3D printed Mould
Fusion 360 model

Fusion 360 file : https://a360.co/3sqnplD

Video : https://youtu.be/BJTsWPBXNDI

Introduction

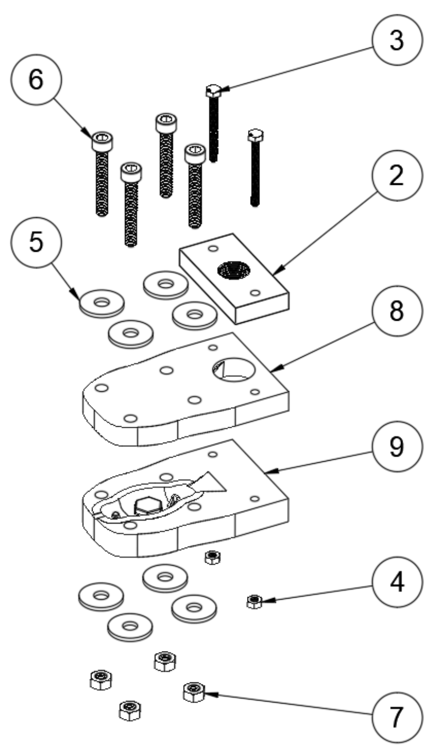
Mould injection revolutionised manufacturing, enabling precise production of intricate plastic parts. It's a cornerstone in various industries, optimising efficiency and design possibilities. Plastic injection moulds have inherent constraints dictated by moldability. The final shape must allow for easy removal from the mould. This constraint influences design, affecting not only aesthetics but also the mould's practicality and efficiency.

Various moulds, such as aluminium, plaster, epoxy, silicone, and 3D print resin, cater to diverse needs, offering flexibility, durability, and precision for different manufacturing processes.

This document is dedicated to the 3D design process of creating 3D print resin moulds for plastic injection. The mould used in this document is created as an exercise.

Components

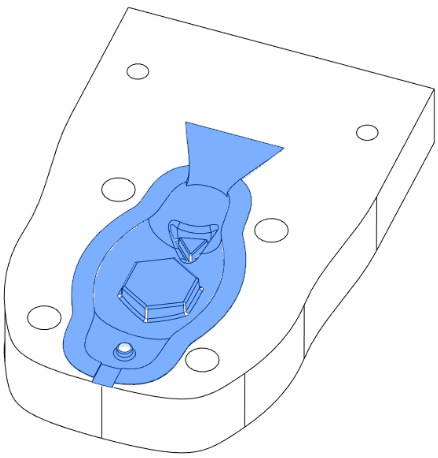
- Mould Shells (8 & 9)
- Injection Bracket (2)
- Assembling Components Screws and washers (3,4,5,6 & 7)

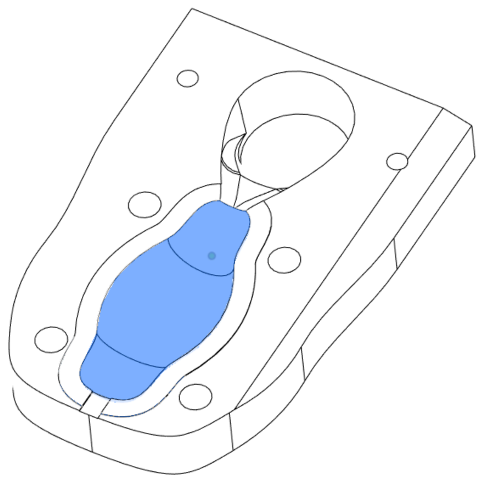


Functions

Shape cavity

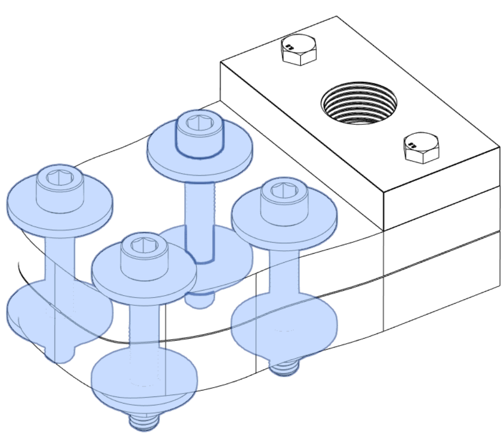
The cavity of the mould will shape the melted material. The mould cavity depends on the model's shape, the material retract after injection and the viscosity of the melted material. For solar plastic recycling the materials used can be PP HDPE LDPE and PLA.





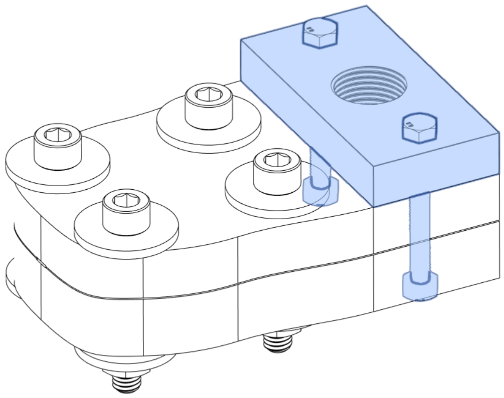
Fixation of mould shells

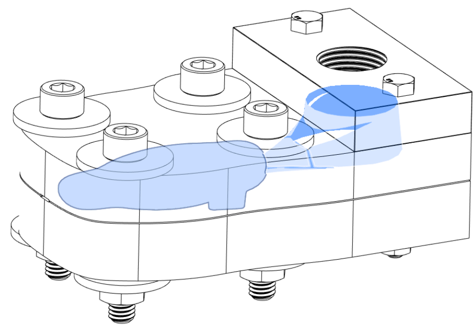
The mould fixation can be done by using metric screws with washers or can be done by using two metal planks to pinch the mould. In our case we will use screws and washers.



Fixation of injection cartridge

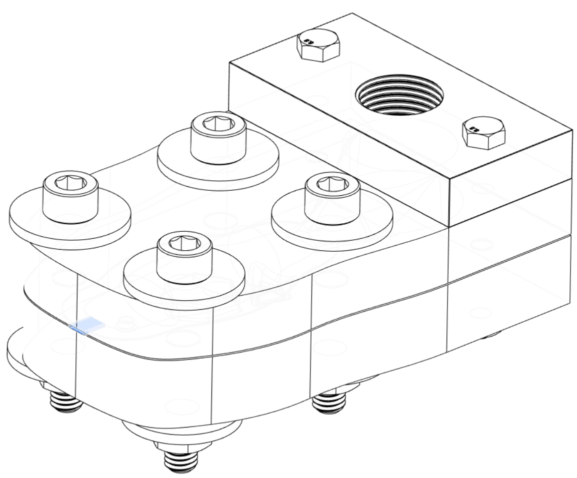
For the cartridge fixation on the mould we'll use an aluminium part called injection bracket. The position of the injection bracket is defined by the injection entry point.





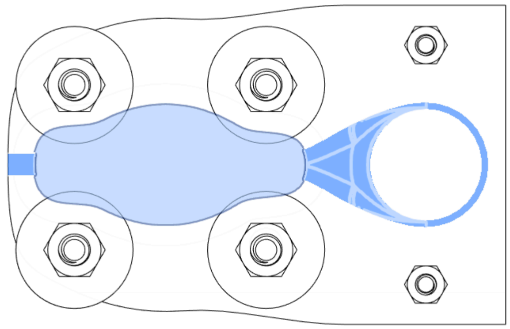
Air outlets

During the injection the air captured inside the cavity need to leave, for this some canals need to be done :



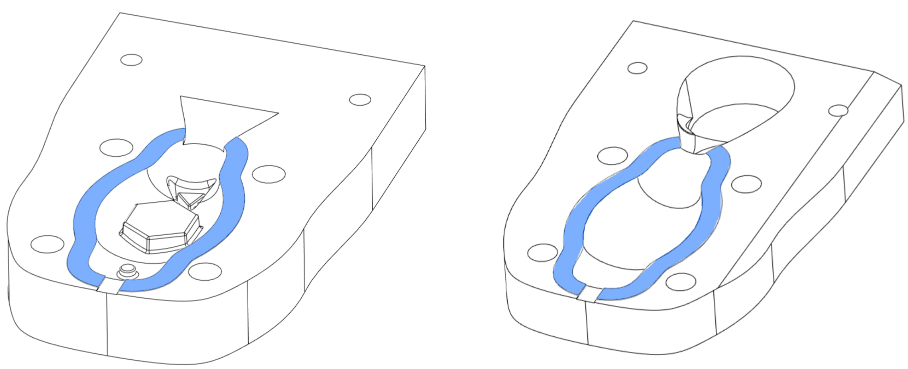
Transparency

The transparency is very important to manage the injection process force and don't break the mould when the cavity is field.



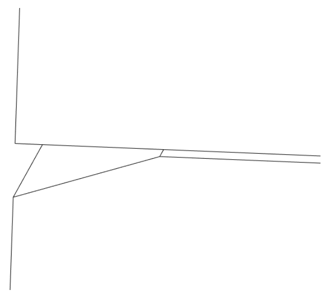
Smart lock

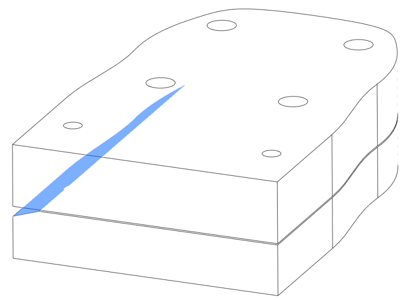
To close the cavity with a maximal pressure and ensure proper closure of the cavity during injection. By reducing the surface contact between the two shells of the mould, the closure pressure can considerably augment.



Smart Open

To open the mould after injection and extrusion





Moulds characteristics

Mould's material

The material used for the mould 3D printing is important because of strength, temperature resistance, melted plastic adhesion and needs to be transparent. The resins used for mould can be water based standard.

Dimensional

The maximum external dimensions of the mould are fixed by the 3D maximum printing size of the 3D print machine.

The mould cavity size depends on the fixation type and injection entry point position.

Strength

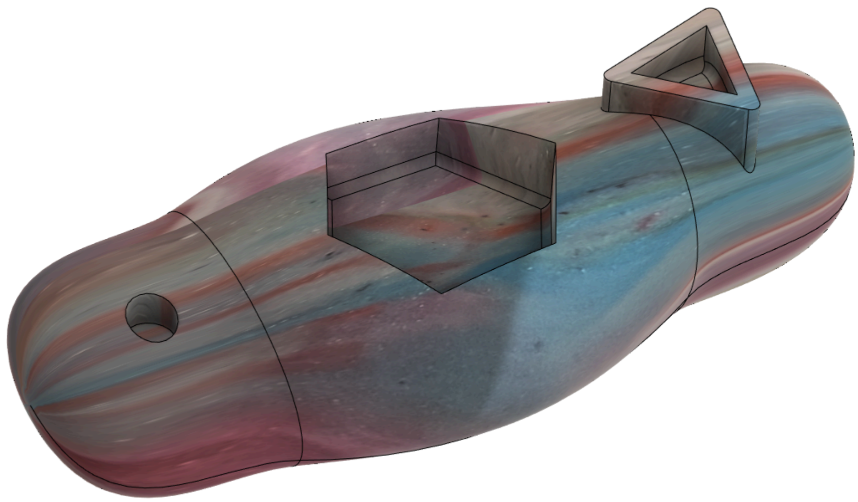
Using 3D printing moulds for solar plastic injection, the maximum pressure of injection needs to be moderated to not break the mould.

Number of injections

During the process, due to the fragility of the material, the temperature, the plastique dilation strength, the pressure or shocks during use generates degradation of the mould.
Used in good conditions a mould can do about 500 injections.

Model Part Preparation

Before starting to create the mould we need to ensure that we can unmould the shape we want to inject. For the example will use a random shape with precise functions in a file called Part_to_inject.



3D model : https://a360.co/46uYqeZ

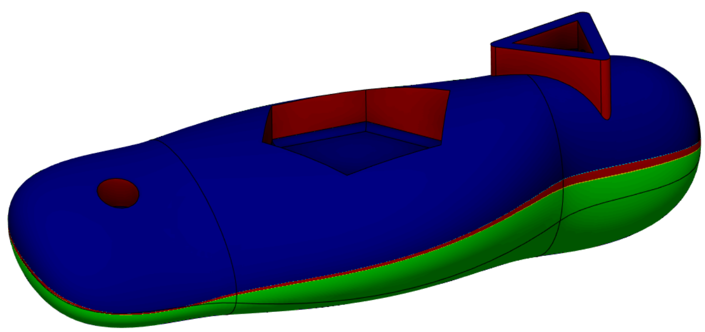
Analysis

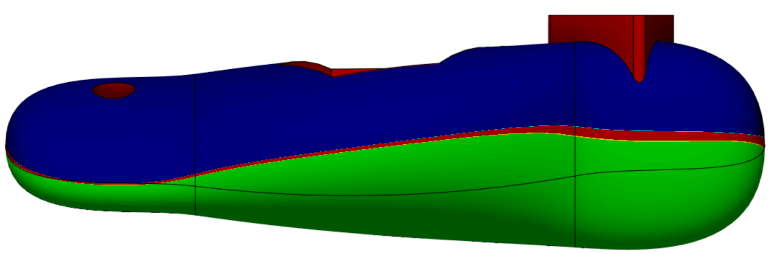
Shape

Silhouette curve

Analysing the silhouette of a part is crucial for mould design. It helps in understanding how the part can be demolded successfully without damage.

Using the Fusion 360 draft analysis tool it's possible to schematise the silhouette line :

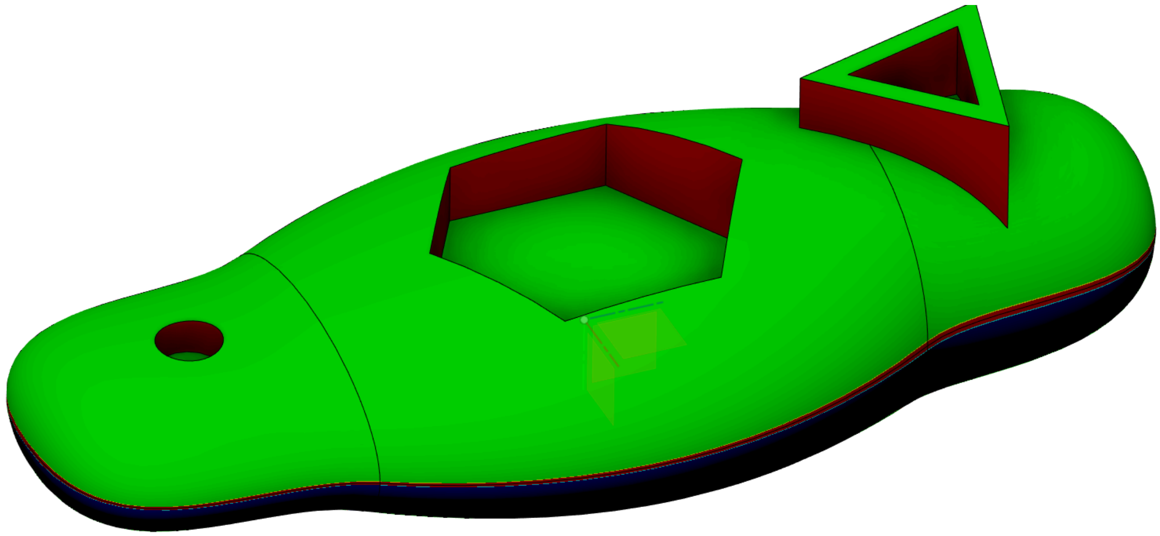




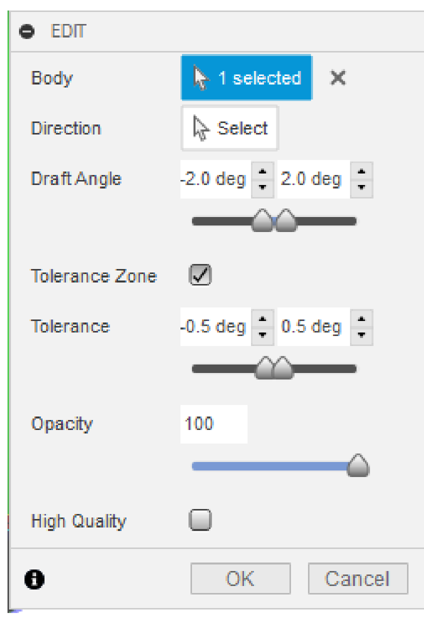
Analysing the silhouette of a part is crucial for mould design. It helps in understanding how the part can be demolded successfully without damage. In this case the silhouette line is tridimensional, schematised in red, separating the green from the blue.
For 3D printing moulds, the silhouette line needs to be in a plan.

See the video of draft analysis : https://youtu.be/5MvCmyP6Lik

Unmolding angle



A minimum plastic moulding angle is required for demolding the part after injection. The analysis displays surfaces with a colour gradient based on the draft angle.

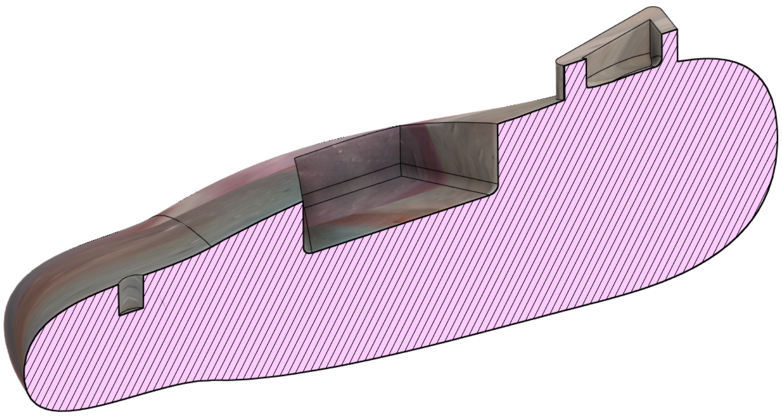


The recommended minimum draft angle is 2°, but for secure moulds, we advise using 4°. Surfaces without a demolding angle are **highlighted in red, indicating that demolding is impossible.**

See the video of vertical faces :https://youtu.be/RmXIM60IBWo

Thin walls and deep holes

Due to the process, with resin non warmed moulds the global shape needs to be analysed and see thin walls and deep holes.



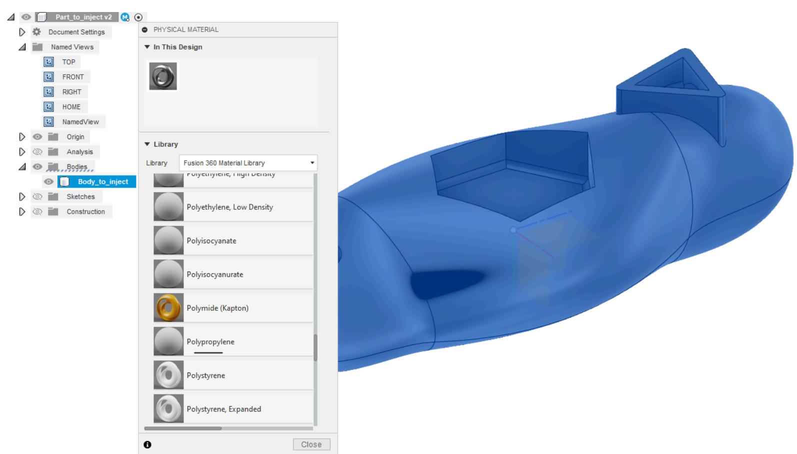
Use the 3D section view

Long and thin walls have some limits depending on the material injected and the fact that resin moulds are not pre-heated. Deep holes in the part means thin tours in the mould in resin, a fragile material sensitive to dilatation.

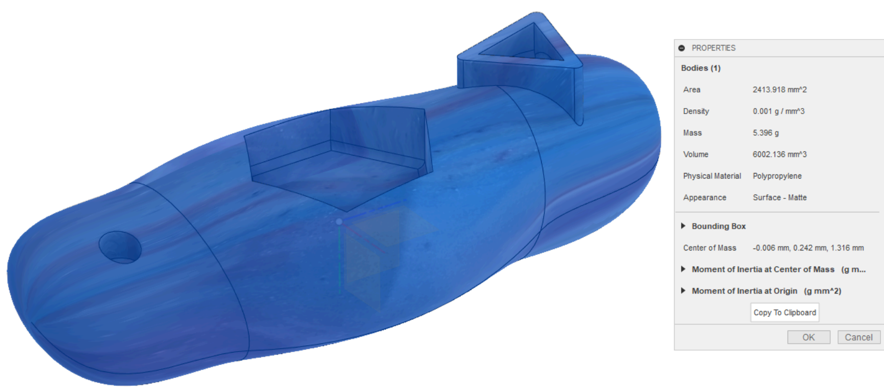
Size for injection

The material used for injection will be stored in a metal cartridge, during the injection process the material will be compressed and some will stand in the injection canals. The best way to ensure the material for injection is by using the mass as a parameter.

To have the mass of the 3D model, the Physical Material needs to be set.



Once the physical material is set, the body properties can give the mass of the part.



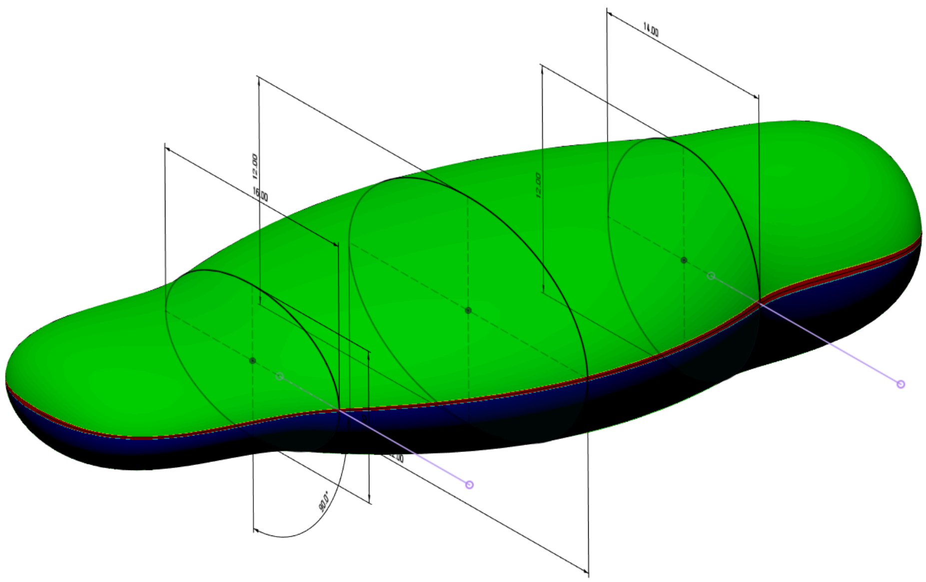
The mass of plastic used for the injection canals includes, needs to be superior to the mass loaded in the cartridge.

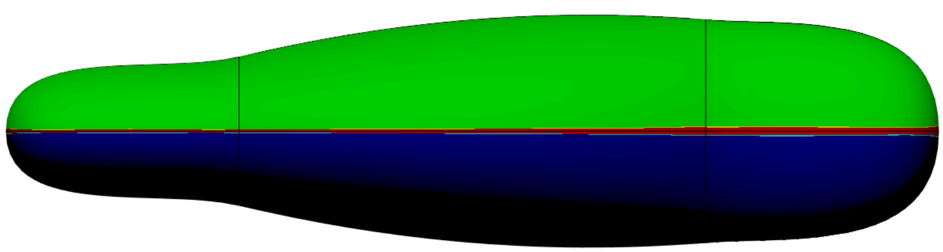
See the video : https://youtu.be/PCGzIctpoj0

Modifying Shapes for plastic Injection

Silhouette curve

Changing the external shape into something symmetrical, to the silhouette line in a plan :



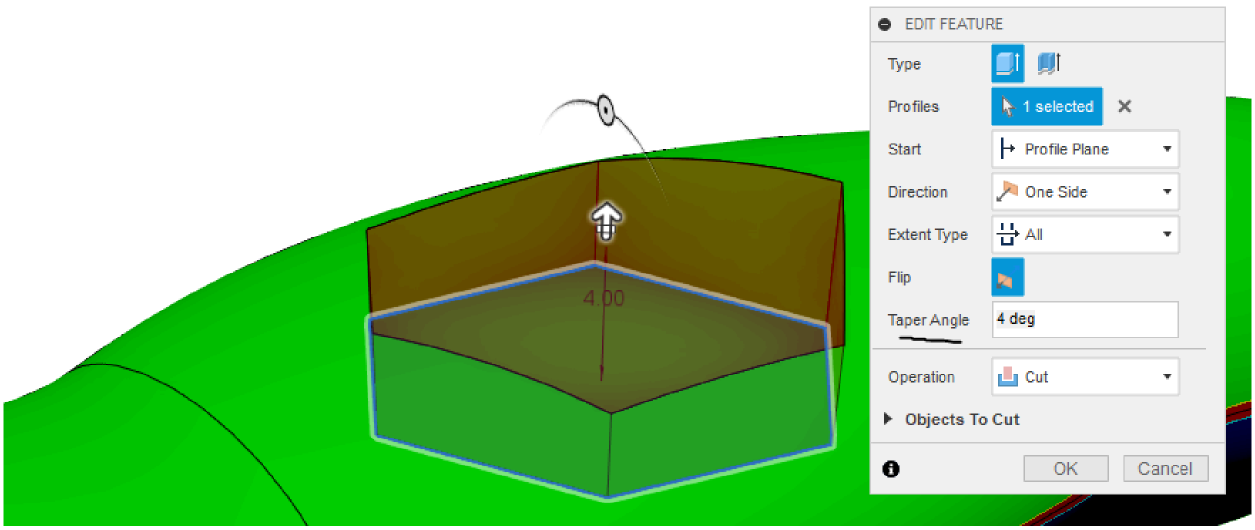


See the video of draft analysis : https://youtu.be/5MvCmyP6Lik

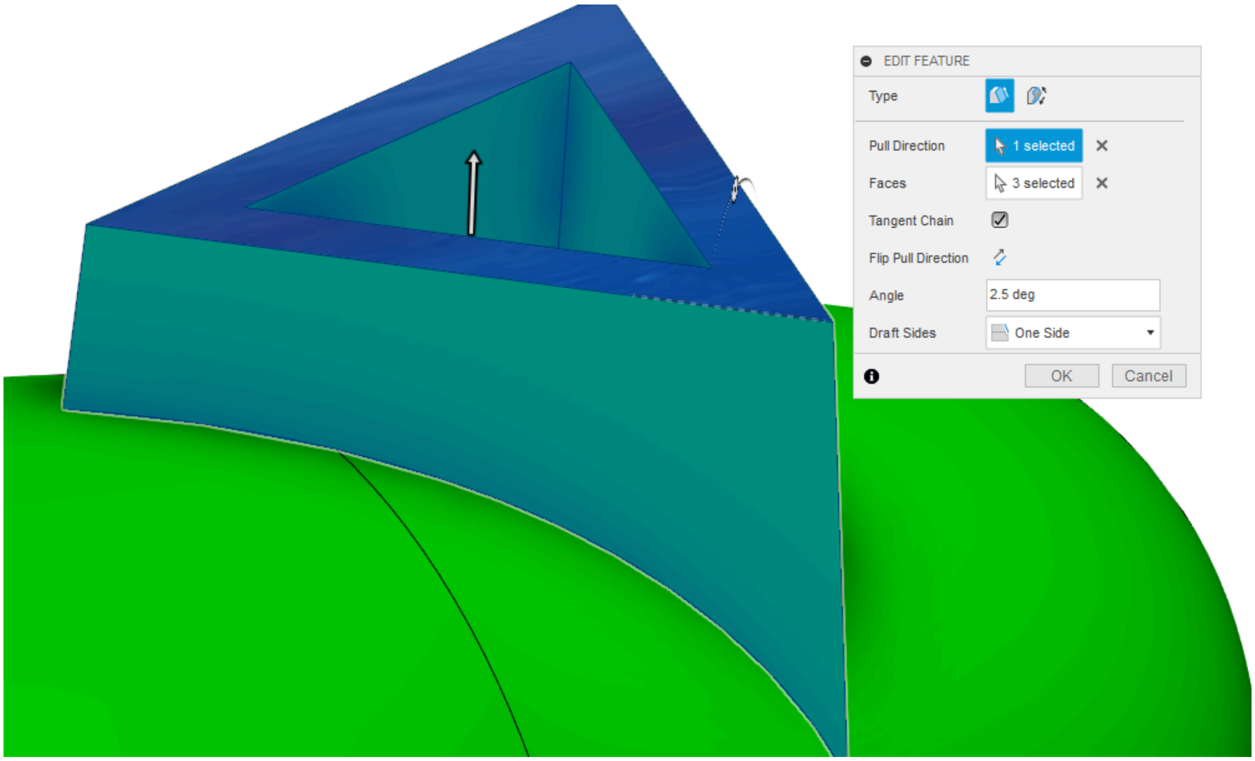
Vertical faces

As shown by the Draft analysis tool, unmold surfaces can't be vertical.

It's possible to create inclined surfaces with the taper angle in the extrusion function



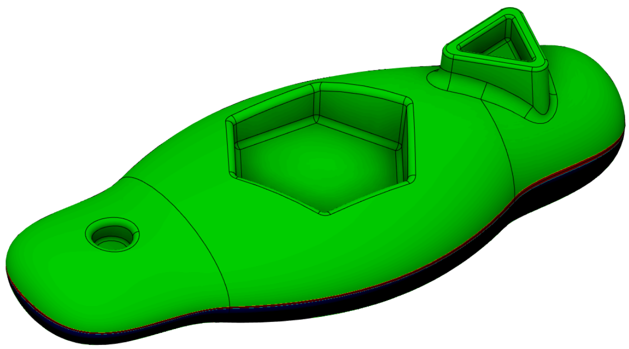
To change existing surfaces, using 3D parametric draft function



See the video of vertical faces :https://youtu.be/RmXIM60IBWo

Fillets

To facilitate the fluid injection, the mould resistance, the part resistance and estetic, is suitable to use the maximum of fillets.

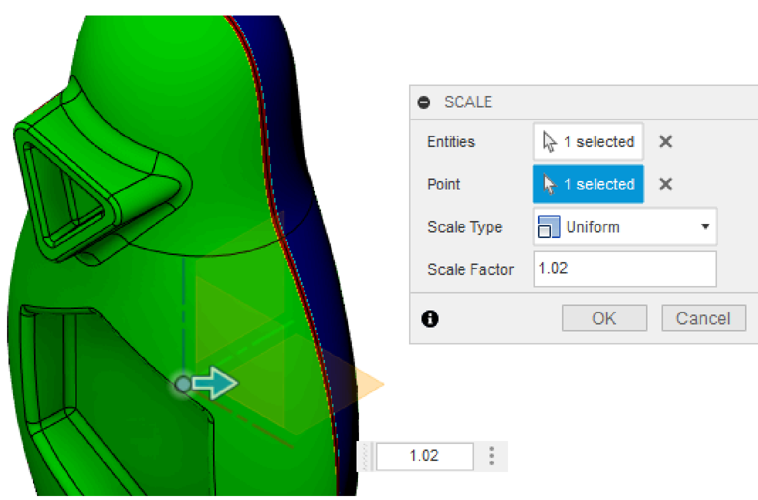


Scale the model

To account for material retraction after injection, it's crucial to adjust the model's scale.

Shrinkage in moulded plastic is influenced by factors such as temperature changes, material composition, molecular weight, crystallinity, and additives like fillers and pigments. The model is scaled using the following shrinkage values for specific plastics: HDPE (3.5%), LDPE (2%), PA (1.5%), and PP (2%) (Source).

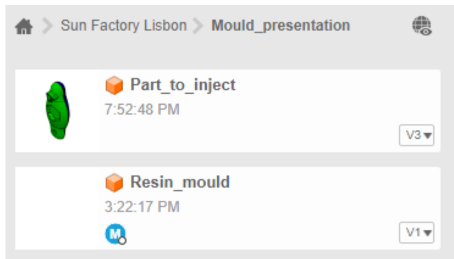
The Scale function is then employed to increase the model's size based on the chosen injection material.



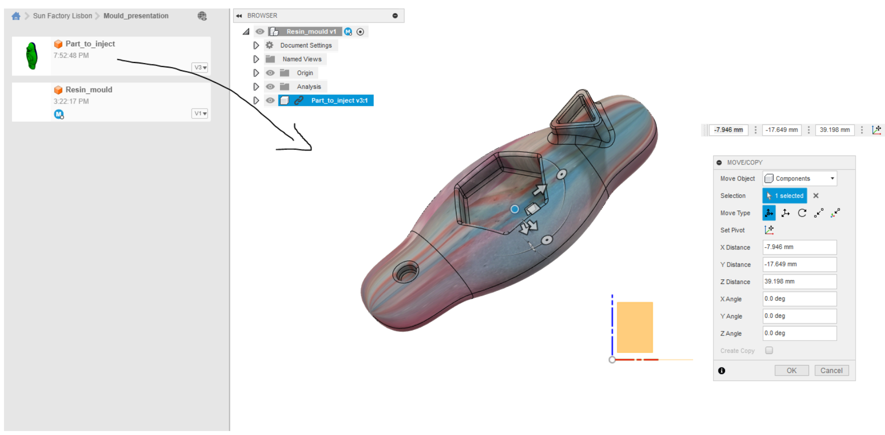
Creating the 3D Mould Model (video)

Using the model file to create the mould

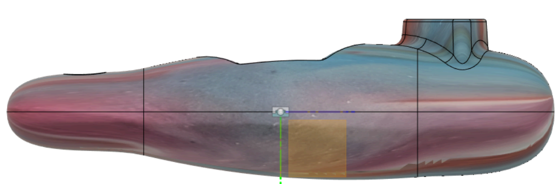
First step in Fusion 360 is to name and **SAVE** your mould file. In our exemple we call it "Resin_mould".



The 3D model used for the mould cavity is imported by drag and drop into the "Resin_mould" file, creating a link between the two files.



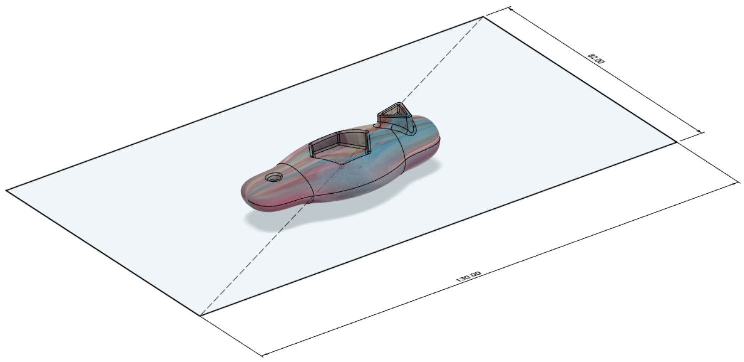
Utilise [the joint function]() to position the imported 3D object by aligning it with the mould parting plane. Ensure the alignment of the demolding plane with the horizontal plane of the mould file.



Defining the outside shape

Printing size of the 3D printing machine

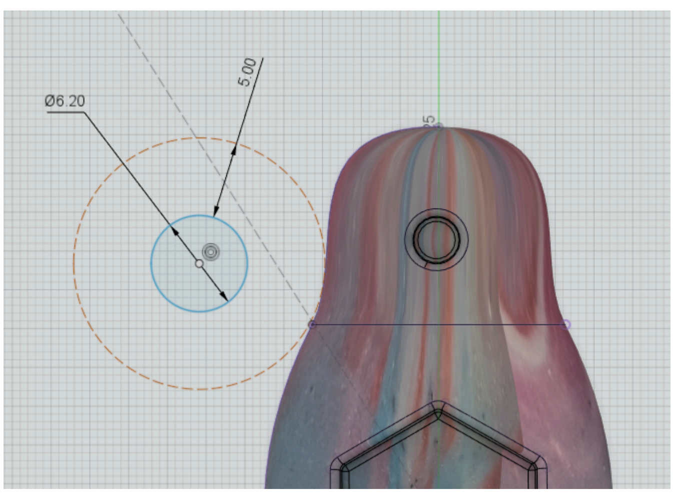
Create a sketch to illustrate the maximum printing size of the 3D printing machine. This step is crucial to assess the printability of the mould. Refer to the machine specifications to determine the precise printing size.

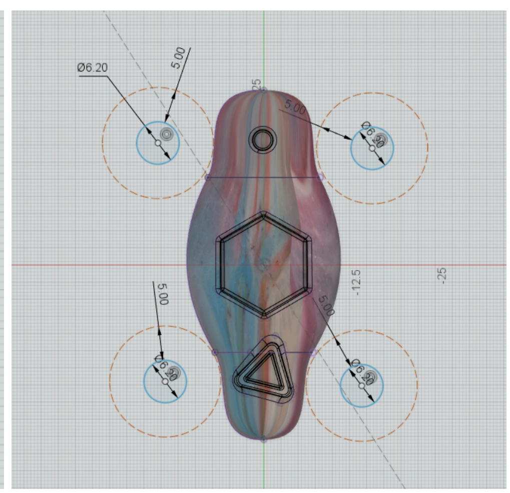


Fixing holes

To fix the resin mould only with screws and washers we preconize at least M6 size with bonded Washers.

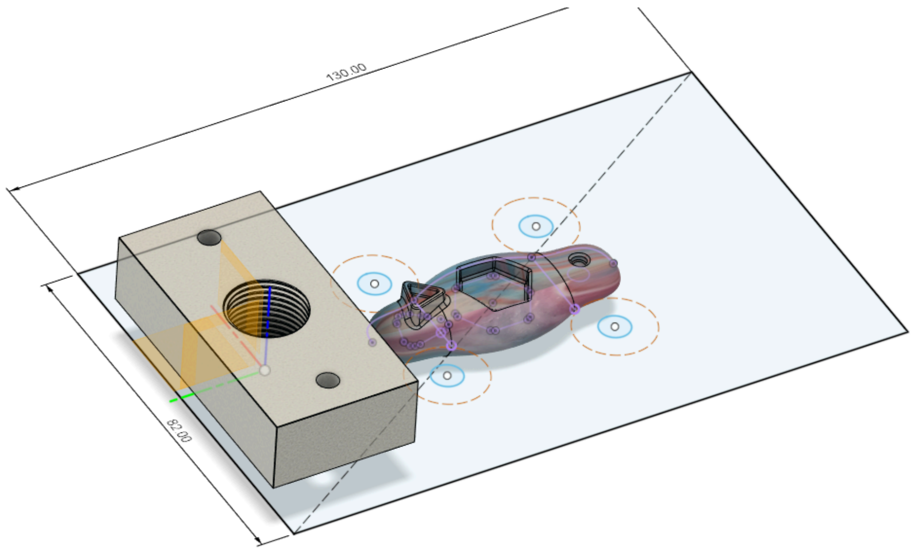
A minimum of material is required in resin moulds for M6 we preconize 6.2 millimetres holes with 5 millimetres





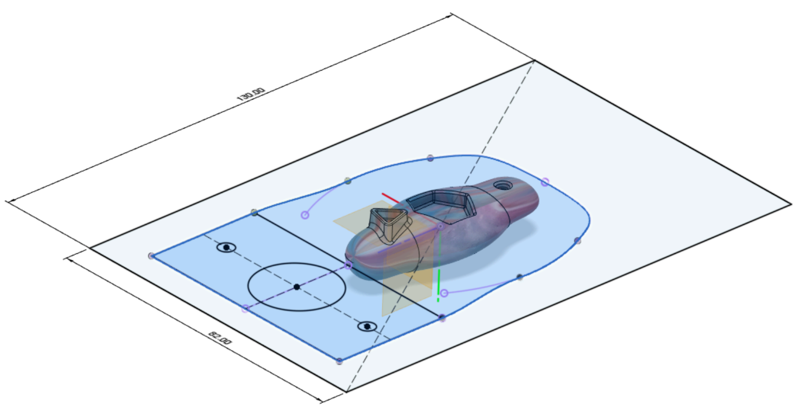
Injection bracket positioning

The positioning of the injection bracket depends on the entry point and significantly influences the external shape of the mould. The injection bracket is secured by two metric screws (M4) to the mould shells, defining the injection point. A base of 60mm x 30mm is required to support the injection bracket.



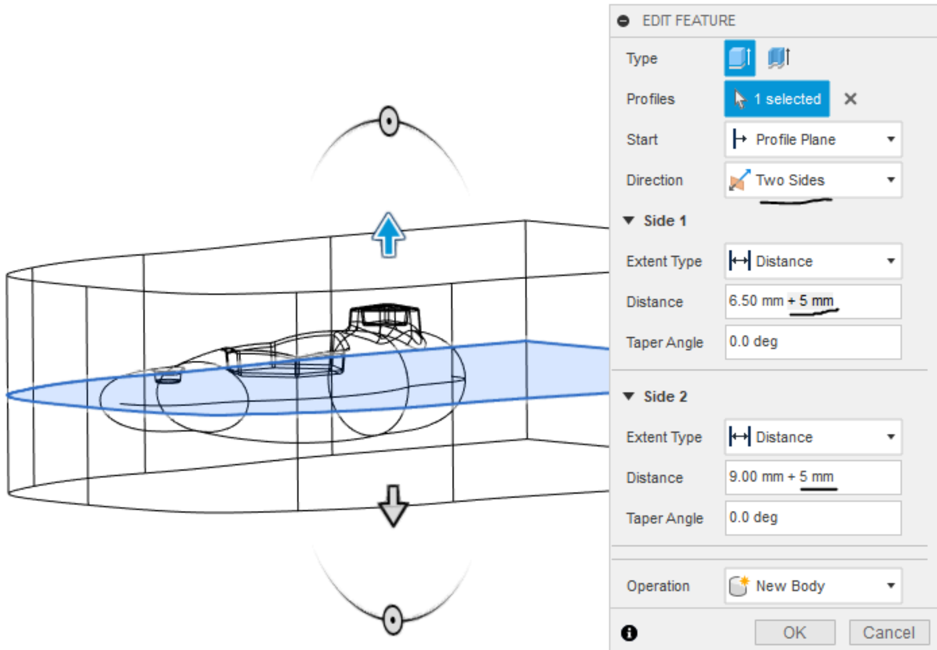
Section of the mould

By combining various pieces of information such as the printing size of the 3D printing machine, dimensions of fixing holes, and the positioning of the injection bracket, the section of the mould can be precisely defined.



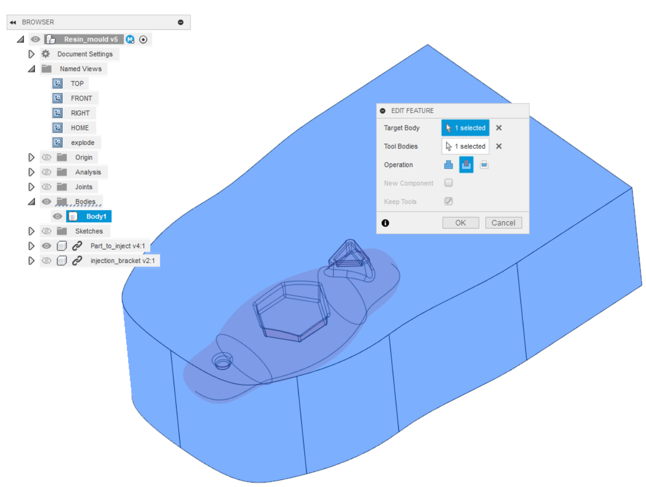
Mould volume

After defining the section of the mould defined we can extrude the volume of the mould



Cavity

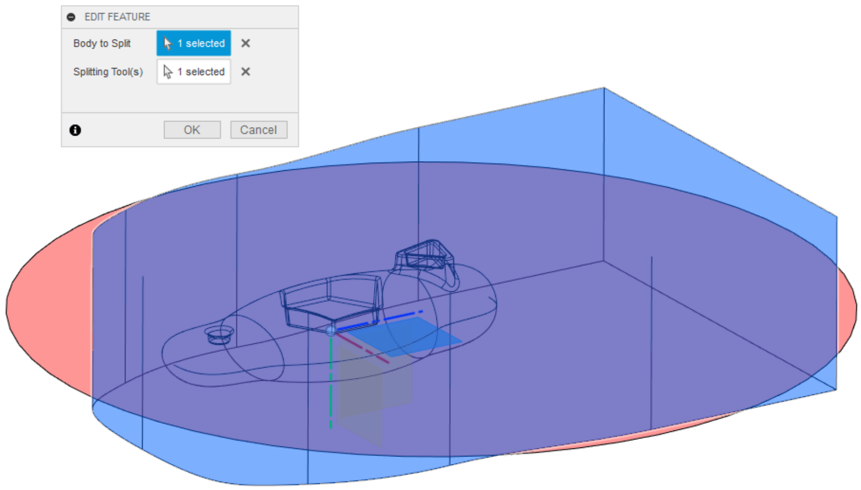
The cavity of the mould is done by volume subtraction using the Combine function

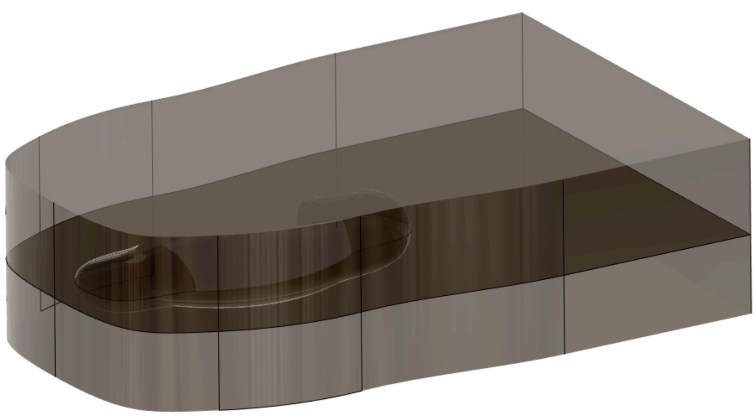


See the video : https://youtu.be/BJTsWPBXNDI

Mould joint plan

After creating the cavity by subtraction the split body function is used, selecting the mould body to split and the horizontal plan as the splitting tool

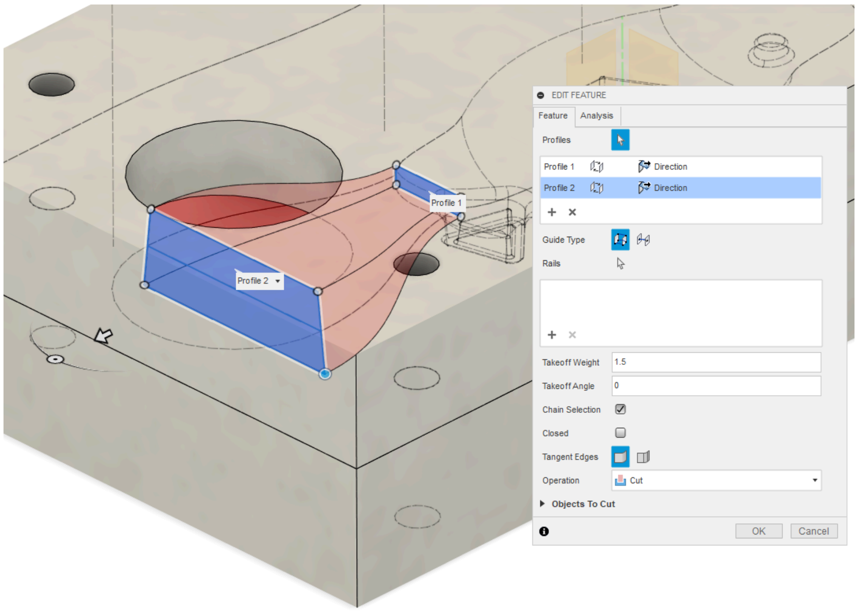




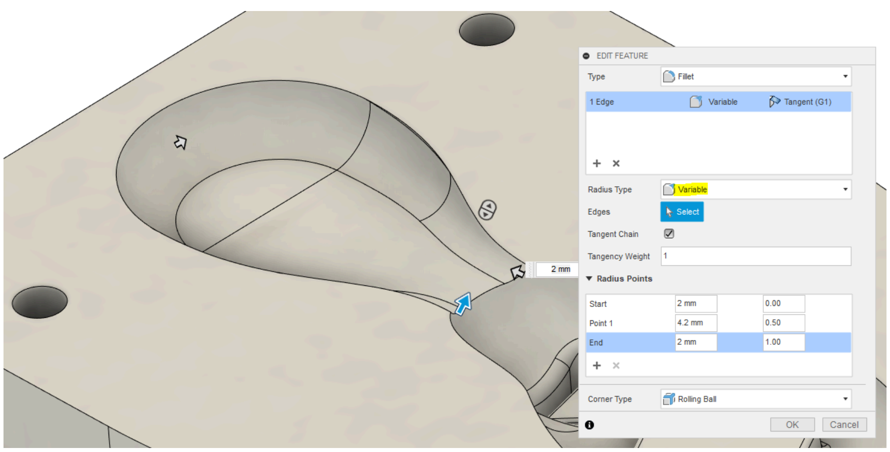
See the video : https://youtu.be/BJTsWPBXNDI

Injection point

Resin moulds used during the solar plastic recycling process aren't heated, the entry point needs to have the biggest section possible without changing the part functionality or design.

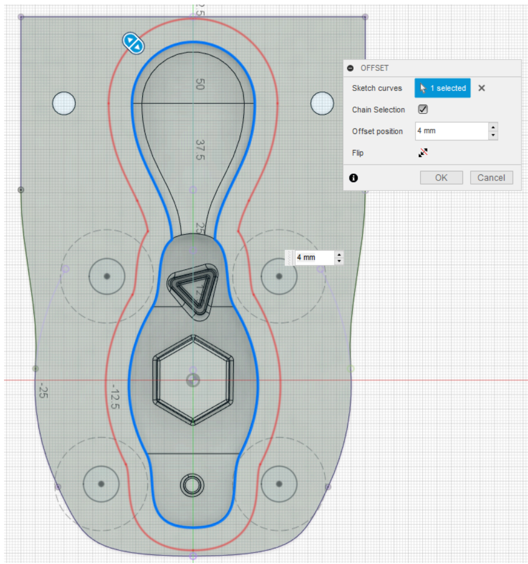


Using the loft function to create a smooth entrance for the melted plastic adding fillets to the canal edges with the the fillet function

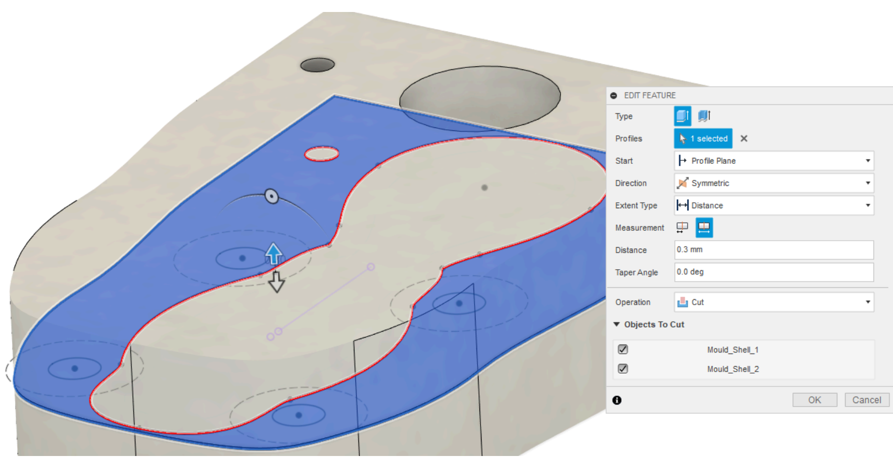


Smart lock

Using the offset function in sketch the surface contact in the plan joint is reduced for more enclosure pressure. A 4mm large band is recommended.

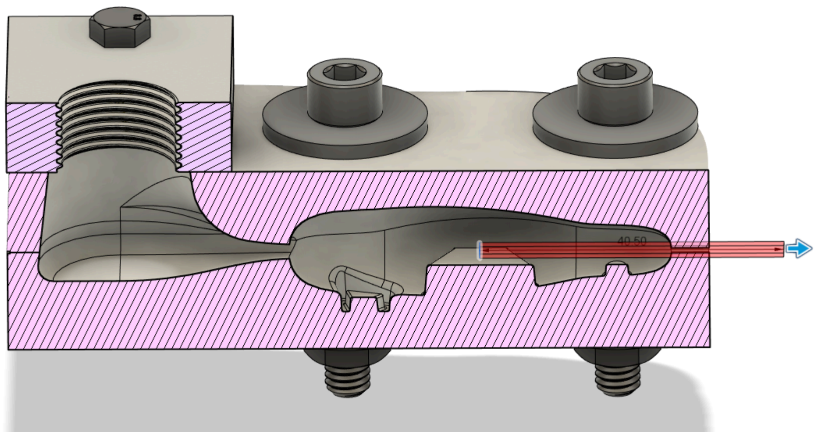


Using the extrusion function to cut both bodies symmetrically about a 0.3mm whole length.

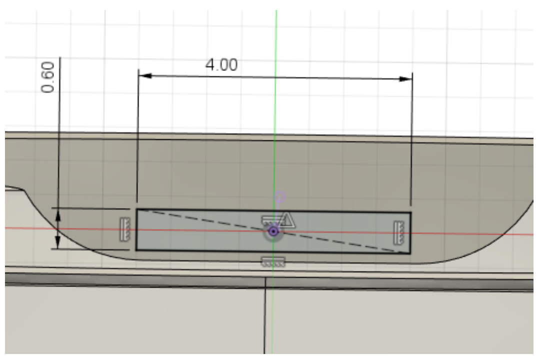


Air outlets

To ensure a smooth injection process, we need to create pathways for air to escape during moulding. This is achieved by using the extrusion function to carve out channels within the mould design.



Using the extrusion function

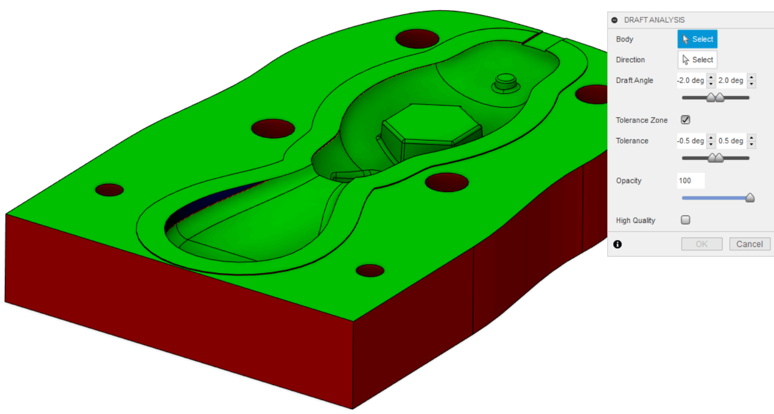


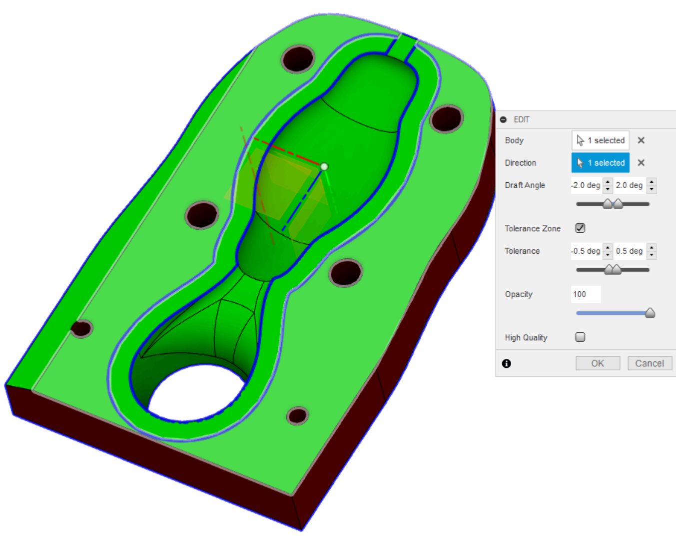
Mould analysis

Before finalising the mould design, it's crucial to conduct a comprehensive analysis to ensure its effectiveness. This involves assessing various aspects such as draft angles, sections, and injection results.

Draft analysis

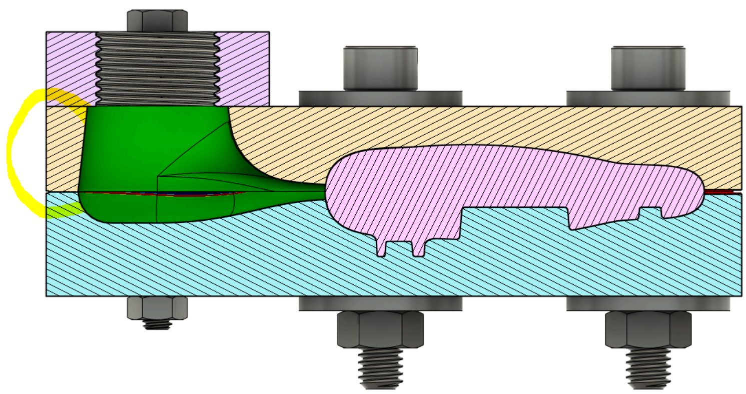
[Draft analysis](#) is an essential step to evaluate the angles on the surfaces of the mould. This process helps in determining the feasibility of demolding the final product successfully. It is a critical factor in achieving a seamless and efficient injection process.

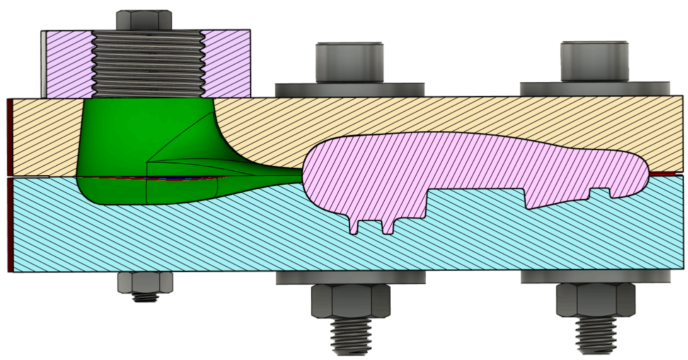




Section

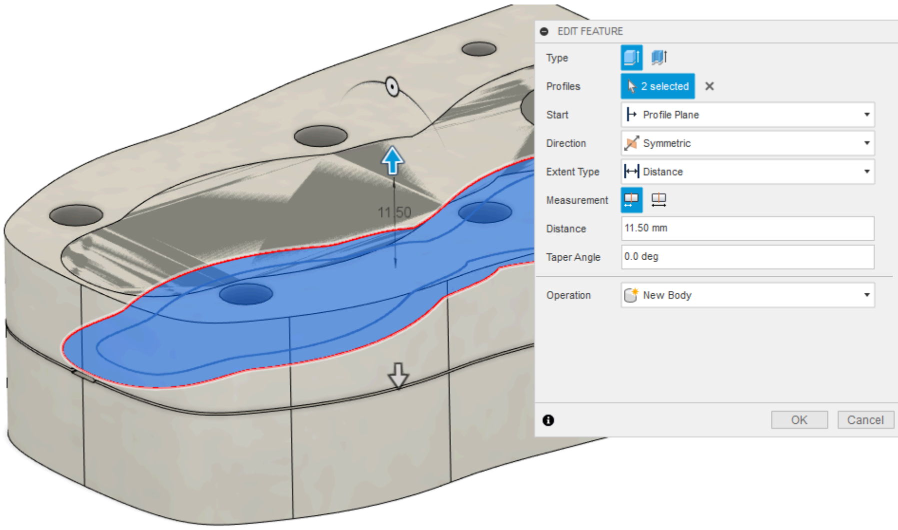
Understanding the sectional view of the mould is vital for a holistic assessment. It provides insights into how different components come together and allows for fine-tuning the design for optimal performance.



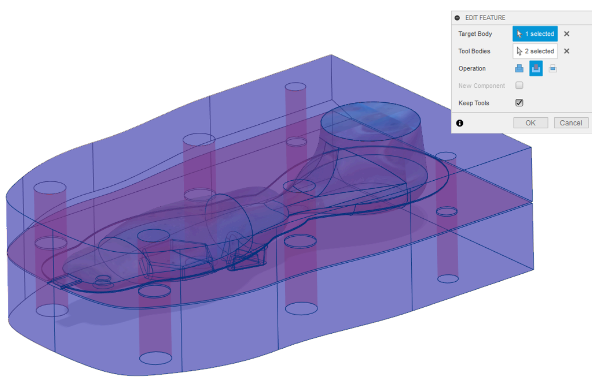


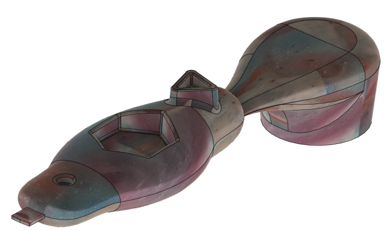
Injection moulding stock

Simulating the injection process is a key phase in the design workflow. This is accomplished by creating a new body through extrusion, mimicking the injection of plastic into the mould.



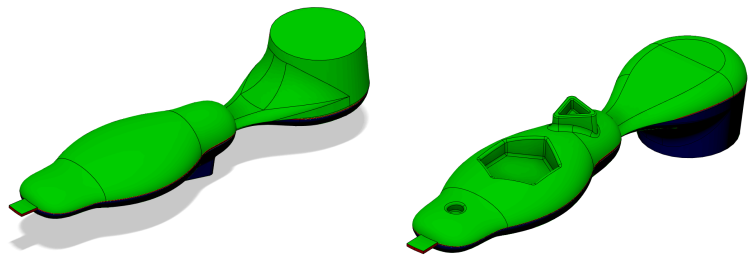
The next step involves using the combine function to integrate this simulation with the overall mould





Draft angle analysis

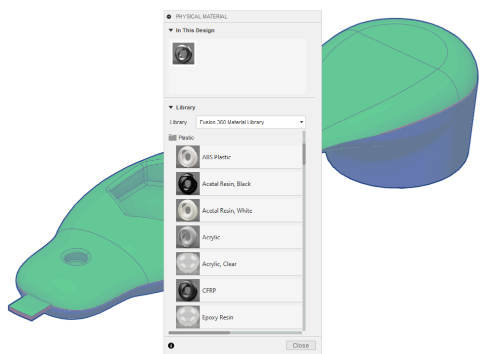
It's always advisable to check if the injection moulding stock is demoldable using the draft angle analysis function.



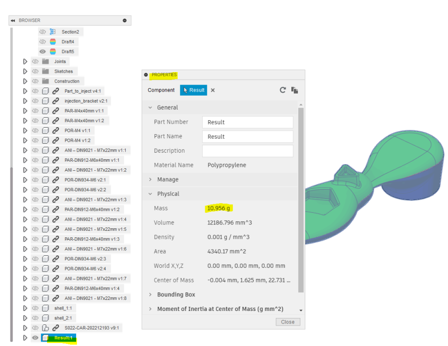
Mass analysis

Mass is a key parameter to scrutinise as it indicates the mass of plastic material required for the injection.

The physical material assigned to the model plays a pivotal role in determining its physical attributes.



In the model browser, using the right click consult the properties of the body to have the mass value.



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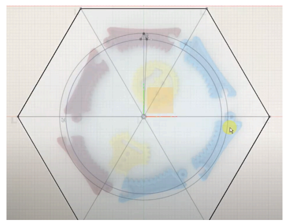

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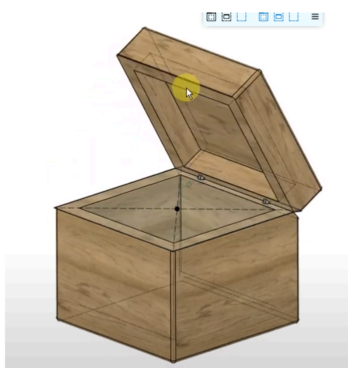

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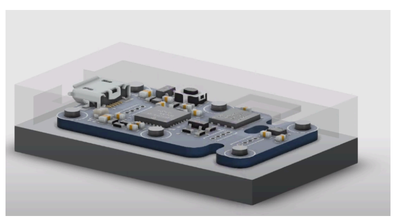

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