced a lot by the amount of force they use for the product. Since it is also a wish for the customer to use less force when operating the product, the forces used are therefore a performance quality.
- The weight of the box is a performance quality, as the lighter the product weights, the more comfortable and attractive the product becomes for the customer. This is because it would be easier for the customer to use the product when it is lighter, such as for carrying the product around. Since the weight reduction is also a wish of the customer, it is therefore a performance quality.

- The more storage the product is able to hold, the more useful and attractive the product becomes for the customer. The more storage the product has for vegetables, the happier the customer becomes, as they can use the space to store more vegetables. This would make the customer more satisfied, as they could more efficiently transport and store larger quantities of vegetables, making their lives in the end easier. Since more storage would influence the customer more positively, it is a performance factor.
- Easy to clean is a performance quality, as the easier it is to clean and re-use the product, the much better quality perception the user gets. Although this quality can be seen as a basic quality, it is a performance quality as it is one of the wishes the customers have for the product. Making the product more easily cleanable would make the customers more happy and perceive the product more positively, as it would make their lives easier.
- Portability of the product is a performance quality, as the more easier it is for the customer to carry the product with you, the more convenient they would perceive the product. More handiness or better portability would make the customer perceive the product with higher quality. When our product is easier to carry with you it is seen superior for customers when compared to if our product was not easy to carry with you.
- Ease of usage of the product is a performance quality, as the more easier it is for the customer to understand how to use the product, the more ergonomic they would perceive the product. Higher ergonomy or user friendliness would make the customer perceive the product with higher quality as product that are easier to use are seen more superior for customers when compared to complex and difficult to operate products. Since the customer also often wishes for a product to be operated in the most simple way possible, it is therefore a performance factor.
- The price of the product is a performance quality as more reasonable prices would give an increased positive perception from customers for the product. Although low price doesn’t always mean the best quality, as customers could perceive the product to be made out of cheap materials then, a reasonable low price would say otherwise. This is because the better the pricing is for the product’s value, the more likely the customer would see that the price matches the value of the product, and therefore the more easily they can see that the quality of the product is good. Therefore price is a performance quality as it determines the performance the product has in the market. This is determined by the ability for the price to persuade customers that the product is a good value of their money. Meaning that it is of price is low but the quality of the product is high. The more reasonable the price the more effective it is in exploiting the positive qualities of the product, and it is because of this that price too is a performance quality.

Excitement
Excitement qualities are aspects of the product that are not necessarily required, but when present would immediately make the product more attractive for the customer.

- The addition of angular forms is an excitement factor, as although it is not completely necessary for the product itself, it does make the product stand out and more exciting too look at for the user.

Indifferent
Indifferent quality factors are aspects of the product that do not necessarily impact the perception of the customer if more or less of it is present.

- The gear system inside the product does not affect the customers perception.

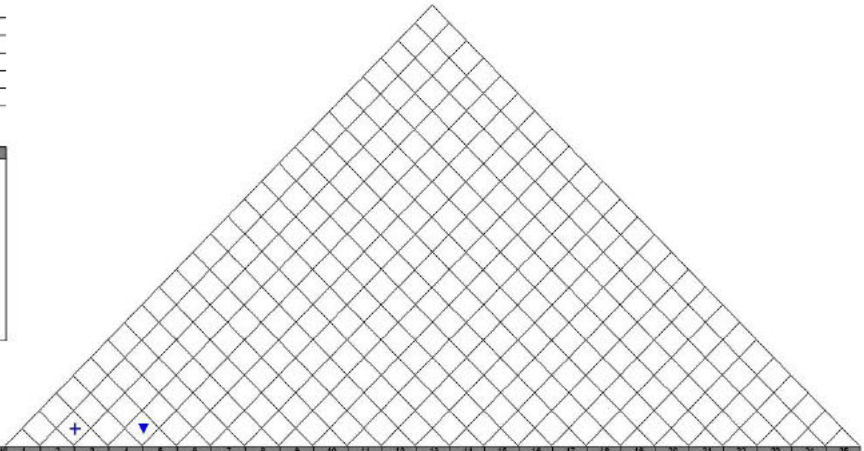
Reverse performance
Reverse performance quality factors are aspects of the products which should not be made abundant as it does not interest the customer.

- The size of the box is a reverse performance factor. First you think a bigger box is more handy because you can storage more vegetables, but from a given moment, as the bigger the product, the more unhandy the product becomes for the customer. The product would become less portable for example. This would lead to making the customer perceive the product negatively if the size would be too large.

House of Quality

Title: Vegetable Cutter
Author: Group 7
Date: 3/23/2019
Notes:

Legend		
Θ	Strong Relationship	9
O	Moderate Relationship	3
▲	Weak Relationship	1
++	Strong Positive Correlation	
+	Positive Correlation	
−	Negative Correlation	
▼	Strong Negative Correlation	
▼	Objective Is To Minimize	
▲	Objective Is To Maximize	
X	Objective Is To Hit Target	



Row #	Max Relationship Value in Row	Relative Weight	Weight / Importance	Quality Characteristics (a.k.a. "Functional Requirements" or "Hows") / Demanded Quality (a.k.a. "Customer Requirements" or "Whats")	Meet EU standards	Number of gears used	Handle height	Container volume	Size of housing	Sharpness of knives	Rubber pads	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
				Column #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
				Direction of Improvement: Minimize (▼), Maximize (▲), or Target (x)		X	▼	▲	▼	▲																			
	9	11.1	3.0	ightweight			O		Θ																				
3	9	14.8	4.0	Sufficient storage				Θ	Θ																				
4	3	11.1	3.0	Easily Cleanable				O	O	O																			
5	9	11.1	3.0	Portability			O	▲	Θ																				
6	9	18.5	5.0	Safe	Θ					Θ	▲																		
7	9	14.8	4.0	Ease of usage			O	O	Θ		Θ																		
8																													
9																													
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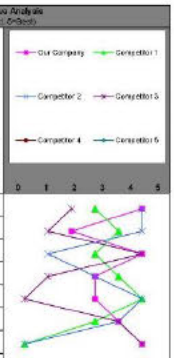
25																													
				Target or Limit Value					150*80*200 mm		4																		
				Difficulty (0=Easy to Accomplish, 10=Extremely Difficult)	7	8	4	7	7	6	1																		
				Max Relationship Value in Column	9	9	9	9	9	9	9																		
				Weight / Importance	166.7	166.7	277.8	222.2	600.0	366.7	181.9																		
				Relative Weight	9.0	9.0	15.0	12.0	27.0	19.8	8.2																		

Competitive Analysis (0=Worst, 5=Best)

Our Company	Competitor 1	Competitor 2	Competitor 3	Competitor 4	Competitor 5
5	3	5	2		
2	4	5	1		
5	3	1	5		
3	4	3	1		
3	5	5	0		
4	3	4	4		
5	0	0	5		



Room 1: Performance Criteria

From the Kano Model Analysis, we have successfully filtered the original list of requirements and obtained the following performance qualities. The reason why the following qualities are performance qualities is because they are wishes the customer have for the product, and increase the products quality perception when they become more present.

1. Minimal force
2. Light weight
3. Sufficient Storage
4. Easily Cleanable
5. Portable
6. Safe
7. Ease of usage

Room 3: Technical Aspects (This part is for Room 3 in the HoQ)

1. Meet EU safety standards
2. Number of gears used
3. Handle length
4. Container volume
5. Size of housing
6. Knives
7. Rubber pads

Room 2. Benchmarking

We need to compare our product to other companies products. Therefore we choose 3 other vegetable cutters and looked at the reviews and specifications of the product to compare them with our vegetable cutter. We need to give a mark to every performance criteria, this mark can be given based on the reviews which people gave to the product. All the products come from the site bol.com.

Competitor 1

Combined reviews from certain clients:
The product is very powerful. But sometimes it is hard to cut tough vegetables. Because there are no cables attached, you can easily grab the device. Cleaning is also easy in the dishwasher. Only sometimes water stays in the product. Also ideal to take with you and prepare something fresh on the spot. When you use the product you can't touch the knives, otherwise you could.
The product doesn't have rubber pads at the bottom.
Price: 25 euro
Weight: 868 grams

Competitor 2

Combined reviews from certain clients:
Product works very good for unions, paprika, garlic and and other small tapas dishes. It is quite strong. The storage tray is easy to clean but knives are a bit harder to clean. There is not very much storage place for the vegetables. You can very easy carry the product with you.
The product doesn't have rubber pads at the bottom.
Price: 13 euros
Weight: 120 grams

Competitor 3

Combined reviews from certain clients:
Very extensive vegetable cutter. However, the blades are not sharp enough. Tomatoes are too soft to cut properly and, for example, onions are too hard again. In addition, the vegetable cutter is not dishwasher safe. A lot of space for storage of the vegetables, but you can't take the product with you.
The product has rubber pads at the bottom.
Price: 38 euros
Weight: 1600 grams

Analyse the House of Quality

Benchmark

- We perform quite good on the force someone needs to exert to cut the vegetables. We have relatively a long handle, so someone can exert a larger moment than a vegetable cutter with no handle. So we don't really need to improve the force required.
- We see that most of the competitors' products weigh much less than 2 kg. So our constraint is still to weigh less than 2 kg, but our objective is that the vegetable cutter weighs less than 1 kg.
- We also perform quite good at sufficient storage, this is because our product compared to competitor 1 and 2 is a larger size and therefore has more space for storage.
- We're quite average when it comes to the ease of cleaning. Our product can go in the dishwasher and the upper and down part are detachable. But it is always hard to clean in between the knives. We could try to improve the ease of cleaning but it isn't a big problem.
- The product is portable, but not the best at it, we should improve this. This is related to the size of the product. So again we should find a nice balance between the size of the housing and the container volume. Portability is also related to the weight of the product. So again we could make sure that the product weighs less.
- Our product is as safe as most of the other products. Because safety is mainly based on the sharpness of the knives and competitor 2 and 3 use almost the same knife mesh. We do use rubber pads at the bottom of the product and therefore you prevent the product from sliding away when cutting the vegetables, which achieves more safety. But safety is a performance quality therefore it is always good to improve this.
- When it comes to ease of usage, our product performs on average. Our product is portable but the products of competitor 1 and 2 are lighter and smaller. However we need to exert less force to cut the vegetables because we have a handle. Product 3 isn't suitable for taking it with you, so on this aspect we perform better than competitor 3.

Contradictions

- The size of housing and sufficient storage have a strong negative correlation. We want to minimize our size of housing. The product should be portable and easy to carry with you, so the size of the housing shouldn't be too large. On the other hand, we want to maximize our container volume. We want to have sufficient storage for the vegetables. Therefore we should come to a nice balance between these two aspects.
- The handle height and the number of gears used have a positive correlation. If we use less gears or have a smaller gear transmission ratio, the length of the handle should be longer to be able to exert the same force on the vegetables. If we hit our target with the number of gears (make such a gear system that the top part goes down the right distance), we can minimize the length of the handle.
- The sharpness of the knives and the number of gears used have a positive relation. We want to hit our target with the number of gears and maximize the sharpness of the knives. If the knives are sharper, there is less force on the gears and this has influence on the gear system.
- The sharpness of the knives and the handle height also have a positive correlation. We want to maximize the sharpness of the knives and minimize the length of the handle. If we make the knives sharper, the handle can be shorter because someone needs to exert less force to cut the vegetables.

Empty rows or columns

We don't see any empty rows or columns. This indicates that there are enough technical aspects to fulfill the voice of the customer. And that all the technical aspects indeed contribute to the customer demands. So we don't have to add technical aspects or remove technical aspects or add aspects to the voice of customer.

Relations

The most important technical aspect is: The size of the housing.
Our design task is: Design the size of the housing so that it is lightweight, it can have sufficient storage, it is easily cleanable and is portable.
Second important technical aspect: The knives
Our design task is: Design the knives so that one should exert minimal force and that the product is safe.
Third important technical aspect: The length of the handle

Our design task is: Design the length of the handle so that one should exert minimal force and that the product is lightweight and the product is portable.

<u>Conclusion</u>

What is the quality of the product?

If we compare ourselves to competitors we see that we perform already on average. But there are a few important things we could improve and we have investigated these aspects with the House of Quality.

What should be improved for the future users?

The most important aspects to improve in our product are the size of the housing, the knives and the length of the handle.

What should be improved compared to the competitors?

The weight, portability and ease of cleaning.

Assignment 2: Process Planning

Before the workshop we made a sheet with everything that needs to happen in the 4 workshops. Then per workshop we made a detailed workplan and divided the tasks for that workshop to each person. The tasks for the next workshop were based on the materials we had available and the tasks which were indeed finished the workshop before. Everyone made the technical drawing of the part they had to make in the workshop so that every measurement was clear and available. Below one sees the Excel sheet with all the tasks that needs to happen. On the next page is the detailed workplan per workshop session.

Task division parts

Part	Material	How	Dimensions	What	Who	Time estimation (min)
Inner part	2mm cold rolled sheet meta	Sheet metal cutter	2x (192*86), 2x (118*86)	Cut	Darius, Tom, Mo	5
		Double-burr		Deburr	Floris, Eliza	5
		Drill	2x 4 holes (D:3,4) in (118*86)	Drill	Floris, Eliza	30
		Welding machine	Weld 2x(192*86) together with 2x (118*86) as shown in drawing inner pai	Weld	Floris	30
Outer part	2mm cold rolled sheet meta	Sheet metal cutter	2x (341*66)	Cut	Darius, Tom, Mo	5
		Double-burr		Deburr	Eleanne, Rik	5
		Sheet metal bende	Bend as shown in drawing outer part	Bend	Eleanne, Rik	60
		Drill	Drill 2 holes in each (341*66) of (D: 7,4)	Drill	Eleanne, Rik	30
		Spot welder	Spot weld the 2 parts together	Spot weld	Eleanne, Rik	60
2x C-part	2mm cold rolled sheet meta	Sheet metal cutter	(84*35)	Cut	Darius, Tom, Mo	5
		Double-burr		Deburr	Elisa	5
		Sheet metal bende	Bend as shown in drawing C-part	Bend	Elisa	30
		Drill	Drill 2 holes in C-part of (D: 7,4)	Drill	Elisa	30
Lid upper part	2mm cold rolled sheet meta	Sheet metal cutter	(163*202) With two extensions of (45*10) on the short ends	Cut	Darius, Tom, Mo	5
		Double-burr		Deburr	Darius, Tom, Mo	5
		Sheet metal bende	Bend as shown in drawing upper lid	Bend	Darius, Tom, Mo	30
Lid under part	2mm cold rolled sheet meta	Sheet metal cutter	(192*122)	Cut	Darius, Tom, Mo	5
		Double-burr		Deburr	Darius, Tom, Mo	5
2x Handle side	3mm cold rolled sheet meta	Sheet metal cutter	(160*20)	Cut	Darius, Tom, Mo	10
		Double-burr		Deburr	Darius, Tom, Mo	5
		Drill	Drill one hole of (D:7,4) and one hole of (M6)(D:13,71)	Drill	Darius, Tom, Mo	30
		Drill		Deburr	Darius, Tom, Mo	15
Knifes	Raster	Handfile		Sand	Darius, Tom, Mo	90
		Metal scissors	(160*116)	Cut	Darius, Tom, Mo	30
		Hands		Bend	Darius, Tom, Mo	10
2x L-brackets	2mm cold rolled sheet meta	Sheet metal cutter	(120*23)	Cut	Darius, Tom, Mo	10
		Double-burr		Deburr	Darius, Tom, Mo	5
		Sheet metal bende	Bend in the middel	Bend	Darius, Tom, Mo	30
Shaft	Metal	Shaft cutter	(300), (D: 6)	Cut	Tom, Rik	10
		Sander		Sand	Tom, Rik	10
		Milling machine	(2*2*3) width, depth, length	Mill	Tom, Rik	60
		Turning table	2x (1) in length, (5) in between	Turn	Tom, Rik	60
		Shaft cutter	2* (25), 2*(37)	Cut	Tom, Rik	30
		Sander		Sand	Tom, Rik	10
4x Gear rack	Hardened metal	Hydrolic saw	(32) length	Cut	Darius	60
		Drill	2x (M3) in each	Drill	Darius	60
		Sander		Deburr	Elisa	15
Closing mechanism	Lunch box	Saw	Biggest area for glueing as possible	Cut	Elisa	15
		Sandpaper		Sand	Elisa	15
Handle		Table saw machine	(229) length	Cut	Darius, Tom, Mo	15
		Sandpaper		Sand	Darius, Tom, Mo	15
Angular forms	Blue foam	Hot wire cutter		Cut	Mo	90
		Sandpaper		Sand	Mo	90
4x gear	Plasic	SLS printer	20 teeth, inner (D:6) Module 1, width of (10)	Print	Tom Vaneker	n.v.t.
Key	2mm cold rolled sheet meta	Sheet metal cutter	(2*3)	Cut	Darius, Tom, Mo	30
		Double-burr		Deburr	Darius, Tom, Mo	15
Raster	Plasic	3D printer	(192*122)	Print	Floris	90

TASK DIVISION ASSEMBLY

Assembly	How	What	Time estimation (min)	Who
C part on outer part	Welding machine	Weld	60	Rik
Handlesides on shaft	Scewdriver	Screw	10	Tom
Knifes on L-brackets	2 component glue	Glue	20	Eleanne
L-brackets on inner box	Spotwelder	Spotweld	20	Rik, Mo
Gear rack on inner box	Scewdriver	Screw	15	Darius
Closing mechanism on both lid	2 component glue	Glue	60	Elisa, Eleanne
Handle between handlesides	Scewdriver	Screw	30	Tom
Angular forms on upper lid	2 component glue	Glue	30	Mo
Raster on lid upper part	2 component glue	Glue	30	Elisa, Eleanne
Put sleeves in holes			15	Tom, Rik
Assemble everything together		Assemble	60	Everybody
Spraypaint		Paint	120	Elisa

Detailed workplan

Workshop plan session 1

Floris and Elisa:
Inner box
4 part 2x long 2x short
2x 4 holes for the gear rack
Weld together → Floris (TAG welden)

Eleanne en Rik:
Outer box
2 parts
4 holes for the shafts sleeves
Bend
Spotweld

Elisa (while Floris is welding):
2x C part outer box
2 holes in 2 C parts for shaft and sleeve
Bend

Darius, Mo, Tom:
Lid upper part
Cut
Fold

Darius, Mo, Tom:
Lid under part
Cut

Eleanne en Rik:
2x handle side
3mm cold rolled
Cut
2 holes in each handle one shaft, one for screw

What if I am done, before workshop has ended?
-Start whit the angular forms.
- Start to assemble the prototype with needed sleeves. Use the 3D printed gears.

*Notes:*After you have cut deburr!

Everything 2mm thickness cold rolled, except for the handle

Keep testing if new parts do fit where they need to fit

Preparation

Make your own technical drawings for your parts.

WORKSHOP PLAN SESSION 2

What do we have?

Inner part (Floris Elisa) →Done

Outer part (Eleanne Rik) → UNFINISHED

C outer box (Elisa) → UNFINISHED

Lid upper part (Tom, Darius, Mo) →Done

Lid under part (Tom, Darius, Mo) →Done

Handle sides (Tom, Darius, Mo) → UNFINISHED

Shafts (Tom) → UNFINISHED

Who is going to do what?

Tom: Makes keyway in both handle sides. Makes shafts in right proportions and keyways.
Darius: Makes keyway in both handle sides. Cuts the knifes in right proportion, it must be sturdy, only if the knifes are already sharp enough, otherwise help sand. (only if you have enough time).
Mo: Cuts sheet metal part of handle (icebox closing system) and cuts and bends the L form for the knifes. And cuts the keys out of 2mm thick sheet metal.
Elisa: Makes the C parts.
Floris: Welds (Handle closing system)& sands knifes. Answers questions
Eleanne and **Rik**: Join the outer box carefully together with inner box to compare.

- **Questions? Ask Floris (or Rik).**

What is I am done, before workshop has ended?

-Connect the L forms to the inner box together with the knifes. Take a careful look where exactly to mount it.
-Start whit the angular forms.
- Start to assemble the prototype with needed sleeves. Use the 3D printed gears.

Notes:

Darius must leave at 16.00

After you have cut deburr!

Everything 2mm thickness cold rolled, except for the handle

Keep testing if new parts do fit where they need to fit

Preparation

Make your own technical drawings for your parts.

Workshop plan session 3

What do we have?

Inner part (Floris Elisa) →Done

Outer part (Eleanne Rik) → Done

C outer box (Elisa) → Done

Lid upper part (Tom, Darius, Mo) →Done

Lid under part (Tom, Darius, Mo) →Done

Handle sides (Tom, Darius, Mo) → UNFINISHED

Shafts (Tom) → UNFINISHED

Gears → UNFINISHED

Gear rack → UNFINISHED

Box closing mechanism → UNFINISHED

Knifes in the box → UNFINISHED

Wooden handle round → UNFINISHED

Who is going to do what?

Tom: Make shaft → including holes for the attachment handle
Darius: Gear rack (at least 40mm)
Mo: Angular forms
Elisa: Box closing mechanism with Eleanne
Floris: Sand gear keyway and key
Eleanne: Box closing mechanism, knifes in the box → two component glue
Rik: Make shaft with Tom

- ➔ **Questions? Ask Floris (or Rik).**

What is I am done, before workshop has ended?
- Make the wooden handle
- Help with the angular forms.
- Start to assemble the prototype with needed sleeves. Use the 3D printed gears.

Notes:

After you have cut deburr!

Everything 2mm thickness cold rolled, except for the handle

Keep testing if new parts do fit where they need to fit

Darius will go 15 minutes early (again)

Preparation

Technical drawings of the: Gear rack, gear (keyway), key, shafts, (box clips)

WORKSHOP PLAN SESSION 4 (LAST!)

What do we have?

Inner part (Floris Elisa) →Done

Outer part (Eleanne Rik) → Done

C outer box (Elisa) → Done

Lid upper part (Tom, Darius, Mo) →Done

Lid under part (Tom, Darius, Mo) →Done

Handle sides (Tom, Darius, Mo) → Done

Shafts (Tom) → UNFINISHED

Gears → UNFINISHED

Gear rack → UNFINISHED

Box closing mechanism → UNFINISHED

Knifes in the box → UNFINISHED

Wooden handle round → UNFINISHED

Who is going to do what?

Tom: Cut the shaft in right proportions, cut the key
Darius: Finish gear rack, make the wooden handle
Mo: Finish angular forms → maybe paint?, if finished then glue on top lid.
Elisa: Finish box closing mechanism, spaypaint
Floris: -
Eleanne: Glue knifes on the L-brackets, glue raster on the lid
Rik: Help Tom, weld C-parts

Darius, Elisa, Eleanne: Assemble gear racks to inner box. Assemble handle to box.

Notes:

After you have cut deburr!

Everything 2mm thickness cold rolled, except for the handle (3mm)

Keep testing if new parts do fit where they need to fit

Floris is absent

Assignment 3 Cost Estimation

In order to calculate an estimate of the cost of a product there are multiple methods. The first is by analysing the competition and deducing a market price from competing products. This will give a general idea of the general price category of your product. The drawback of this method is that it is very difficult to pinpoint where the costs lie. The other drawback is that profit and overhead rates will then not be known either, and this is a big problem as these rates are essential for a lot of companies.

To get a more precise representation of the costs of a product it is also possible to describe every production method used and assign a price to it. By doing this you can build up a very precise cost estimation that will also immediately tell you were the biggest costs are (and thus biggest opportunities to cut costs) and also how big the margins (overhead, warranty, profit) can be when selling the specific product.

Material Cost

First the list of components is drawn up with a precise description of materials and production processes. This will give us the first information about the material costs. It is also important to note that with every production process there are certain specific costs related. For example, the wasted material is different for every production process as well as being different for every produced part. In this case, the waste percentages have been related to the production process and have not been calculated specifically for every single produced component.

Part	Materials	Material Price/kg	Weight of part (kg)	Production technique	Waste percentage	Total Weight with Waste (kg)	Price of material per piece (Euro)	Price to buy product	Amount needed	Price to buy product (Euro)
Inner box	ABS Plastic	2.61	0.112	Plastic Extrusion	0.15	0.1288	0.336168			0
Outer box	ABS Plastic	2.61	0.09	Plastic Extrusion	0.15	0.1035	0.270135			0
Top lid	ABS Plastic	2.61	0.165	Injection Moulding	0.3	0.2145	0.559845			0
Bottom lid	ABS Plastic	2.61	0.073	Injection Moulding	0.3	0.0949	0.247689			0
Grip of the Handle	ABS Plastic	2.61	0.02	Plastic Extrusion	0.15	0.023	0.06003			0
Handle sides	ABS Plastic	2.61	0.04	Injection Moulding	0.3	0.052	0.13572			0
Knives	Stainless Steel	5.21	0.167	Punching	0.1	0.1837	0.957077			0
Outer Lining of Knives	ABS Plastic	2.61	0.13	Injection Moulding	0.3	0.169	0.44109			
Raster	ABS Plastic	2.61	0.027	Vacuum Forming	0.05	0.02835	0.0739935			0
Clip Locks	ABS Plastic	2.61	0.025	Plastic Extrusion	0.15	0.02875	0.0750375			0
Spur Gears	Delrin	Not available		Buy				0.3	4	1.2
Gear rack	Delrin	Not available		Buy				0.1	4	0.4
L bracket	ABS Plastic	2.61	0.02	Injection Moulding	0.3	0.026	0.06786			0
C part	ABS Plastic	2.61	0.02	Injection Moulding	0.3	0.026	0.06786			0
Shaft	Stainless Steel	5.21		Buy				0.05	4	0.2
Magnets	Neodynium	Not available		Buy				0.1	4	0.4
Total (Euro)							**3.292505**			**2.2**

Part List	Height	Width	Max Thickness	Number of surface patches	Does extrusion include hollow shape?
Inner box	192	120		1	1
Outer box	196	127		1	1
Top lid	200	127	5	5	0
Bottom lid	100	100	3	3	0
Grip of the Handle	20	20		1	0
Handle sides	100	40	2	3	0
Knives					0
Raster	190	120	1	2	0
Clip Locks	140	40	2	2	0
Spur Gears					0
Gear rack					0
L bracket	20	20	1		0
C part	120	100	2	2	0
Shaft					0
Outer Lining of Knive	100	100	3	2	0

After determining the material cost and the cost of the bought products the costs for every single process has to be determined; Injection Moulding, Plastic Extrusion, Punching and Vacuum Forming.

Injection Moulding

In order to get a good cost estimation of all the parts that have been produced by injection moulding there are two values to be calculated. The first one is a “One-off” cost related to the mould and initial costs of the machine. These two are a little different as the initial costs (shipment, installation costs etc...) are really one-off, the moulds however have to be renewed every so many cycles. In this case as we only produce 100’000 products we will assume that only one mould is needed, as well as renting the machines as this will lower the other “One-off” costs. The second category of costs are the costs related to every single produced part, these are mainly determined by machining time and material costs.

These costs have been described by William Lovejoy, Sebastian Fixson and Shaun Jackson in their paper named “Product Costing Guidelines”.

First to calculate the approximate costs of the Moulds the following formula is used:

Mould base costs in dollars = 1000 + 10.58 A (d+6)^(.4)

A = the projected area of the object in the mould in inches with a 2 inch margin around the part

d = the max thickness in a part in inches

In addition the Mould base cost, there are ejector pins to be added and machining costs. These can be calculated with the following formula:

Mould machining costs in dollars= 75 A^.5 + 2700*(.08 + .04*SP)^1.27 + 300 + 120*A^(1.2)

SP= Amount of surface patches in the mould

These formulas are very useful as they allow us to recognize which variables impact the costs of a mould directly, this means that we could potentially design our product to reduce these variables in order to reduce the “One-off” costs of injection moulding

For the costs per product they are mostly connected to the cooling time of the product in an injection moulding method. The longer the part takes to cool off the more expensive it becomes as it requires employees to be paid and the machine to produce less. The time used for a part to cool off can be approximated with the following formula assuming renting the machine costs 120$/hour:

Cost per shot = $4.36*d^2/alpha$ where Alpha = thermal diffusivity of material

Injection Moulding					
Part Number	Part	Projected Area with 2 inch margin (A) (inches^2)	Max thickness (d) (inches)	Mould base cost ($)	Ejector Pin costs ($)
				1000+10.58 A (d+6)^(.4) (D	30*2.5*A^.5
1	Top lid	106.8662121	0.1968505	3345.278872	775.3208644
2	Bottom lid	62.99612774	0.1181103	2375.455181	595.27575
3	Handle sides	44.2472751	0.0787402	1963.601863	498.8896896
4	Outer Lining of Knives	62.99612774	0.1181103	2375.455181	595.27575
5	L bracket	22.91921791	0.0393701	1497.831209	359.05515
6	C part	69.24574529	0.0787402	2508.009907	624.1052133
7					
8					
9					
10					
Total ($)				14065.63221	3447.922417

Size and complexity Price	Total Mould Cost	Machine cost per Shot assuming 120$/hour for the machine	Material cost per Shot ($)	Amount of shots produced	Total cost ($)
2700*(0.8+0.02 SP)^1.27+300+120*A^1.2		4.36*d^2/alpha	Material cost*1,12		
35304.8229	39425.42263	1.299619387	0.6270264	1	1.926645787
19841.76619	22812.49713	0.4678629795	0.27741168	1	0.7452746595
13859.73835	16322.2299	0.207939102	0.1520064	2	0.719891004
19776.13072	22746.86165	0.4678629795	0.4940208	1	0.9618837795
7479.127422	9336.013781	0.0519847755	0.0760032	2	0.255975951
21857.06254	24989.17766	0.207939102	0.0760032	2	0.567884604
118118.6481	**135632.2028**	2.703208326	1.70247168		**5.177555785**

As can be deduced from this excel extract, the “One-off” costs are 135’620$ in this case and the costs per group of pieces produced by injection moulding is 4.60$

Plastic Extrusion

In the case of Plastic Extrusion it is the exact same situation with different formulas. In order to determine the die costs:

Costs of the die in dollars = 500*500H+3A

Where H= binary value, 0 if extrusion has no hole in the product and 1 if the product has a hole

This means that adding a hole in a product that is being extruded it adds 250’000$ to the mould cost

For the variable costs of plastic extrusion we assumed that every part took about 15 seconds to produce. This is a guesstimate that is probably rather big, but this allows for a bigger error margin with the cost estimation.

Plastic Extrusion					
Part Number	Part	Projected Area with 2 inch margin (A) (inches^2)	Die cost	Estimate Cost of the machine 80$/hour	Material cost per Shot ($)
			500*500H+3A	With an estimate of 15 seconds per product	Material cost*1,12
1	Inner box	100.8459948	250302.538	0.3333333333	0.37650816
2	Outer box	105.448888	250316.3467	0.3333333333	0.3025512
3	Grip of the Handle	22.91921791	68.75765373	0.3333333333	0.0672336
4	Clip Locks	53.02649873	159.0794962	0.3333333333	0.084042
5					
6					
7					
8					
9					
10					
Total			**500846.7218**		0.83033496

Amount of shots produced	Total cost ($)
1	0.7098414933
1	0.6358845333
1	0.4005669333
4	1.669501333
0	**3.415794293**

Punching				
Part Number	Part	Estimated from similar products ($)	Amount of parts	Total cost
1	Knives	0.3	1	0.3
2				
3				
4				
5				
6				
7				
8				
9				
10				
Total		0.3		**0.3**

Concluding that the “One-off” costs result in 500’846$ and the cost for every batch of all parts produced by extrusion is 3.41$.

PUNCHING

In order to estimate the price of the knife parts made by punching we researched multiple similar products to get an average price. With this average price it is possible to estimate the price the knives will be. This has been done with this method as it would be the most representational method.

VACUUM FORMING

The Vacuum forming part has been determined with the same method as the knives. By researching similar products and making an estimate of the production price.

Vacuum Forming				
Part Number	Part	Estimated from similar products ($)	Amount of parts	Total cost
1	Raster	0.2	1	0.2
2				
3				
4				
5				
6				
7				
8				
9				
10				
Total		0.2		**0.2**

Assembly and Labour

As this project required for the least amount of manual labour as possible the assembly would be done by robot arms and conveyor belts, removing as much manual labour as possible. The costs of the multiple aspects of automating this assembly process have been estimated by looking at products that could potentially be used.

Then a calculation was made to assess the price of the remain manual labour that needed to be done (in this case some help for the assembly, testing the product for quality insurances and packaging). This was calculated with an average European salary of 21.14 and adding 35% to pay for insurance, pension and other costs.

Assembly				
	Part	Cost	Amount	Total price ($)
1	Robot arm	10000	4	40000
2	Robot set-up	20000	1	20000
3	Conveyor belt	1000	10	10000
4	Ultrasonic welder head	5000	2	10000
5	Drill	500	10	5000
6	Vacuum grip	3000	2	6000
7				
8				
9				
10				
Total				91000

Labor					
	Job	Time per product (hours)	Price per hour (Euro)	Price per hour with pension etc... (Euro)	Total price (Euro)
1	Help for assembly	0.016	21.14	28.539	0.456624
2	Testing	0.032	21.14	28.539	0.913248
3	Packaging	0.083	21.14	28.539	2.368737
4					
5					
6					
7					
8					
9					
10					
Total (Euro)					3.738609

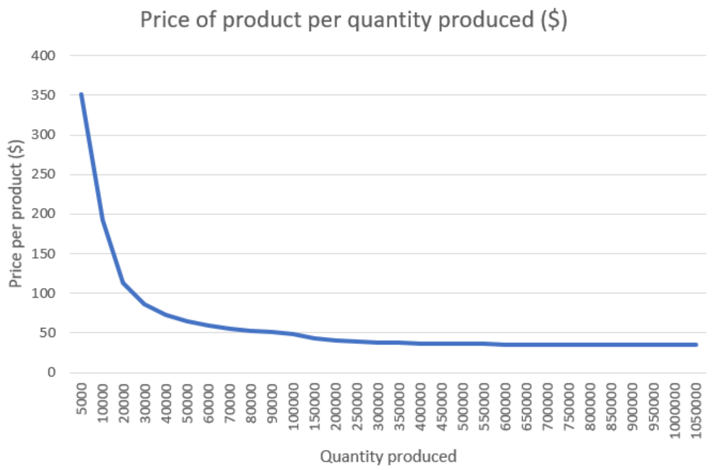
Final costs

In order to come to a final result, the “One-off” costs are summed up and divided by the amount of products produced. This will result in a “One-off” cost distributed over all the products. The divided “One-off” costs and variable costs are added in order to make one total.

We then arrive at a total of 23$. We then need to add some percentages in order to make a more realistic cost estimation. In this case we assumed that there would be a 5% margin for forgotten element within the cost calculation. The overhead in this case is 80%, this is due to the fact that this company would not have a big portfolio yet. However, if we would produce for another company this overhead could be greatly decreased as offices, marketing, managers and others could be reduced. A 5% is then added in order to make sure there is a margin to deal with warranty issues of our product. Then we add 10% in order to make profit as a company, this is on the lower side of the spectrum, but as a starting company it is important to first build up a clientele. In order to end up with a sales price of 60.80$ or **54.09 Euro** we add the 21% taxes that are compulsory in the Netherlands.

	One-off Costs ($)	**Costs per product ($)**	**Type**		**Extra percentages**	
Injection Moulding	135632.2028	1.356322028	One-off Costs		Margin for forgotten elements	0.05
		5.177555785	Produced parts Costs		Overhead	0.8
Plastic Extrusion	500846.7218	5.008467218	One-off Costs		Warranty	0.05
		3.415794293	Produced parts Costs		Profit	0.1
Punching		0.3	Produced parts Costs		Amount of products produced	100000
Vacuum Forming		0.2	Produced parts Costs			
Bought Parts		2.464	Produced parts Costs		BTW.	0.21
Assembly	91000	0.91	One-off Costs			
Labor		4.18724208	Produced parts Costs			
Total		23.0193814				
Total with margin		24.17035047				
Total with Overhead		43.50663085				
Total with Warranty		45.6819624				
Total with Profit		50.25015864				
Sales Price incl. BTW.		**60.80269195**				

It is also very interesting to analyse the price curve when related to the production quantity of our product, as can be seen on the chart, the more product are produced the less expensive it becomes until it hits a certain plateau. This is of course a simplified view of the sales prices as it does not take into account the moulds that need to be changed after X uses and other details.



Assignment 4 Design for X

Introduction

Design for X part is show the detailed design and the background information of the mass production. They are based on the requirement and production processes. In this assignment will include the design for three key element of the product which are the manufacturing, size and weight and the safety.

Design for Manufacturing

This part will be used to inform the choice of the materials and the processes also will include the detail design for the product in order to make the products successfully and make the products work well. This will include the introduction and reason of the materials we will use, the main processes we choice, and the design part in order to achieve the mass product.

Materials (also discussed in the mass production)

1. ABS Plastics

Components Made from ABS Plastics:

- Top Lid
- Bottom Lid
- Handlebars
- Handle
- Inner Box
- Outer Box
- Raster

Main properties (from CES)

- Non-Toxic
- Low price (2.60 - 2.63 Euro/kg)
- Tough
- (Stiffest of all thermoplastics) （Highest impact resistance of all polymers）
- Accepts color well
- Dish washable
- Easily Moldable
- Recyclable
- Excellent resistance to acids, alkalis, salts, and many more solvents
- Can be extruded, compression moulded, and formed to sheet for thermoforming
- Can be joined with ultrasonic of hot plate welding
- Can be bonded with polyester, epoxy, isocyanate and nitrile-phenolic adhesives.

Reasons of choice this material

The body of the product include the lids, handle, raster, inner and outer boxes are made by the ABS plastic. There are four points of reasons we choice ABS plastic to make these parts. First, in order to meet the food safety standards, the material need to be non-Toxic and within the food grade plastic. Second, we need to make sure the top lid can strong enough while cut the hard vegetables such as carrots and onions. Third, the material need to be possible to made by the injection machines in order to get the shape we want. Also it can fix other parts in several ways. Last but not least, because the product need to be carry and wash, so the weight, color and dish washable is also important to the material. Due to these main reasons and we compared different materials by the price, quality and suitability, we choice the ABS plastic.

2. 300 Series, Stainless Steel

Components Made from 300 Series, Stainless Steel

- Knives
- Shafts
- Tapered Screws
- Washers
- Nuts

Main properties (from CES)

- Does not rust
- High price 5.04 - 5.28 Euro/kg
- Dish washable
- High Strength
- Difficult to bend, draw, and cut
- Available in sheet, strip, plate, bar, wire, tubing, and pipe
- Can be readily soldered and braised.
- Surface finish can be controlled by rolling, blasting and polishing
- Welding is possible as long as the filler material maintains an equivalent composition to ensure that the stainless steel remains corrosion resistant.
- Welding is more preferable with the 300 series type of stainless steel.

Reasons of choice this material

This material will be used to make the knife, shafts, screws and nuts parts. For the knife part, in order to cut the vegetable easily and ensure a longer lifespan of the knife the material need to be high strength and does not rust. Also it need to be able to welding. The stainless steel is a suitable choice and also works well as a material of the nut and shafts which required a very high strength. Although, the stainless steel is not light, we only use it for small and necessary parts. Since the 300 series stainless steel has a high price only small part has to be strength enough will use this material.

3. Polyoxymethylene (Delrin)

Components made from polyoxymethylene

- Spur Gears
- Gear Rack
- Sleeve Bearings

Main properties (from CES)

- Stiffer and better water resistant than nylon and other polymers of similar class
- Worse abrasion and impact resistance than nylon
- Fatigue resistant
- Dish washable
- Low coefficient of friction
- Good moldability
- Recyclable
- Easy to mold by blow molding, sheet molding and injection molding.
- Minimum required wall thickness for injection moulding = 0.1 mm
- Can be coloured
- Can be extruded for components like fibres and pipes.
- May require drying before forming as it is hygroscopic. (tends to absorb moisture from the air)
- Can be joined with welding through welding methods that use high energy and long ultrasonic exposure.
- Adhesive bonding can also be used for joining, and is the more commonly used method.

Reasons of choice this material

The gears, sleeve bearings and rack parts will make by delrin because of the delrin is stiff and has a low coefficient of friction. The delrin is non- toxic, dish washable, strong enough for the vegetable cutting and can make parts by injection molding. We decide to use the delrin instead of metal is because the delrin has a longer lifespan, cheaper, lighter and work smoother than metal after use it for a longer time. Also the gears can be made in easier and faster way by using the delrin. So, as the delrin is strong enough for the parts we need and also non-toxic, we will not use the meatal to make the gear and rack parts.

4. Silicone

Components made from silicone

- The grip of the handle
- The opening part
- Protect the top lid from the knife

Main properties (from CES)

- Low strength
- Chemically very stable
- Used often for water sealing and food applications
- Not recyclable
- Non-Toxic

Reasons of choice this material

We will use the silicone to the side of the box, in between the raster and the top lid and the handle. The silicone will make sure the sauce and juice will not exudation out of the box when people are holding it. Also the silicone will protect the top lid when cutting the hard vegetable in a big force rather break it. Another part we use it is on the handle, we use it to make increase the friction between the hand and the handle which can avoid the slip when the hand is wet, this is always happens when cooking salads. Also the silicone feels softer than the ABS plastic which can make a more computable feeling while using it and avoid to hurt the hand.

Choice of processes

The choice of the processes is based on the materials and shapes we need in different parts. Also we decide to make some parts together at the same time in order to save the time of the processes.

There will be four stages which will have injection moulding, 2k injection moulding, extrusion, vacuum forming, punching, ultrasonic welding, drilling and robotic assembly.

Some detail reasons and designs

1. Make different parts at the same time when injection moulding

We decide to make several parts at the same time when injection moulding with more machines because it can save lot of time of the process. Although we will spend more money on the machines, we think this will save money in a long -term perspective.

2. Use the robots to assembly

This can make sure all the parts can fix together well because it is important to fix the gears and the gear racks to make the movement smoothly. In another hand, use the robots can also save the money of employment.

Throughput time

We made a hypothetical length of the time we need in the processes. Although, it is not possible to make a test or do clear research of how long each step we need, it is also important to make a vision of the time. So that we can get an idea of what is the time we expected. In order to make a clear vision we divide all the processes in four stages show as following. Every stage will be finish at the same time so the longest time of the stage will be the total time of the stage. We assume there will be 15 seconds to move the products to next stage.

Stage 0: Per- shaping

Punching

The knife parts will be made by punching out of sheet metal

The average time of punch it is 6 seconds

The total time of finish this stage is 6 seconds

Stage 1: Shaping

Injection Moulding

There will be four groups of injection mouldings.

1.two handle sides: 6 seconds

2.the mould of the outerlining of the knife:14 seconds

3.the C-part:6 seconds

4.the L-brackets:2 seconds

So the total time will be 14 seconds

2K INJECTION MOULDING

The top and bottom lid will made by 2k injection moulding

The time of injection mould the top lid: 39 seconds

The time of injection mould the bottom lid: 14 seconds

So the total time of 2k injection moulding:39 seconds

EXTRUSION

There are four parts need to be made by extrusion

The grip of the handle, inner box, outer box and the clip locks every parts will take 15 seconds

So the total time of extrusion is 15 seconds

VACUUM FORMING

The raster will be made by vacuum forming

The average time of this is 35 seconds

So the total time of it is 35 seconds

These steps not not the share the machines We need to finish all this parts before go to the nest stage so the longest time in this stage will be the total time of this stage which 35 seconds

STAGE 2: SURFACE TREATMENT

Use the ultrasonic welding to attach the angular forms to the outer box

This will take 3 second for each side and 2 seconds for change the side. There are four sides on the outer box so we need to change the side three times

The total time is 3*4+2*3=18 seconds

The total time of this stage is 18 seconds.

STAGE 3: MACHINING

ULTRASONIC WELDING

There are five groups need to be welding together

The C-Part to the outer box

The clip locks to the outer box

Raster to the top lid

L- brackets to the inner box

The gear rack (delrin) to the inner box

The average time for each group is 2 seconds

The time to change the group is 3 seconds

The total time is 2*5+4*3=22 seconds

Drilling

We need to drilling two holes for the shaft on the outer box

The average time of drilling one hole is 3.5 seconds

The time of moving is 3 seconds

The total time is 3.5*2+3= 10 seconds

We will not do this two steps at the same time, so the total time of this stage is 22+10=32 seconds.

Stage 4: Assembly

Robotic Assembly of Entire Product

This step will take 210 seconds to finish all the assembly by using the robot with four arms.

Human aid for assembly

This step will take 58 seconds

The total time of this stage is 210+58=268 seconds.

Stage 5: Testing

This step is aimed to test the products in order to make sure the product can work will and increase the quality of the product.

The time of this stage: 115 seconds

So the total time of this stage is 115 seconds

Stage 6: packaging

The time of this stage will be 299 seconds

As a result the total time for the process till stage 4(the production part only)

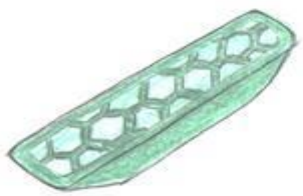
6+35+18+35+35+268+（15*5）=434 seconds which is 7 min and 14 seconds

The total time till finfish the packing will be 434+115+299+15=863 seconds which is 14 min and 23 seconds

Detail design for production processes

1.Handle

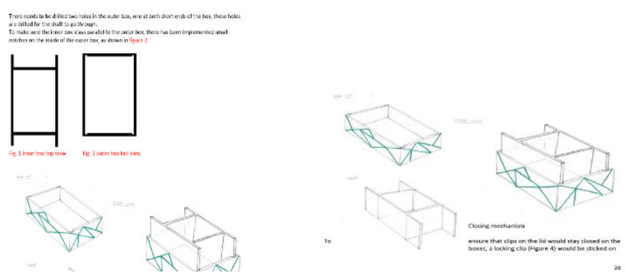
Different from the prototype we made the handle of the mass product will be made by injection molding. However, it is impossible to make a handle of thick. So we need to redesign the handle for the injection molding. In order to make the handle by the injection and also make the handle stronger we need to add the triangles inside the handle which shows in the form below.



In this way the we can make sure that all the part is 3mm and there are triangle lines in between the handle. So the handle will not break in such force we need. Also we can save the material, decries the price of the product and reduce the weight of the product.

2.Slide between the inter box and outer box

For this part is aimed to make the outer box move smoothly and straight. Also it will be a guide for people to fix the outer box and inner box. In order to make the two box more stable there will be two slide on both side of the box. These slide will become the guide of the movement and support the two box while moving.



Design for Size and weight

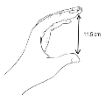
This part is aimed to explain the design of the size, shape and weight. Due to the requirement we need a box that able to carry enough salads and not too heavy to bring it. So the size and weight is very important. In flowing paragraph, we will illustrate the size and weight design of the product.

1.Size design

From the research of the salads in the Albert Heijn the volume of the salad is usually about 250g to 350g therefore box will be around 1200ml.

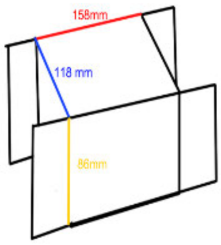
AH vegetable salad Caesar mix	285g
AH vegetable salad Italian mix	250g
AH vegetable salad tomato and cucumber mix	340g
AH lunch salad white cheese humus	250g
AH vegetable salad chicken and apple	325g

We also look at the suitable shape for the box. In order to let people take the box over easily, we count the total height of the box when it is closed. We want to know how big the box which people can hold stable which is the length show below.



We decide the length cannot longer than 110 mm in order that all the people can take the box easily.

Due to there are also two lids with angular form and there need space to put a clamp for the top lid, so the height of the inner box cannot be higher than 90 mm. We decide the dimensions below.



As a result, volume of the salad will be: (86-10) *118*158=1398.3 cm3 =1398.3 ml which is also within the volume we need.

2.WEIGHT CALCULATION

We need the box to be as light as it can while is it strong enough to cut the vegetable. In order to calculate the weight of the product we calculated the majority of the product. This will be treated as a guide of the following pages:

Parts make by ABS plastic

Density of the ABS plastic: 1.05g/cm^3

VOLUME OF THE INNER BOX:

2*11.8*8.6=202.96 cm^2

2*19.2*8.6=330.24 cm^2

0.2*(202.96+330.24) = 106.64 cm^3

Weight of the inner box: 1.05*106.64=111.972g

VOLUME OF THE OUTER BOX:

2*6.6*12.7=167.64 cm^2

2*6.6*19.6=258.72 cm^2

0.2*(167.64+258,72) =85.272 cm^3

Weight of the outer box: 1.05*85.272=89.5356g

VOLUME OF THE TOP LID:

2*20.2*13*0.3=157.56 cm^3

Weight of the top lid: 1.05*157.56= 165.438g

VOLUME OF THE BOTTOM LID:

19.2*12.2*0.3=70.272 cm^3

Weight of the bottom lid: 1.05*70.272=73.7856g

VOLUME OF THE RASTER:

20.2*13*0.1=26.26cm^3

Weight of the raster: 1.05*26.26=27.573g

VOLUME OF THE HANDLE:

2*2*2*16*0.3=38.4 cm^3

（3.14*1^2-3.14*0.7^2） *23=36.8322 cm^3

38.4+36.8322=75.2322 cm^3

Weight of the handle: 1.05*75.2322=78.99g

The total weight of the ABS plastic: 547.2942g

Parts made by 300 series stainless steel

Density of the 300 series stainless steel： 7.7g/cm^3

*Volume of the 1cm*1cm knife*

14*8*1*0.1=11.2 cm^3

7*15*1*0.1=10.5 cm^3

11.2+10.5=21.7 cm^3

Weight of the knife:21.7*7.7=169.09g

Parts made with Delrin

Density of the Delrin: 1.42g/cm^3

Volume of the gears

4*1*3.14*1^2=12.566cm^3

Weight of the gears: 1.42*12.566=17.8437g

Parts made with silicone

Density of the silicone: 1.2g/cm^3

Volume of all parts make by silicone

20.2*13*0.1=26.26 cm^3

0.5*(20.2*13-19.4*12.2) = 12.96 cm^3

0.5*(19.2*12.2-18.4*11.4) =12.24 cm^3

26.26+12.96+12.24=51.46 cm^3

Weight of all parts make by silicone

1.2*51.46=61.752g

The total weight of the product: 508.6242+167.09+17.8437+61.752=755.3099≈755g

Design for Safety

The safety design is aimed to keep safety of the product. We look into the safety force, use ability and the washing situation. In flowing paragraph 3 detail parts about these topics will be present.

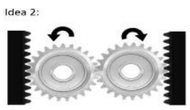
1.Force safety

The force need to be big enough to cut all kinds of vegetables and the materials need to be strong enough to support the force. The form below shows the force we need to cut different vegetables and the biggest one is the force we cut the onion which is 5.3kg≈53N.

vegetable	Tomato	Cucumber	Celery	Chinese cabbage	Lettuce	Onion	Carrot
Force (kg)	1.3	1.2	3.4	4.3	3.7	5.3	3.4

We also measured the force to cut an onion by using a 1 cm*1cm knife plate which is 250 N. In order to cut all kinds of vegetables we decide to use a force of 300 N.

The box has the following system in both sides



From the weight calculation we got the weight of the upper part which is include the top lid, outer box, raster and the silicone parts.

Upper part weight: 89.5356+27.573+169.09+12.96+26.26=321.17666g≈0.3kg

Than the force on the gears will be 3N

The total force on the gears will be 300+3=303N

So each side got 303/2=151.5N

2.Safety factor

We calculate the safety factor for the gears in order to know if the gears are available for a force we need.

F_t = 151.5N

Our gears are from Plastic so $\sigma_{f,lim}$ = 28 N/mm2

Gear width b = 10 mm

Y_{Fa} (plastic) = 2,9 (read from table DIN3990)

KA = 1,0 (uniform load)

Maximum force the teeth can resist is;

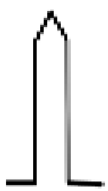
Bending stress = σ = (Ft*YFA) / (b*m) = (151.5*2,9)/(10*1,0) = 43.935 N/mm

So our bending stress safety factor Sf = 2* σflim / σ * KA = 2*28 / 43.935*1,0 = 1,27

This is not a very large Safety factor but it is sufficient.

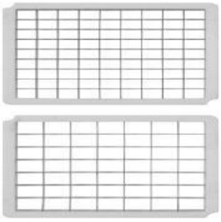
3.KNIFE AND RASTER

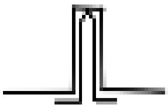
Knife is the most dangerous part in the product, although the target group will already have the safety consciousness we still need to improve the security. We make only one side of the knife is sharp enough to cut, so people only need to pay attention to the side they know is sharp to cut the vegetable. This is also good for people to wash the knife part because they can always know which side is the sharp side and pay attention to it. Also, we add a raster to store the knife when people can eat from the inner box (similar as the part in the red circle).



Only one side of
the knife is sharp

We decide to make the raster as the smallest size of the knife so all size of the knife can fit in the raster. Also the raster will be the same height of the knife. We also add silicone between the raster and the top lid in order to protect the top lid when the we cut the vegetable with a big force.



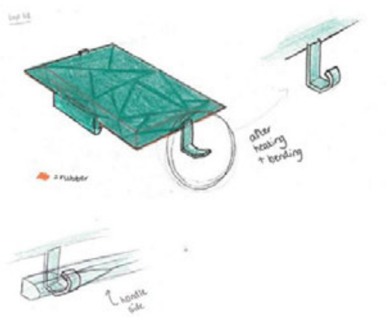
4.Lock mechanism

While designing we found that there might be a security risks while people can open both side of the box. Because the knife will touch the lid while the vegetable is cut which means that if open the top lid at this period people might touch the knife. In order to keep the safety, we added a lock mechanism to make sure the box cannot open the top lid while the knife is touch it.

We want to use a similar way with the cool box system down below. Which means that the handle will be stuck when it is at a specific position.




As we will use the angular from for the product, we want to use the feature of the angular form also in this lock system. We decide to make a small clamp on the lid of the box which is similar as the prototype but a little bit different. In the prototype we only use a clamp in a L shape but in the mass product we will use a clamp more like a J shape. The handle will stuck in the clamp because of the angular form which can help the handle keep an 180° . The clamp can make sure the box cannot turns easily when holding the handle which helps people to carry the box like a handbag.



Assignment 6 FMEA

Function decomposition item	Potential failure mode	Potential effects of failure	S	Potential causes failure	O	Current detection method	D	RPN
Innerbox	Fails to sink in	Box would not be able to function at all.	8	Misalignment of the gears	2	Synchronized sinking of all sides	2	32
Outer box	Fails to allow inner box to sink in	Vegetables cannot be pushed on the knives, therefore cannot be cut	8	Vegetables that get between the boxes can make the system stuck.	2	See vegetables that are in between the boxes	4	64
Top lid with clips and coolbox mechanism	Fails to open	Cannot put vegetables inside box	7	Clips hold top lid to thightly	5	Click sound of lock for lids	1	35
	Opens unexpectedly	Vegetables could fall out and spoil	5	Clips fail to hold the top lid after force is applied to them for a while	5	Click sound of lock for lids	1	25
	Fails to close	Cannot press vegetables through the knives	7	Does not click in	4	Click sound of lock for lids	1	28
	fails to lock handle	Handle can still rotate after the box has been rotated	6	The handle can fit inside the lock mechanism but isn't hold by it.	4	Click sound of handle lock	2	48
Bottom lid	Fails to open	Cannot take vegetables out	7	Clips hold bottom lid to thightly	5	Click sound of lock for lids	1	35
	Opens unexpectedly	Stored vegetables fall out and spoil	5	Clips fail to hold bottom lid after force is applied to them for a while	5	Click sound of lock for lids	1	25
	Fails to close	Vegetables could fall out of the box and spoil	5		5	Click sound of lock for lids	1	25
Handle handgrip	Fails to provide much grip for user	Customer becomes disatisfied as it is uncomfortable to use	5	Slippery hand grip due to water or other liquids	8	Feels slippery	2	80
Handle sides	Break	Customer can no longer use handle to exert enough force to cut vegetable	8	Handle designed too thin	1	Comparison made with other products	4	32
			8	Not sufficient strength	1	Breaks in a short amount of time	4	32
			8	Too much force applied by user	6	User feels a resistance when using the handle	2	84
Raster	Fails to cover knives	Cut finger or parts of the hand	10	Height of raster is too low	1	Feel sharpness of blade	5	50
Knives	Breaks	Can not cut vegetable at all	8	Too much force required for knives to cut vegetables	4	User feels a lot of resistance	2	64
	Fails to cut vegetable	Vegetables are not cut	8	Knives are blunt	3	A lot of force required to cut the vegetables	5	120
		Customer disatisfied	5	Knives are blunt	3	A lot of force required to cut the vegetables	5	75
	Cuts unexpectedly	Cut finger	10	User put finger on knives	7	Feel sharpness of blade	5	350
	Bend	Knives cannot cut vegetables effectively	8	Too much force required for knives to cut vegetable	4	User feels a lot of resistance	4	128
C parts	Breaks	Food poisoning to client	10	Fatigue of material	1	See broken parts come out of the product after usage	4	40
Clip locks	Fails to lock clips	Top and bottom lid cannot be locked	5	the lock isn't able to hold the clip	4	Click sound of lock for lids	1	20
	breaks off	cannot close lid	8	too much force applied	5	Click sound of lock for lids	1	40
Spur gear	Fails to turn	Mechanism is still functional but stuck	7	Misallignment	1	User feels a resistance	3	21
	Teeth break	Mechanism would no longer be functional	8	Too much tangential force	6	Upper part does not go go up/down	2	96
Gear rack	Teeth break	Mechanism would no longer be functional	8	Too much tangential force	5	Upper part does not go go up/down	2	80
Knife locking system	Knife cannot lock inside box	Vegetables are not cut	6	Misalignment of knives	6	Click sound of lock	2	72
		Vegetables are not cut	6	Misalignment of knives	6	See that knives are not positioned correctly in inner box	2	64
Shaft	Fails to transfer torque	Makes difficult to turn handle	6	Slips	2	Turning does not result in the inner box to sink easily	3	36

Highest RPN value: 350

Function decomposition item: Knives

Potential failure: Cuts unexpectedly

Potential effects of failure: Cut finger

Potential causes failure: User put finger on knives

Current detection method: Feel sharpness of blades

Eliminating this failure is not possible, since we have to cut the vegetables and this is not possible without sharp knives. We also can't decrease the severity because the knives have to stay sharp.

The first possible solution is improve the detectability. The knives can get a striking color for example. Therefore they are clear and you can't touch them by accident.

The second possible solution is decrease likelihood. In the mass product we already have a system that the top lid can't open after you have cut the vegetables and the knives are right underneath the top lid. Also the raster between the knives is a good option to decrease the likelihood of unexpectedly cutting yourself because the raster goes in between the knives and you can't touch them anymore.

Unexpectedly cutting can happen when you want to wash the knives. We could make a little plastic part around the knive mesh with holes in it large enough for your fingers to go through. In this way you can grab the product by the plastic when you want to take them out or to clean them for example. This reduces the occurrence of the failure or even eliminates the failure.

Second highest RPN value: 128

Function decomposition item: Knives

Potential failure: Bend instead of cut

Potential effects of failure: knives cannot cut vegetables effectively

Potential causes failure: too much force required for knives to cut vegetable

Current detection method: User feels a lot of resistance

Well, for this failure mode the best option is that the knives are as sharp as possible. Then it will take less force than to cut the vegetables and therefore the knives are way less likely to bend. Although this cause doesn't occur a lot it still has a high RPN value because the severity is quite high. If the knives cannot cut vegetables effectively the whole vegetable cutter can't do his function anymore, this is a very severe effect. The best solution is to make the knives sharp, this decreases the likelihood of the problem and therefore reduces the RPN value.

THIRD HIGHEST RPN VALUE: 120

Function decomposition item: Knives

Potential failure: Fails to cut vegetable

Potential effects of failure: Vegetables are not cut & customer dissatisfied

Potential causes failure: knives are blunt

Current detection method: A lot of force required to cut vegetables

The failure cause of this problem is that the knives are blunt. This could be because of a lot of use of the knives with a lot of cutting of tough vegetables.

Since our knives in our mass product are detachable a good way to solve this failure mode would be that the user is able to only buy/order new knives for this particular vegetable cutter. Then after a lot of usage and cutting you could just replace your blunt knives with new sharp knives. This will Eliminate the failure. This is preventative maintenance.

FOURTH HIGHEST RPN VALUE: 96

Function decomposition item: Gears

Potential failure: Teeth Break

Potential effects of failure: Mechanism would no longer be functional

Potential causes failure: Too much tangential force

Current detection method: Box does not move up and down.

Gears would break when too much tangential force is applied on them. Too much force on the gears could happen by either applying a lot of force in a short period of time, or applying a lot of force constantly after a while. A possible solution for this might be to calculate the maximum force the gears can endure, and then fastening the handle to the box in such a way that when pushed by the user the handle can only move with a tangential force lower to that required to break the gears. Even if the user would apply a lot of force the handle would move consistently with a lower tangential force than that required to break the gears, hence the user would feel even more resistance as their force is pushed back to them and not transferred to breaking the gears. With more resistance the user would also more likely know that what they are doing is wrong and detect that it could lead to potential failures in the product, this would lower the RPN as higher detectability could result in lower occurrences, resulting in an overall lower value. Using this solution it would completely eliminate the failure.

Fifth highest RPN value: 84

Function decomposition item: Handle sides

Potential failure: Teeth Break

Potential effects of failure: Mechanism would no longer be functional.

Potential causes failure: Too much force applied by user

Current detection method: User feels a resistance when using the handle

Like the gears the handle sides would break when too much force is applied to them. The problem itself could not be eliminated, as there would always be a user that would apply to much force on the product through its lifetime. Therefore detectability would be the main focus, to teach the user to handle the product with care, and to unlearn their habit of applying to much force. Detectability could be improved by adding a small extension perpendicular to the handle that would hit a extension below the locking system of the handle when too much force is applied. This would create a distinct click sound that would warn the user that too much force is being applied on the handle. Doing so it would allow the user to more easily detect the problem at hand, and prevent from doing it in the future, decreasing the frequency. Having both lower occurrence and detectability ratings, it would eventually result in a lower RPN value.

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