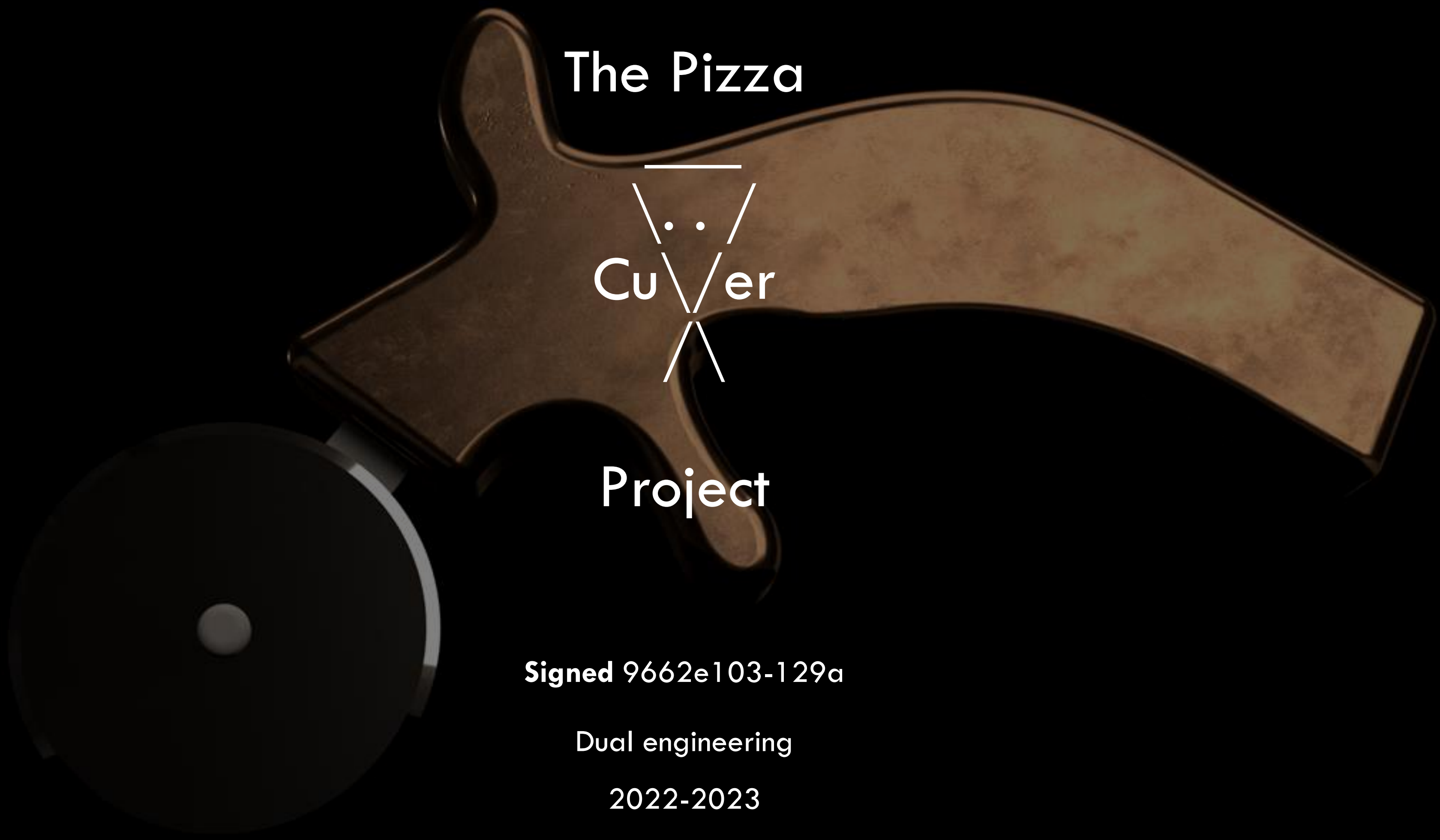


The Pizza Cutter Project

Signed 9662e103-129a

Dual engineering

2022-2023

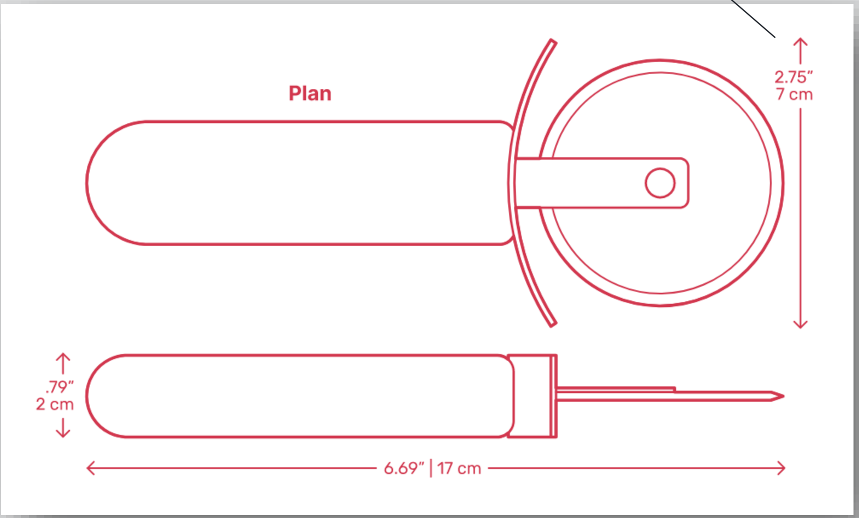
Cold-press rivet (joining the disk to the shaft)

Stainless steel cutting disk
(Material choice to stop corrosion and make cleaning easier)

Metal hand guard

Metal blade shaft (to prevent rusting in a crucial movement region of the cutter)

Total width (from the tips of the metal hand guard)



Injection molded plastic handle (to reduce manufacturing complexity and therefore costs)

Pre-existing Pizza Cutter

IKEA pizza cutter

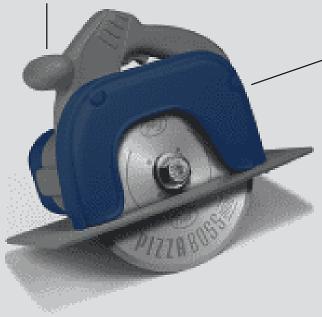
The fundamentals of this example has a simple designed handle which allows for easy, cost-efficient manufacturing (most likely injection molded using plastic).

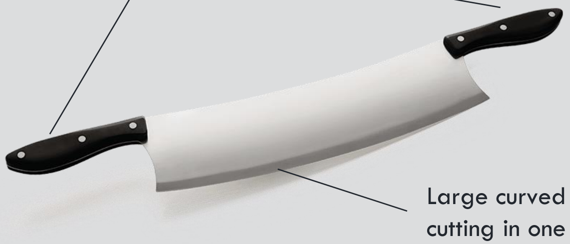
It also has a metal guard to not only protect the user from their hand slipping onto the blade whilst also making sure that residue from cutting, does not get onto the user's hand.

We can also see that the cutting blade is made from stainless steel which has excellent properties for pizza cutting. This is because stainless steel is anti-corrosive and rust resistant which means that no rust (or any other residue or particles) can end up harming the users' health. It also means that the product is more hygiene friendly.

In the images with the cutter in real life, we can see that it is only held by 6 joints which were most likely ultrasonically fused together and the metal tang from the blade is quite small which was most likely to reduce costs for the metal required for this cutter.

RIGHT IMG SRC: https://www.dimensions.com/element/ikea-stam-pizza-cutter





Decision criteria	Circular-saw pizza cutter (far left)	Rocking blade pizza cutter (center)	Circular blade pizza cutter (far right)
Safety	10/10	6/10	3/10
Ease of use	8/10	7/10	5/10
Aesthetics	7/10	9/10	8/10
Ergonomics	7/10	7/10	2/10
Final marking	**32/40 1st**	**29/40 2nd**	**18/40 3rd**

Market Analysis

Existing products

Circular-saw pizza cutter Description

This cutter looks to be a circular-saw style cutter with the guard resting on the pizza and the grey handle at the top acting as the "lowering mechanism". The handle also looks quite ergonomic, using what looks to be a thumb-rest for the user so they can apply a downwards force. One thing to mention is that the blade inside the cutter is covered almost entirely by the guard which can make cleaning the cutter quite difficult.

Rocking blade pizza cutter Description

This cutter uses a rocking motion to cut the pizza and features two handles which the user can use to create a downwards force as well as a rocking force which essentially makes the cutter a thin wedge which allows it to cut the pizza. Two downsides are that the sideways stability of the cutter is quite minimal (which means there is a chance of the cutter leaning and falling to one side whilst cutting) and the second is the small curved sections at each end of the blade (at the bottom) which can pose a safety concern if the users' hand slips from the handle onto that small curved section.

Circular blade pizza cutter Description

This cutter uses a plastic guard as the holding mechanism for the circular blade and is the most compact out of all the designs, making it a better option for smaller kitchens although one downside is the stability and safety of the cutter. If a users' hand slips whilst cutting, it could get caught in the blade which can cause harm. Also, another downside is how difficult it can be to clean the cutter (especially inside the guard where most of the food residue is most likely to stay at.

Decision criteria	Circular blade pizza cutter
Safety	7/10
Ease of use	5/10
Aesthetics	8/10
Ergonomics	3/10
Final marking	**22/40**

Market Analysis (cont.)

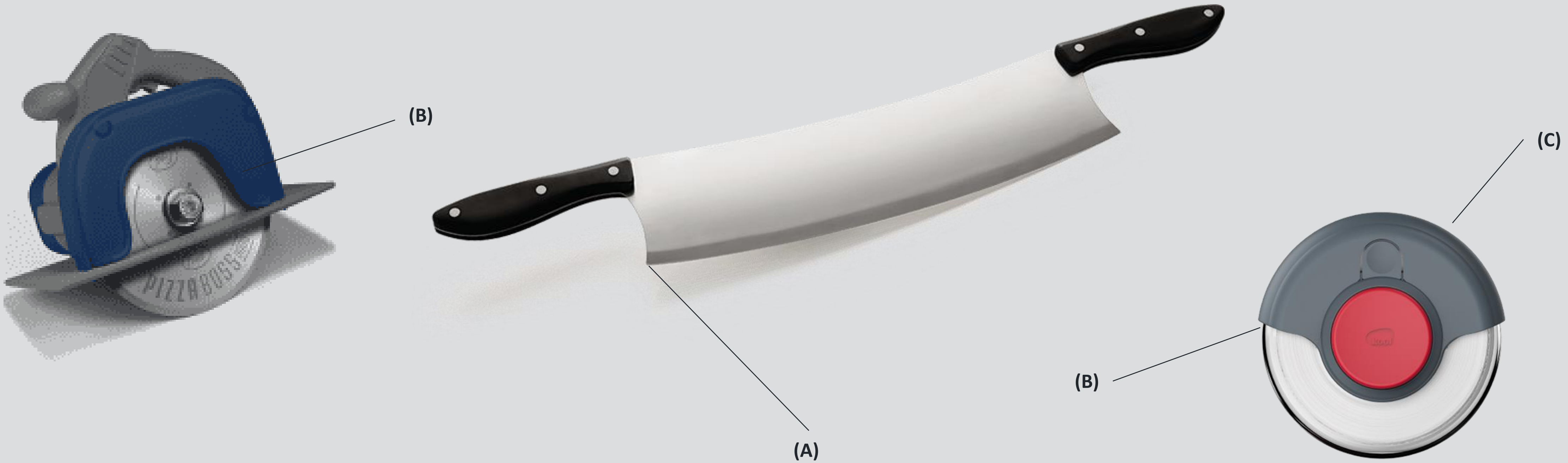
Existing products

This design uses an all-metal handle, guard, as well as a blade. One of the major downsides when I personally used it, one of the downsides that I noticed was that my hand would most of the time slip down to the guard and if the guard was not in place there, it could become a hazard to the user. This means that the pizza cutter might not be safe, and consumers might not want to use it although one of the strengths of this design is that the blade is super easy to clean since most of its surface area has not been covered.

Conclusion (Market analysis)
I noticed that the circular-saw design performed the best in terms of score, mainly because of the safety and ease of use (due to the thumb rest which allows you to apply a greater amount of pressure on the pizza/cutting board although the circular-blade type performed quite well in aesthetics because it is a super slim design and looks quite modern.

Conclusion (Pizza cutter above)
I think that this design, although looking aesthetically pleasing, does not perform that well because of A: the material of the handle and B: the shape of the handle which means that it is quite hard to grip whilst applying downwards forces on the pizza/cutting board especially if you take into consideration that the handle is not always clean (with for example the juices from the pizza)

Improvements (Pizza cutter above)
I think to improve the design, firstly I think they should have changed the shape of the handle as well as the material to for example a matte or rough surface (such as a matte paint coat) and for the handle, a rectangle with fileted or chamfered edges (which would increase the grip reliability because I have noticed that the handle can also twist in my hand during cutting)



Market Analysis (cont.)

Existing products

Overall conclusion
I still think that the circular-saw has performed the best in the decision matrix because the function of it makes it quite easy to use and personally, I like the design of the cutter although I know that others might not. One thing that I don't think is efficient, is how washing the blade would work because most of the blade is hidden under the massive guard.

Final specification point impacts
Overall, there have been multiple factors which contribute to the final spesifications points but the main factors I looked at were the safety of the cutter, the ease of cleaning the blade after use, and pressure created on users' hands whilst cutting.

Two examples from the existing market were the main influence because each had major safety issues such as if the users' hand slips whilst cutting the pizza which can cause them to cut their hand **(A)**.

Another impact on the specification points is how easy the blade is to clean after cutting. This is because two of the designs had a guard which covered almost all the blade which could be quite hard for the user to clean afterwards **(B)**.

One of the last main points is that the cutter must be able to be used for quite a lot of time without creating painful pressure on the users' hand such as in **(C)** where the guard/handle is on the blade itself which means that the user must grip the cutter in an awkward position which might be painful after a long period of usage.

Decision criteria	Justification and explanation
Safety – 4 points	S1 There must be a cover/guard which covers at least half the blade (DURING USE and "half" is determined by the blade once viewed) S2 There must be a removeable cover so that the user can cover the blade after use S3 When used correctly, it should not create any pressure points on the hand S4 Must be able to withstand a substantial amount pressure applied for 5 continuous minutes
Ease of use/storage – 4 points	Eu1 Should be able to cut 5 pizzas in a row without user fatigue or other harm/aches Eu2 Must be able to be stored in smaller spaces (within 15cm^3) Eu3 Should be able to be replicated (design wise) in multiple sizes Eu4 Should not have that many hidden sections of the cutter (for ease of washing)
Aesthetics – 4 points	A1 Should look sleek with minimal detail for example a matte covered surface A2/ Should be able to blend into the color scheme of most kitchen designs (different color schemes available to the user) A3 Should be a cost-effective design (e.g., in the range of 15-20 dollars per piece) A4 Should look as clean as possible without sharp or unnatural edges (such as acute angled edges)
Ergonomics – 5 points	Er1 There should not be any sharp corners and angles on the grip (for safety) Er2 Should be able to fit multiple hand sizes whilst being as efficient in size-to-performance Er3 The handle should rest on the pizza without leaving too much room for sideways movement during cutting Er4 Should have multiple angles at which the user can hold the blade (experiments showed that certain hand positions can affect the users' wrist movement) Er5 Must be capable of allowing left-handed users to operate the cutter (either having a separate category/build or one uni-handed cutter)

High importance highlighted orange
"Must haves" are highlighted red
"Should haves" are highlighted green

Final Design Specifications

Final pizza cutter

Most of the pointers in this slide are for the safety and ergonomics of the device because most of the designs I reviewed did not have the best rankings in those areas for example with safety (mainly the circular-blade design because the users' hand could easily slip onto the blade whilst cutting) as well as ergonomics because for example the rocking blade (because of the users' hands hitting the cutting board due to the cutter not having any angled handle [instead, having a handle which is almost horizontal to the cutting surface]).

I did notice that all the designs I reviewed earlier did have quite high scores for aesthetics which is why all the requirements are in green (for this design I am going with function over form mainly because of the safety of the user). If we go back to the point of most of the must-haves are to do with safety, the only reason why is that even though the blade is not sharp enough to cause severe cuts, it can still cause considerable harm whilst the blade is rotating.

The last point I will mention is that although the point of the project is to improve the ergonomics of a pizza cutter handle, I have not focused too much on that because if there are too many details (e.g., small curves), it could become harder to manufacture as well as more expensive which is one of the factors, I wanted to have a limit on during the recreation of the handle design.

Measurements required	Justification (impact upon design)	Methodology
Length of hand	To determine a comfortable diameter for the handle	I will make sure the user's hand is flat on the table. I will then record the length of the users' hand using a ruler from the base of the wrist to the tip of the middle finger.
Palm width of hand	To determine a comfortable length of the handle above the guard	I will first make sure that the user's palm is pointing upwards, I will then take a caliper and measure from one side of their hand to the other horizontally.
Depth of hand	To determine the size of the guard required	I will make sure that the user's hand is in a light fist shape. I will then take a caliper and measure the distance between the bottom to the top of the knuckle that is closest to the thumb
Pressure points	To alleviate stress during use (when designing for example silicon padding for the handle)	Make them grip a type of handle and ask them to draw areas where they feel the most pressure when holding a handle-like object. I will then then overlay multiple sheets of paper and draw a trend heatmap
Angle of arm	To figure out what is the average angle at which users hold pizza cutters whilst cutting pizzas	Ask to hold some type of object and take a ruler and lay it on the user's arm. I will then take the measurement app and place my phone horizontally and take down the measurement and give ~+- 5 degrees of freedom

Anthropometrics

Final pizza cutter

What is the TMG?
The target market group for this project is around [redacted]-year-olds. This is because the data that I will collect will be based around that age group.

What is anthropometrics?
It is the science that defines physical dimensions and the design of an object in relation to a set of dimensions created by the average of numerous people in numerous size categories

Why does this affect the pizza cutter project?
It affects this project because we need to make sure that the handle is the correct size for the users' hand (and have an average of sizes so that users with different sizes of hands will be able to use the cutter)

How would I collect and display data for the project?
I would initially find out the data that I would want to collect (such as hand width and depth) and take measurements of a group of at least 15 students (to get a small average which I can use for the final design. I would then display that as a percentile graph on another slide

Source
https://www.cdc.gov/niosh/topics/anthropometry/default.html

Criteria	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	95th %tile
Length of hand (mm)	180	170	200	180	175	162	120	195	170	165	185	180	182	187	180	**196.5**
Palm width of hand (mm)	79.4	84.7	80.5	75.2	76.2	68.5	79.2	87.2	70.5	74.4	87.4	73	83.5	83.3	88	**87.58**
Knuckle width (mm)	29.2	28.1	27.5	25.2	29.2	26	24.2	31	20.5	27.5	34.5	35	31.5	34	34.6	**34.72**
Angle of arm (°)	50	53	48	60	39	37	44	50	29	77	46	37	42	50	44	**65.1**

Anthropometric Data – Collection

Final pizza cutter

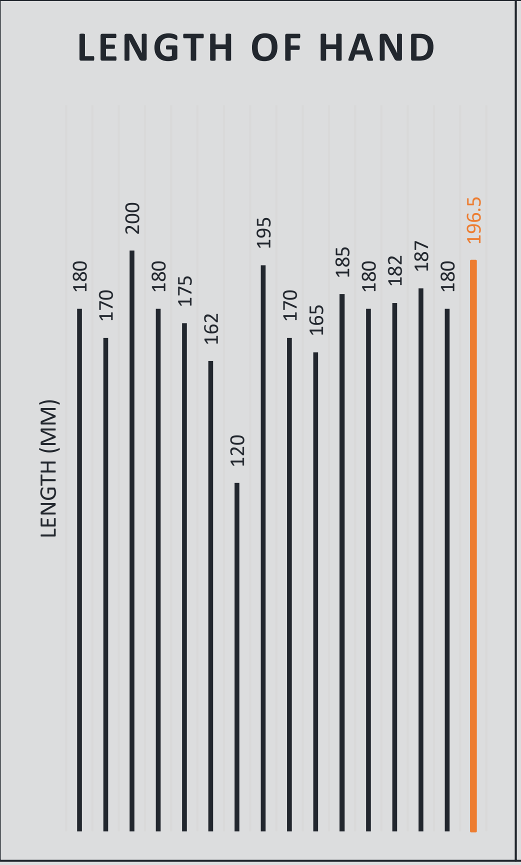
We can see from the table above, there are not many large gaps between dimensions and the 95th percentile calculations were quite close to the averages which shows us that the 15 subjects that were tested had relatively the same hand dimensions.

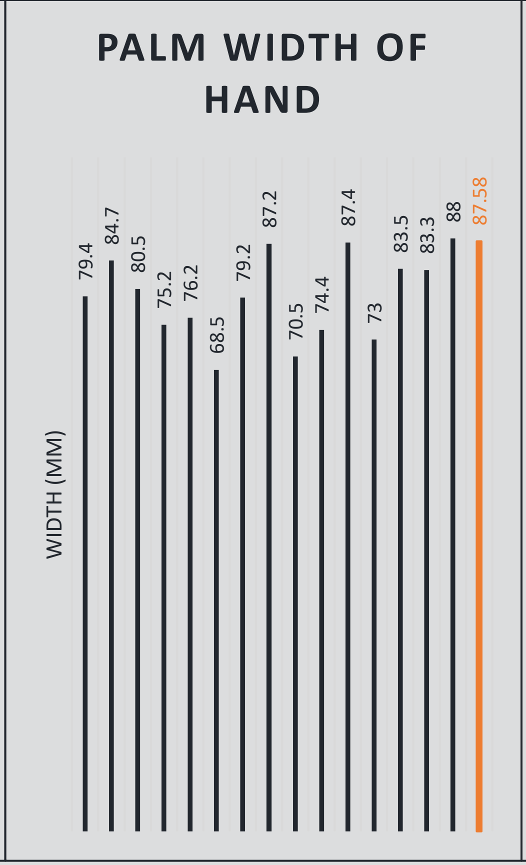
We can also see that except for one subject, most of the others had a cutting angle of ~50° which shows that most of the subjects hold the cutter at relatively the same angle which means that the final product I design will be able to fit a large proportion of the subjects (all 14 subjects besides #10).

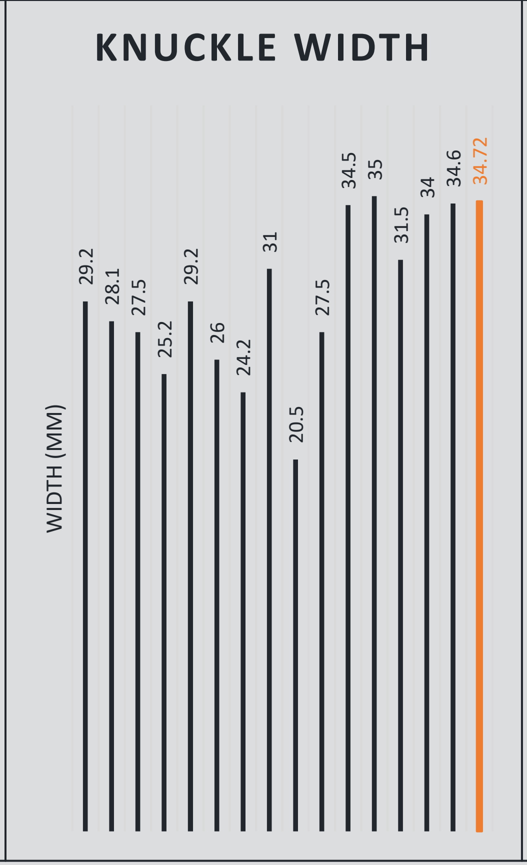
Almost all the dimensions taken across the subjects have a 95th percentile which sits above most of the numbers (except in a few cases e.g., #10 with the angle of cutting)

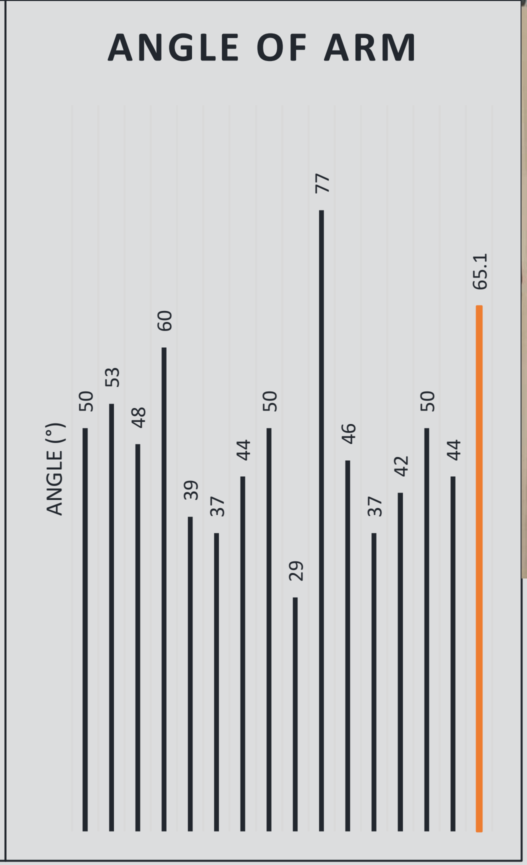
From the pressure point heatmaps, I can see that the areas most affected were near the tips of the fingers and near the top-center of the palm.

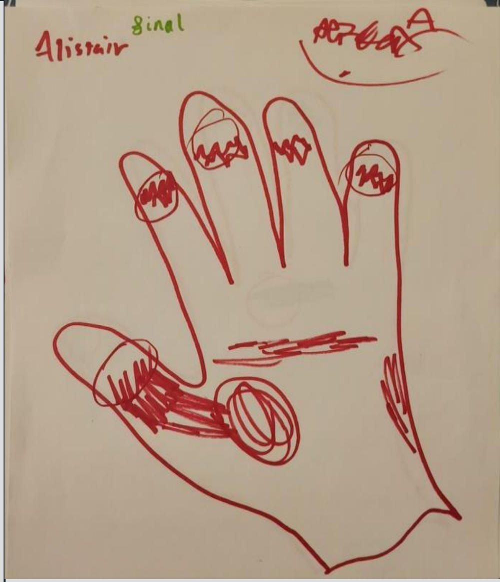
The most important set of data here is the pressure point heatmap because it will allow us to design padding/protection in specific areas instead of needing to cover the whole cutter in padding which can save up on costs when our designs start to get mass produced











Pressure point heatmap (average)

Anthropometric Data – Conclusion

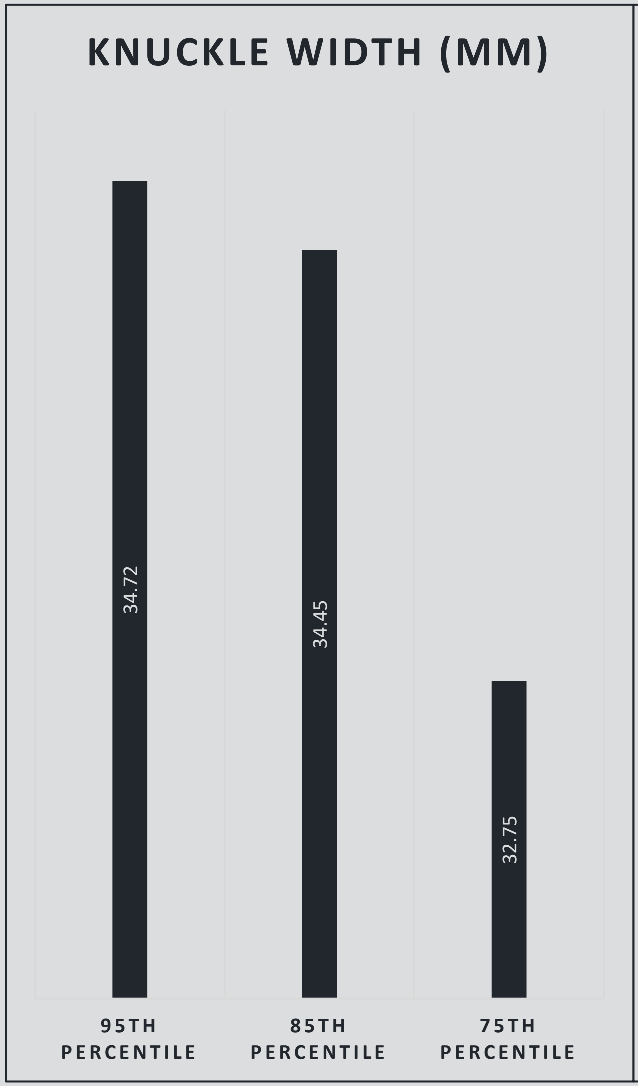
Final pizza cutter

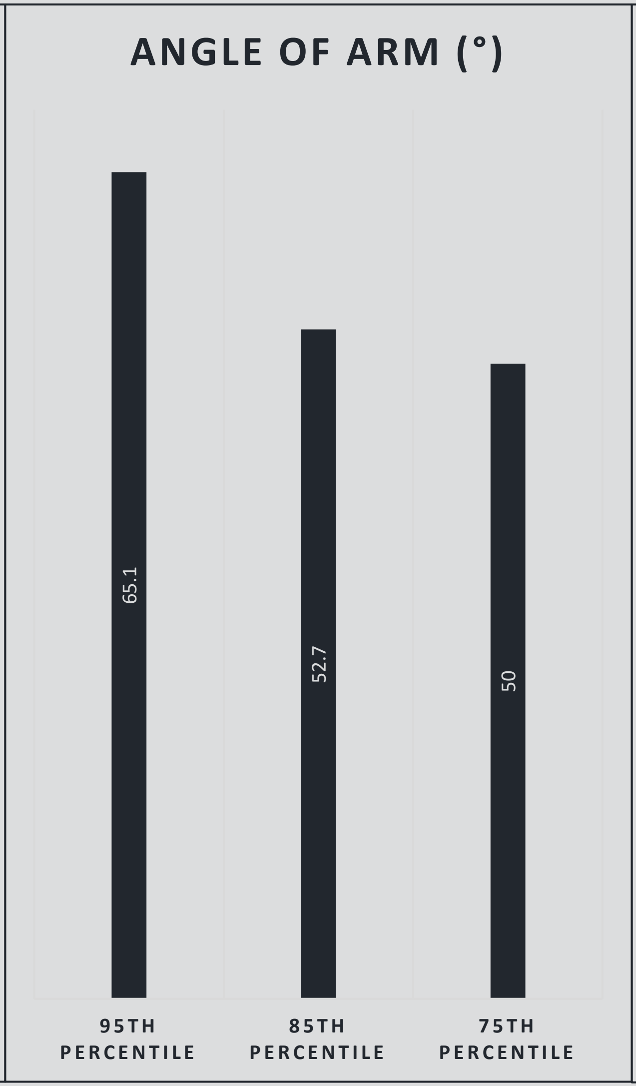
Based off the data from all these tables, the most optimum cutter will include the following dimensions:
The width of the handle: ~196.5mm
The length of the handle: ~87.58mm
The width of the guard: ~34.72mm
Angle of blade-to-handle: ~65.1° relative to horizontal (0°)

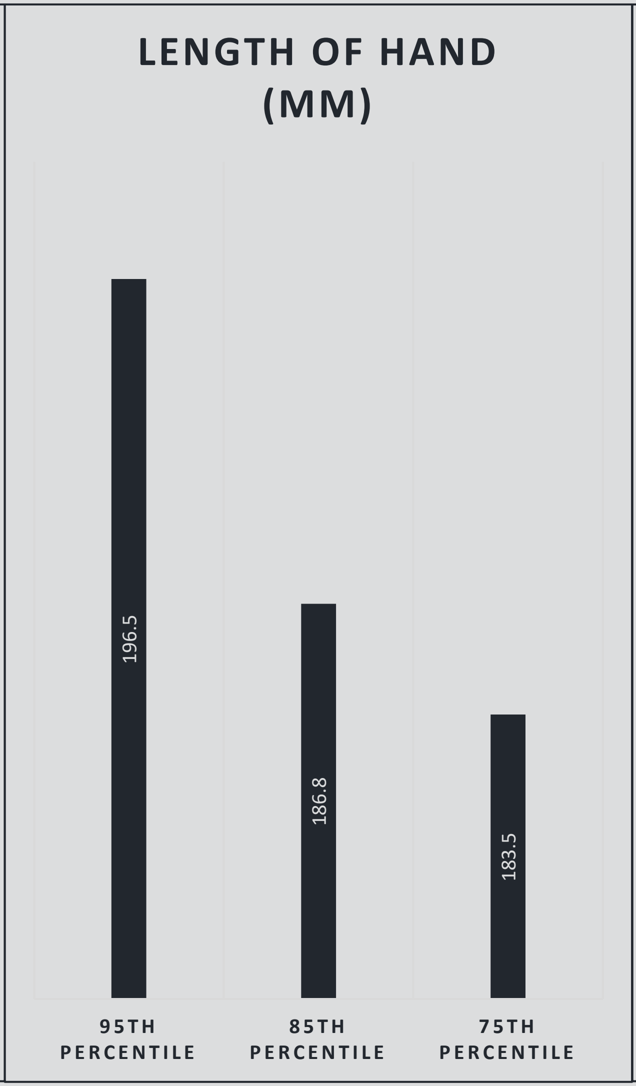
Since this data was collected from the 95th percentile, it will allow the design to fit 95% of the subjects with only ~1 subject whos' dimensions will be over the 95th percentile mark

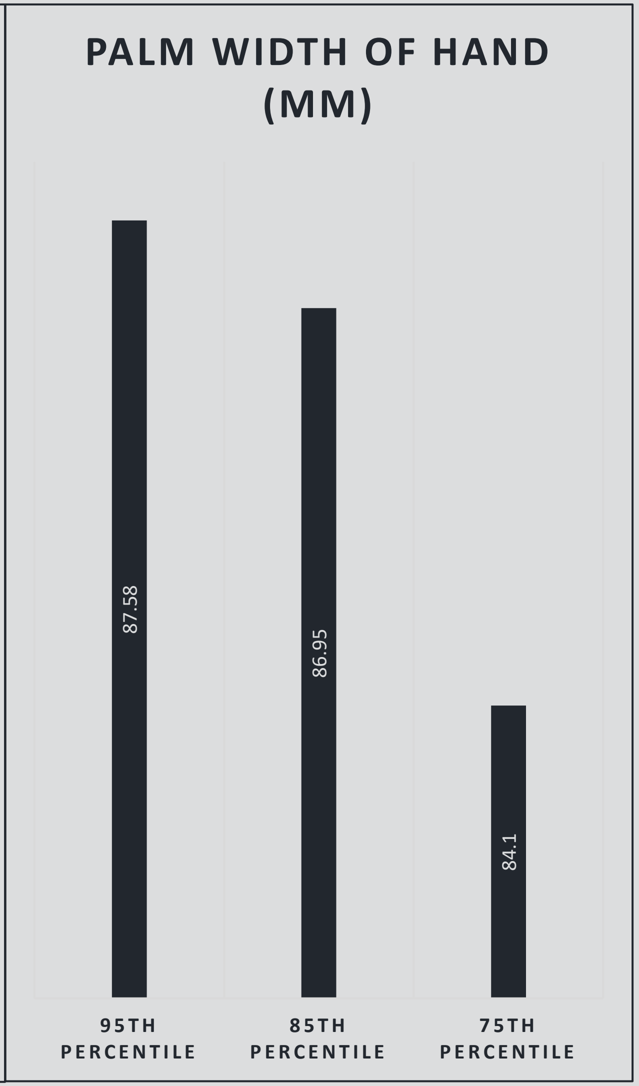
We can also use data from the pressure point heatmap to show that the subjects felt an average pressure around the 1st section of each finger (excluding the ring finger) as well as the 2nd section of the thumb and mid-center of the palm

This data will also allow me to make sure that my design is cost effective, meaning that the handle will be neither too small, nor waste too much material being larger that the 95th percentile which can greatly reduce material consumption, manufacturing complexity, harmful emissions created from manufacturing, and costs









Anthropometric Data – Conclusion (cont.)

Final pizza cutter

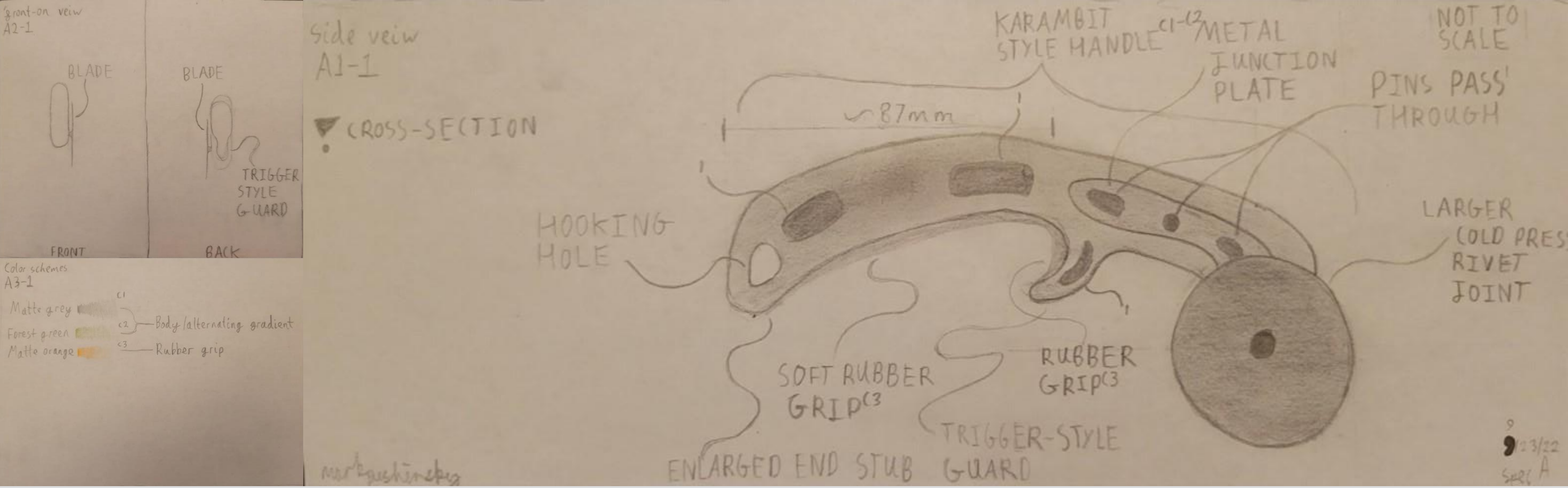
I have also made extra graphs which show the 95th, 85th, and 75th percentile from the datasets which will allow me to have a varied selection of sizes during the designing processes. These percentile ranges will also allow me to make for example the guard big enough for the 95the percentile but small enough so that material is not wasted during the manufacturing process as mentioned in the previous slide.

Note that the units place for the dimensions will not matter much because in real life with models, they won't be the most accurate due to (for example) PLA warping/shrinking/expanding whilst printing.

Topic from 10A Engineering	Example
Production Technique	Since for now this is a custom handle design, I will be using the One-off production technique. The reasoning behind this is because not only is this design custom made, it also does not have to be replicated multiple times (unless we transfer the new handle design into large-scale production). We also need to make sure that the product design is of its best quality from drawing to CAD to CAM (3D printing and CNC machining)
Form vs Function	In this case, form would follow function because although one of the specifications is that it has to be able to look aesthetically pleasing, most of the points are directed towards the safety of the product as well as the ease of use and storage after use.
Environmental Consideration	Since this pizza cutter handle will be used in a kitchen environment, it will need to be able to somewhat blend in with the environment (such as not using bright colors as a color scheme or having an unnaturally large size compared to other tools in the kitchen.
Research and Market Analysis	People in some countries might want to have more vibrant colors in their kitchen (such as ones in the Caribbeans) although others might want a more slick and clean color scheme (such as in more modern houses in the US) so the color scheme is a key factor which is controlled by regions and regional preferences.
QA and QC	For QA, I would make sure that the materials sourced for this project don't have any defects when imported such as the cardboard used, making sure that the cardboard can withstand water whilst forming the polymorph around it and with the polymorph itself, making sure for example, that there are no metal shreds before using the polymorph. For QC, I would make sure to run tests with the cutter such as applying pressure for a continuous amount of time, seeing which parts would break down fastest (e.g., the connection point between the cutter handle and the blade itself.

Factors Taken into Consideration from 10A Engineering

Final pizza cutter



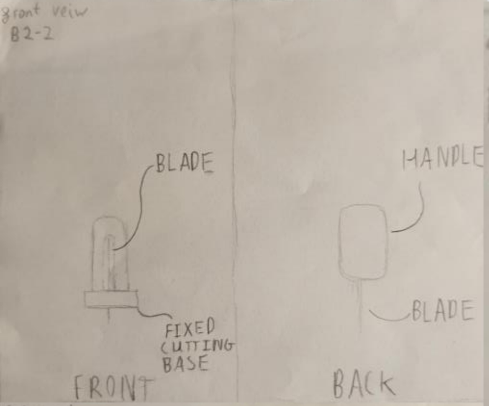
Sketch Spec. A – Sketch

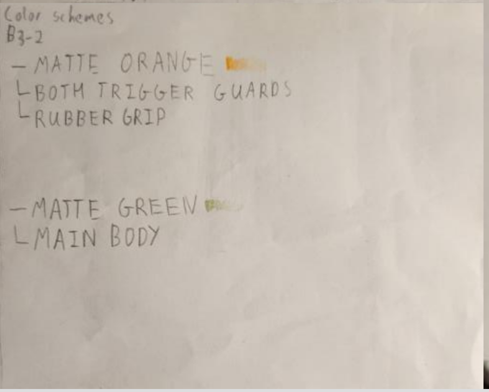
Final pizza cutter

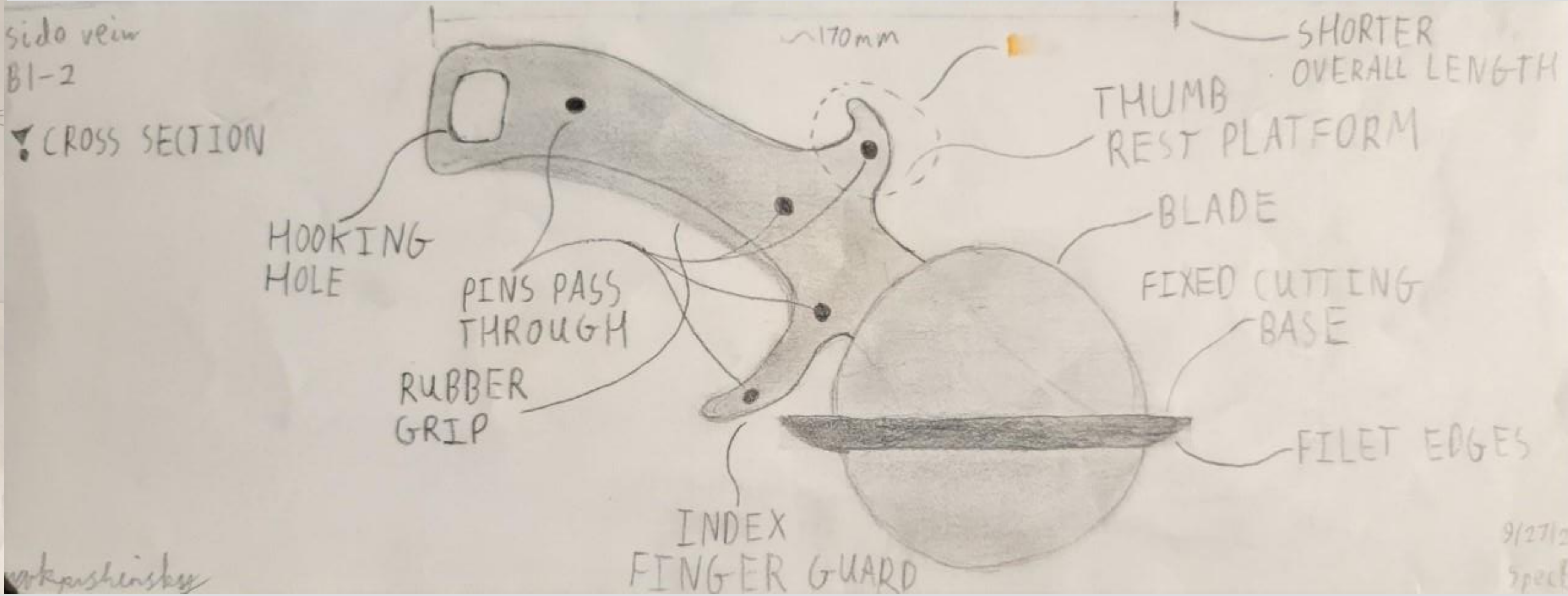
This first design has a karambit-style handle shape with a trigger style thumb rest to allow the user to rest the outer area of their thumb on whilst cutting. There is also a hooking hole which allows the user to hook the cutter after use. Since this is a cross section drawing, we can also see where the joining pins are located (which are the darker shaded areas) which run along the internals of the handle. There is also a soft rubber grip which runs along the underside of the cutter as well as the inside of the trigger guard which will allow the user to have a firm grip whilst cutting as well as for the pressure points on the palm of the user's hand.

DIMENSIONS
End of handle to trigger grip ~87mm
Height from tip of trigger grip to base ~34mm
Relative diameter of handle ~170mm (to account for where hand does not encounter the handle)

MATERIALS USED
PLA – For the main body of the pizza cutter







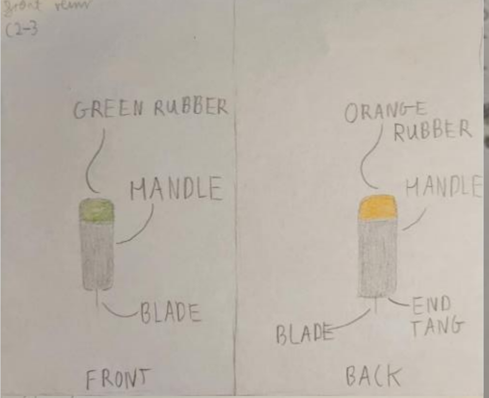
Sketch Spec. B – Sketch

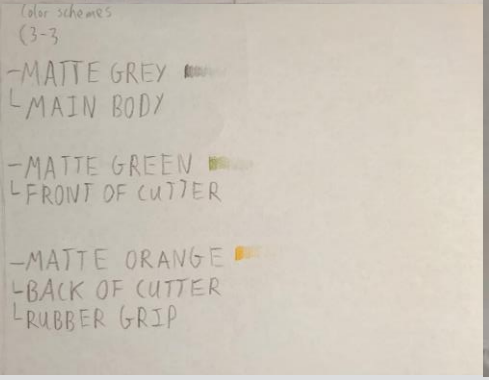
Final pizza cutter

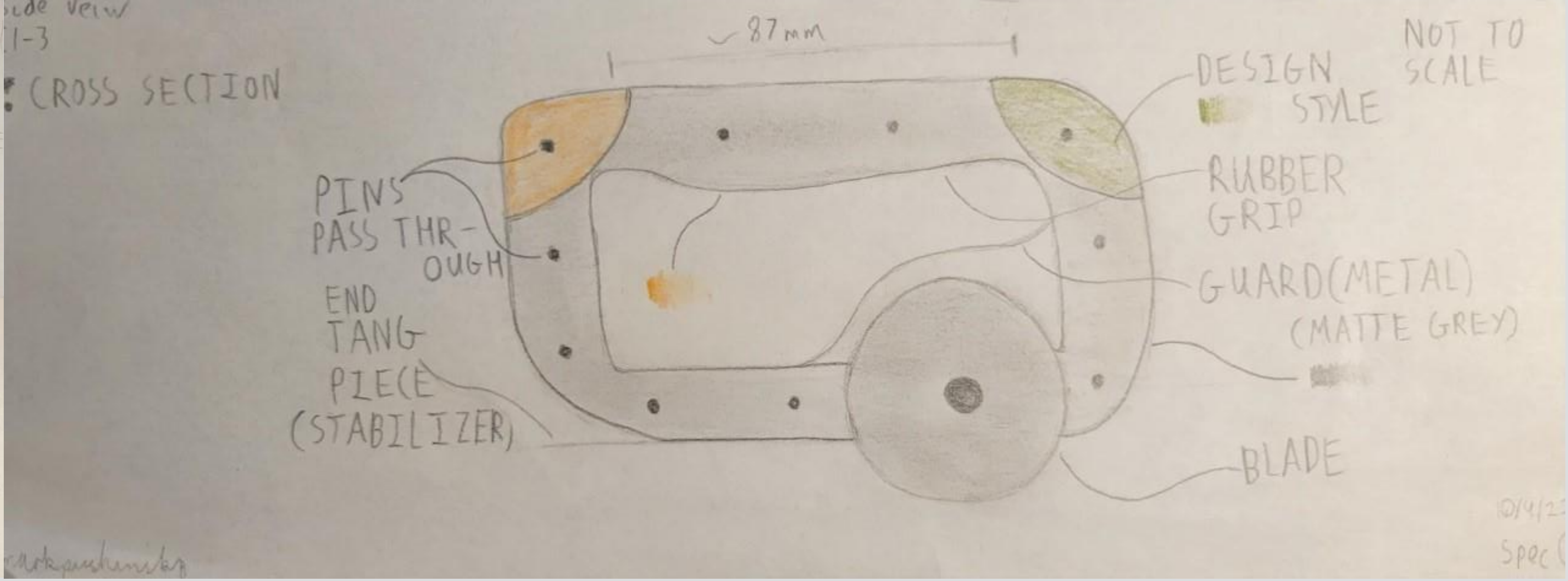
This second design is slightly inspired by the first although in this design, there is a cutting base piece which will rest on the pizza (which has filleted edges to prevent it from digging into the pizza whilst the user is cutting whilst making sure that the pizza cutter has as little sideways motion) and a second trigger-style guard which will provide the user with two areas to apply pressure to the blade (which also makes it safer compared to the first design because of the second guard on top of the cutter)

DIMENSIONS
Total cutter length ~170mm
Height from tip of trigger grip to base ~34mm
Relative diameter of handle ~170mm (to account for where hand does not encounter the handle)
End of handle to trigger grip ~87mm

MATERIALS USED
PLA – For the main body of the pizza cutter
Photopolymer resin – For use in the "RUBBER GRIP" section of the handle







Sketch Spec. C – Sketch

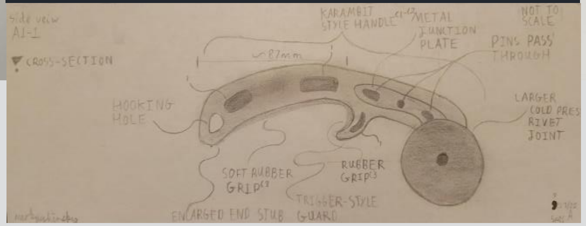
Final pizza cutter

The third design is different to the other two and has two different rubber pieces on each of the top sectors of the cutter (which is used for aesthetic). Also, another feature is the end tang piece which rests on the pizza whilst the user is cutting the pizza. Another feature is that the blade is placed near the front of the cutter because if it was placed in the middle, it would interfere with the user's hand as well as cause a safety concern (this is because the blade could cut into the user's hand if their hand slips.

DIMENSIONS
Orange grip to green grip ~87mm
Total cutter length ~130mm
Distance from the underside of the top handle to the guard ~35mm

MATERIALS USED
PLA – For the main body of the pizza cutter
Photopolymer resin – Two caps at each end of the pizza cutter (different colors preferred)

Criteria	Point ratings
Safety	S1 3/10 S2 N/A/10 S3 5/10 S4 4/10
Ease of use/storage	Eu1 6/10 Eu2 10/10 Eu3 4/10 Eu4 9/10
Aesthetics	A1 N/A/10 A2 N/A/10 A3 4/10 A4 8/10
Ergonomics	Er1 6/10 Er2 4/10 Er3 4/10 Er4 3/10 Er5 7/10



Sketch Spec. A – BUILD

Final pizza cutter

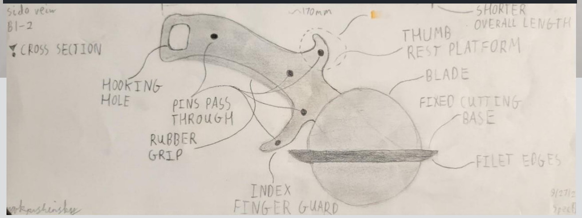
Feedback

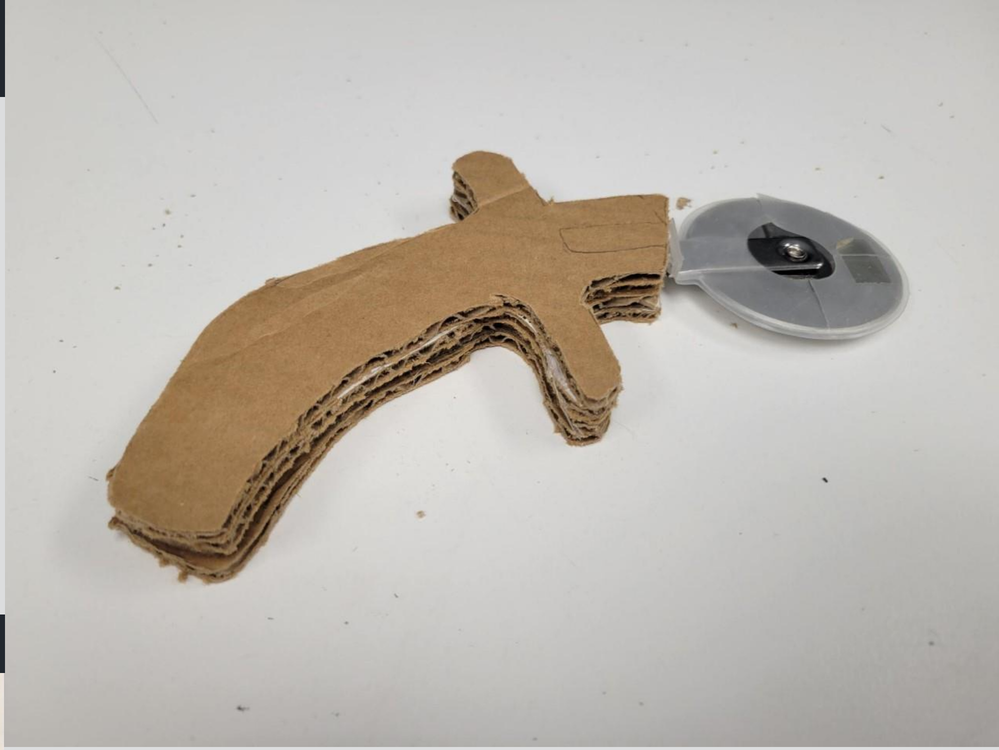
- Main: Handle length was too short (SCALE ISSUE)
[redacted] said that the handle length to hold the cutter was too small and that it could be prone to slipping when the user cuts a pizza
- Sub: Handle was too thick (SCALE ISSUE)
[redacted] also said that it was a bit too large to hold comfortably because of the thickness of the handle. This also links back to the handle length because [redacted] mentioned that it could slip whilst cutting

Next time, I will try to make the handle as close to scale as possible (by measuring the drawing on carboard with a ruler before cutting [especially with the handle since the feedback was aimed mainly towards the handle not only being too thick]), but also not having a long enough handle (from finger trigger style guard to the end of the cutter).

FOR REDESIGN:
Work on the depth of the handle (show the dimensions of the depth of the hand in both the drawings and on the cardboard cutouts to ensure that the scale is correct instead of eyeballing it)
Make the model to scale (length of handle) with scale dimensions on both the drawing and the cardboard cutouts

Criteria	Point ratings
Safety	S1 6/10 S2 N/A/10 S3 8/10 S4 8/10
Ease of use/storage	Eu1 7/10 Eu2 10/10 Eu3 8/10 Eu4 10/10
Aesthetics	A1 N/A/10 A2 N/A/10 A3 7/10 A4 8/10
Ergonomics	Er1 9/10 Er2 8/10 Er3 5/10 Er4 9/10 Er5 9/10





Sketch Spec. B – BUILD

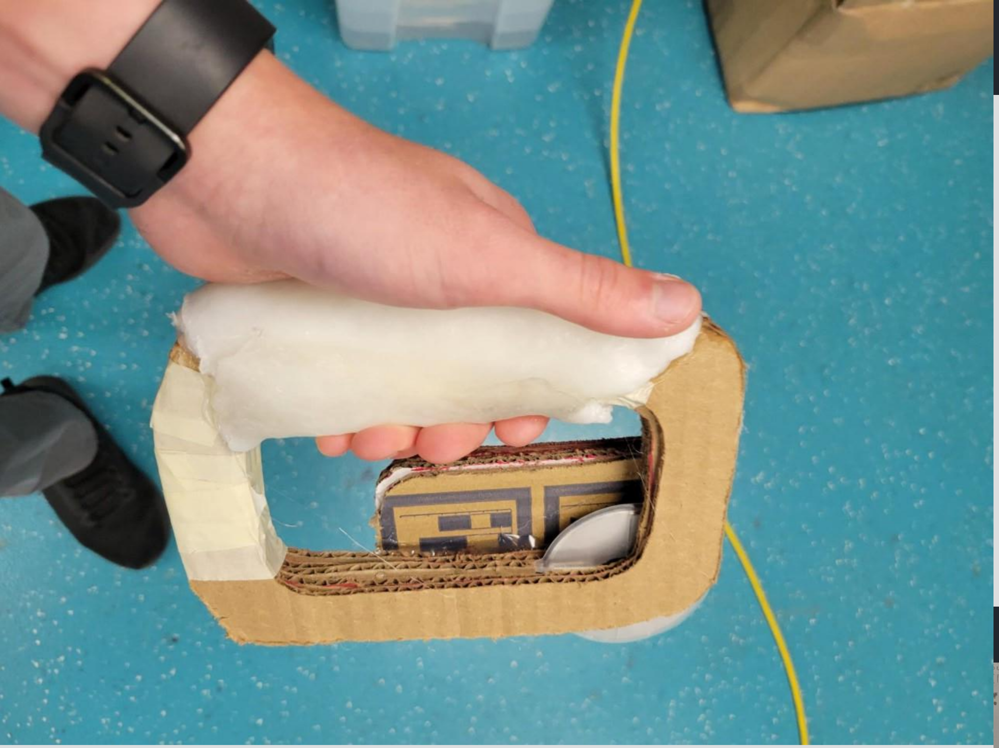
Final pizza cutter

Feedback

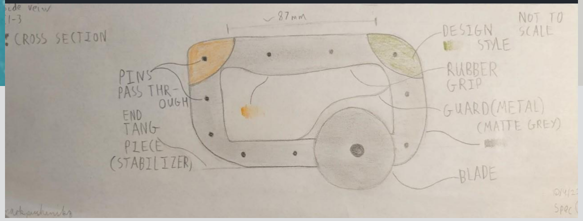
- Main: Add support for pointer finger (DESIGN ISSUE)
The main feedback is that [redacted] mentioned was adding in a small indent near the guard for the pointer finger so that the user has more control over the handle.
- Sub: Slightly increase the length of the back of the handle (SCALE ISSUE)
A lot of people also mentioned that the handle might be too short (from the guard to the end) for people who have larger hands.

Next time, I will make sure to add in the indent for the users' pointer finger so that the pizza cutter is easier to handle (in terms of how much grip the user can have on the handle) and I will also make sure that the final length of the handle is a little bit larger

FOR REDESIGN:
I will redesign the drawing to take into consideration the finger indent as well as the length of the handle. With the handle, I would next time increase the size at the back of the handle at around 5mm. I will also make sure to reduce the size of the pointer finger guard because I think I have used too much material which could increase manufacturing costs.



Criteria	Point ratings
Safety	S1 8/10 S2 5/10 S3 6/10 S4 7/10
Ease of use/storage	Eu1 3/10 Eu2 8/10 Eu3 8/10 Eu4 6/10
Aesthetics	A1 N/A/10 A2 N/A/10 A3 6/10 A4 8/10
Ergonomics	Er1 8/10 Er2 9/10 Er3 6/10 Er4 5/10 Er5 8/10



Sketch Spec. C – BUILD

Final pizza cutter

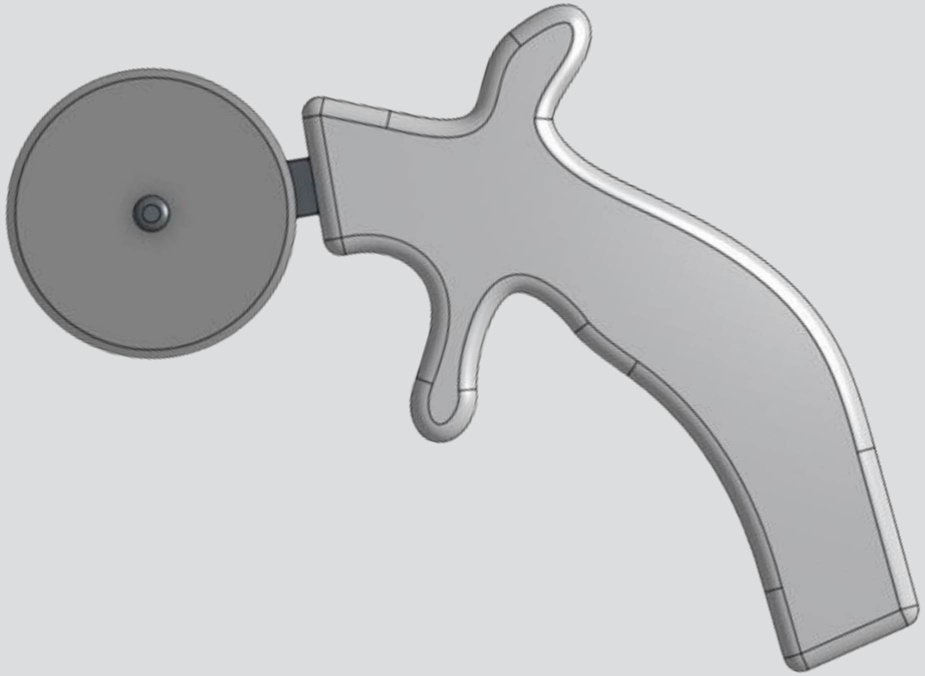
Feedback

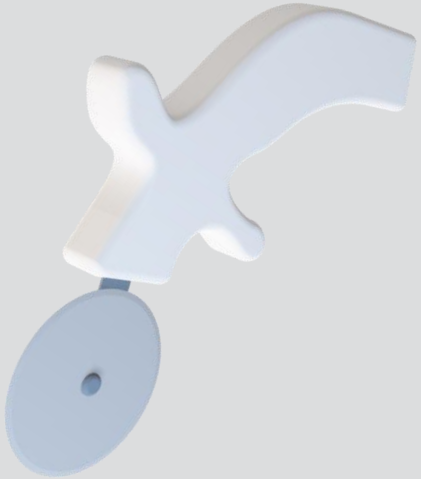
- Main: Cannot see where user is cutting (DESIGN ISSUE)
Many students mentioned that when they were handling the cutter, it was quite difficult (because of the angle) to see where the cutter is cutting. This is mainly because of the square frame + where the handle is in relation to the blade itself which unless you are looking right above, your view can be blocked from the handle.

- Sub: Weight of the handle (WEIGHT ISSUE)
Many students also mentioned that the handle (with the polymorph) was getting quite heavy and would cause it to be quite hard to use over a longer length of time. Also, it is unable to stand vertically by itself without external interaction because of the weight from the polymorph

Next time, I will make sure that the handle of the cutter is thinner (to decrease overall weight), make sure that the blade is more visable to the user (so that they know where they are cutting), and make sure that the overall shape of the cutter is as simple of a shape to manufacture as possible (to reduce the need for complex manufacturing tools (such as 5-axis CNCs) as well as operating costs).

FOR REDESIGN:
Try to reduce the amount of polymorph used in the handle to not only make the handle thinner (and therefore easier to use) but to also reduce the overall weight of the cutter.
Remove material from the back of the cutter (from where the tape is on the left image, all the way down to the resting bar [left of the blade]) to reduce weight (although might increase manufacturing costs)





The Design Process Pt. 1

Final pizza cutter

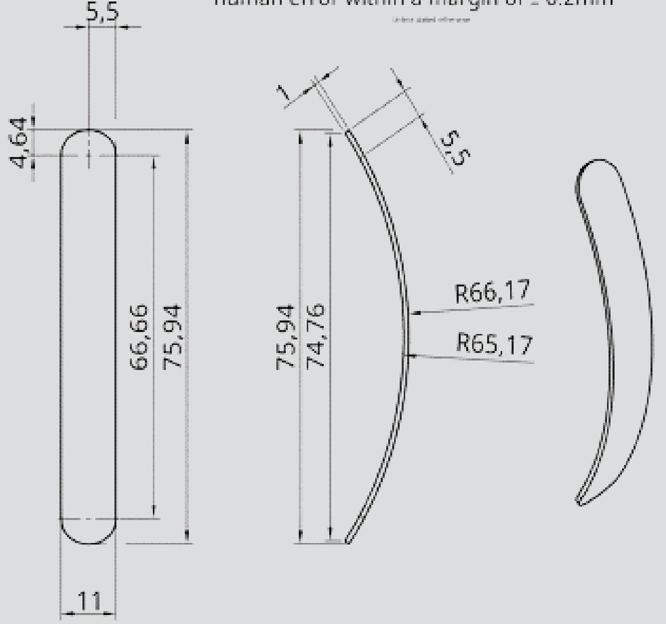
Over these next few slides, there will be different pictures and screenshots of the design process on OnShape as well as AD Dimension

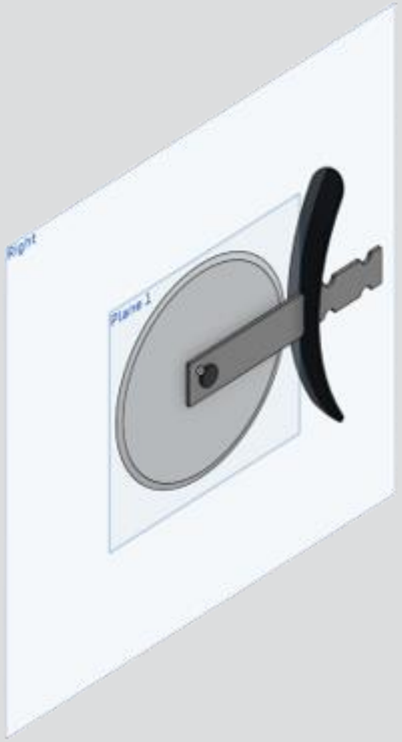
What is "OnShape"?
OnShape is a 3D modeling online software which I will use in this project to not only model the blade, but also to model the handle itself. It does not have a rendering engine though, so we will have to use another tool called AD Dimension

What is "AD Dimension"?
AD Dimension (Adobe Dimension) is an Adobe product which allows users to create high quality renders of objects but also includes multiple presets of objects which allows the user to make scenes with for example water (there is a water preset) as well as assign "material" appearances to 3D objects to make them look more realistic in the render

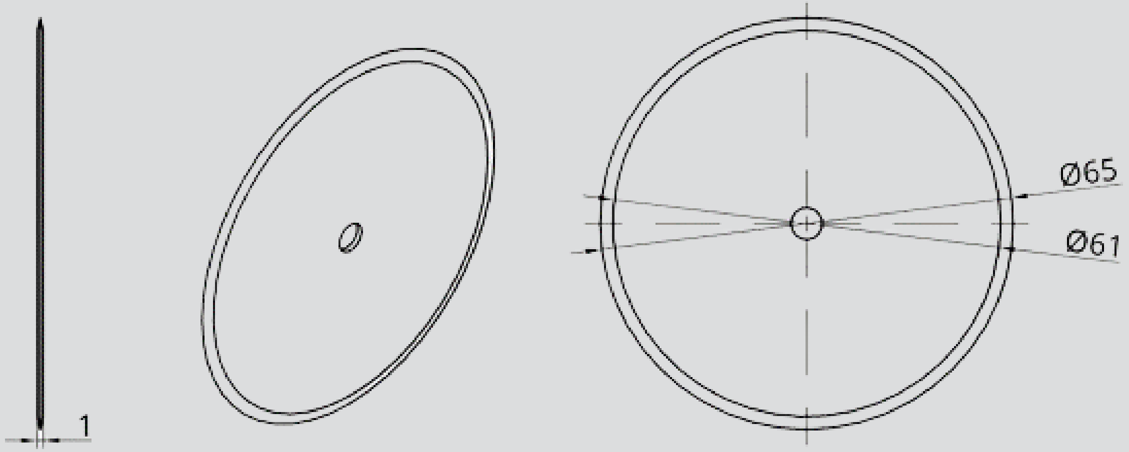
Considerations in the 3D design process
Since FDM filament can contract whilst printing, I will have to make sure to leave small gaps between the semicircles so that the blade shaft can fit inside the mounting slot. Also, when designing, I will have to split the final part in half because in the shaft mounting slot, there is still a gap, and since 3D printers can't print over long distances and overhangs without support underneath, it would be difficult to fit the shaft later without residual plastic being stuck inside the slot (mainly due to material sag while its still warm). I have also designed the slot to the exact shape of the shaft for the blade and added 1mm of space to take into consideration material warping and contraction.

Most measurements present **will** include
human error within a margin of ± 0.2mm





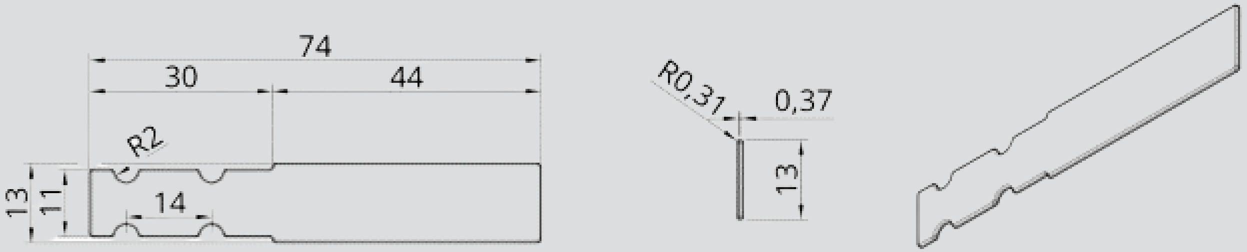
Most measurements present **will** include
human error within a margin of ± 0.2mm



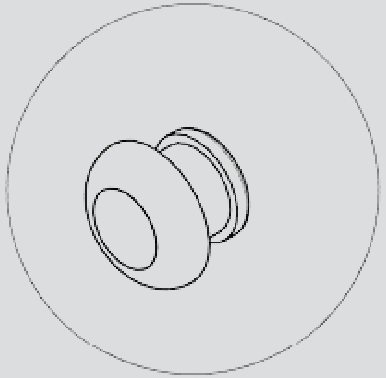
Drawings & Model – Blade

Final pizza cutter

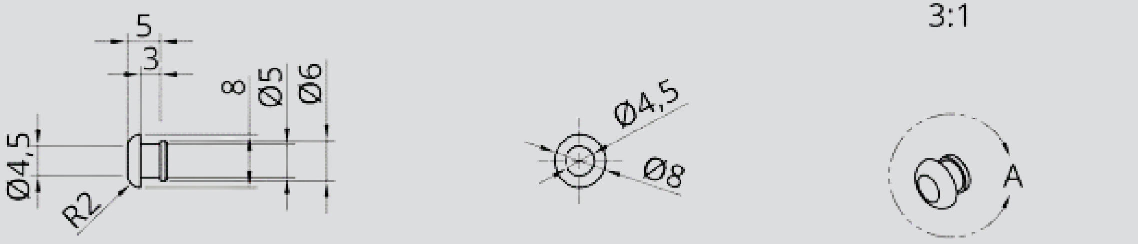
Most measurements present **will** include
human error within a margin of ± 0.2mm

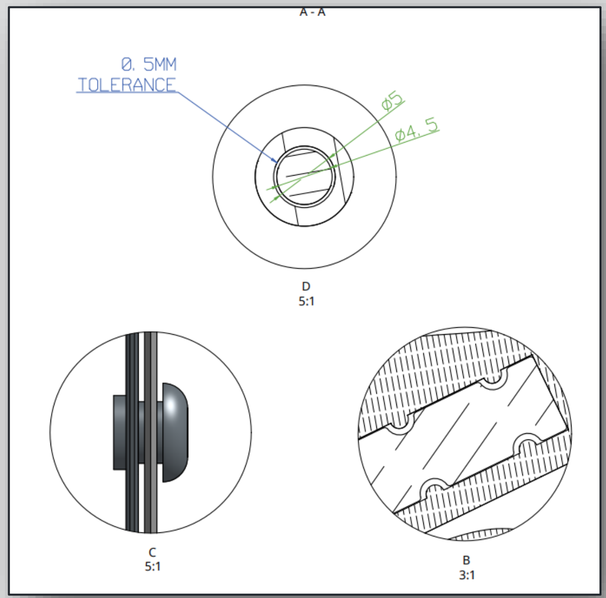


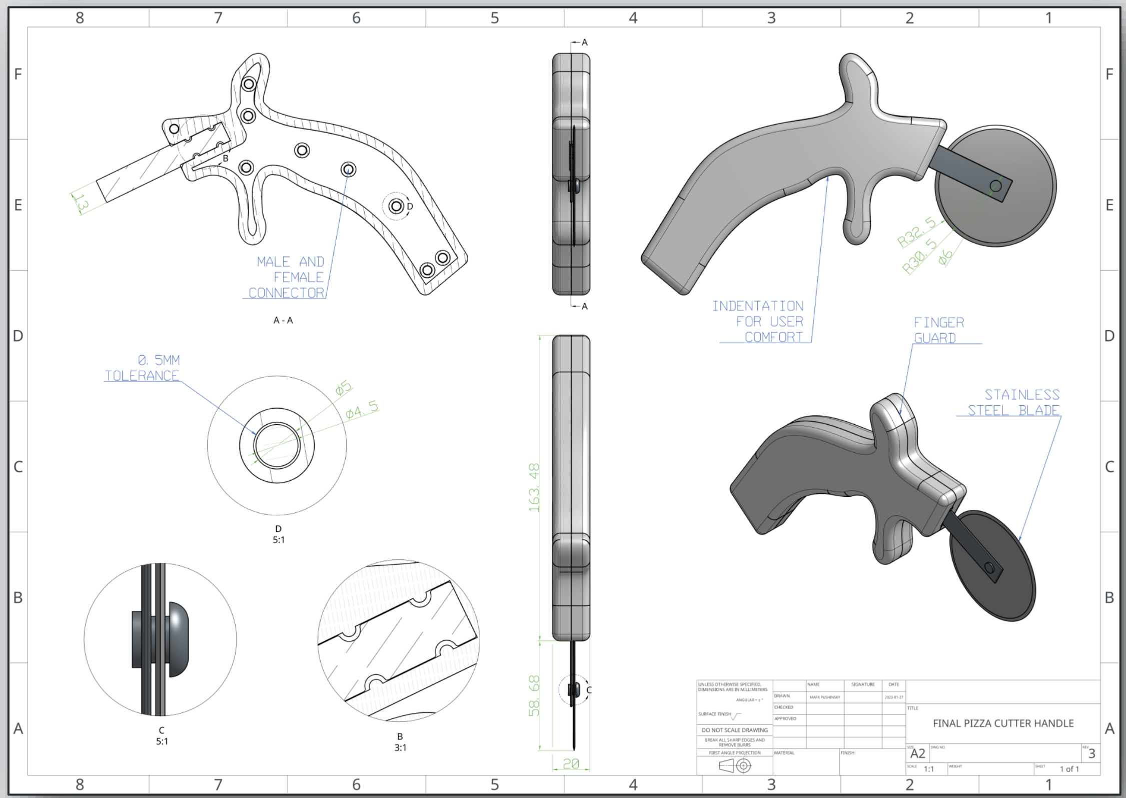
Most measurements present **will** include
human error within a margin of ± 0.2mm

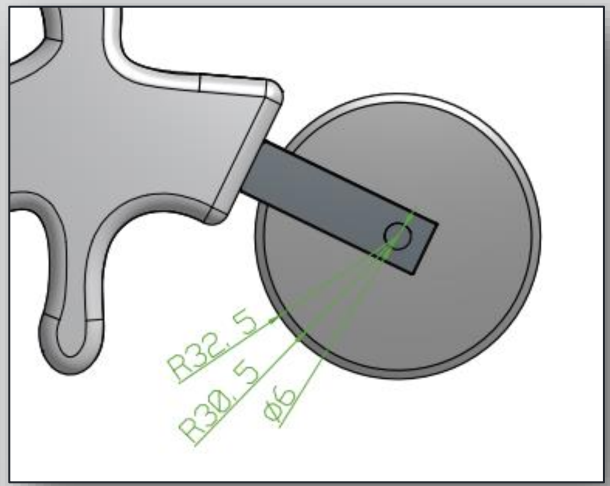


A
3:1









Engineering Drawings

Final pizza cutter

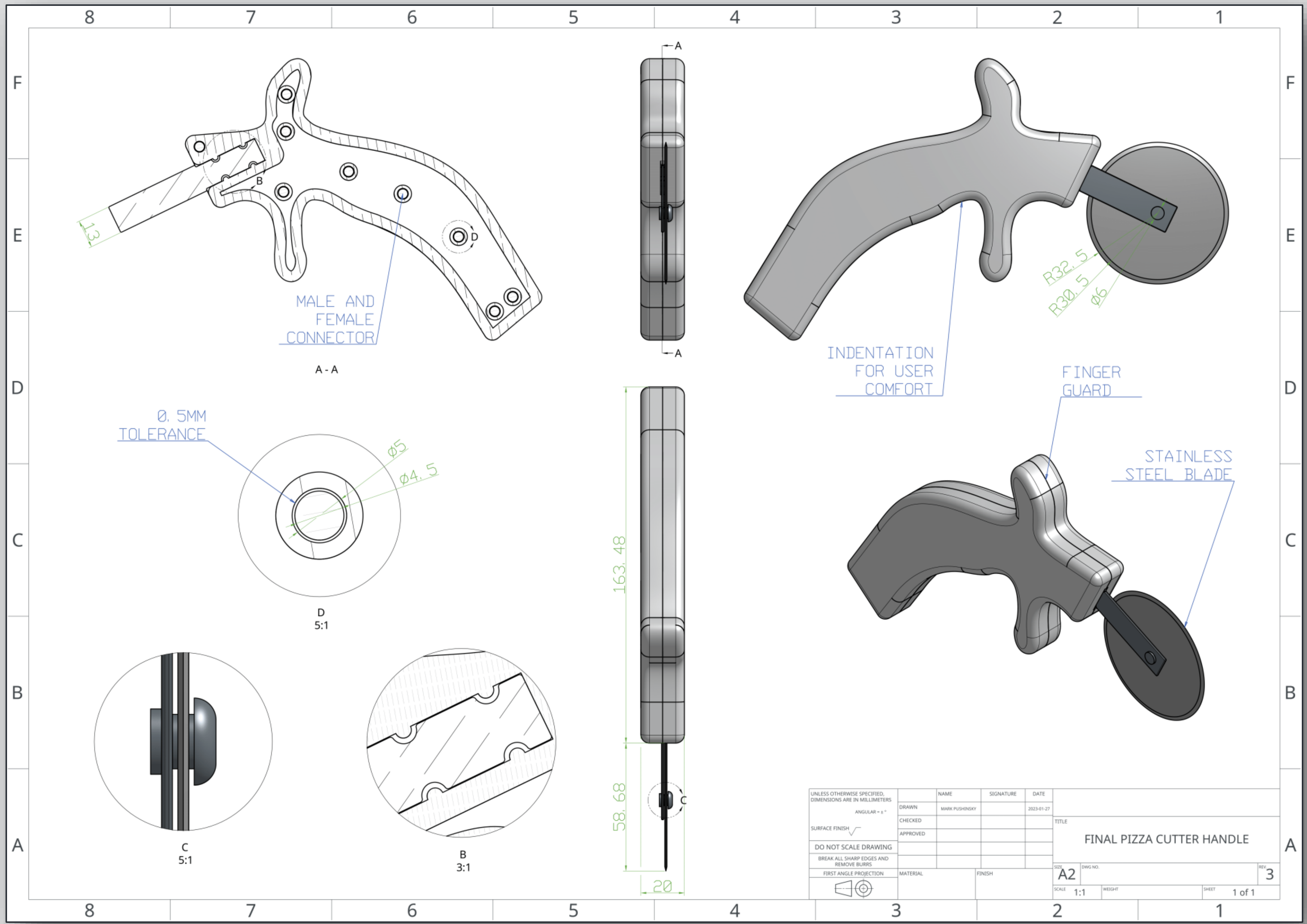
Engineering drawings are important because they can provide manufacturers a clear and detailed visual representation of the product as well as key dimensions and tolerances (which were used in this project for the female and male connectors). Overall, they are critical to providing manufacturers the desired spesifications for a product.

In this project, I am using engineering drawings to show the different dimensions as well as cross-sectional views which otherwise might not be clearly visable to people looking at the 3D model. Below are some key aspects I took into consideration when creating the drawings. You can also view a full version of the drawing by clicking the button on the top right!

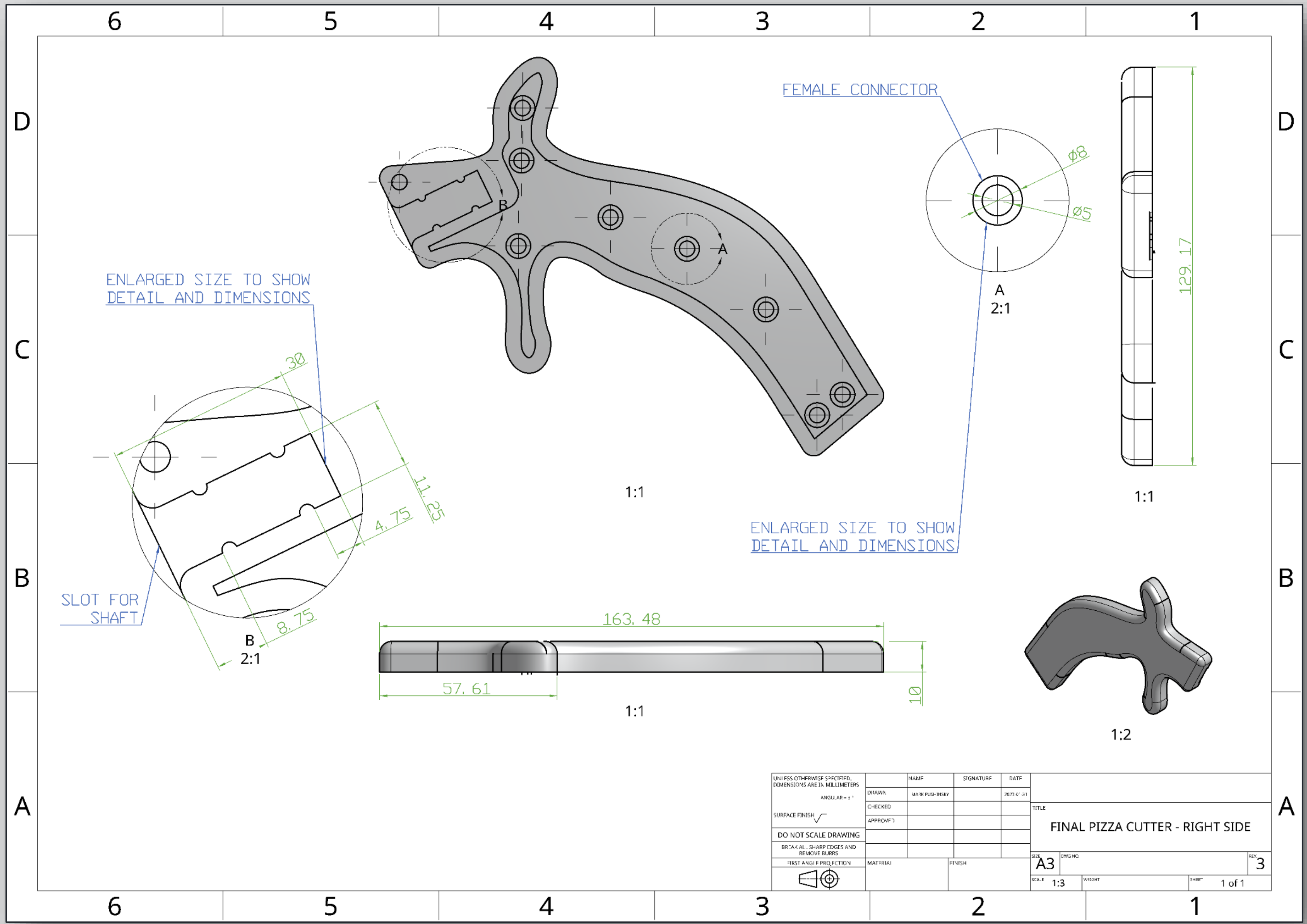
When showing different views, I made sure to include a cross-sectional view of the handle mainly because the inside of the handle is not visable in any of the other views but also to show the clearances in the female and male connector which would be crucial to know in manufacturing.

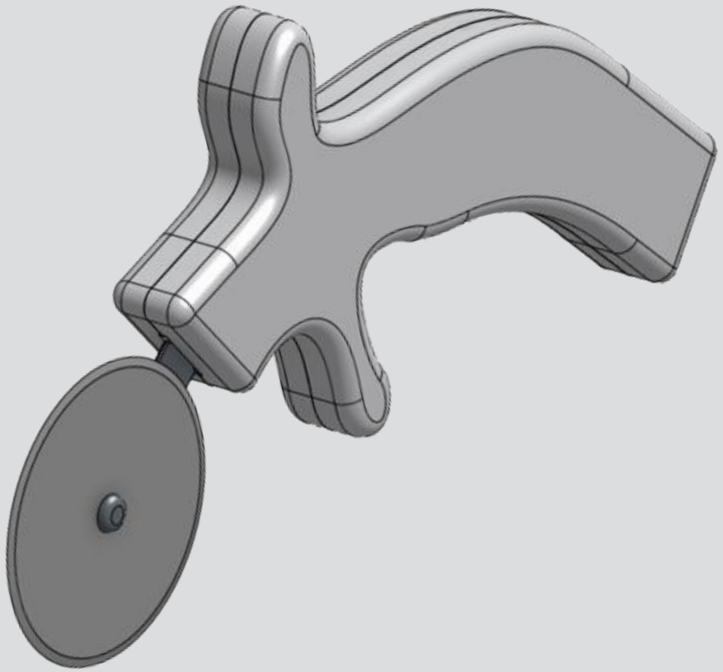
I have also made sure to enlarge the size of some of the parts which would be otherwise quite hard to view. This includes the tolerances for the connectors, the tolerances around the shaft and the handle body, and the rivet which holds the blade and shaft together. They are marked with different letters and the ratio at which its “zoomed in” at the bottom of the enlarged views so that engineers can tell which part is zoomed in.

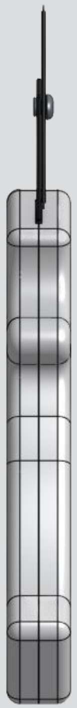
Lastly, I made sure to include annotations to describe the different functions of the pizza cutter handle design so that people who view the drawing for the first time, can get an idea of what the pizza cutter is about and how its designed .



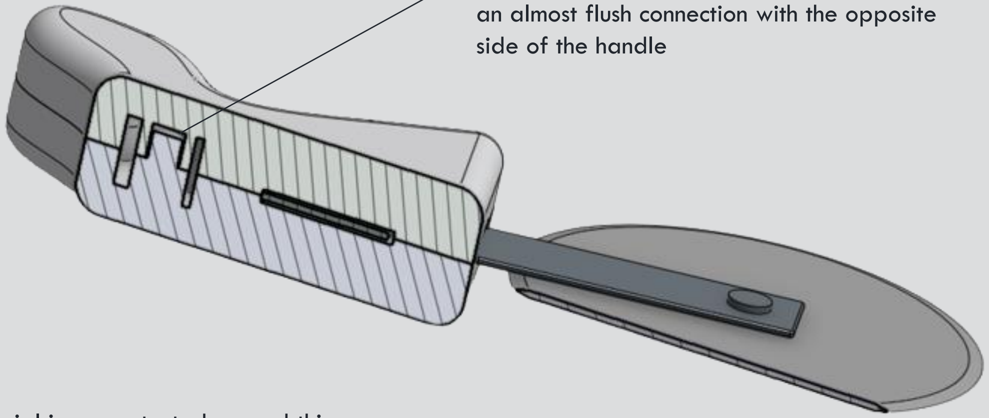
MALE AND FEMALE CONNECTOR
13
B
D
A - A
A
0.5MM TOLERANCE
ø5
ø4.5
D
5:1
C
5:1
B
3:1
163.48
58.68
20
C
INDENTATION FOR USER COMFORT
R32.5
R30.5
ø6
FINGER GUARD
STAINLESS STEEL BLADE
UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN MILLIMETERS
ANGULAR = ± °
SURFACE FINISH
DO NOT SCALE DRAWING
BREAK ALL SHARP EDGES AND REMOVE BURRS
FIRST ANGLE PROJECTION
NAME
SIGNATURE
DATE
DRAWN
MARK PUSHINSKY
2023-01-27
CHECKED
APPROVED
MATERIAL
FINISH
TITLE
FINAL PIZZA CUTTER HANDLE
SIZE
A2
DWG NO.
REV.
3
SCALE
1:1
WEIGHT
SHEET
1 of 1


FEMALE CONNECTOR
Ø8
Ø5
A
2:1
129.17
1:1
ENLARGED SIZE TO SHOW
DETAIL AND DIMENSIONS
30
11.25
4.75
8.75
SLOT FOR
SHAFT
B
2:1
A
B
1:1
ENLARGED SIZE TO SHOW
DETAIL AND DIMENSIONS
163.48
57.61
10
1:1
1:2
UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH
DO NOT SCALE DRAWING
BREAK ALL SHARP EDGES AND REMOVE BURRS
FIRST ANGLE PROJECTION
NAME
SIGNATURE
DATE
DRAWN
MARK PUSHINSKY
CHECKED
APPROVED
MATERIAL
FINISH
TITLE
FINAL PIZZA CUTTER - RIGHT SIDE
SIZE
A3
DWG NO.
REV.
3
SCALE
1:3
WEIGHT
SHEET
1 of 1





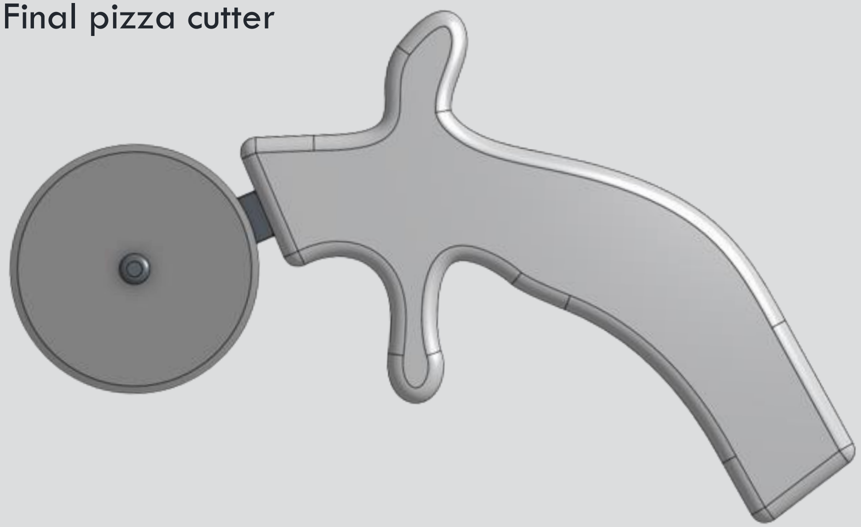
The gap here is a tolerance that I made so that when the material expands from the rapid change in temperature, it would make an almost flush connection with the opposite side of the handle

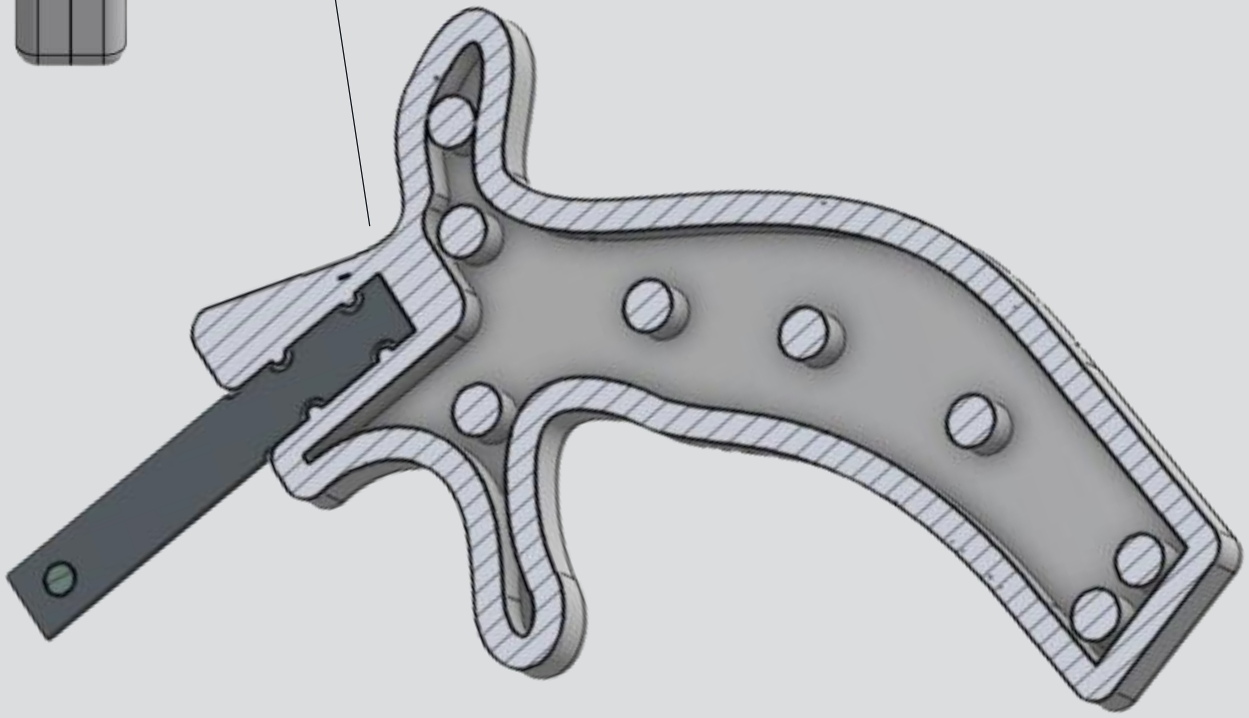


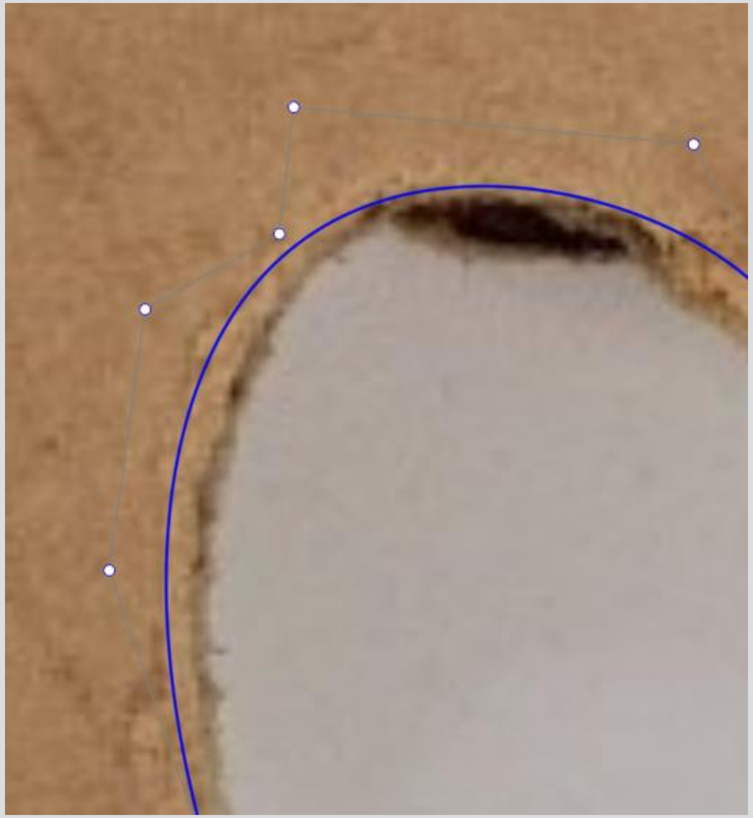
Drawings & Model – Handle v3

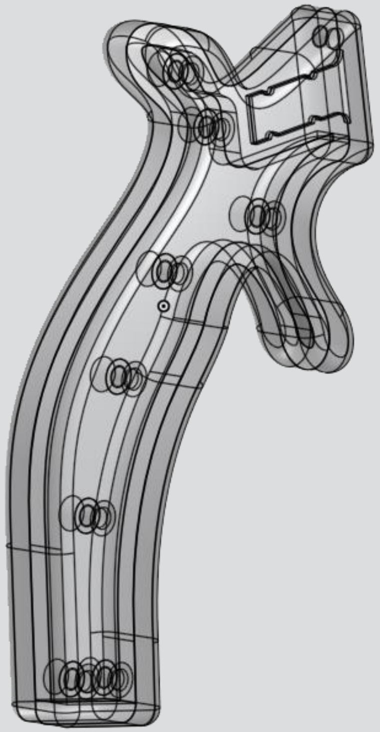
Final pizza cutter

Material is concentrated around this area because this section of the pizza cutter is where a lot of force might be applied whilst cutting









The Design Process Pt. 2

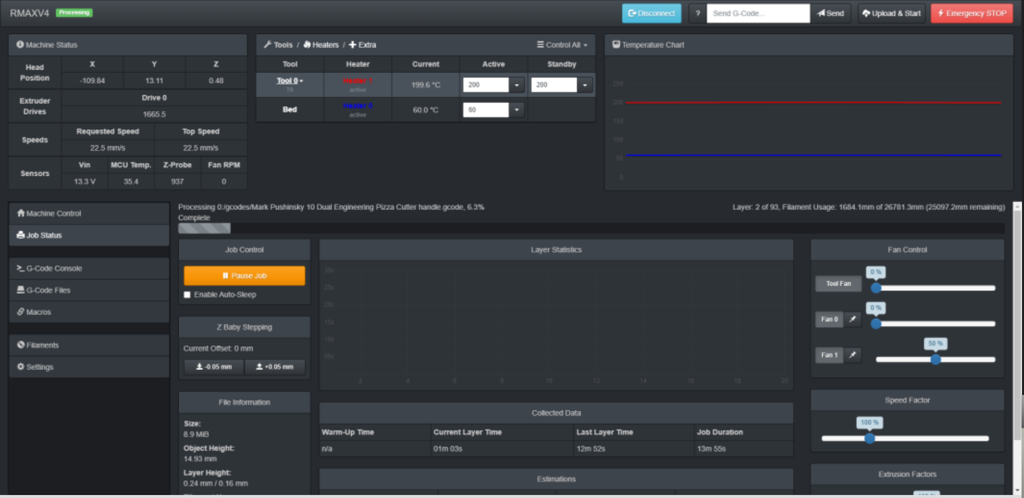
Final pizza cutter

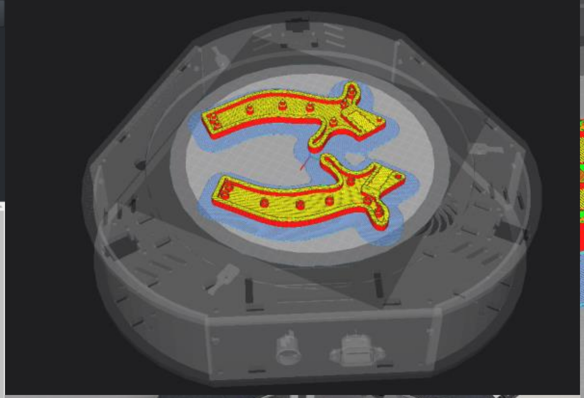
Whilst designing the new handle, I used multiple tools such as the Bezier curve tool (top left image) which allows me to get the uniform curves that make up the shape of the handle. I also used tools like the filet tool to round off the edges so that, whilst cutting, the user does not end up with indents in their hand.

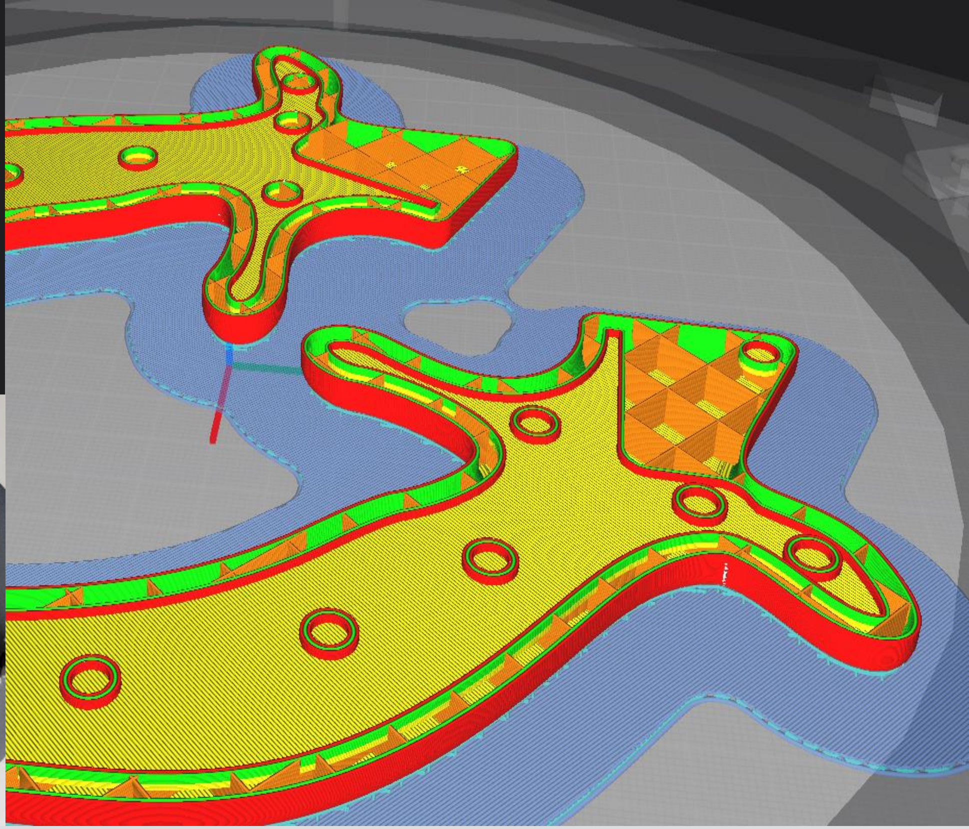
I have also made sure that there is a base where the blade shaft can sit as well as adding in two notches which will make sure that the blade does not move in/out of the cutter handle (top center image) as well as adding in the slots with a small clearance gap so that both sides of the handle can be joined together (top right image) as well as making sure that the overall insides of the cutter is hollow so that it does not require a lot of material to manufacture as well as to save time on manufacturing and the overall weight of the handle.

Also, when I was designing the final model, I considered the feedback that I got from the cardboard model which included adding in a small notch for the users' finger so that they can have a better grip on the handle.

One issue I had to fix whilst making the final design was that the mounting stud on the far left of the center image was overlapping the shaft holder and I fixed it by first filling in the space between the holder and the shell of the cutter and then creating a 5mm hole which I extruded to the back plane.







The Manufacturing Process – From OnShape to 3D Printing

Final pizza cutter

In order to turn the 3D model into a physical model, we need to use a small range of software to slice and upload the model using .stl and .gcode files: OnShape for exporting the parts in .stl format which was then uploaded to CURA (the slicing software) in which I made sure to edit some of the print settings such as adding in a raft and having only 10% hexagonal infill. The reason why I chose 10% infill was because I wanted the design to be strong enough (especially near the finger guards) to withstand considerable pressure being applied on the handle from the user whilst at the same time making sure that I did not use a lot of filament (in order to reduce material usage and optimize print time.

After that, I exported it as .gcode (which are essentially instructions that the printer uses to move the gantry to spesific locations for printing). After that, I used the web interface for the printer (found by entering the printers IP address) to import and send the file to print.

Before printing, I made sure to check that the bed was level (this was important because in the next slide I will go over what happened) and had to preheat the print bed and extruder so that the 3D printer was ready to print as soon as the gcode was sent over.

I also had to make sure that the placement of both sides did not interfere with each other although in this case, it did not matter if the raft material overlapped because it would just combine to make one larger raft. I also had to consider the orientation of the handles to reduce the amount of material needed for the raft layers.


Setting name	Values used	Setting name	Values used	Setting name	Values used
Print speed	60mm/s	**Bed temperature**	60C	**Build plate adhesion**	Raft
Infill	10% Grid	**Nozzle temperature**	200C	**Support**	Everywhere @ 50°

The Manufacturing Process – 3D Printing

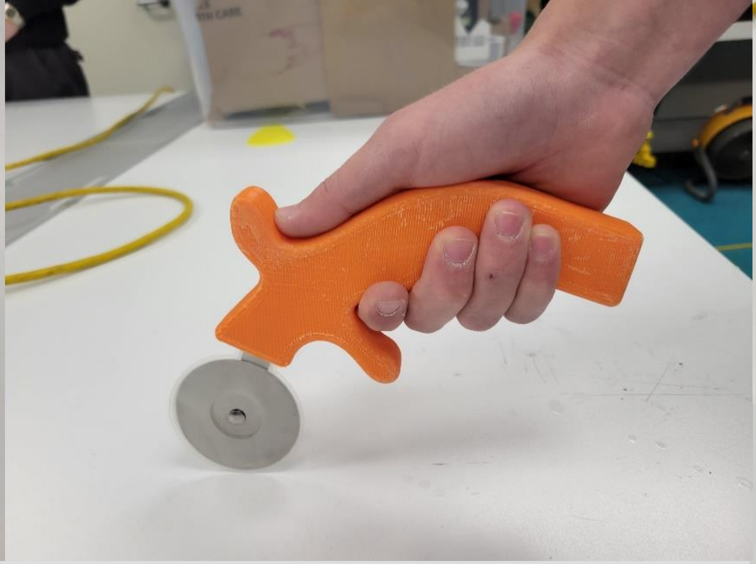
Final pizza cutter

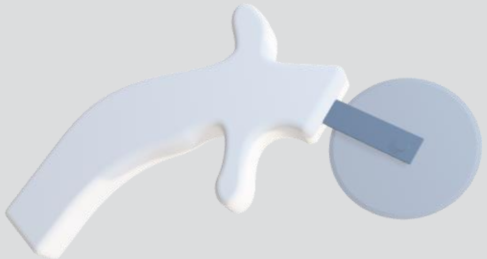
In the example above, I used a ROSTOCKMAX v4 which is a type of printer called a delta printer. It moves only using three gantry arms which are height controlled by stepper motors in the main hub of the printer.

When I sent out the first gcode file as seen on the top right image the print failed because the extruder was offset by the Z axis by around 4-5mm (which is a lot when it comes to fine printing). We thought it was either the printer or how I sliced the model in CURA, but we checked over the CURA settings and we found no issues, so we assumed that the printer was at fault. Before printing the model for the second time, we homed the axis and calibrated the offset of the print surface (since a 3D printers' base plate is not always perfectly level and calibration of the offset allows the printer to make fine adjustments in the gcode it receives to consider the dips and troughs of the surface.

Unfortunately, I was not able to get a screenshot of a 3D model that the printer made with the offset heights) although the second time, it happened again, and the printer was printing with a Z offset of ~3mm. We tried a last time with homing and calibrating the printer extruder and gantry system and it finally printed without the weird Z offset (as seen in the image on the left)

We also noticed that in the final print, although the male connector was extruded both ways, it looked like there was material only going one direction so next time, I will make sure that the infill density is a bit higher to make sure that it is not a weak point which can break during the use of the cutter





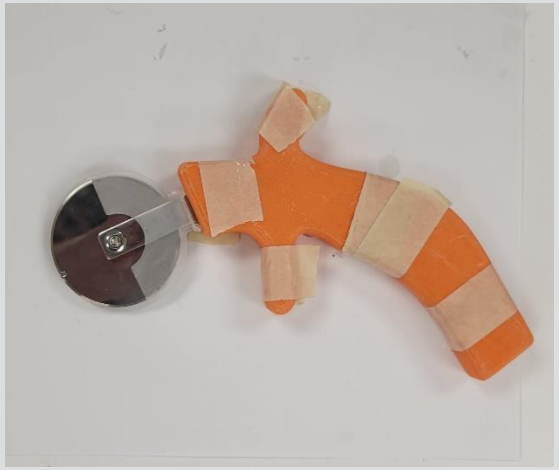
The Manufacturing Process – The Final Product & Post Processing

Final pizza cutter

After getting the model printed, it still requires some post-production finishes such as sanding down the edges as well as removing the raft that came with the print. Right out of the printer, it looked like the image on the top left but now it looks like the image in the center.

In order to remove the raft, I used a chisel-type tool which I then wedged under the raft (rafts are slightly connected to the print but there is a gap between the print itself and the raft) and started “peeling” off the raft. In order to smooth down the edges, I used 120 grit sandpaper (the higher the grit number, the finer the sandpaper. Source: Mr. Davies) and rounded off the edges (because support material was generated near those edges.

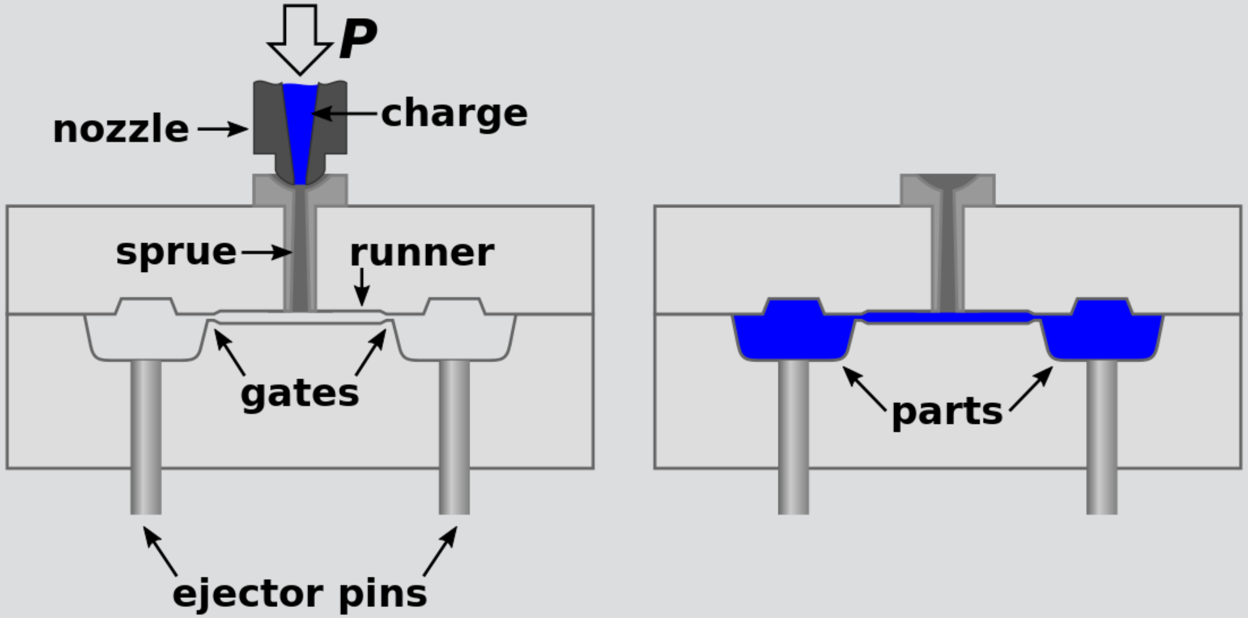
Also, you can see the clearance I left for the shaft so that the fitting is not too tight. This was another design consideration because I wanted to consider the 3D printers accuracy especially with for example with the male and female connectors (which ended up fitting just right without needing to do any post process sanding!).



The Assembly Process

Final pizza cutter

After the handle comes out of the printer, it needs to be assembled and the way that I assembled it was by first taking off the raft (with a chisel) and sanding off the rest of the raft with sandpaper so that the edges are smoothed out. I also had to remove the support material (which was not much) and I removed it using a chisel and 60 grit sandpaper. Lastly, I used a mixture of two different glues in order to glue the shaft of the blade to the handle. After gluing the shaft to the handle, I noticed some rougher edges and had to sand them down with 120 grit paper in order to create the final product



Materials and Manufacturing Process

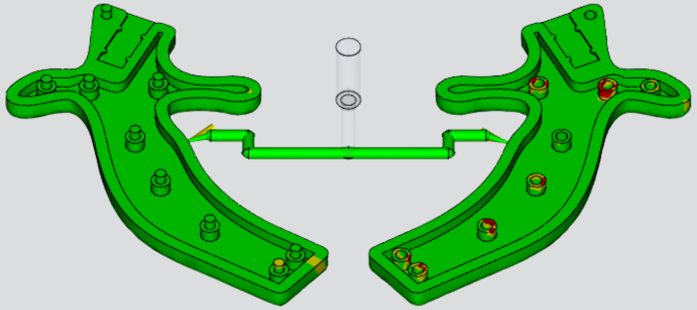
Final pizza cutter

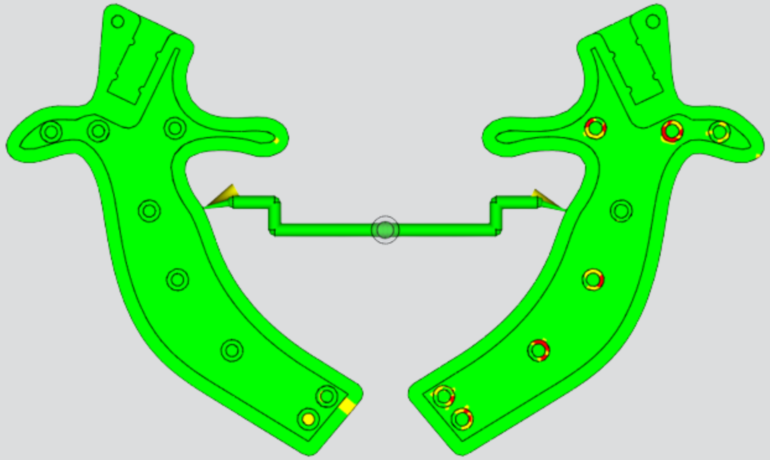
Although the current prototype might be good for visualizing the model itself, the materials used would not be suitable for use with food.

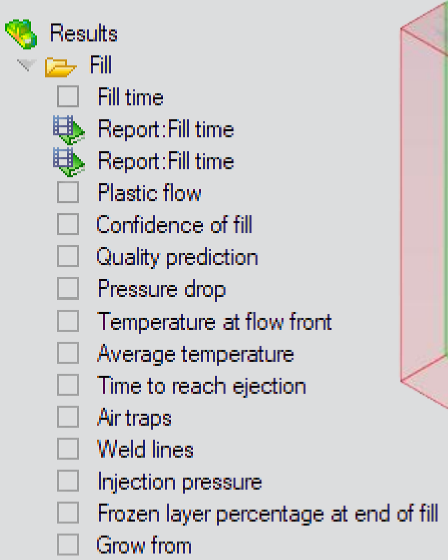
Mainly, PLA is not safe for use with food consumables which means that I will need to find an alternative material which would: be easy to manufacture as well as food safe. 21 CRF standards from the FDA cover the different types of substances "safe for food contact". Some of them include the following: Silicone, Nylon, Acetal, and Polyethylene (source). The easiest material to manufacture is silicone since it can be injection molded although it is not structurally stable. The most suitable material for this case would be Nylon (spesifically Nylon 6/6) since it's a plastic and can be molded.

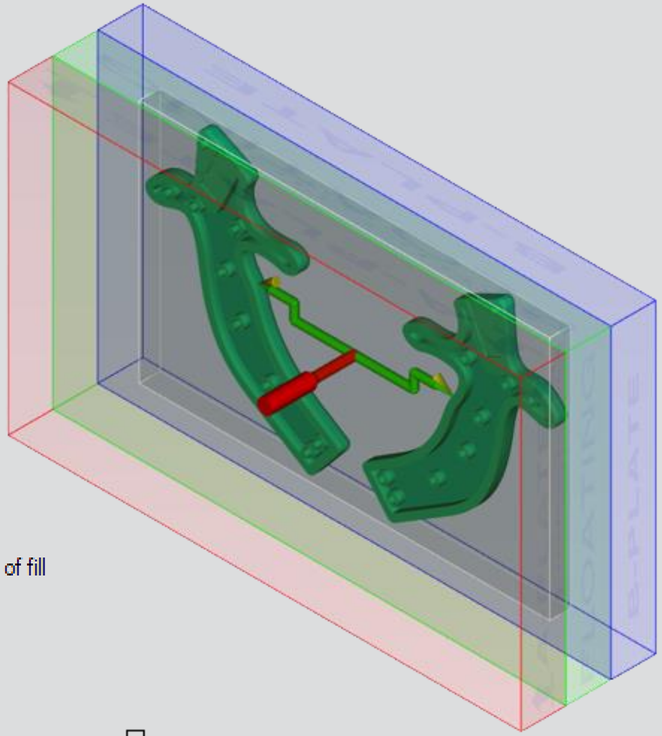
When manufacturing the final product, I will need to create a "negative space" mold of the part since the nylon material will fill in all the negative space and a model of the mold block is above! Same with 3D printing, I will need to separate the handle into two parts because if it was injection molded in one part, it would be impossible to get out of the mold (because of the two notches in the shaft holder). Another note to add is that there needs to be a hole where the nylon can get fed into the model. The next slide goes into depth of the manufacturing process of the handle using molding forms!

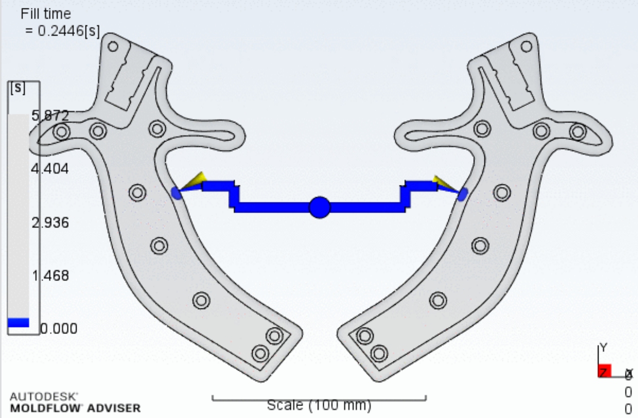
The small diagram in the middle shows how mold machines work as well as the different components inside it. We can see that material first enters whats called a sprue. A sprue allows the molten material to flow into the molding mechanism. That is followed by long sections of space called runners. Runners allow material to travel to different sections of the mold which will allow material to go to areas not directly in line with the sprue. The last mechanism in a mold are the gates which regulate the pressure of the material and normally go from a larger diameter from the cooled runners all the way to a much smaller diameter which forces the material into the model. Forcing material is beneficial because it means that there are no areas which are not filled. Another component that is used in industrial manufacturing to automate the process are ejector pins which will push the model out of the mold once the molding machine has finished injecting the material.

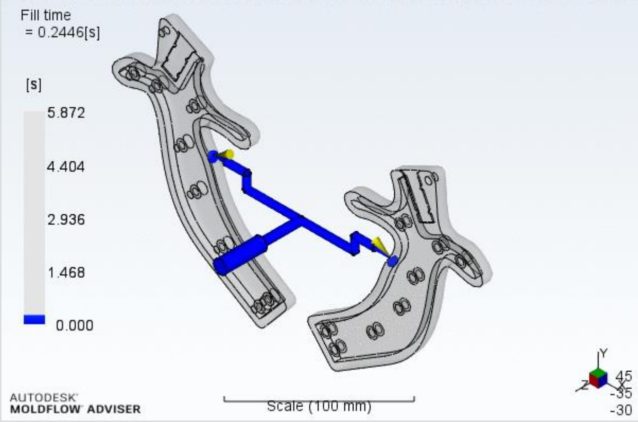


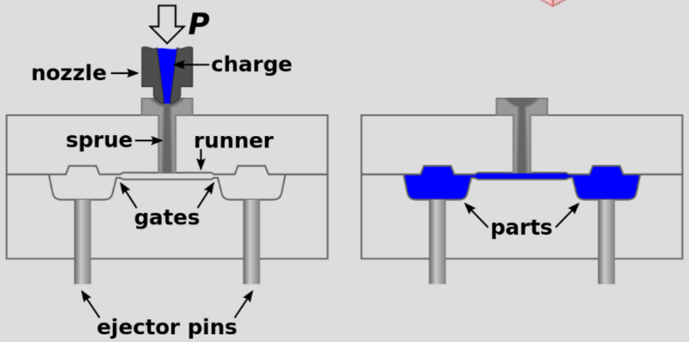












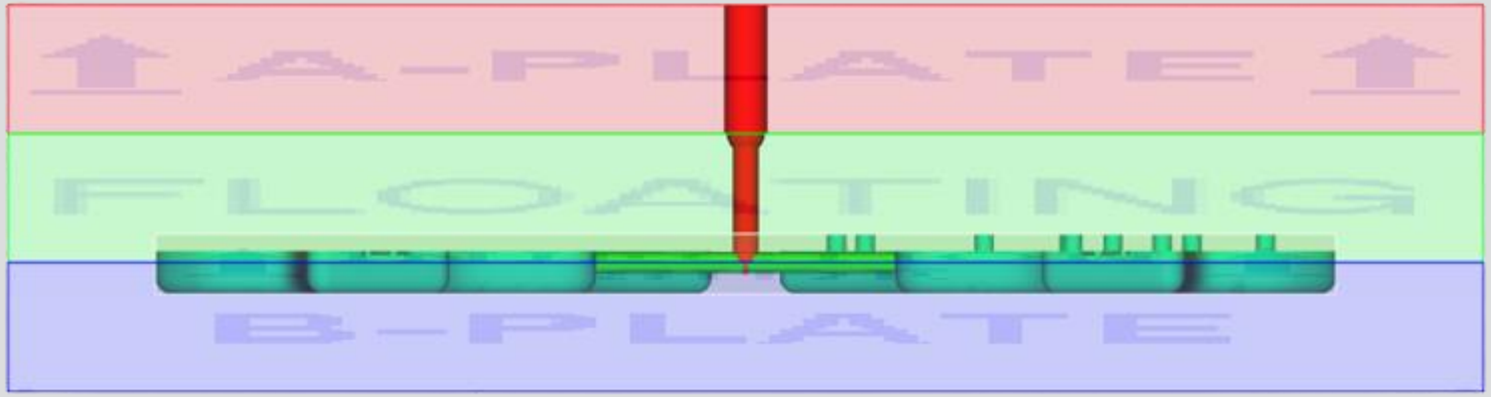
Form Molds and Simulations

Final pizza cutter

For the simulation results above, I used an Autodesk product called Autodesk MoldFlow Adviser which is an injection molding suite which allows us to see how different materials will enter the sprue and the gates as well as how long it takes for the material to flow to spesific locations on the model. The center top image shows the different results you can get from running a simulation!

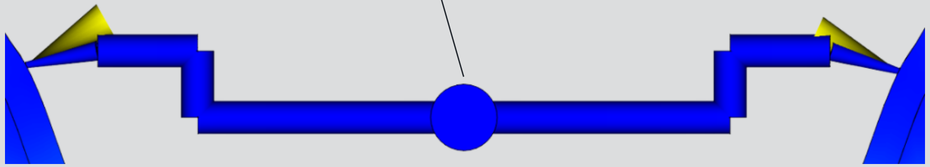
The top left image(s) show how easy it will be for material to reach certain locations of the handle. As we can see, the left side of the handle has a greater probability of filing all the way compared to the right model. This is mainly because the walls for the female connectors on the right model is quite small which means that there will be excess pressure build-up as the volume of the cylinder decreases. In this case, the green color signifies that those sections are the easiest to fill and red signifies that there might be part quality issues coming out of the mold in those locations.

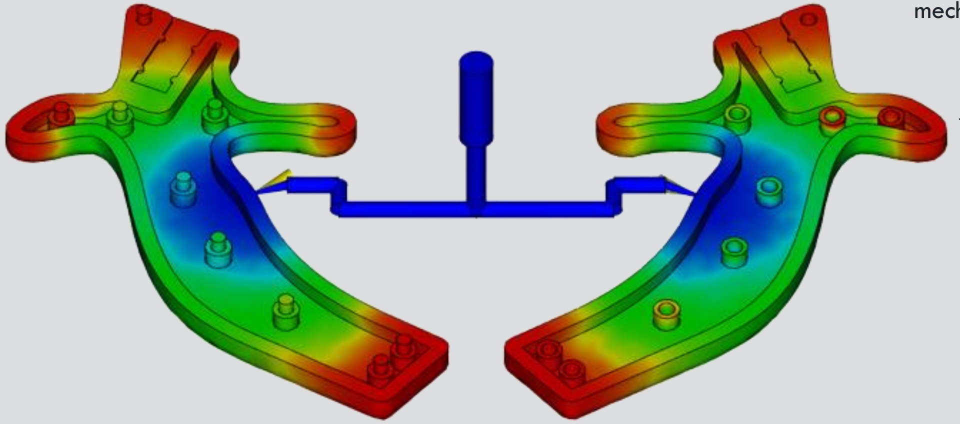
The animations on the far right show the real-time flow rate of the material I chose which was closest to Nylon 6/6. We can see that both handles will take a maximum of around 6 seconds to fill up which is quite fast given the fact that the sprue, runner, and gate diameters are quite small for filling up that large of a volume of a shape. You can view more simulations and animations on the next two slides!



The different layers of the mold block.

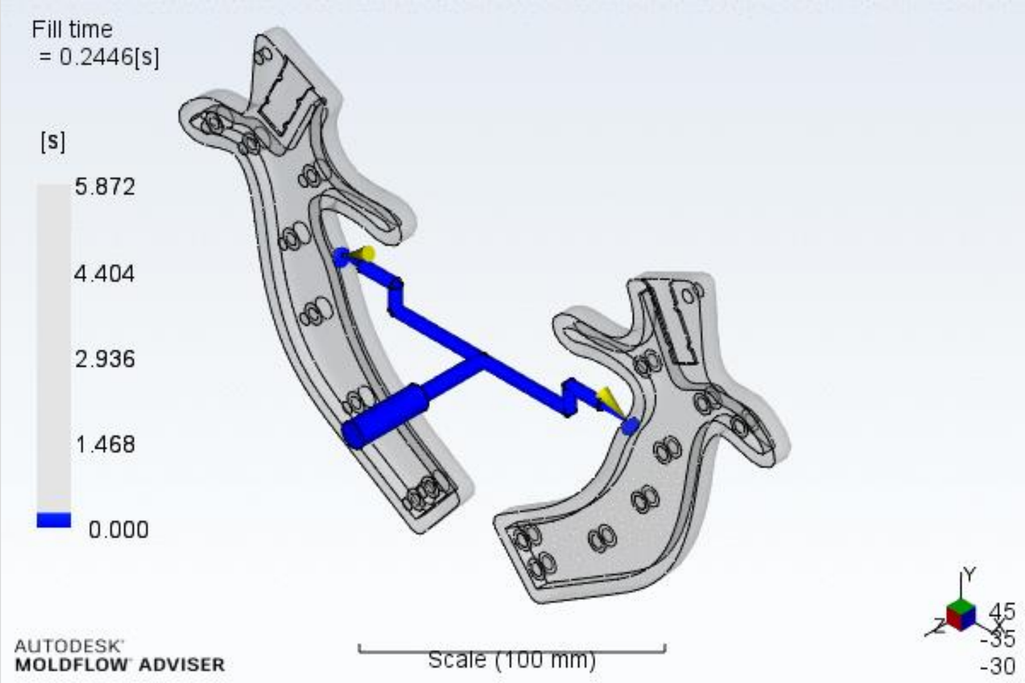
Enlarged view of the runner and gate section of the mold

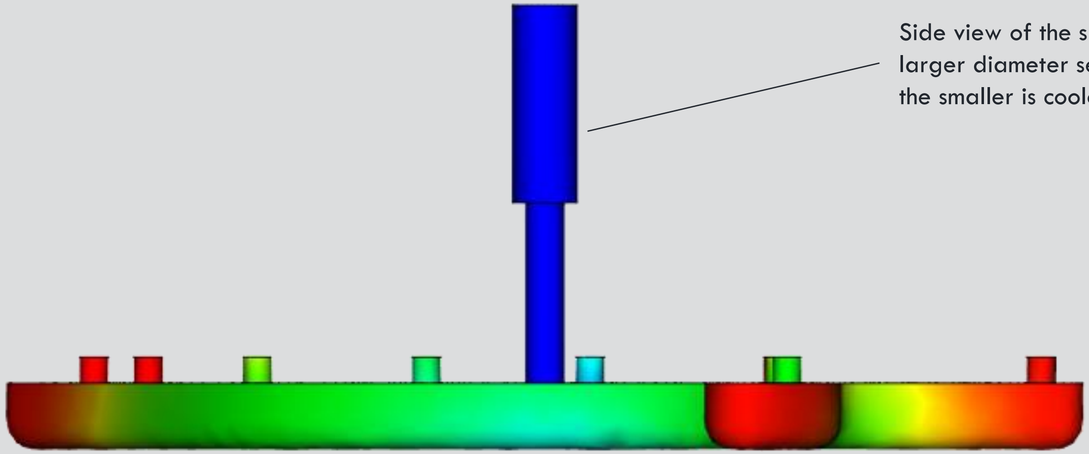




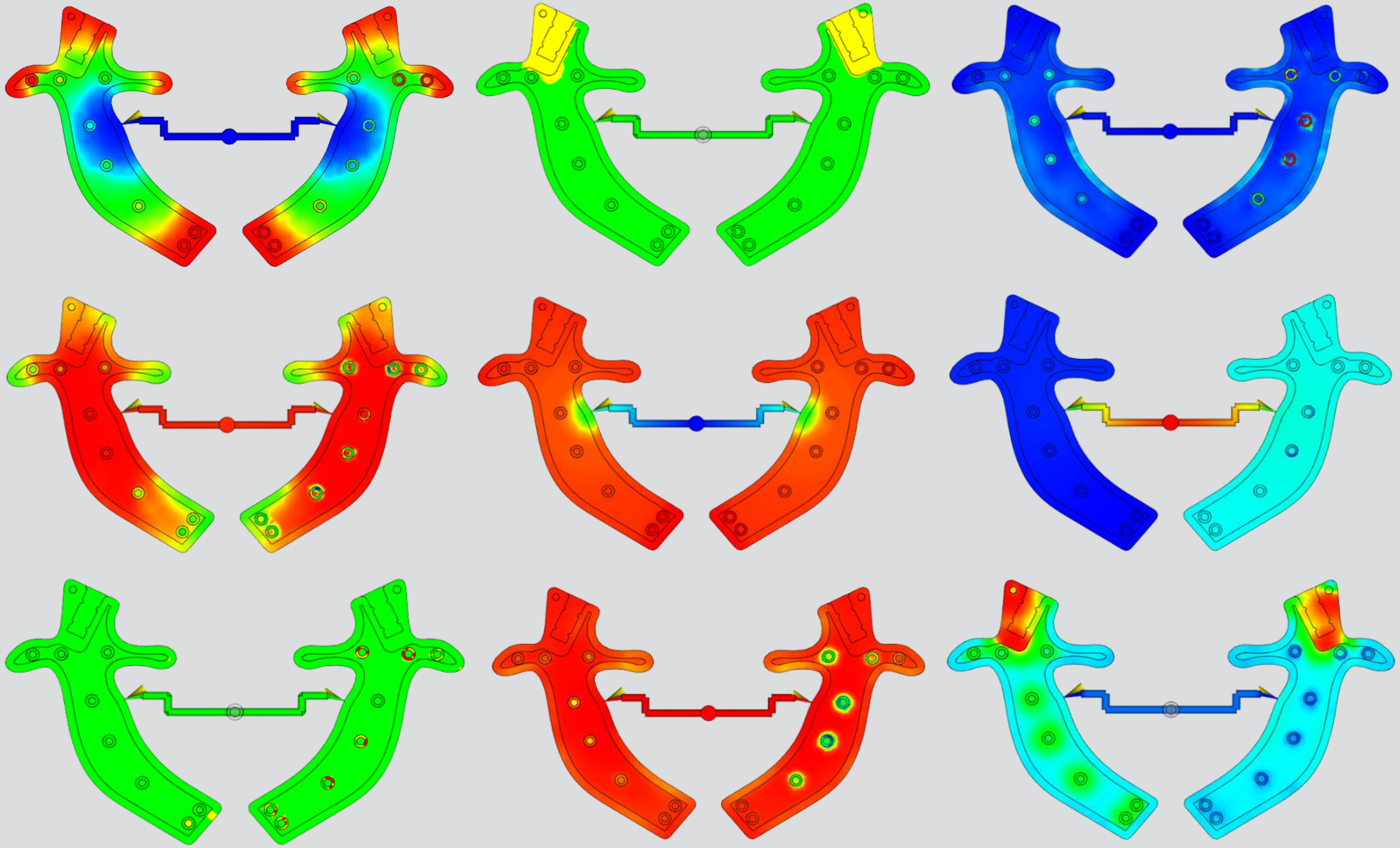
3D view of the sprue, runner, and gate mechanisms

An animation of the fill time for Nylon 6/6





Side view of the sprue system. The larger diameter section is heated and the smaller is cooled



Simulations Using Autodesk MoldFlow Adviser

Final pizza cutter

The screenshots above show more results from simulations that I ran such as which areas would be difficult to reach in a molding machine (bottom left) all the way to the time it takes for the material to reach certain locations (top left) and the probability that the section of the handle that will be filled with the settings used in the simulation (top center).

Each of these screenshots can be helpful when manufacturing the product because if for example, an area of the handle has a low probability of material getting filled in, the designer could redesign the handle to account for that space which cannot be filled up.

Another reason why these screenshots are important is because it can help the engineer (who is working at the machine), what settings to use (for example material temperature and injection speed) in order to produce the best model in relation to the design that the designer has created in CAD software

Evaluation

Final pizza cutter

What have you learned through this topic regarding product design and manufacturing?

Throughout this topic, I have learnt mainly about how go gather and apply anthropometric data as well as the exact definition and how it links to the ergonomics of a product. Another major topic I have also learned is how to turn a 3D prototype into a physical prototype as well as how I could apply the 3D model into a mold form simulation software and design a form block so that the pizza cutter handle could be created from different materials (in my case, I chose Nylon 6/6 because of its properties as well as it being “food-safe” according to the FDA).

The final major thing I learnt about during this project is how to create detailed enough drawings of parts (mainly because before, I would fill the drawings sheet up with a lot of dimensions which were not needed but, in this project, I learnt how to make annotations more compact as well as which dimensions are key for manufacturing and which dimensions will unnecessarily take up space on the drawings sheet)

Why do you feel its important for a designer to show consideration for these aspects (stages of your project)

Some of the main factors that you must take into consideration when designing a new product is the initial sketching phase, gathering anthropometric data, interpreting the data, creating an initial prototype, getting user feedback from the prototype, designing a final product for mass production, and finally figuring out how to scale the manufacturing of the product and creating batches of the new design. Each of these stages are important during the design phase with the first three being important because if you are not able to gather anthropometric data from users, you won’t be able to know the physical scale of the model and if you are not able to make initial sketches, you might not be able to create a design which fits the specification points you created.

What do you feel is the most important section of developing a new product and why?

I think that when developing a new product, the manufacturing and scalability of making the product is quite important especially if you scale up the design into mass or batch production (as mentioned on previous slides with the production techniques used for this kind of product) I also think its important because if you are a small business that has made a product which is competing in a large market, you want to make sure that you are as profitable as possible.

Overall conclusion

To sum up this project, I have learnt multiple new things such as how to create engineering drawings (although I knew how to before, it turns out I was not creating them properly with for example positioning the different views in a drawing) as well as how to create molds in Autodesk MoldFlow so that I can scale this product up to batch production. I also learnt how to use Autodesk MoldFlow and how to use their injection molding functions as well as how to read the different colored graphs created by the simulation software. Finally, I have learnt about how