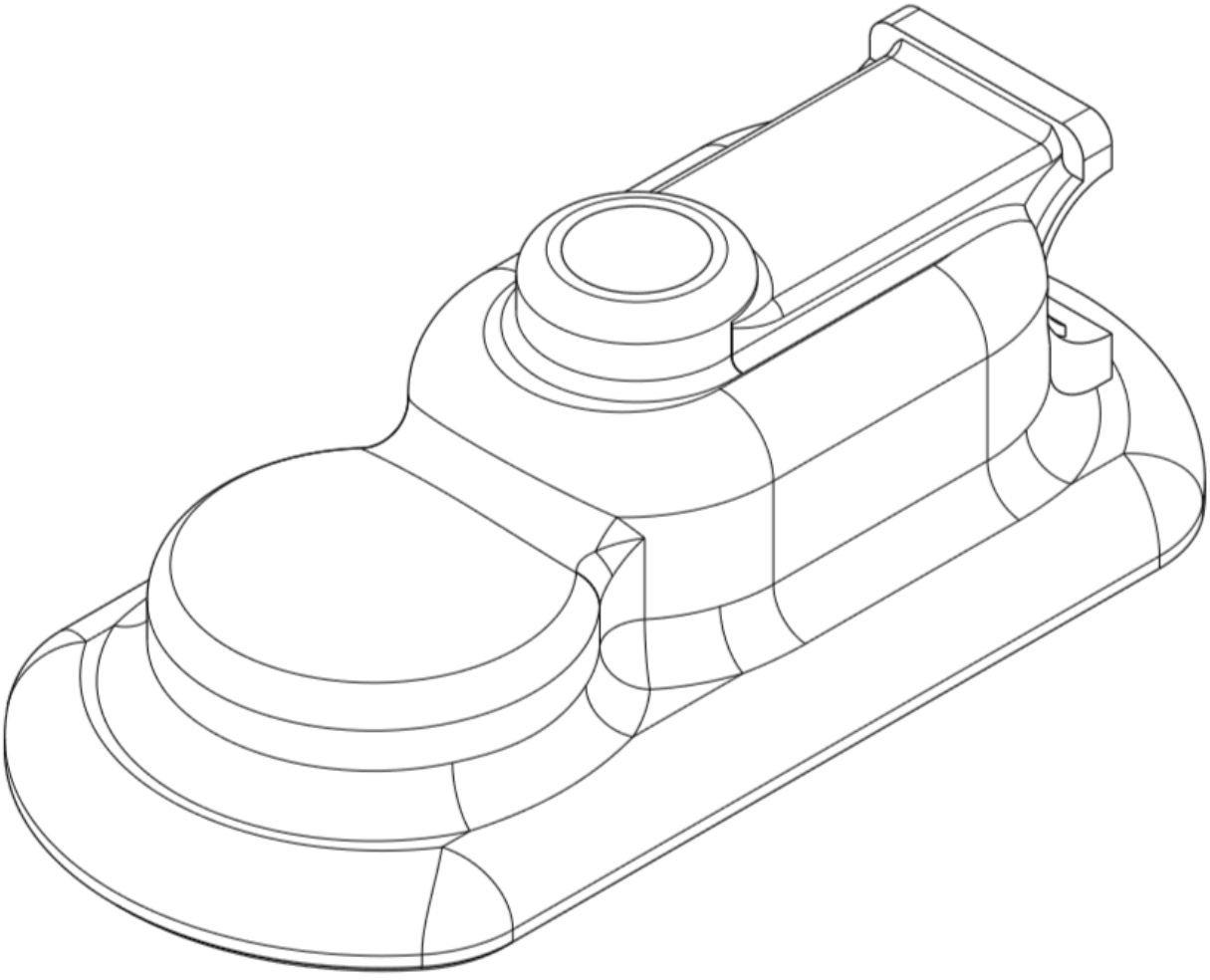
CAM PROJECT

MPE SINO-ITALIAN CAMPUS

1351706 SHI ZHEN YU 1352050 CAI ZHONG TIAN 1353125 CHEN JUN LIE



- Declaration & Notification

All the units of length in this document are in “mm”.

All the **CAD parts** are designed exactly as is drew in ‘RawPart.pdf’. If any dimension is missed in the drawing, we measure it manually.

In chapter ***‘CAD design - b. Setup Assembly Design’***, if not mentioned additionally, the fixture elements would have the same dimensions as is employed in the previous step.

(“4. File to be submitted: The report (PDF), *.CATPart, *.CATProduct, *.CATProcess, documentation file (*.html). “)
……
The folder “Model in CATIA” contains all the CATIA files, in which there is a file named ‘**Process.CATProcess**’, and four extra folders for each setup assembly, containing all the final parts, stock (semi) products, and fixture elements used in that setup.

When opening the ‘Process.CATProcess’ file, a window may pop out to remind you that a ’SetupAsm.CATProduct’ file could not be found. **Please ignore it and click ‘Close’**.
This error is due to a wrong correlation among files in the early stage of the project and unfortunately so far we have found no method to delete it.

…

- Catalog

CAD Design……P3
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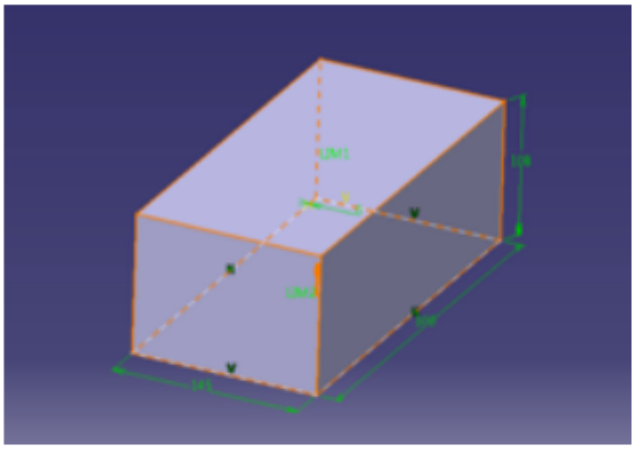
– CAD Design

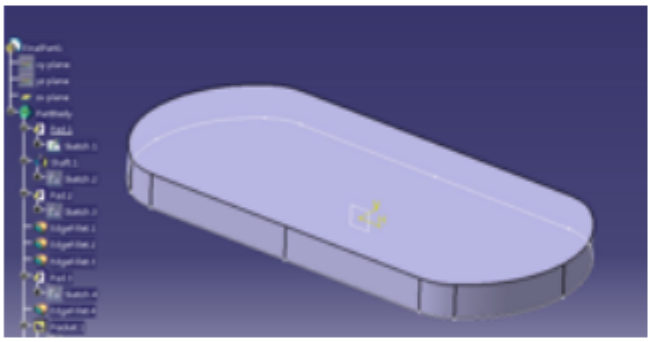
a. Steps to build the CAD model

- **RawPart.CATPart**



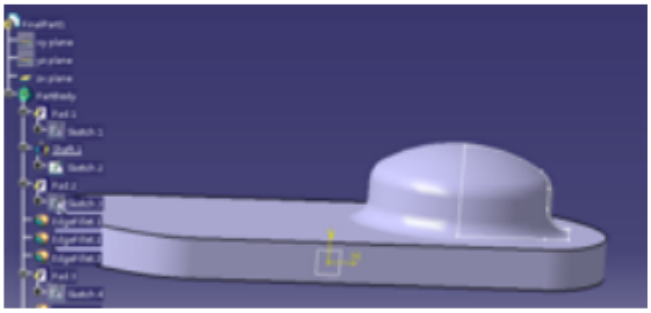
A cubic with dimension 145*300*108.

- **FinalPart.CATPart**



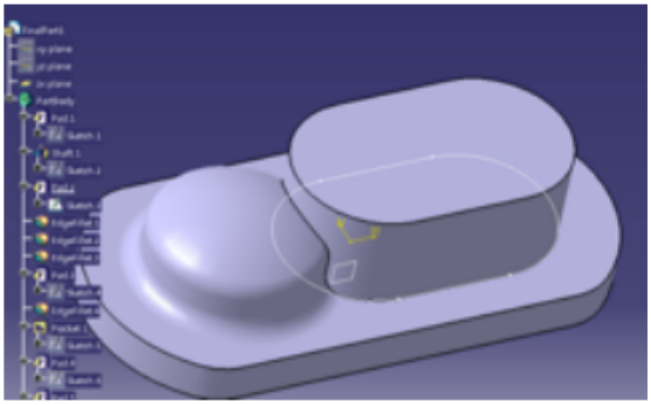
1.
Sketch.1 & Pad.1

The bottom part of the final part.



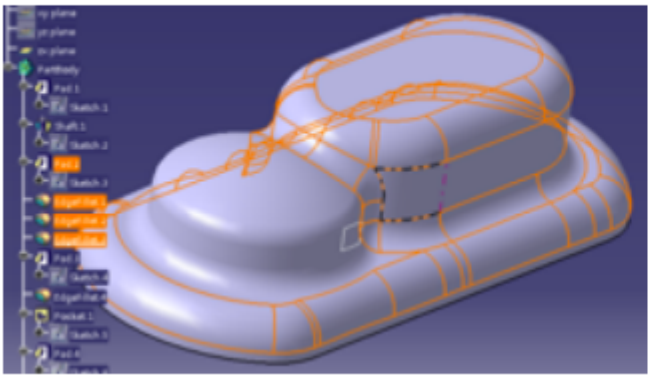
2.
Sketch.2 & Shaft.1

The round feature with a cambered-surface top.



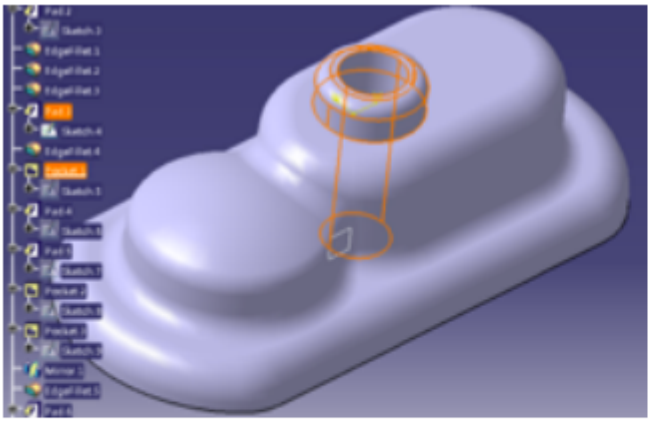
3.
Sketch.3 & Pad.2

The shape of the other upper feature



4.
EdgeFillet.1 & 2 & 3

Fillets with different radii on the final part.

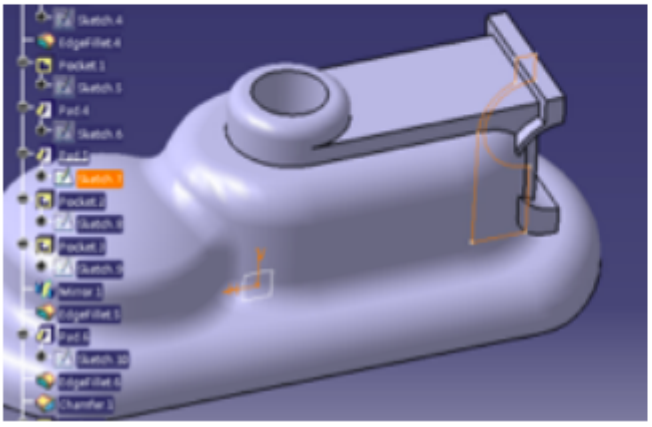


5.
Sketch.4, Pad.3,
EdgeFillet.4 & Sketch.5,
Pocket.1

To make the cylindrical feature with fillet on top, and a through-hole in middle.

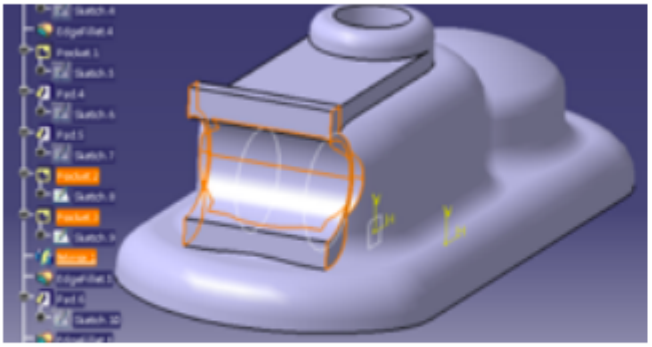
6.
Sketch.6 & Pad.4

Pad definition in both directions (up & down), to make the bridge feature.



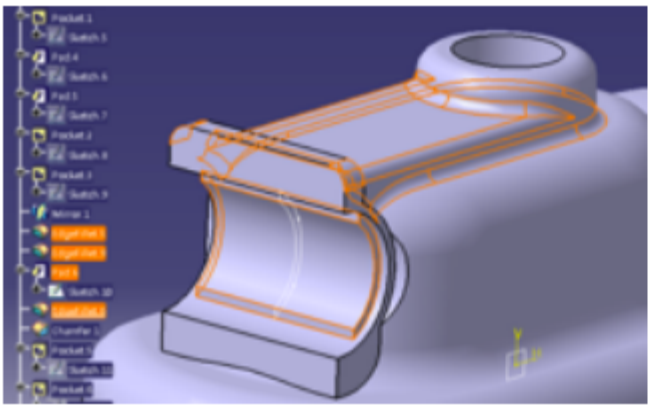
7.
Sketch.7 & Pad.5

Pad definition in mirror mode to make the special side feature.



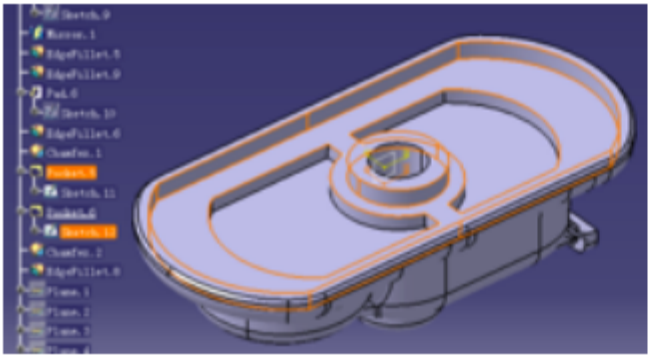
8.
Sketch.8 & Pocket.2,
Sketch.9 & Pocket.3, Mirror.1

Pockets and mirror feature to eliminate all the odd parts on the final side feature.



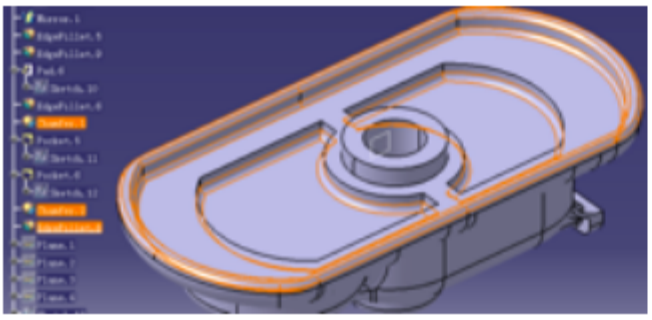
9.
EdgeFillet.5 &6 &9,
Sketch.10 & Pad.6

The fillets on top of the bridge feature, and the shorter thin curve-shaped pad on side.



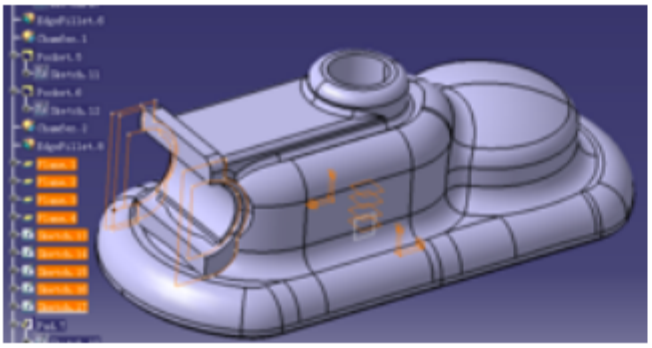
10.
Sketch.11 & Pocket.5,
Sketch.12 & Pocket.6

The double-layer pockets feature on the bottom surface.



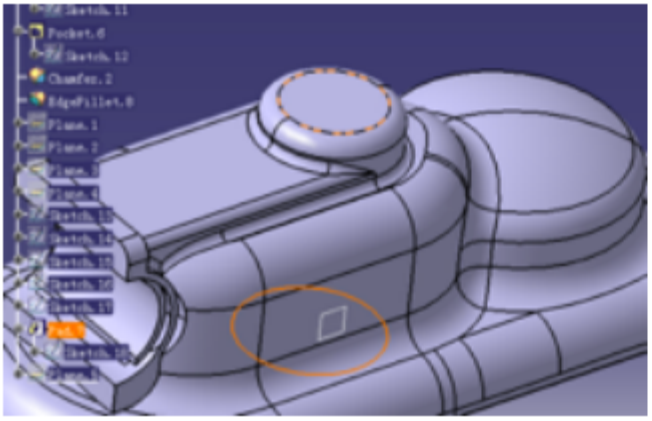
11.
Chamfer.1 & 2,
EdgeFillet.8

Chamfers on three edges of the first layer of pocket, and the fillets on the second layer bottom(the radius is not given in the drawing, so we measure it to be 3mm).



12.
Plane 1 & 2 & 3 & 4 & 5,
Sketch 13 & 14 & 15 & 16 & 17

Assistant planes and sketch serving as limit surfaces or guide lines in CAM processes.



13.
Sketch.18 & Pad.7

An assistant, fictitious pad to temporarily fill up the hole in setup.1 & 2 to easily avoid some processes (mainly 'roughing') digging into it which is unexpected.

b. Setup Assembly Design

- **Setup.1 (SetupFirst.CATProduct)**

Fixture elements:

1. Locator:
   yellow, with height of 24mm (measured from upper surface of the table)

2. Clamp apparatus (type 1):
   blue, with size of 45*75*24

3. Support:
   green

In total, 3 locators and 3 clamp apparatus on the four sides and 3 supports on the bottom are used to fix the raw material.

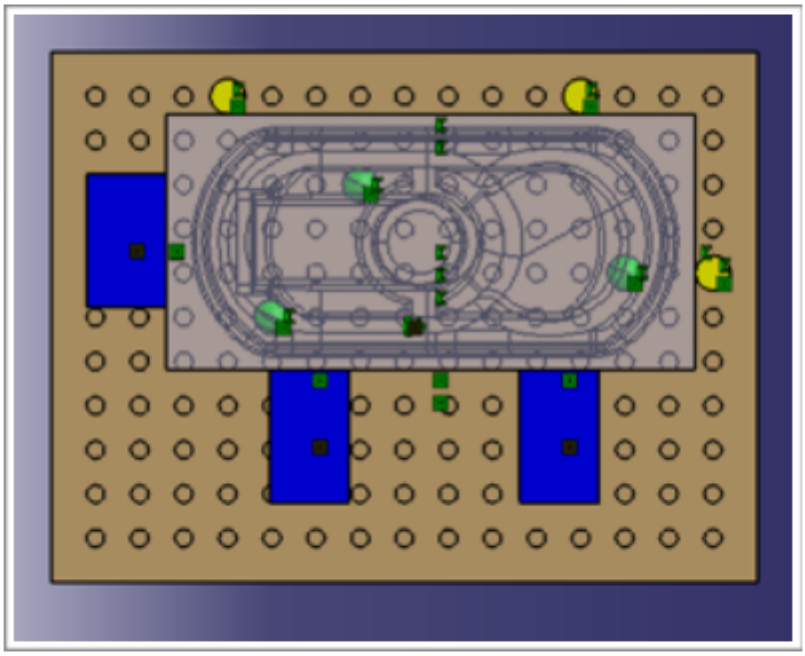


Fig. Topview_Setup.1

- **Setup.2 (SetupSecond.CATProduct)**

Fixture elements:

1. Locator:

2. Clamp apparatus (type 1):

3. Support:

The number of the elements remains the same.

However for this setup, the **semi-finished part is overturned up** (to start machining the upper part), and the supports are moved to be in contact with the first level of bottom pocket.

The height of **locators** (yellow) and **clamping apparatus** (blue) are all 24 in height (same as are used in '*Setup.1*'), **designed not to interfere the processes** in which the bottom of the uncut raw material (25mm away from the table) is machined.

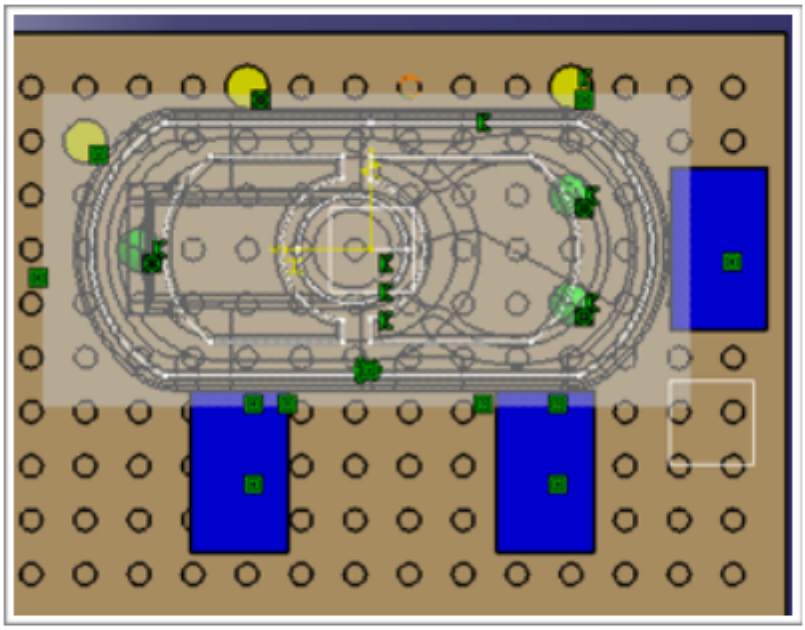


Fig. Topview_Setup.2

- **Setup.3**
  (SetupThird.CATProduct)

Fixture elements:

1. Locator:

2. Clamp apparatus (type 1):

3. Clamp apparatus (type 2):
   pink with L shape (shown in **'Fig. type_2_clamping' 1 & 2**)

4. Support:

In total, 3 locators, 3 supports, 1 clamp apparatus of type 1 and 3 clamp apparatuses of type 2 are used to fix the semi-product.

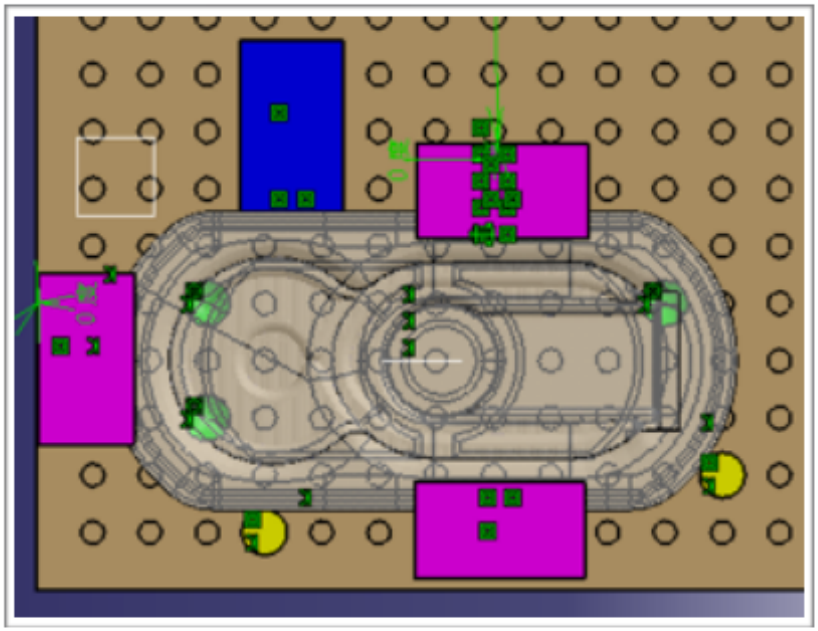


Fig. Topview_Setup.3

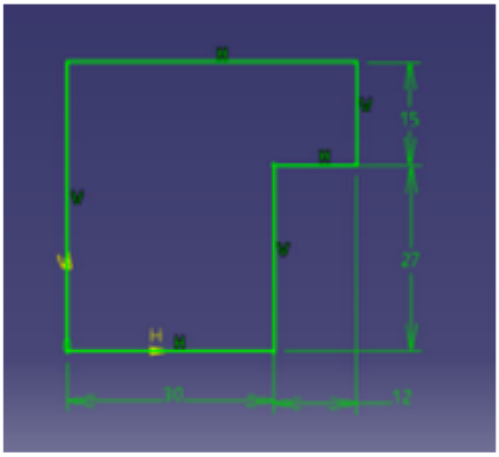


Fig. type_2_clamping_1

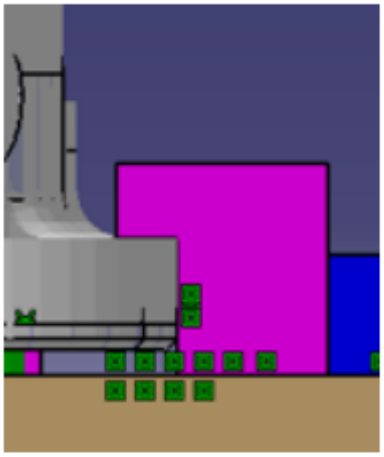


Fig. type_2_clamping_2

The above pictures show the specific dimensions and position of the **type 2 clamp apparatus** (the length is 75mm).

This particular type of clamp apparatus is designed especially to **avoid the unexpected shock and vibration along Z-axis** (parallel to the axis of the middle through-hole), due to the fact that in the following operations the tools would exert inevitably some upward forces to the material (please refer to the chapter *'CAM Setup.3'* if necessary).

- **Setup.4**
  (SetupFourth.CATProduct)

Fixture elements:

1. Locator:
   yellow, with height of 20

2. Clamp apparatus (type 1):

3. Clamp apparatus (type 3):
   orange, with diameter of 30 and height of 20

4. Support:

In total, 3 locators, 3 supports, 2 clamp apparatuses of 'type 1' and 1 clamp apparatus of 'type 3' are used to fix the semi-product. used to fix the semi-product.

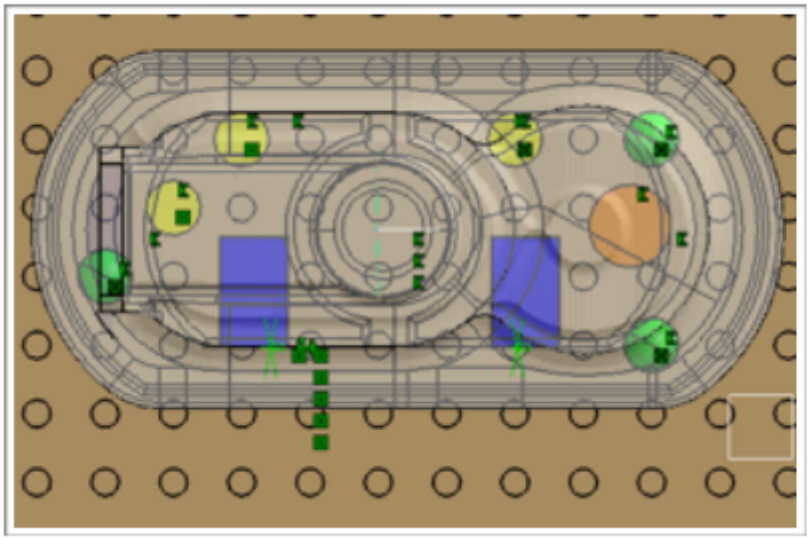
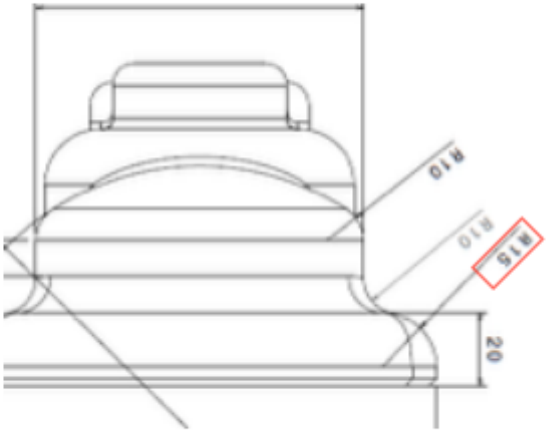


Fig. Topview_Setup.4



This setup is designed mainly to machine the **R15 fillet** (framed out in the figure) and **the middle through-hole**, however in this way the previous ordinary fixture elements would become obstacles.

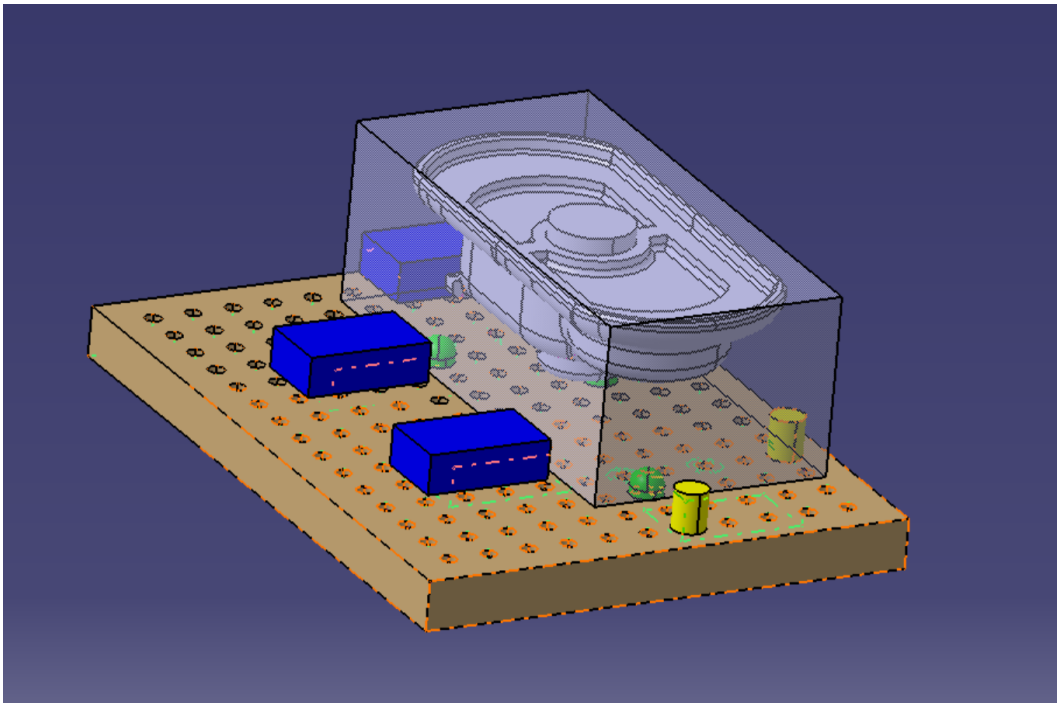
So our solution is to move them all inside the bottom pockets and the dimensions of these elements are changed to fit the size of the pockets.

A round clamp apparatus **(type 3)** is made because a rectangle one would not fit the arc of that part.

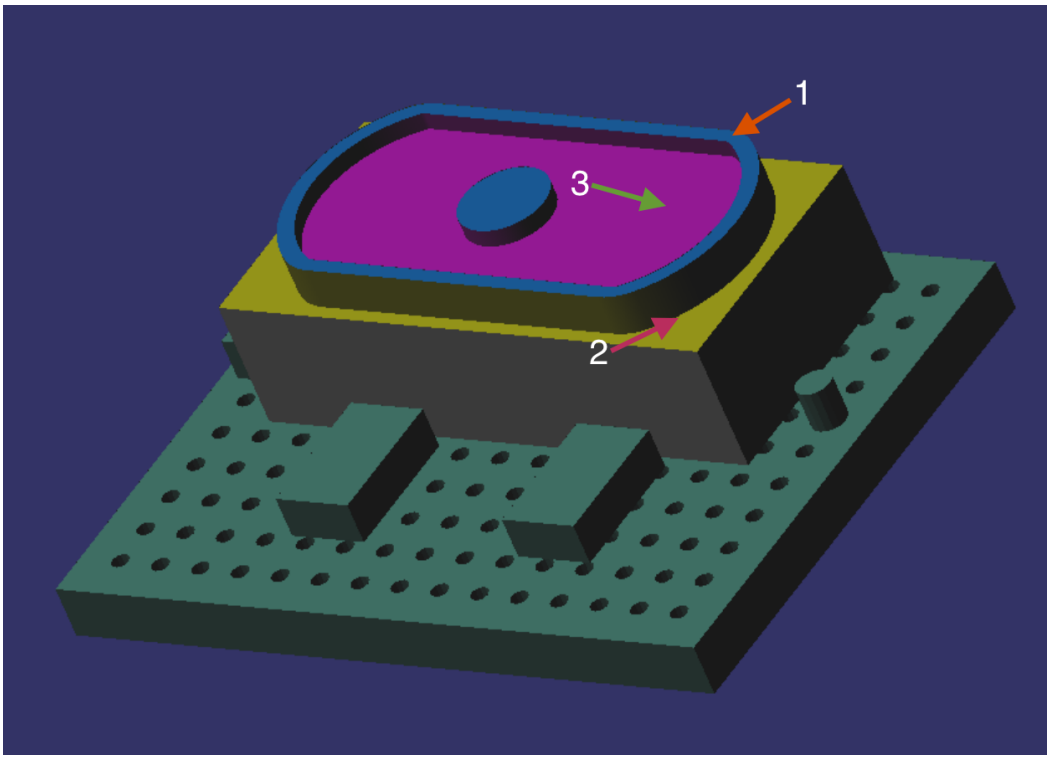
— CAM Process Plan Reporting

PHASE I

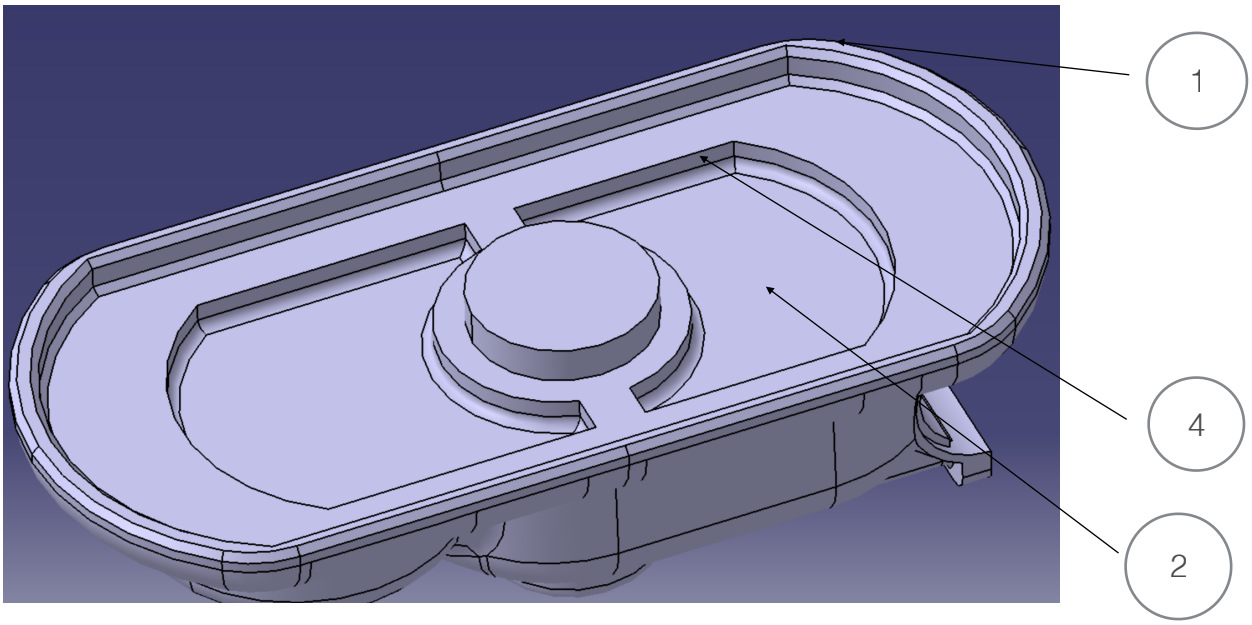
FIXTURE POSITION

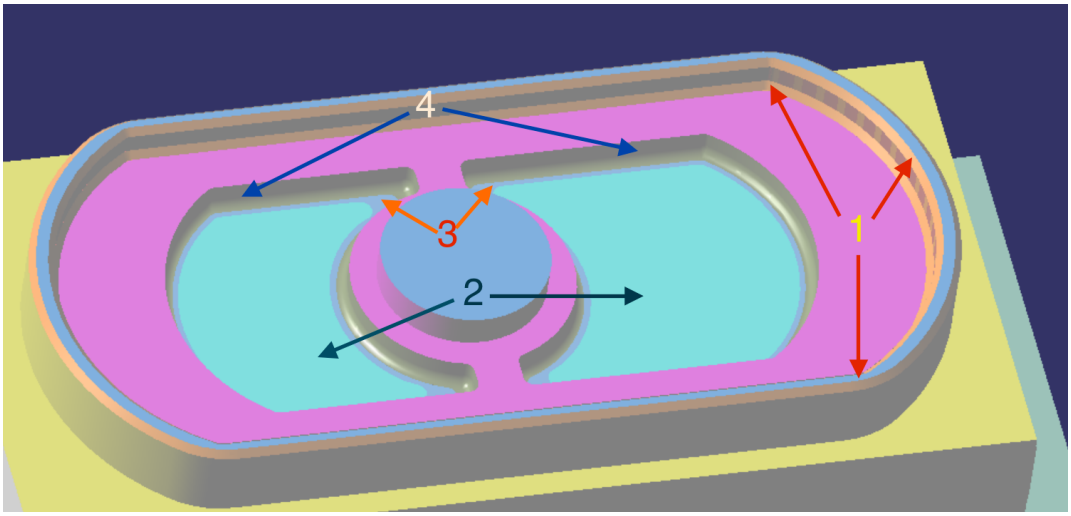


MACHINED FEATURES, OPERATION SEQUENCES & TOOL



1. Facing (T2 End Mill D 50)
2. Profile Contouring (T2 End Mill D 10)
3. Pocketing (T2 End Mill D10)

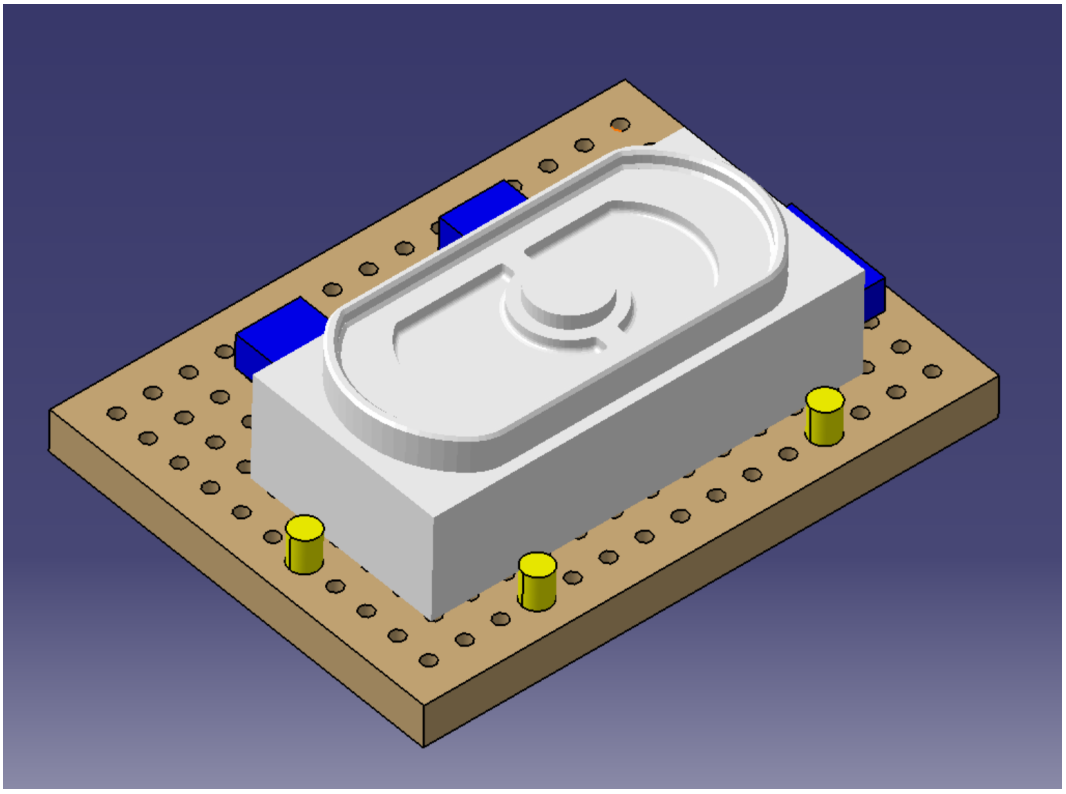




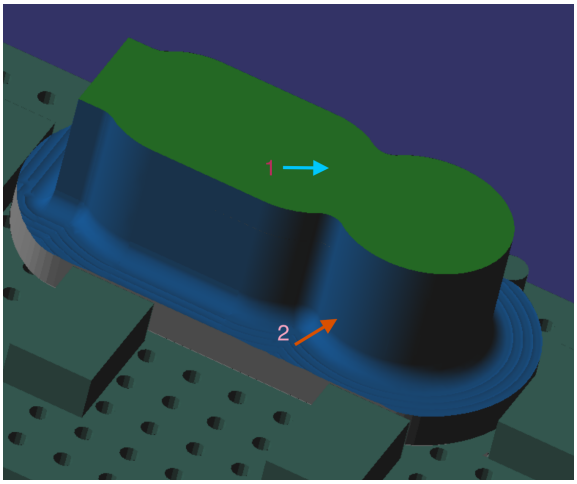
1. Profile Contouring (T12 Two Sides Chamfering Tool D 10)
2. Pocketing (T3 End Mill D 6)
3. Profile Contouring (T3 End Mill D 6 Ball)
4. Profile Contouring (T3 End Mill D 6 Ball)

PHASE II

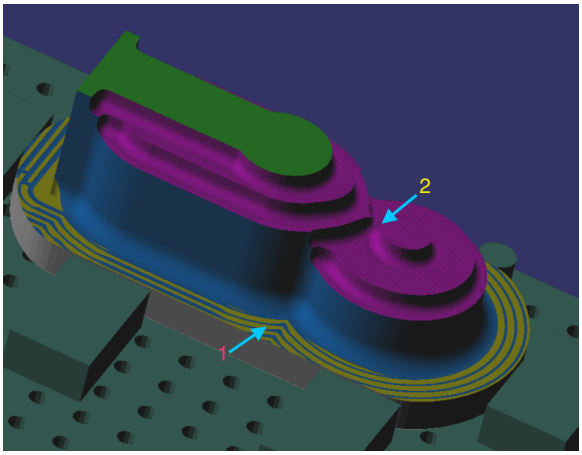
FIXTURE POSITION



MACHINED FEATURES, OPERATION SEQUENCES & TOOL



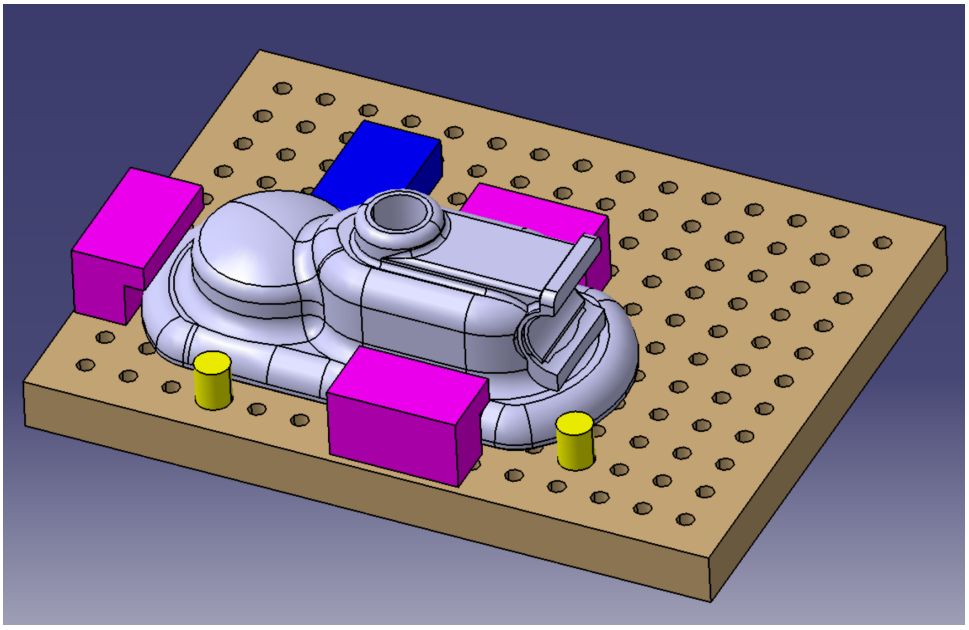
1. Facing(T1 Face Mill D 50)
2. Profile Contouring(T3 End Mill D20)



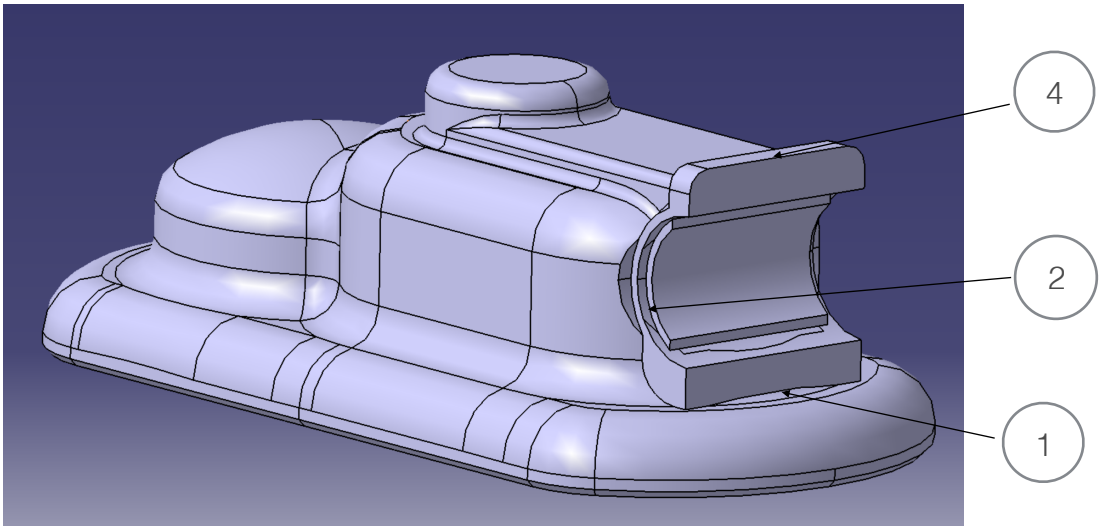
1. Profile Contouring(T3 End Mill D 10 long cutting_edge)
2. Profile Contouring(T3 End Mill D 10 Ball)

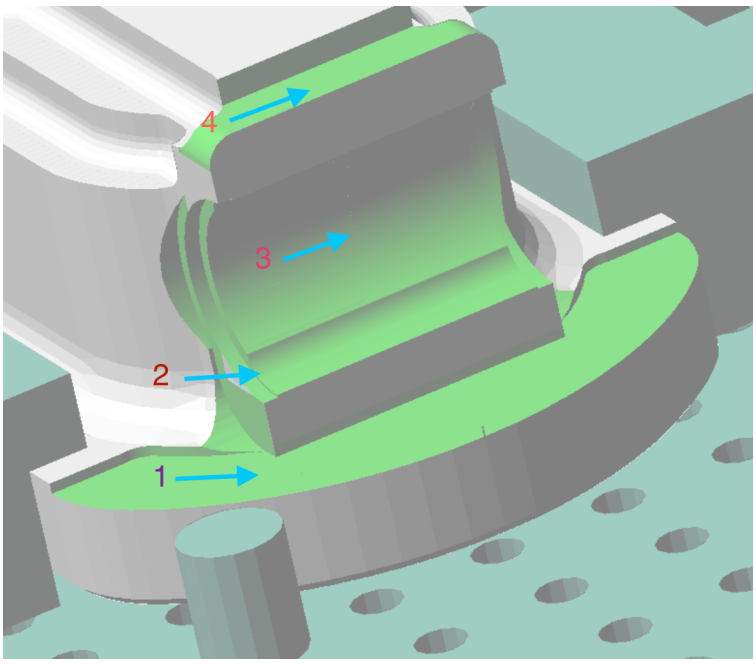
PHASE III

FIXTURE POSITION

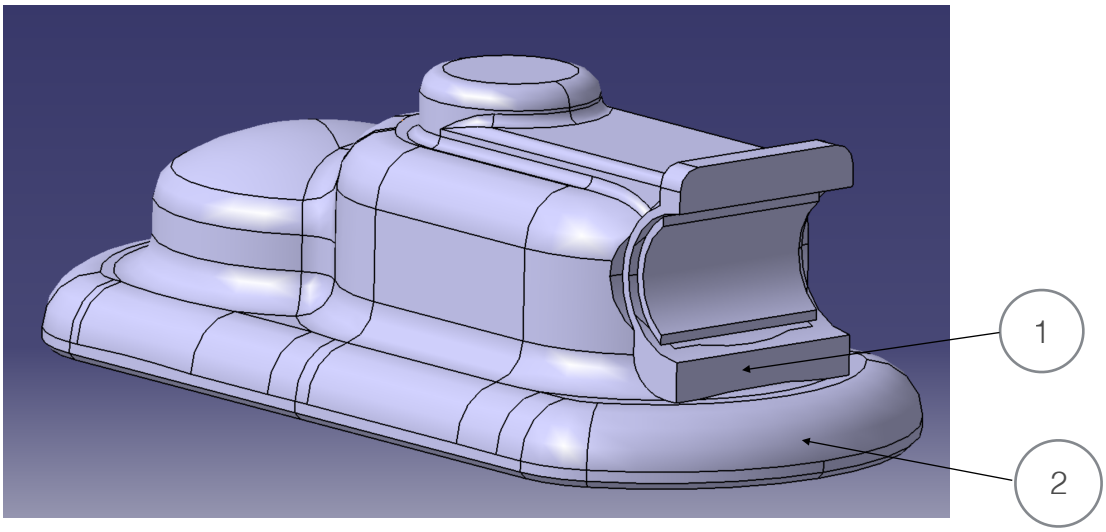


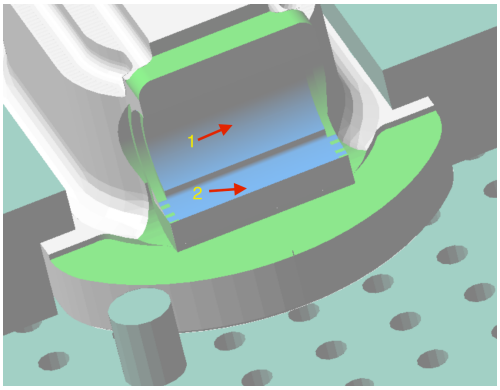
MACHINED FEATURES, OPERATION SEQUENCES & TOOL





1. Profile Contouring(T3 End Mill D 10 long cutting_edge)
2. Pocketing(T3 End Mill D 10 long cutting_edge)
3. Pocketing(T3 End Mill D 10 long cutting_edge)
4. Pocketing(T3 End Mill D 10 long cutting_edge)

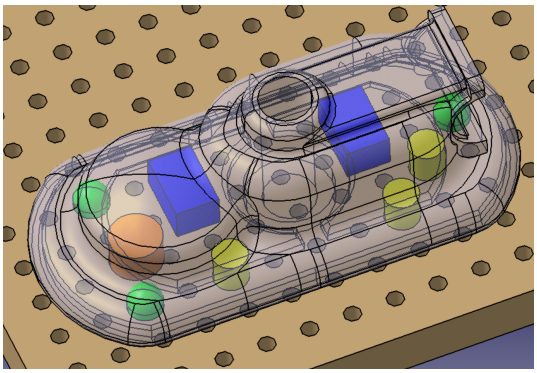




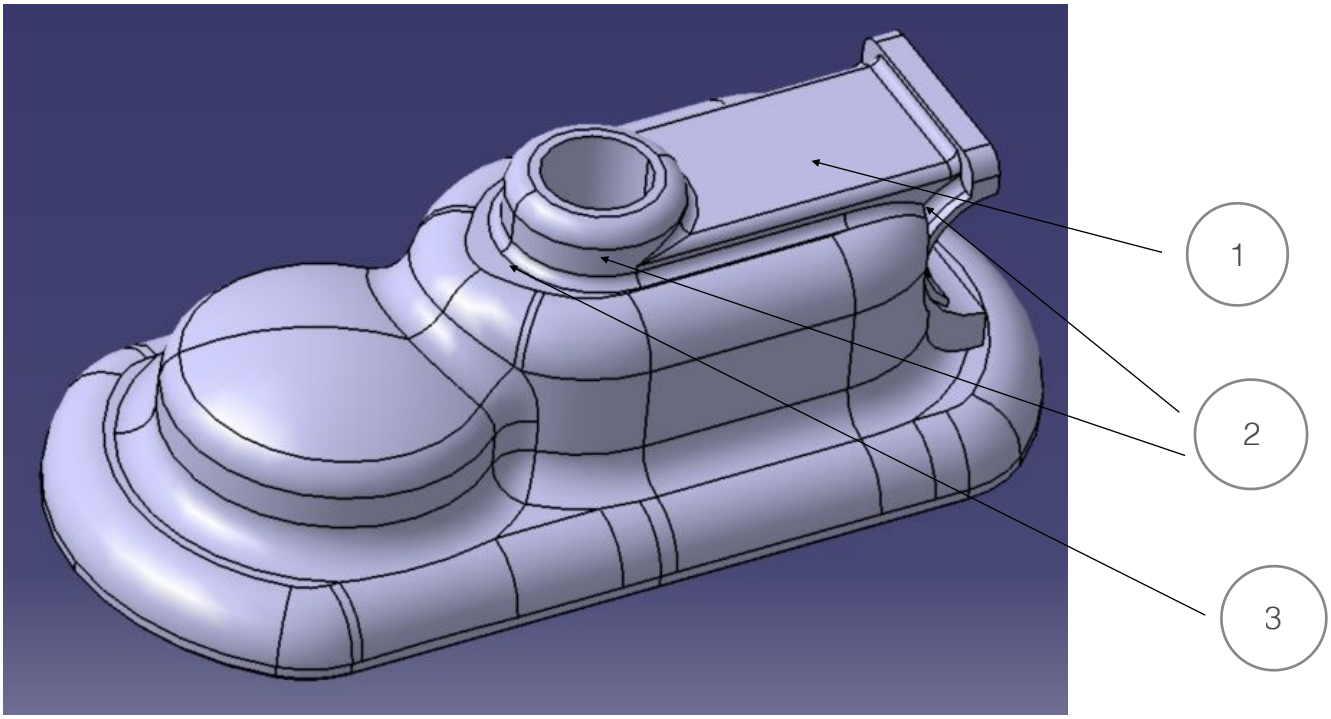
1. Profile Contouring(T3 End Mill D 3 long for side)
2. Profile Contouring(T3 End Mill D 3 long for side)

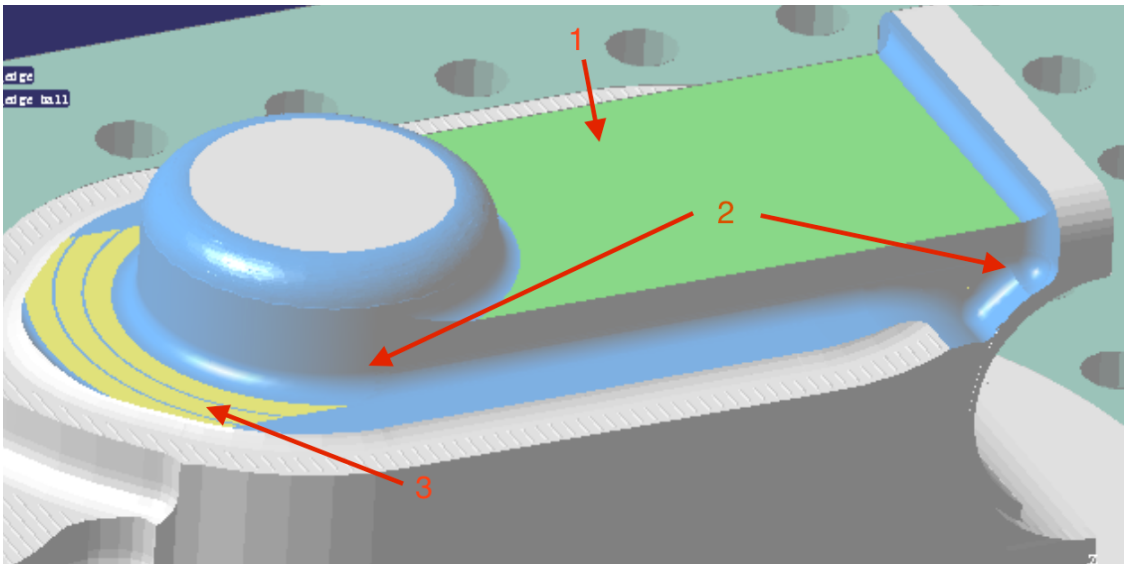
PHASE IV

FIXTURE POSITION



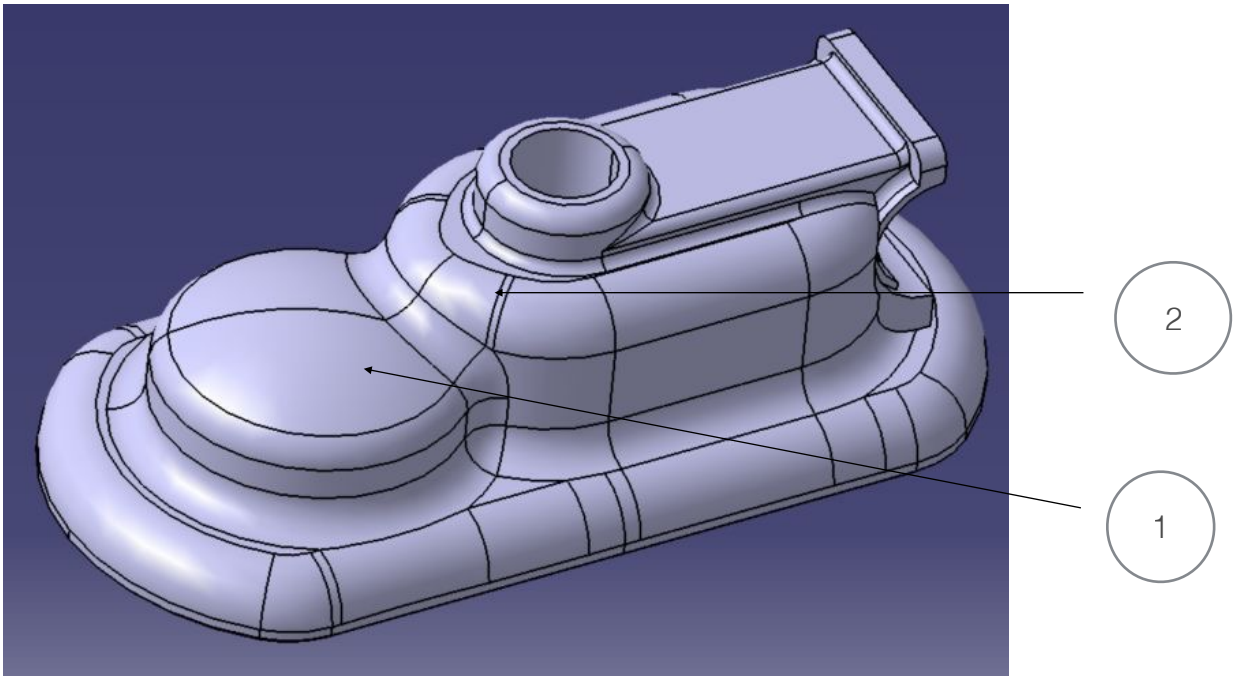
MACHINED FEATURES, OPERATION SEQUENCES & TOOL

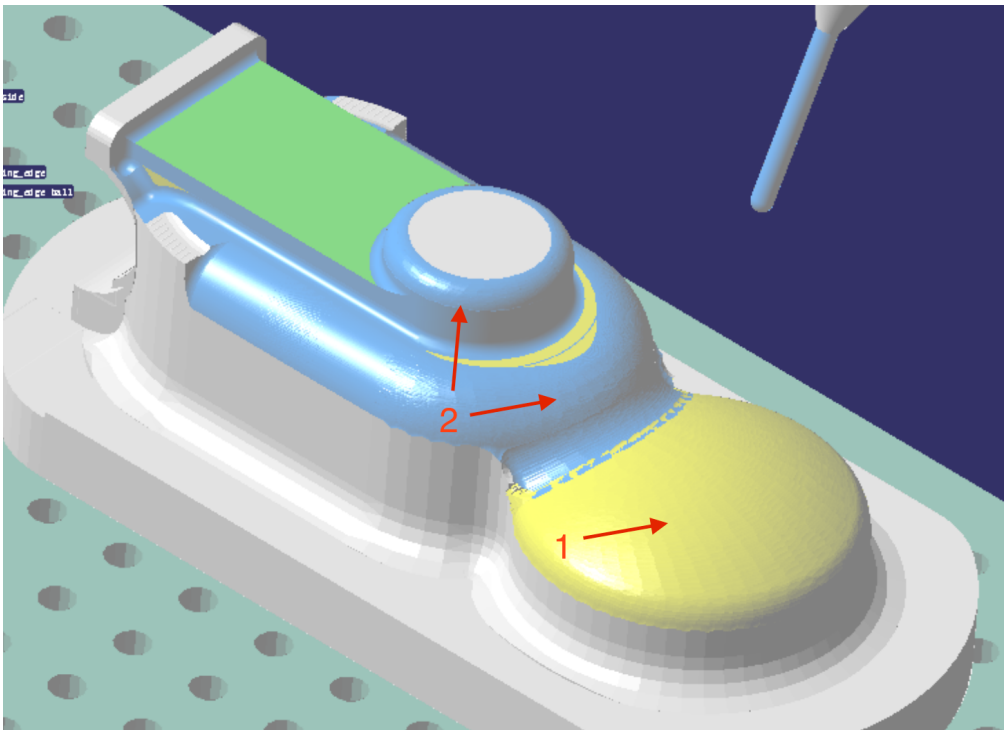




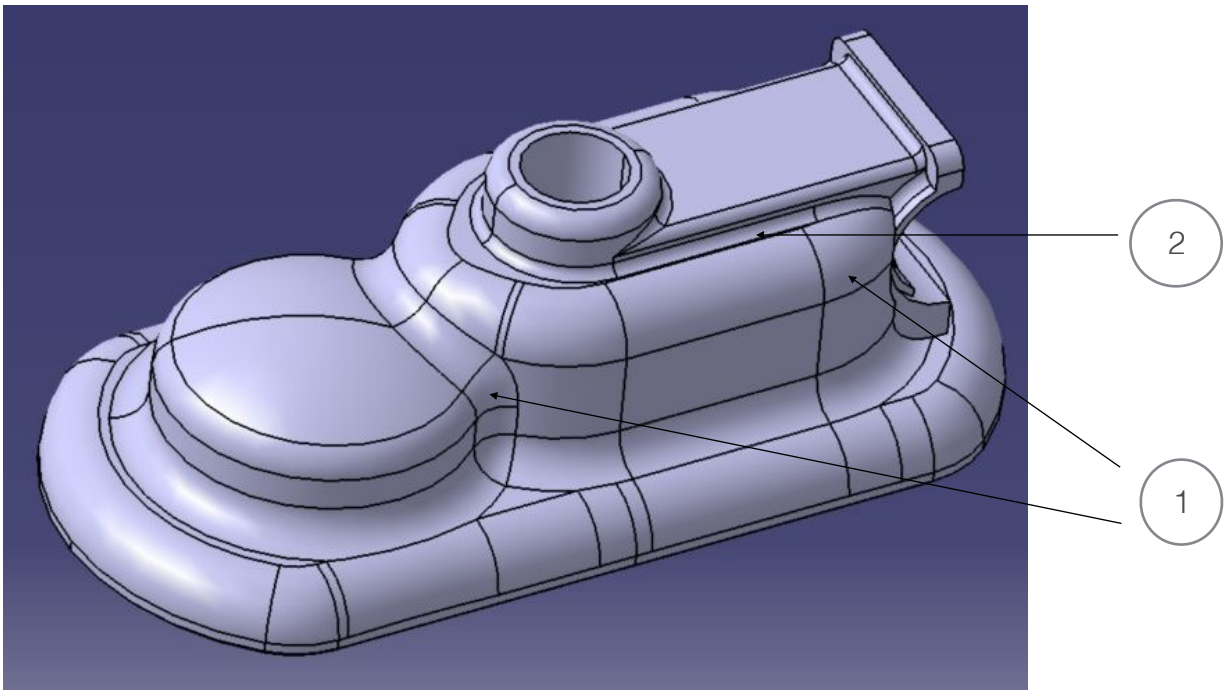
OPERATION SEQUENCES & TOOL

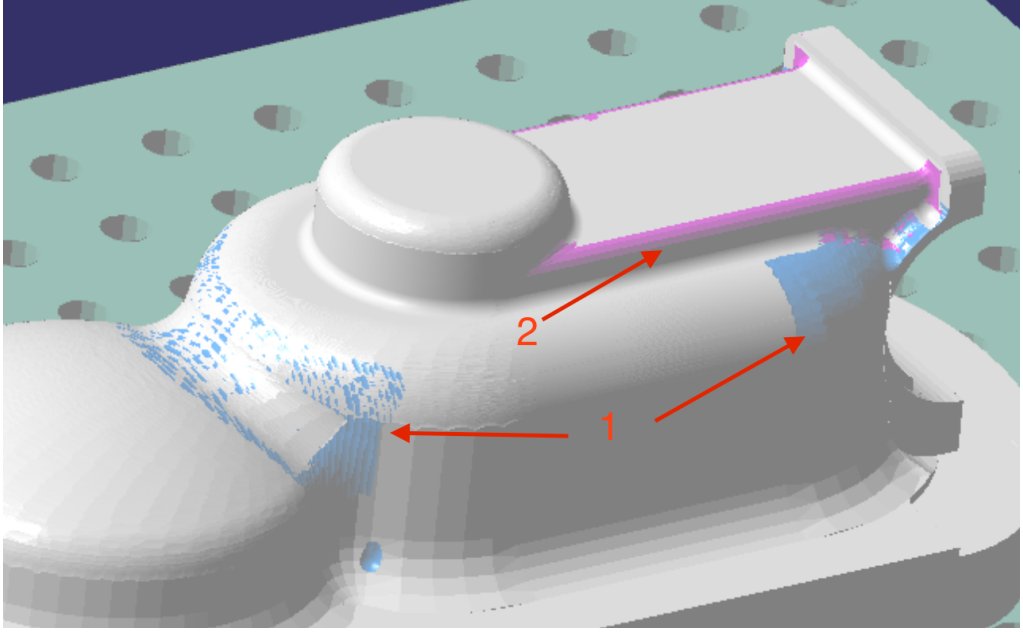
1. Pocketing (T2 End Mill D10)
2. Profile Contouring (T3 End Mill D6 Ball)



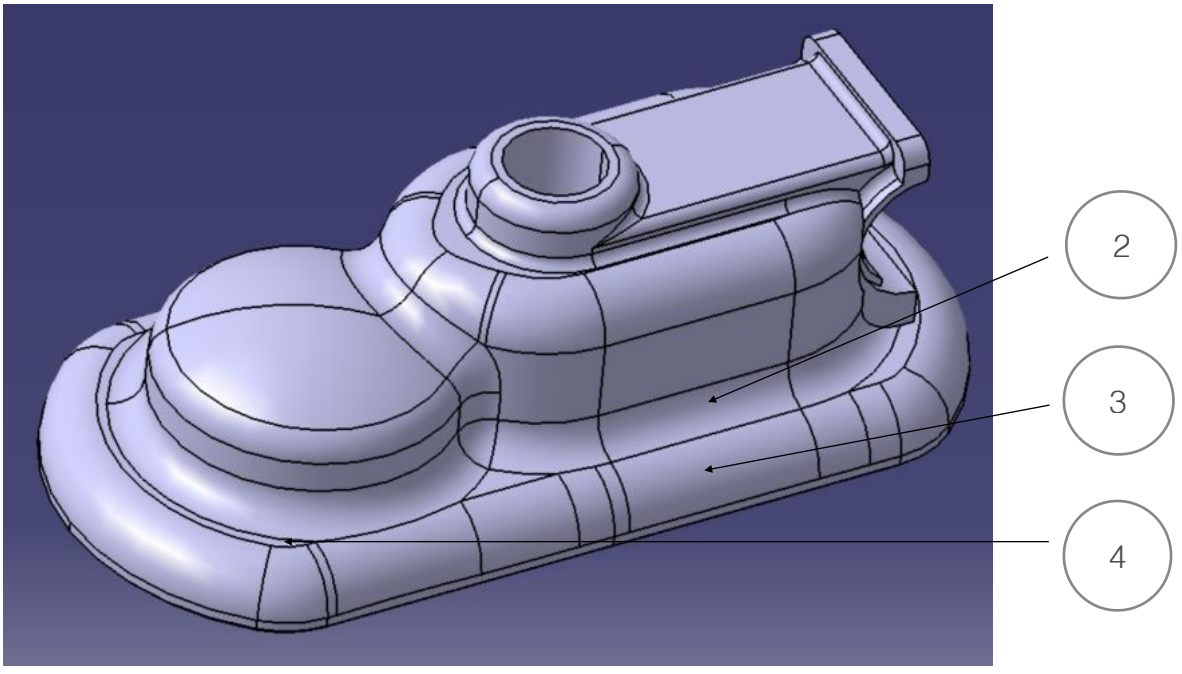


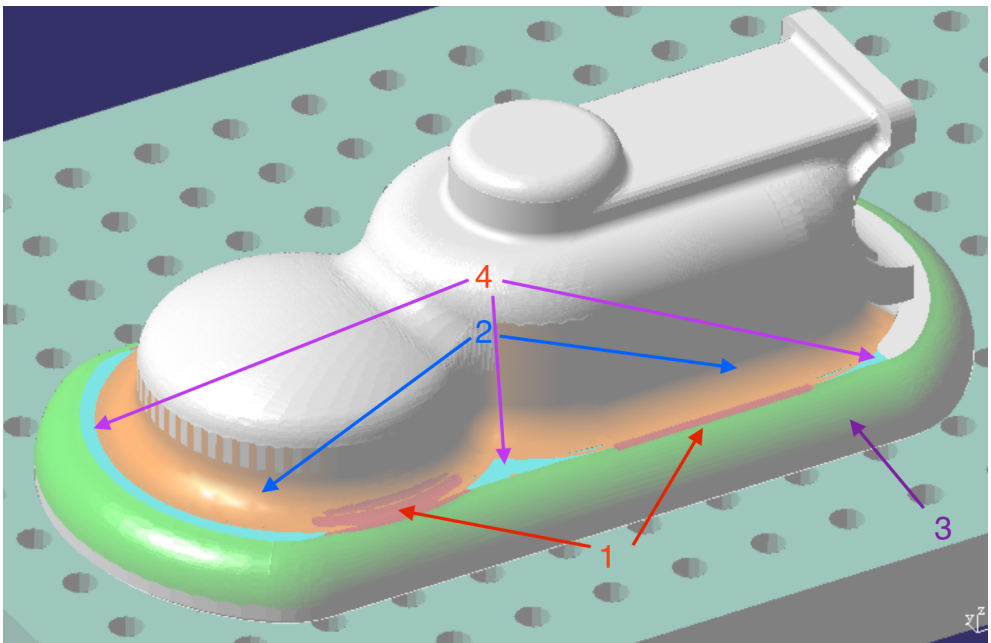
1. Multi-Axis Contour Driven (T3 End Mill D6)
2. Multi-Axis Contour Driven (T3 End Mill D6 Ball)



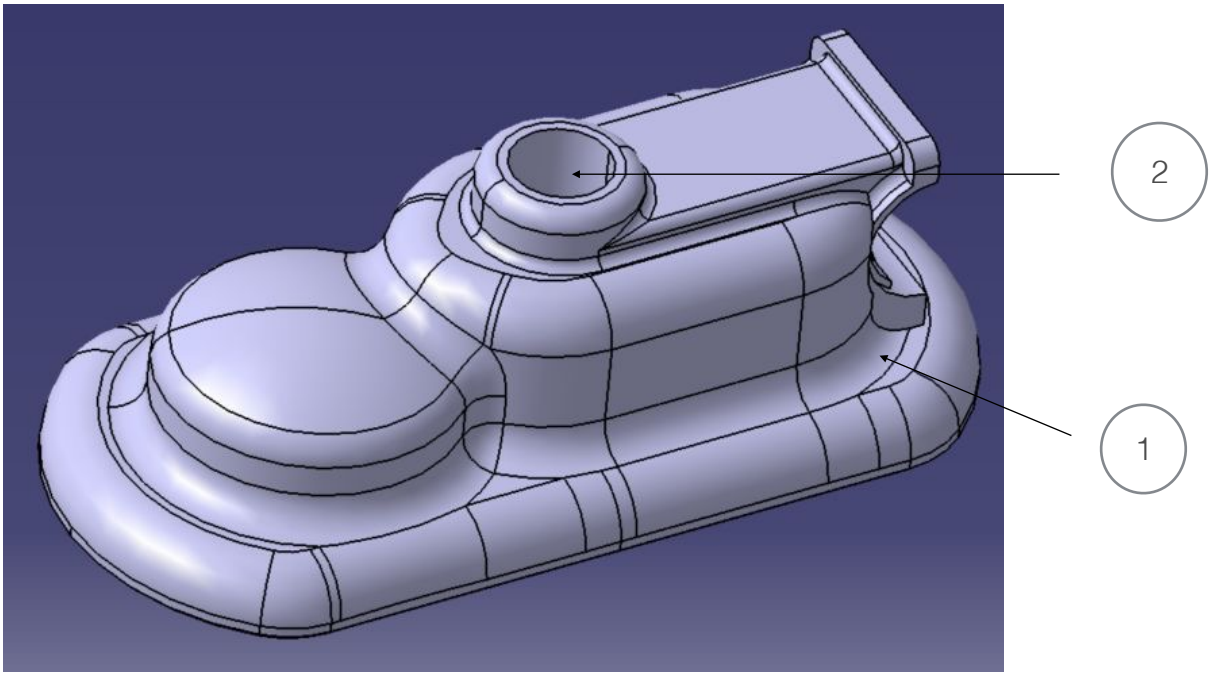


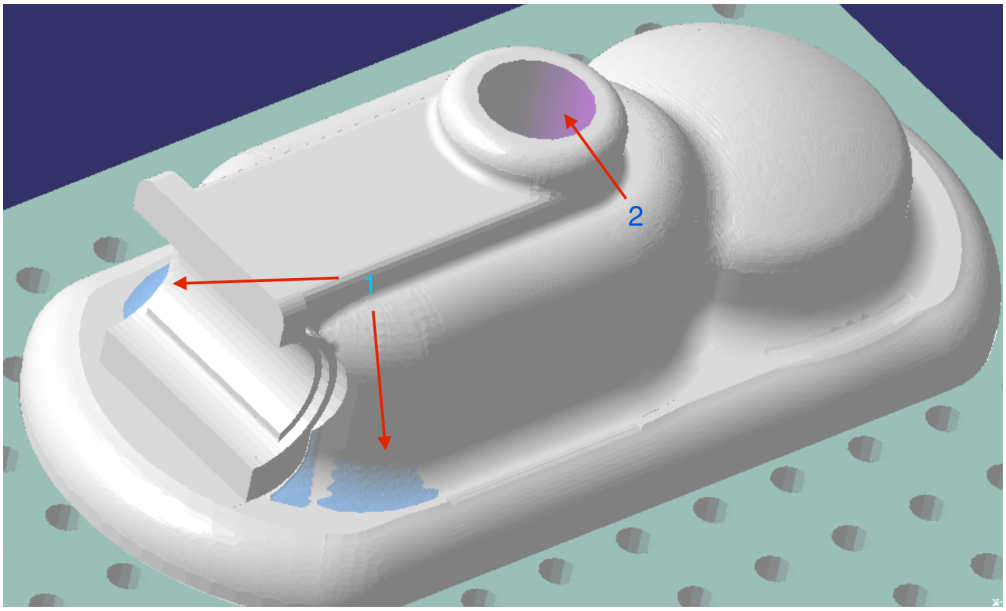
1. Sweeping(T3 End Mill D6 Ball)
2. Sweeping(T3 End Mill D3)
3. Profile Contouring (T3 End Mill D6)





1. Multi-Axis Contour Driven(T3 End Mill D 10 ball)
2. Profile Contouring(T3 End Mill D 20 ball)
3. Multi-Axis Contour Driven(T2 End Mill D 10 ball)
4. Profile Contouring(T3 End mill D 4 long cutting_edge)





1. Sweeping (T3 End Mill D 4 long cutting_edge ball)
2. Spot Drilling (T24 Spot Drill D 15)
2* Drilling(T25 Drill D29+ Boring D30)
Boring: to increase accuracy

— Detail Discussion

PHASE 1

Manufacturing of the bottom side of the part directly from the raw material by using mainly face milling, end milling, chamfering and profile contouring.

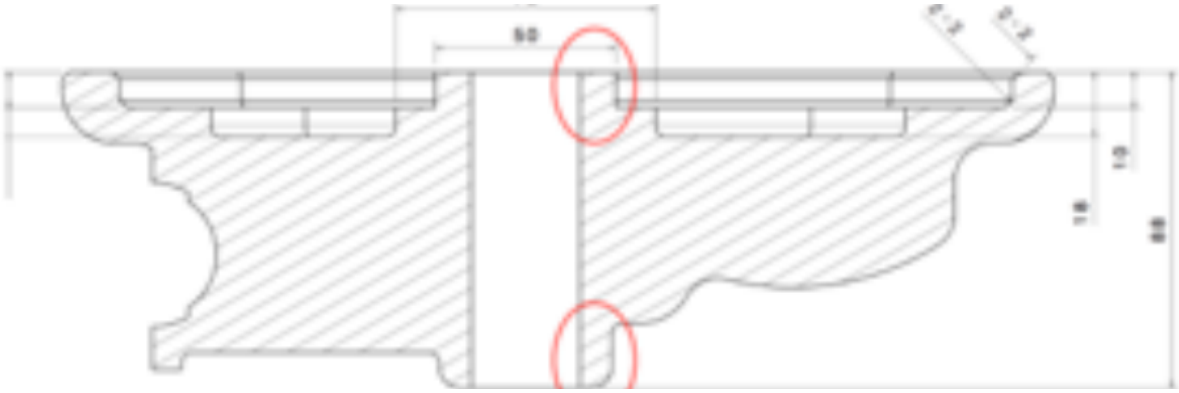
Choosing the bottom side at the beginning phase aims at the convenience of the setups in the following phases, so that turning upside-down the part would not be needed to be done again. The double pool shaped pocket was done by 3 steps which are roughing, finishing and fillet, combining speed and precision, which we believe to be a great solution. Chamfering is done before this process.

PHASE 2

Rough machining for the upper surface. The horizontal plane at the lower part is made for the self-designed fixture object.

The horizontal plane needs to be machined again to be flat because in the previous step the tool was in ball shape so that the plane is not actually flat. The ball shape tool was used to contour the curvature on the side planes.

The big round through hole in the middle is not drilled in this phase due to the fact that if it were made here, the emptiness in the middle and being too thin the ‘wall’ could not be strong enough internally to support well the top surface machining process, causing malfunction.



PHASE 3

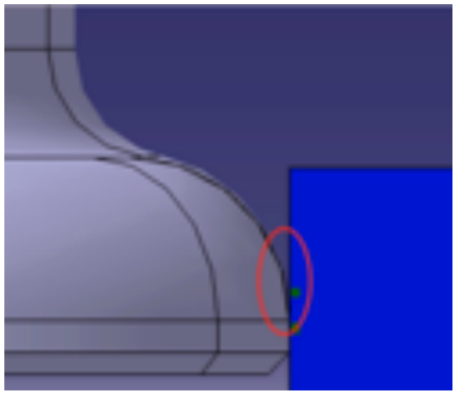
Phase 3 consists of 2 main processes: Roughing and finishing. Roughing follows the order from outside to inside, and the inside surfaces experience finishing process afterwards.

Considering phase 3 is the only one of which the manufacturing process might cause movement or vibration (obviously causing inaccuracy in the production process) in the z-axis, the fixture of the z-axis becomes extremely important. As being expressed above, an object is designed for the fixture.

PHASE 4

The part is fixed from inside in order to contour the camber surface at the lower part of the part which is the only way if the part is machined with only one setup.

1.This particular setup is designed mainly because of two reasons:
One has been discussed above about maintaining the toughness of machining.

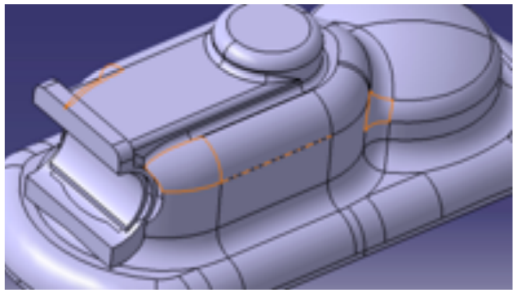


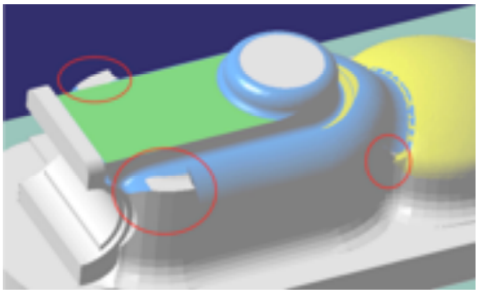
Secondly a setup with all the fixture elements inside the machined body is inevitable (as is already mentioned in chapter ‘CAD-Setup Assembly-Setup.4’), because if not, the part circled out in the figure above on right simply cannot be properly machined. All the upper complex surface machining steps are made in the last setup, minimising the intermediary files ‘SemiProduct*.CATProduct ’(serve as the stock in each setup). A semi-product file (including file ’.cgr’) with such complicated manufacturing process would be as big as 100MB decelerates the running speed tremendously.

2. Within Setup.4, we tried to use ‘multi-axis sweeping’ as taught in lectures, but it turned out to be difficult to realise (unexpected defects happen all the time)

After some discussion with other groups, we turned out to use the same method however the result was not desirable and and the semi-product file was over-sized when trying to optimise the roughness.
The figure above on left is a whole-sweeping result, which is finally acceptable with the parameter ‘distance between routes’ adjusted small to 0.05mm (with the semi-product file size being big, the machining time is too long to satisfy), while the figure on right we have nearly the same roughness level (even better in some parts) with a significantly optimised machining time with a series of different machining steps.
Redesigning all those steps to make the process more feasible and realisable with a large amount of time spent, it looks gorgeous.

3. Some make-up approaches (Tool change.40 - Sweeping.1 & 2 & 3):



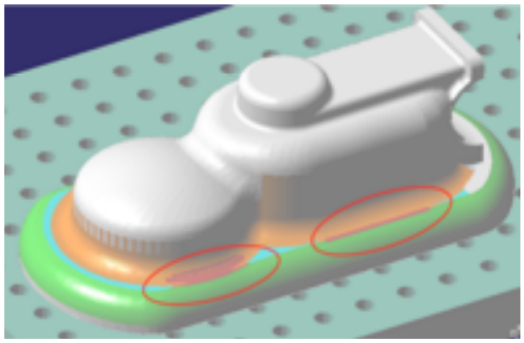


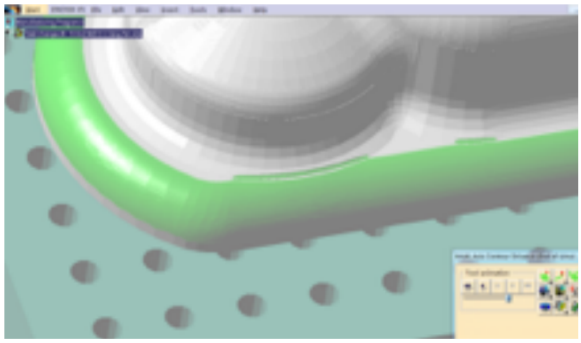
Some alternative machining methods are introduced, because the other methods (like ‘Multi-axis sweeping’, ‘Multi-axis contour driven’ or ‘Isoparametric machining’) which may seem more suitable for some specific surfaces (as is shown in the above two figures) failed to work well, due to the fact that the surfaces are so complex that some advanced settings or methods might be required. So at last sweeping is served to replace them.
It’s clear that this is only a make-up method to demonstrate the whole manufacturing process.

— Conclusion and Insight

Doing the project not only means finishing the tasks. What matters more is the knowledge learnt during the process, mistakes made and even unsolved doubts.

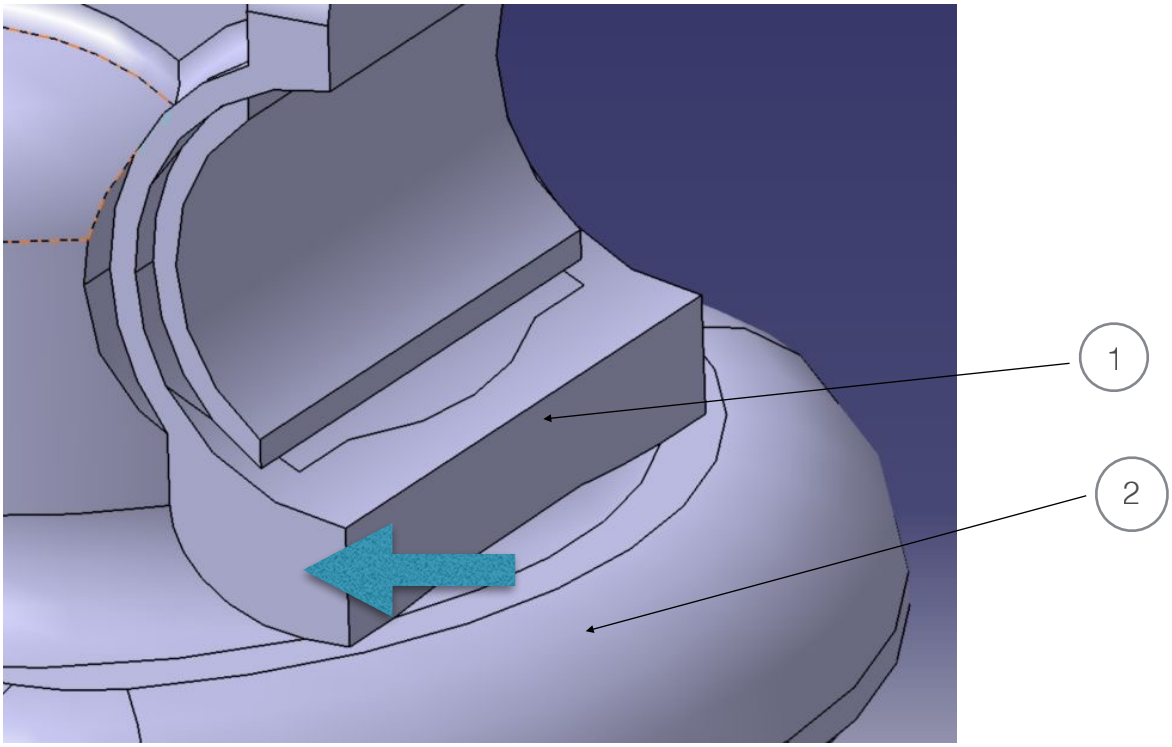
In phase 2 and 4 a mistake was made.





Some bars with different colours (as being circled in the above figure on left) show up in the simulation, during the process ‘Tool change 32 - Multi-axis contour driven’. Contour driven machining is introduced because this is a abnormal connecting area between upper part and the bottom base, which is in fact a little bit higher than the blue plane surface due to the geometrical features of fillets-connecting. As shown in the image, due to miscalculation, the horizontal plane in the lower part of the part occurred in the second phase was in the wrong height. It directly results in the mistake in the fourth phase. When doing the profile contouring, some materials are missed. So an ordinary sequence which is in the above left figure orange fillet before green one, the result would be like the figure on left where a defect occurs. While another solution is found out to adjust the sequence to be green area before orange one.

In phase 3, complex shapes lead to problems.



In the joint line directed by the blue arrow in the image, not until being swept in the fourth phase, it could not be contoured in the third phase by a tool with inevitable round shaped edge.
Also unexpected lumps show up where no.1&2 arrows point at. These are problems that has caught our attention while unfortunately we don't really have the capacity to solve. We look forward to solving them in the future when we are filled with more knowledge and experience.

What's more, during a project there are 2 indispensable things: team-work and continuous thinking.

Great team cooperation and communication mechanism among group members help make a great team. Such things are especially important in this project work, due to the fact that a lot of different types of files are involved, and some irreversible mistakes may happen during the replacement in the assembly, as CATIA files are always highly inherently-correlated and sometimes a tiny wrong correlation might be difficult to adjust in the following stages. Therefore it's important to keep group members updated with various types of files.

Keeping the mind thinking is the driving force of team work. The brainstorm mechanism is necessary to keep generating ideas, communicating and even debating(conflicts are crucial to optimise the project!). Fortunately our group members keep great relationship and close contact so that once we had a fresh idea, we shared and discussed. Even when writing this final report, when there is a new idea, we go back directly to CATIA to improve the process and then modify the report. This is exactly what we mean by 'keep thinking'.