Week 18: Final Project

25.6. 2015

This week we are developing our final project.

The agenda:
http://academy.cba.mit.edu/classes/project_development/index.html

assignment complete your final project, tracking your progress: what tasks have been completed, and what tasks remain? what has worked? what hasn't? what questions need to be resolved? what will happen when? what have you learned? documentation during development demand- vs supply-side time management spiral development

Starting this week I had just done some visual research and material research, as well as ordering materials on the basis of the research. I was in touch with a few companies in USA, France and the UK. The correspondance took some time. The USA companies pointed to their Europe retailers and the french company was not interested in supplying (their pigments were quite interesting) their materials in small quantaties and would not provide information on retailers.

In the end I ordered photochromic pigments and the following casting materials from a UK company – Benham in the UK: http://www.benam.co.uk/

1 IGNITE SAMPLER 9 PACK TUBE(0.2# 0.09KG)
Prod Code(0) PartNum: Lotnum: 0
1 SMOOTH-CAST 325 PINT UNIT (1.90# 0.86KGS)
Prod Code(0) PartNum: Lotnum: 0
1 CLEAR FLEX 50 TRIAL SIZE (3# 1.36KGS)
Prod Code(0) PartNum: Lotnum: 0
1 PAID BY CARD - THANK YOU
Prod Code(0) PartNum: Lotnum: 0

Ignite® Fluorescent Color Pigments

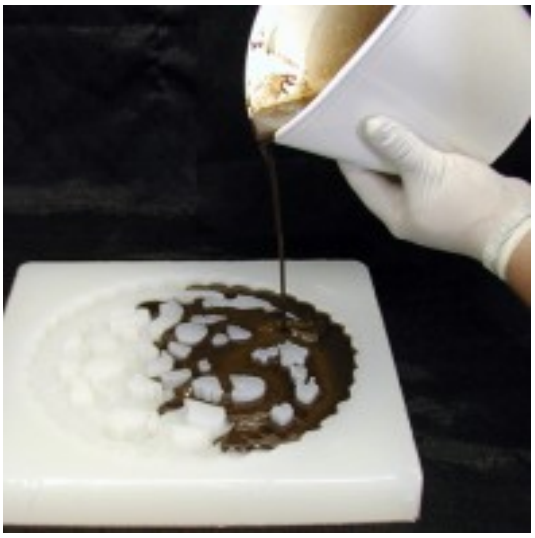
http://www.smooth-on.com/index.php?cPath=1255
The Ignite® line of liquid fluorescent colorants is compatible with Smooth-On urethane rubbers, urethane plastics, urethane foams (rigid and flexible) and silicones. The fluorescent or "glow" effect is maximized under ultra-violet light or "black light." The most dramatic color effect is realized when an Ignite colorant is used with a clear or translucent urethane rubber (such as Clear Flex 50) or plastic (such as Smooth-Cast 325).

The NEW Ignite® 9 pack gives you the opportunity to experience each color without spending a lot of money.

What Makes Castings Made With Ignite® Pigments Appear To Glow? When you add Ignite fluorescent color to a urethane material, more ultraviolet light from the cured material is visible to your eye vs. castings made with SO Strong® colorants. The casting appears brighter in ambient light and appears to glow under ultraviolet light.

Finally the choice for casting materials was:

Smooth Cast 320 Series



http://www.benam.co.uk/products/plastic/smooth-cast-320/

The Smooth Cast® 320 Series consists of new ultra-low viscosity/low cost casting resins that yield virtually bubble-free castings. Smooth Cast® 320 Series resins pigment better and are lower in cost. Applications for Smooth Cast® 320 Series resins include reproducing small to medium size sculptures, making prototype models, special effect props, decorative jewelry, etc. Easy to mix and pour, these resins offer the convenience of a one to one mix ratio (one Part A to one Part B by volume). Fully cured castings are tough, durable, machinable and paintable. They resist moisture and mild solvents.

- Smooth-Cast® 320 - 10 minute demold time
- Smooth-Cast® 321 - 30 minute demold time
- Smooth-Cast® 322 - 2-4 hour demold time

Specifications

Product Name	Pot Life	Demould Time	Net Weight
Smooth Cast 320 (Gallon Unit)	7 minutes	30 minutes	6.99 Kg
Smooth Cast 320 (Trial Unit)	3 minutes	10 minutes	0.86 Kg
Smooth Cast 321 (Gallon Unit)	7 minutes	30 minutes	6.99 Kg
Smooth Cast 321 (Trial Unit)	3 minutes	10 minutes	0.86 Kg

Datasheet:

http://www.smooth-on.com/tb/files/Smooth-Cast_320,_321,_322.pdf

And…

Clear Flex Series

- Clear Flex 30 Data Sheet
- Clear Flex 50 & 95 Data Sheet
- Health & Safety

Clear Flex® urethane rubbers are water white clear urethane liquid rubber compounds designed for applications that require absolute clarity and resistance to sunlight. Low viscosity ensures easy mixing and pouring. Clear Flex® urethanes cure at room temperature with negligible shrinkage. Cured castings are clear, flexible and UV resistant. Vibrant colours and colour effects are achieved by adding pigments. Applications include making clear-cut moulds, model reproductions, decorative cast pieces, special effects, prototype parts.

CAUTION: NOT FOR HOME USE. THIS PRODUCT IS FOR INDUSTRIAL USE ONLY. Proper ventilation, a NIOSH-approved respirator and protective clothing are required to minimise the risk of inhalation and dermal sensitisation. If breathing is affected or a dermal rash develops, immediately cease using this product and seek medical attention. Read MSDS before using.

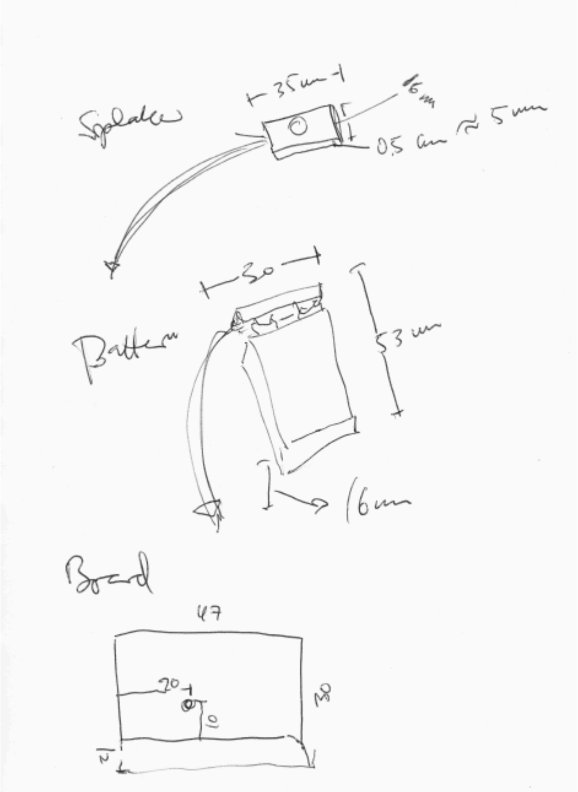
Specifications

Product Name	Pot Life	Demould Time	Net Weight
Clear Flex 30 (Gallon Unit)	15 minutes	16 hours	7.11 Kg
Clear Flex 30 (Trial Unit)	15 minutes	16 hours	0.88 Kg
Clear Flex 50 (Gallon Unit)	25 minutes	16 hours	10.8 Kg
Clear Flex 50 (Trial Unit)	25 minutes	16 hours	1.35 Kg
Clear Flex 95 (Gallon Unit)	25 minutes	16 hours	9.6 Kg
Clear Flex 95 (Trial Unit)	25 minutes	16 hours	1.13 Kg

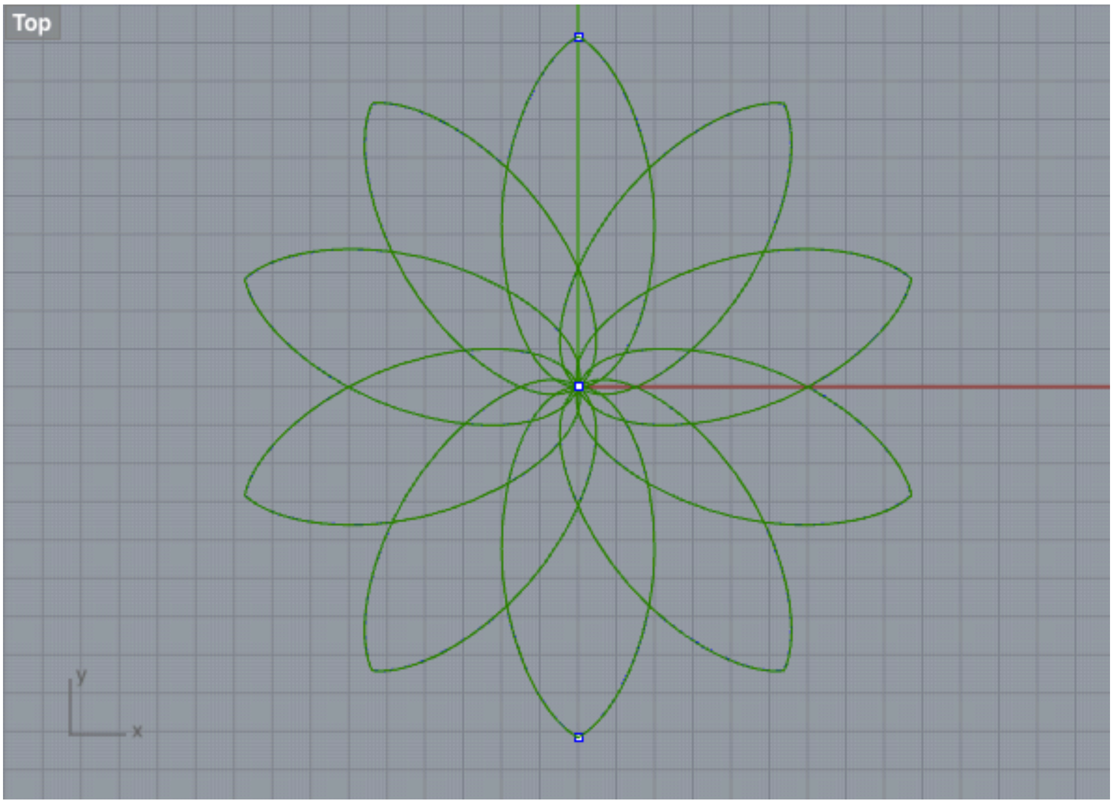
Clear Flex 50 Data Sheet: http://www.smooth-on.com/tb/files/CLEAR_FLEX_50_95_TB.pdf

The design for the case of the flower form to hold the electronics was carried out in Rhino.

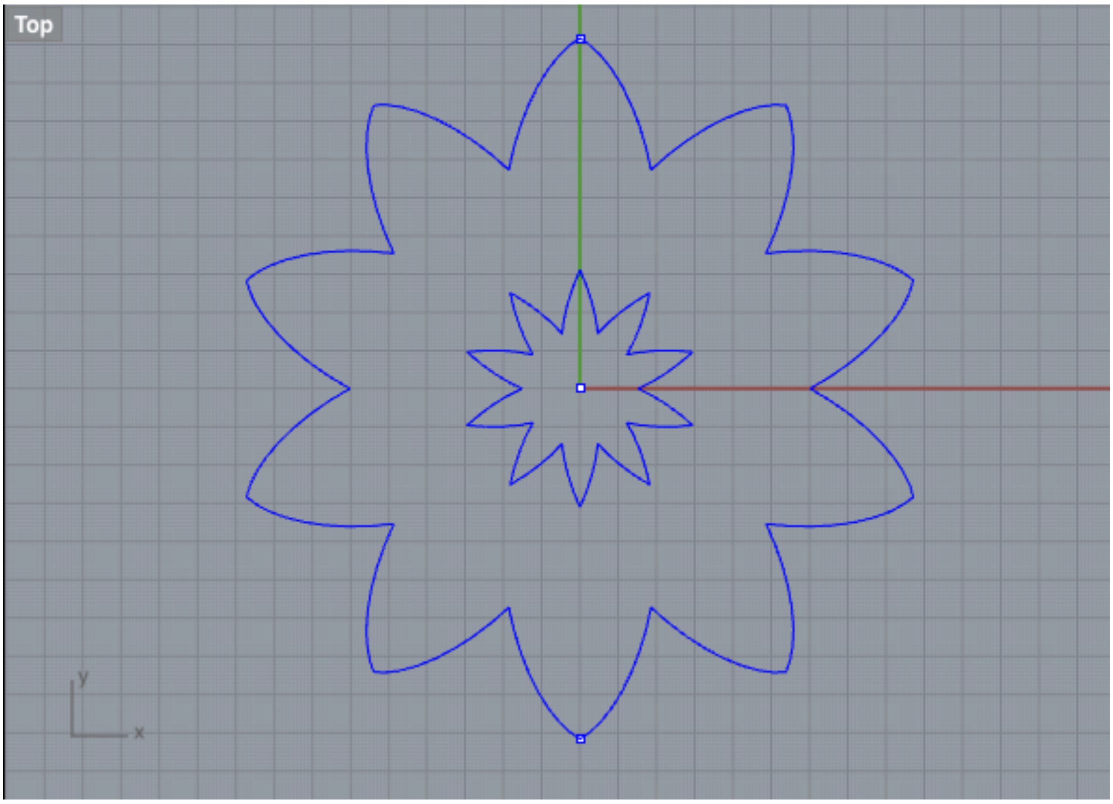
I began by measuring and sketching the electronic parts to get an idea of the needed size for the flower casing:



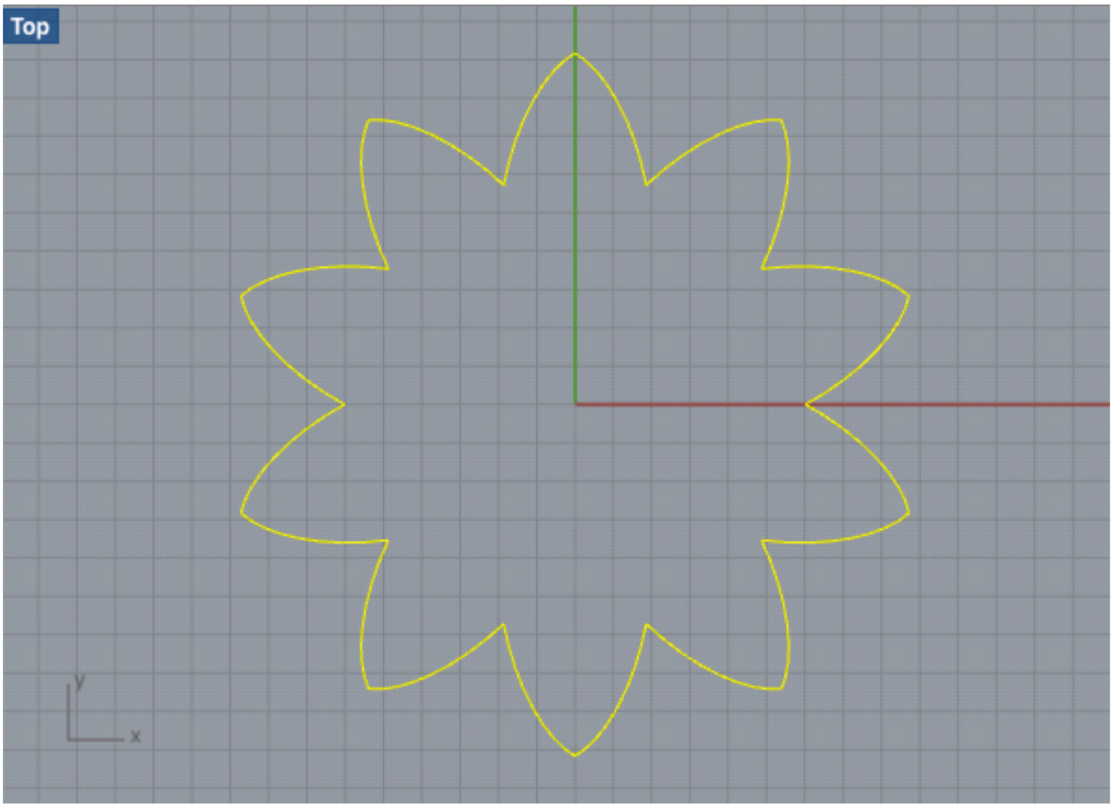
I created the flower pedal shape with an elipse and pulled one point out of it at the top end. Then I did a Transform – Array –Polar (by 8) to create the basic shape:



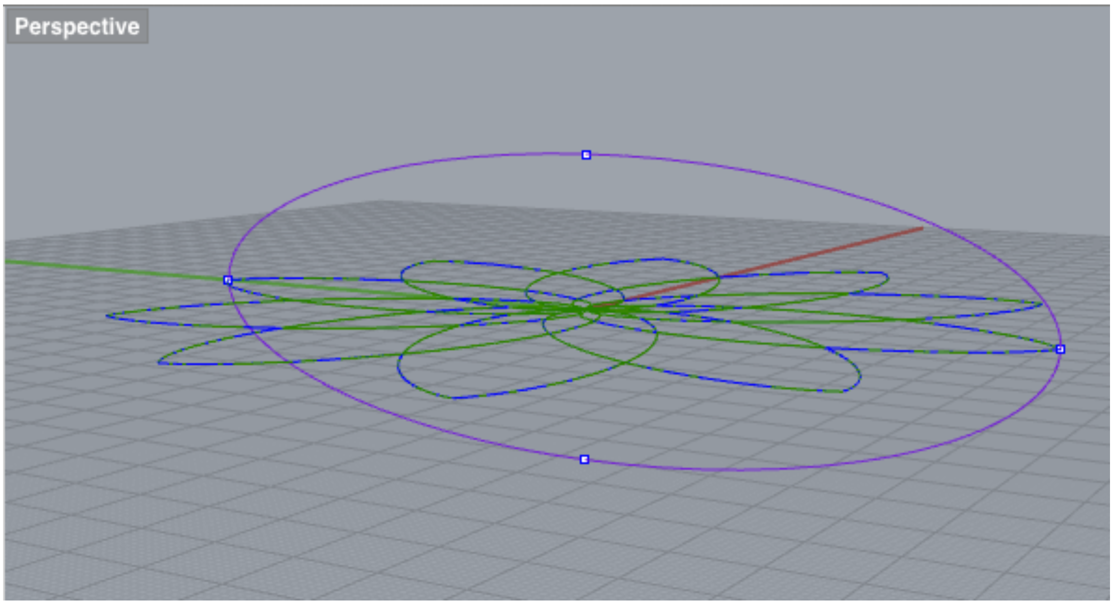
These lines were duplicated to create 2 sets for working separately on the the 2 halves of the flower form. On the top part a Curve Boolean operation was carried out to create a cut-out form in the centre of the shape to let the light in:



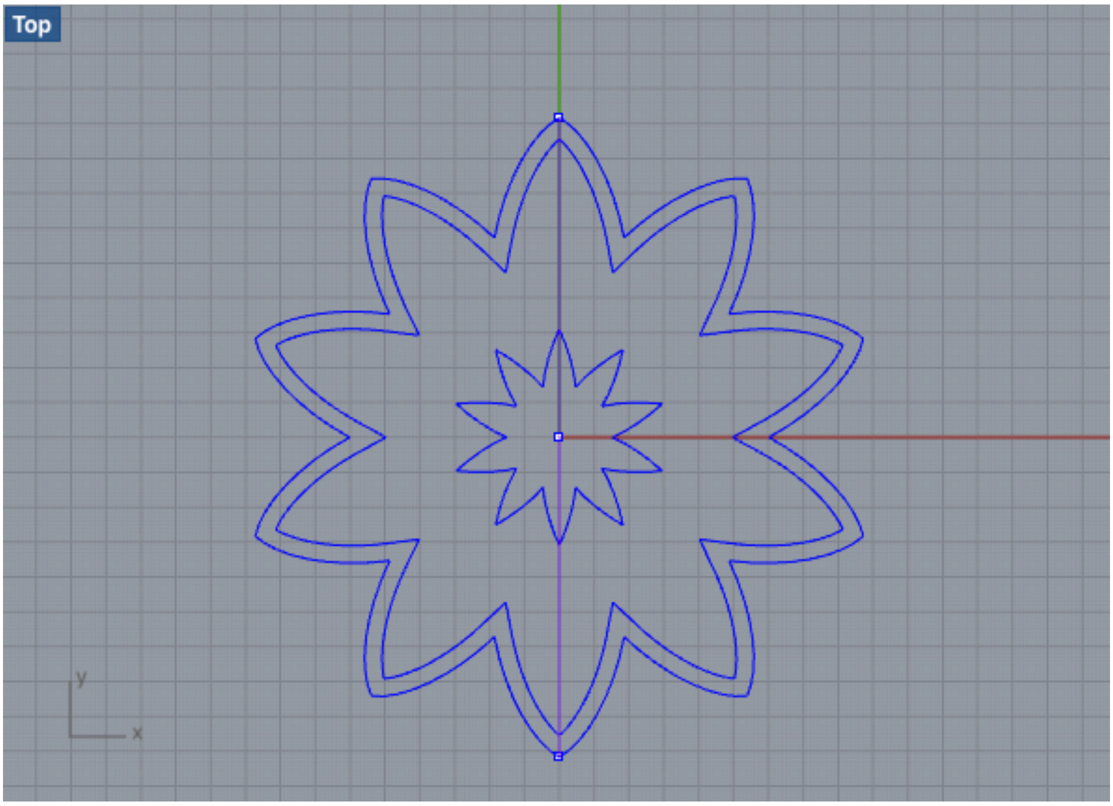
On the bottom shape all the internal lines were removed:

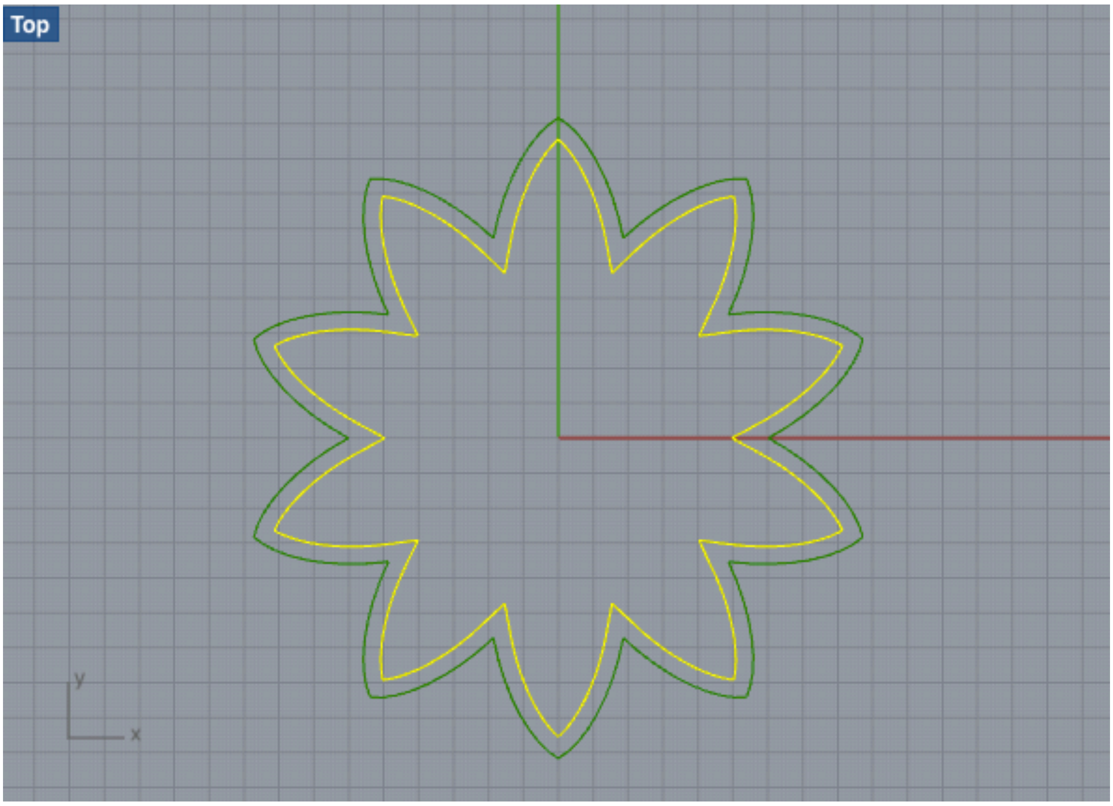


Then an elipse was drawn across end points of the flower shape and segmented by quadrants (splitted):

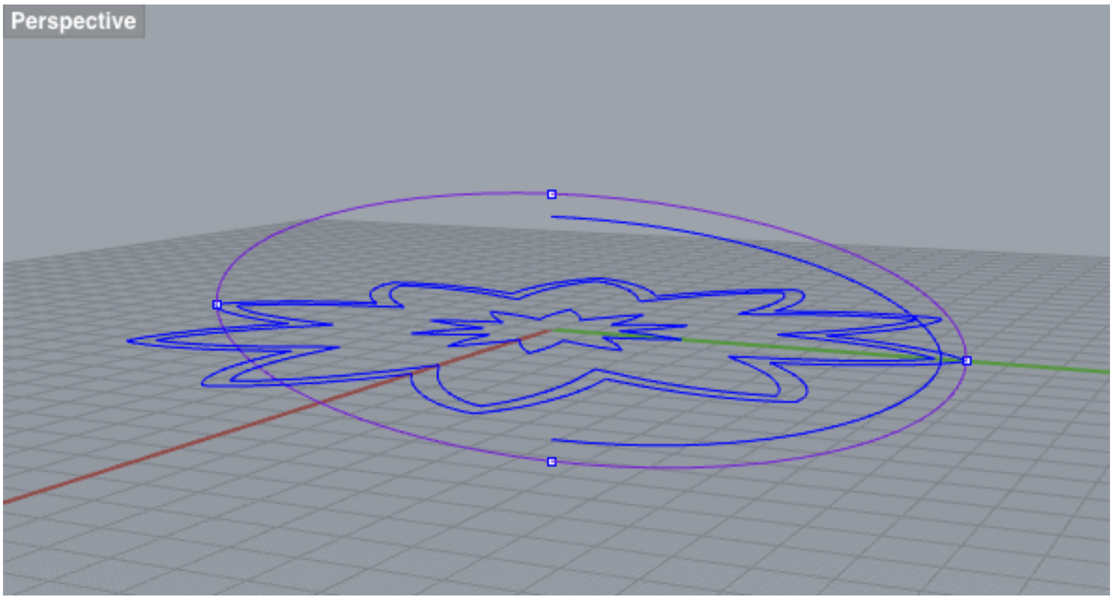


The outer lines of the flower shape were offset to create the wall thickness (5 and 3 mm) for the bottom and top parts:

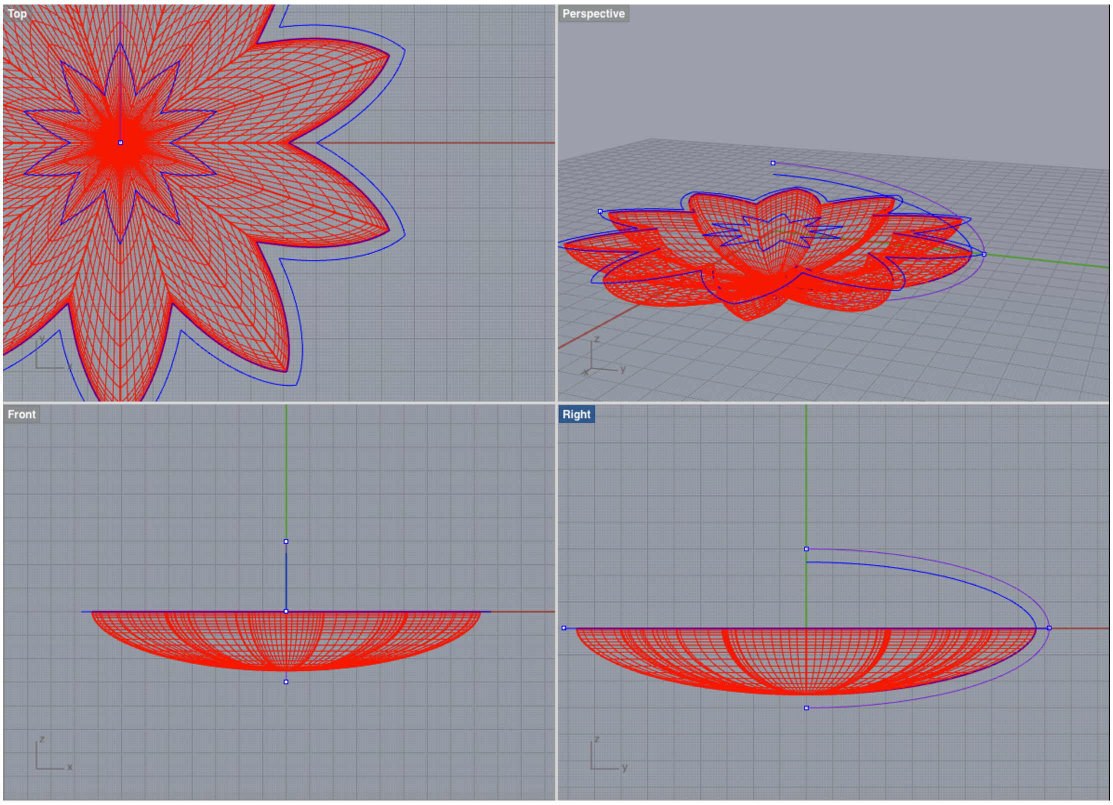




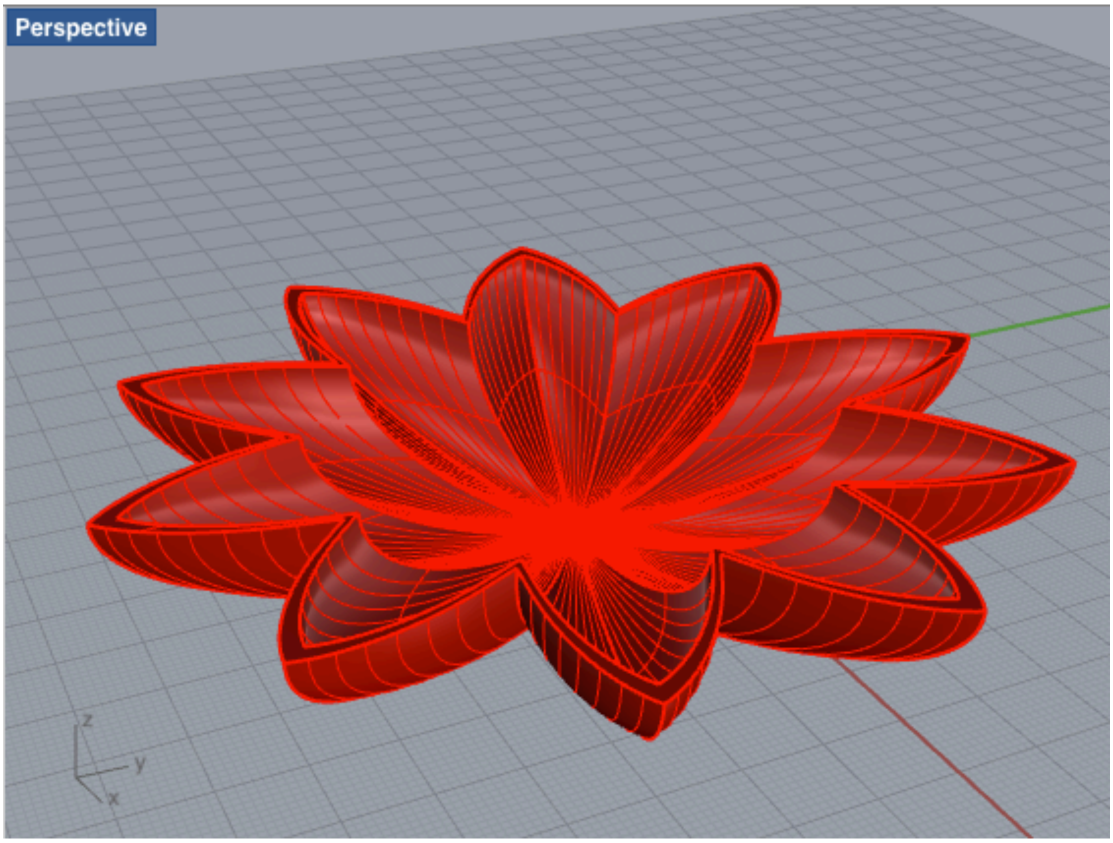
Next, the curves for creating a revolved shape (walls) were offset for thickness by 5 mm:



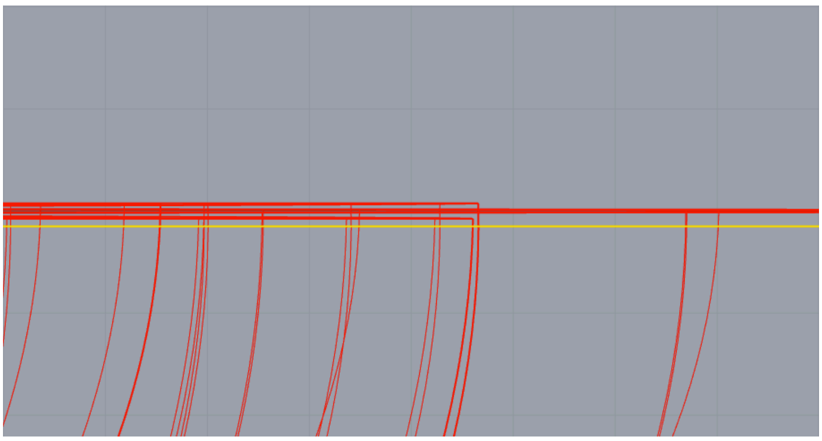
A revolved shape was made from these curves: Surface – Rail Revolve, Select Profile Curve, Rail Curve and RailRevolve axis. A problem arose with the revolve because the revolve axis was not matching the offset line. This was corrected by offsetting the inner flower shape line again to match. On second attempt the revolve did not succeed because of the condition that the "control points for path curve cannot be on revolve axis". I then mirrored the revolve curves on the axis and could create the surface for the bottom part of the form:



This was repeated for the outer wall and the two surfaces were meant to be lofted to create a solid shape. I noticed that the surface mesh created for the two parts was different in that the inner shape was more dense than the outer shape. Lofting did not happen, as "some but not all of the curve end points touch". This could have occurred because the revolve curve was offset from the original one. I therefore drew another elipse, segmented the curve to have a similar curve as the first one. This curve, and a previous one that was an orginal as well, was used to create 2 new surfaces with the Rail Revolve command and those appeared to have a similar amount of splines. These could be joined with Cap Planar Holes command to join the surfaces and create a solid.



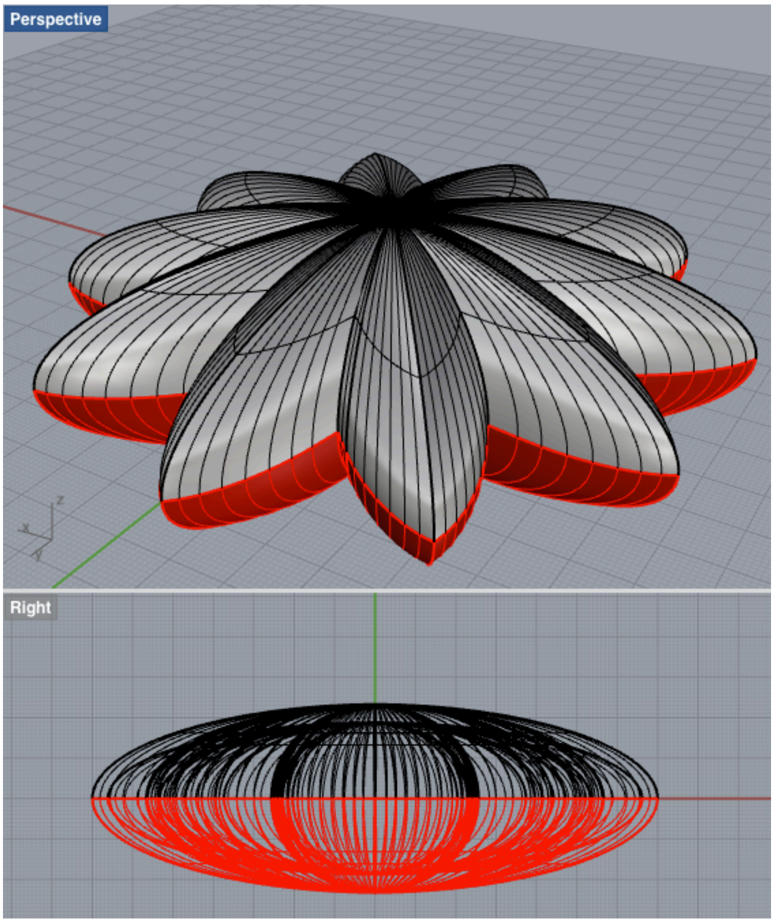
This had to be done in 2-3 steps as the top edges turned out to not align.



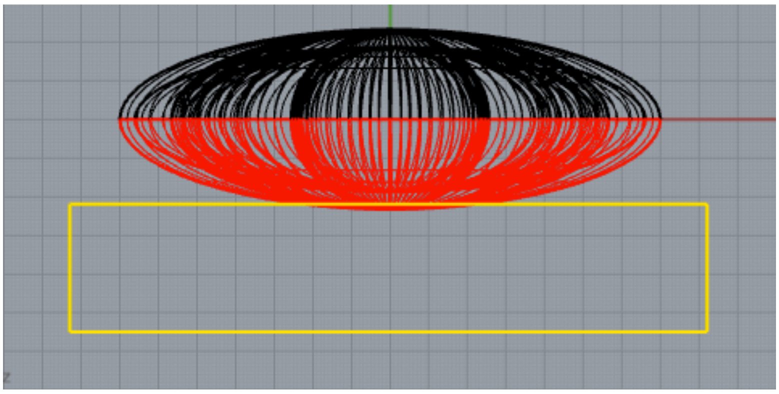
At this point a design decision was made to scale the whole model down to 140 mm width, in order to for it to fit for 3D printing and to be able to create a mould out of the millable wax we had in the lab.

A square box was made to correct this with a Boolean operation, and the botton part moved up to match the x axis.

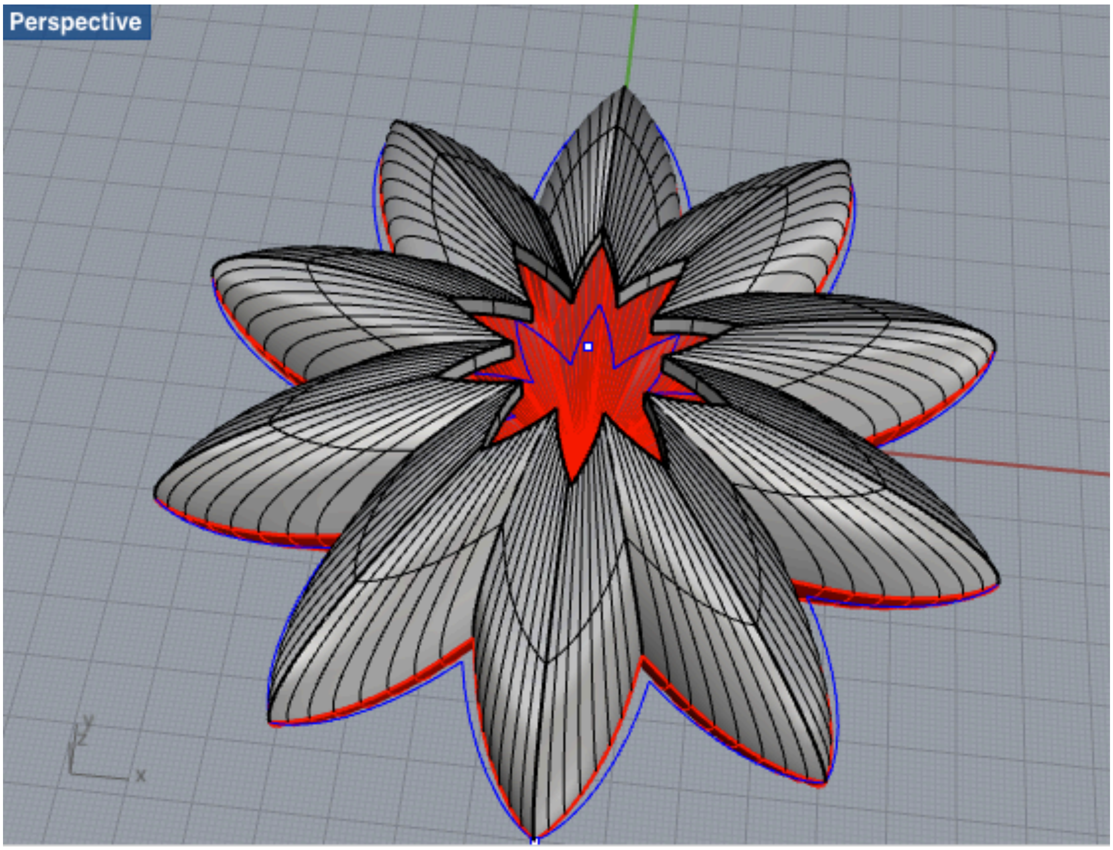
This solid was then mirrored to create to top shape…



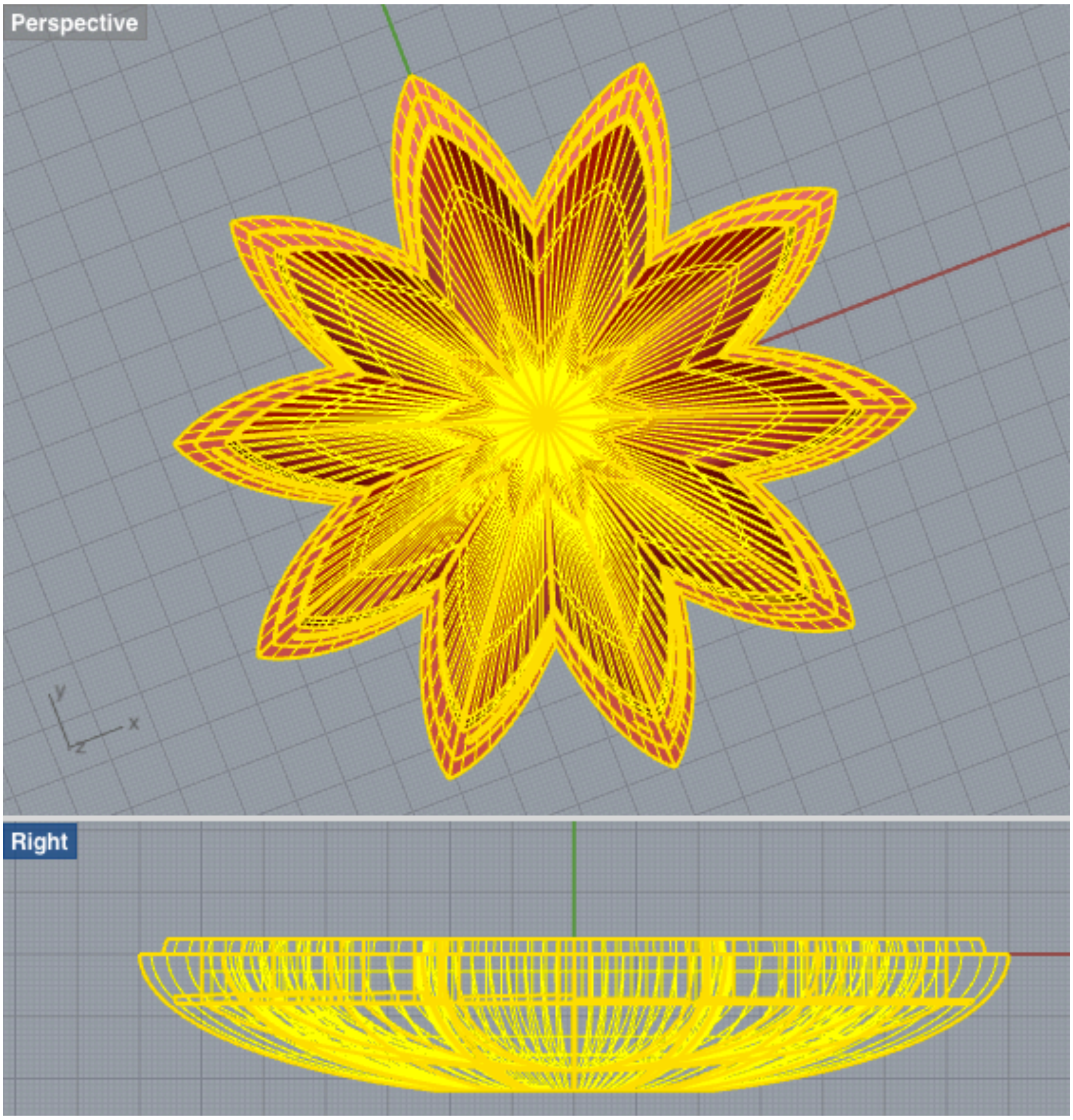
… and a flat surface was made by a Boolean operation, for the bottom part to make it stable.



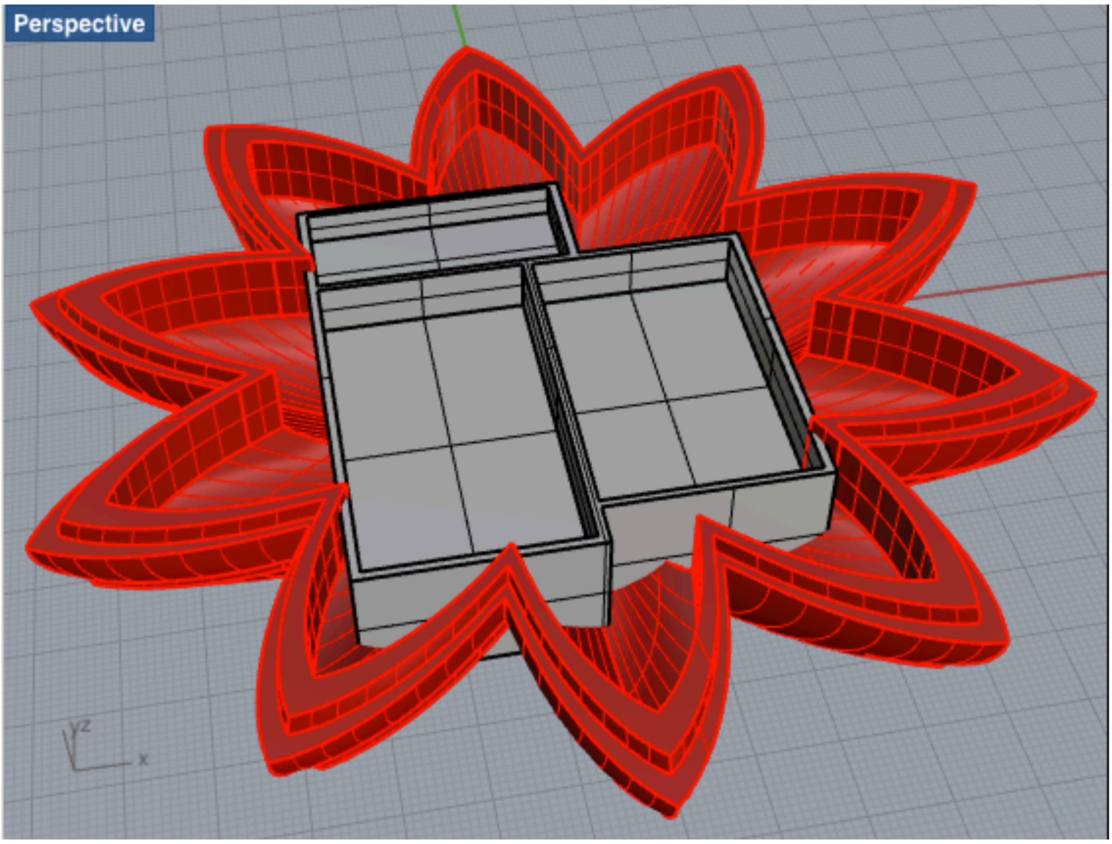
Then a cylinder was made from the small inner curve from the Boolean operation to cut the opening of the top shape:



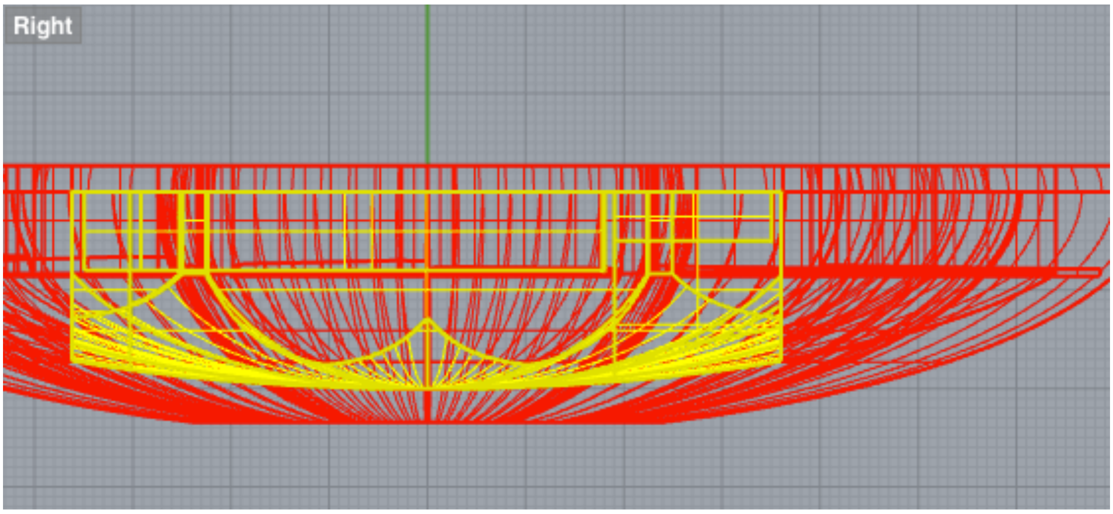
The bottom part now required an extra ridge to be added on the inside of the rim. This was created from curves of the edge.



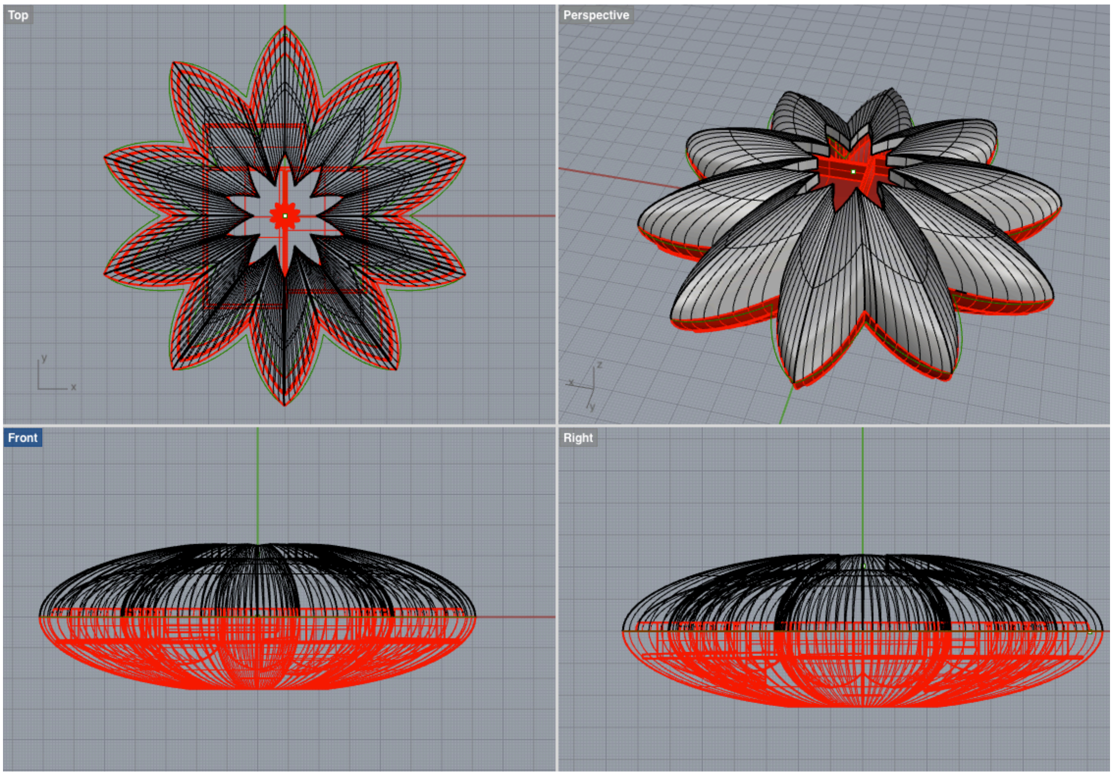
In the bottom part of the form a set of boxes was created to hold the board, speaker and a battery.



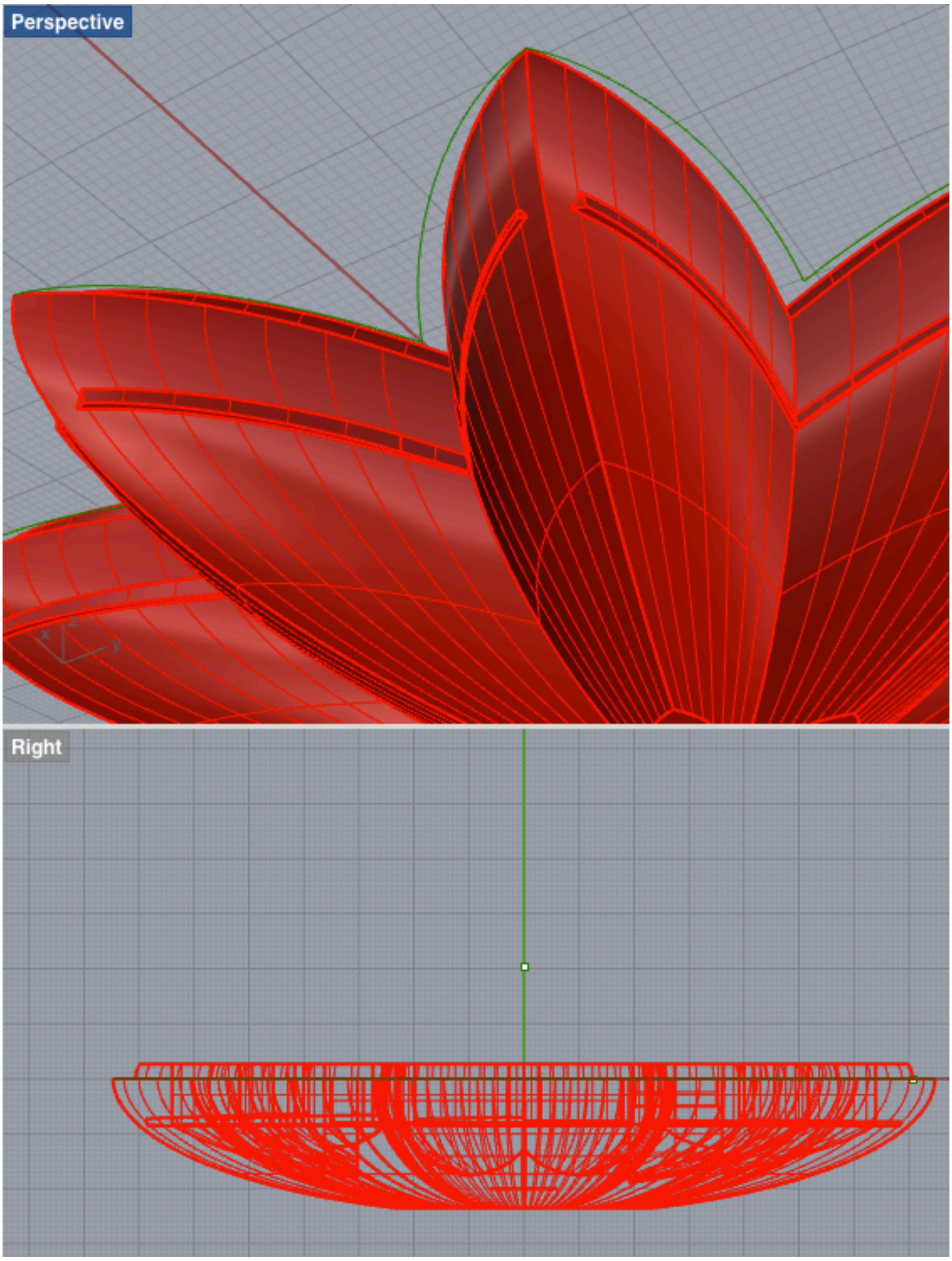
The boxes were then trimmed to fit snugly into the bottom shape.



On finish the model looked like this:



On a closer inspection of a model it turned out that I had made a mistake in a Boolean Union action, with the result that bits were sticking out of the bottom part of the model.



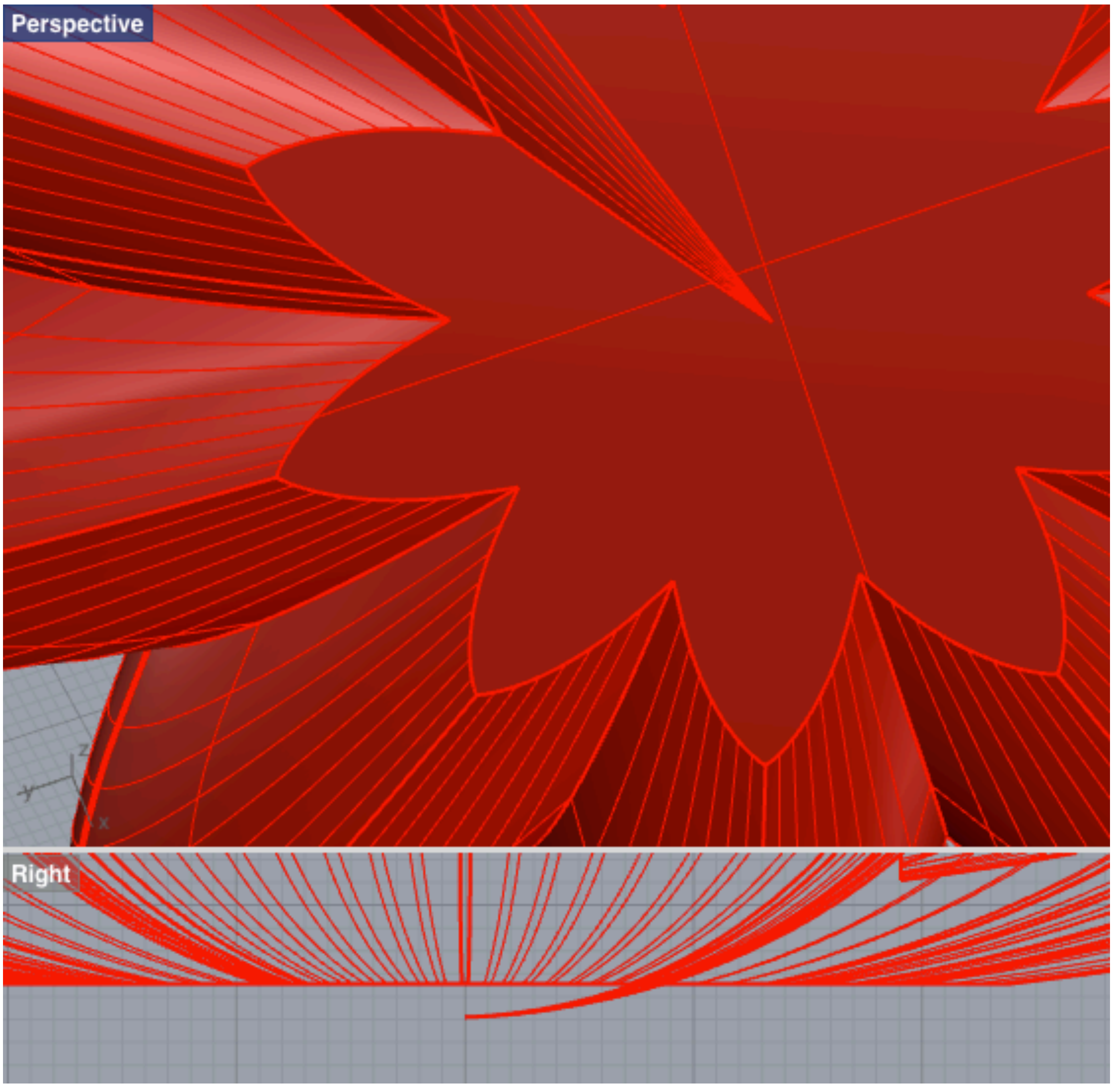
Various actions/commands were tried to remedy this, such as extruding surfaces, deleting the bits standing out and trying to patch the holes. What worked in the end was to delete the holes that were inside a plane, then using untrim surface and cutting the surfaces again to the right size.

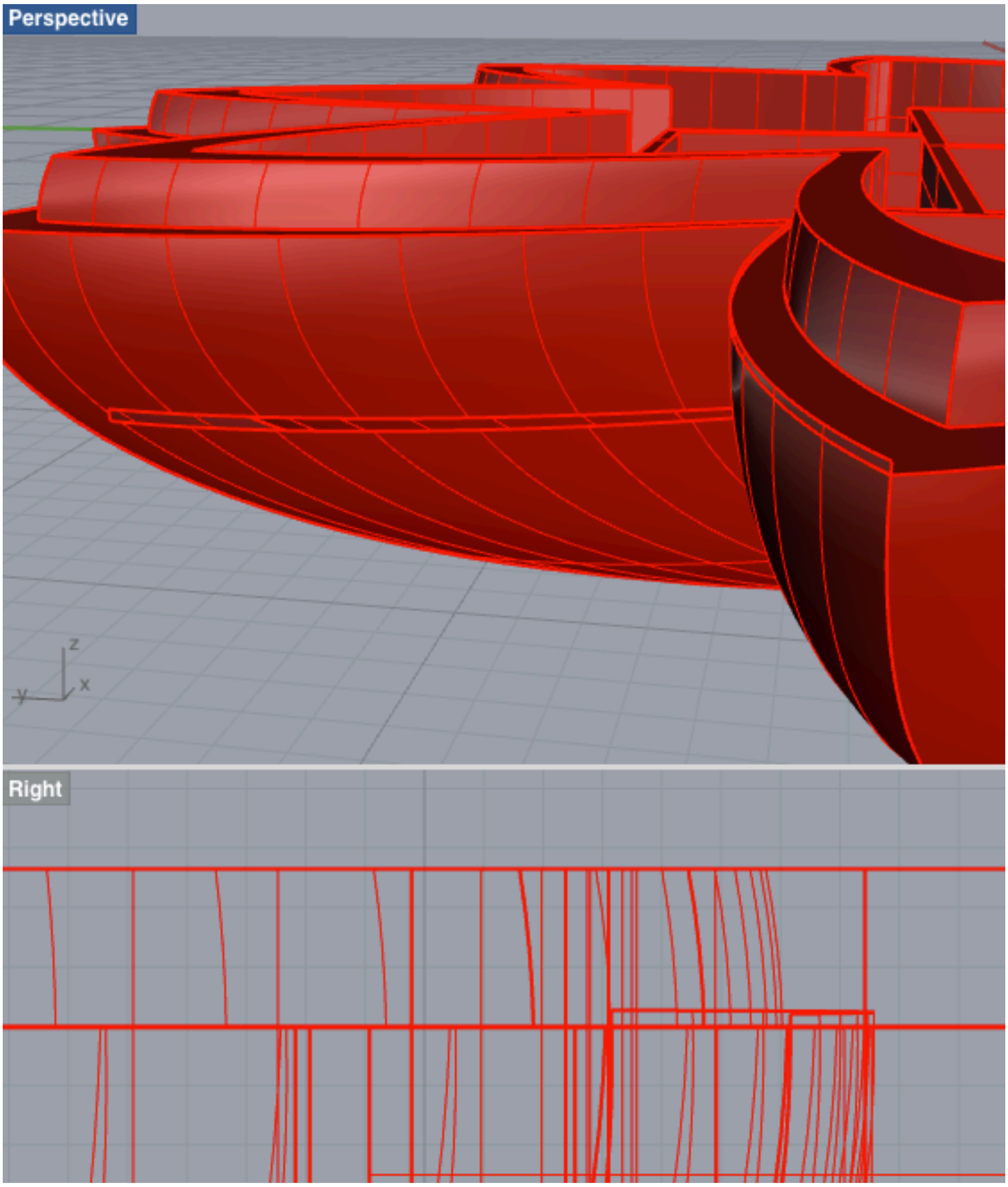
The workaround for this was:

Select all parts of the model – Join
Hide model – and delete all extra model

Show
Explode (exploded the model into 198 parts)
Select horizontally, from left to right, the faces that needed to be removed (this selects only the faces that are contained within that area)
Delete the faces
Select the whole part
Join - Then the 156 surfaces were joined into one open polysurface
Solid Edit Tools – Holes – Delete Holes and select the edge of the hole in question. This mends the face and makes a continuing surface of the face.
Explode the whole model again
Surface – Surface Edit Tools – Untrim Border

This created extra faces at the top and bottom of the model. Visual Notes of those:



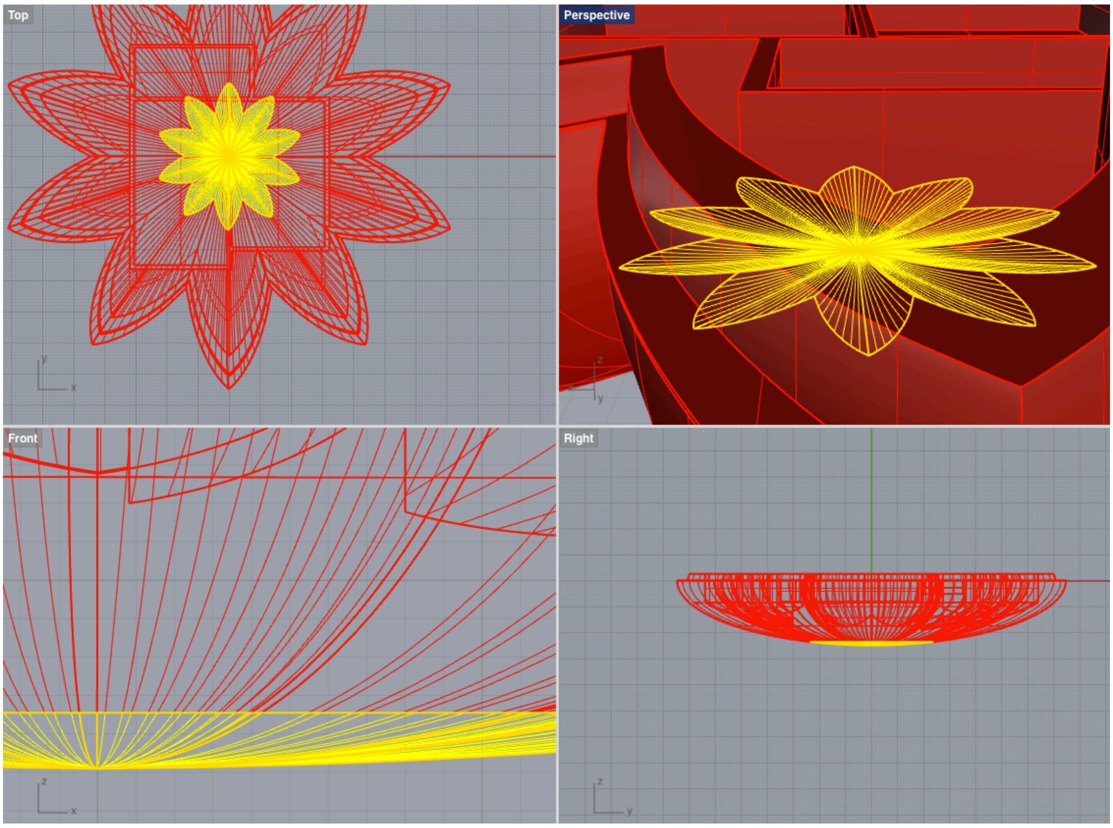


Use the selection tool to select all the surfaces and execute the Trim Border command in one go for all faces.

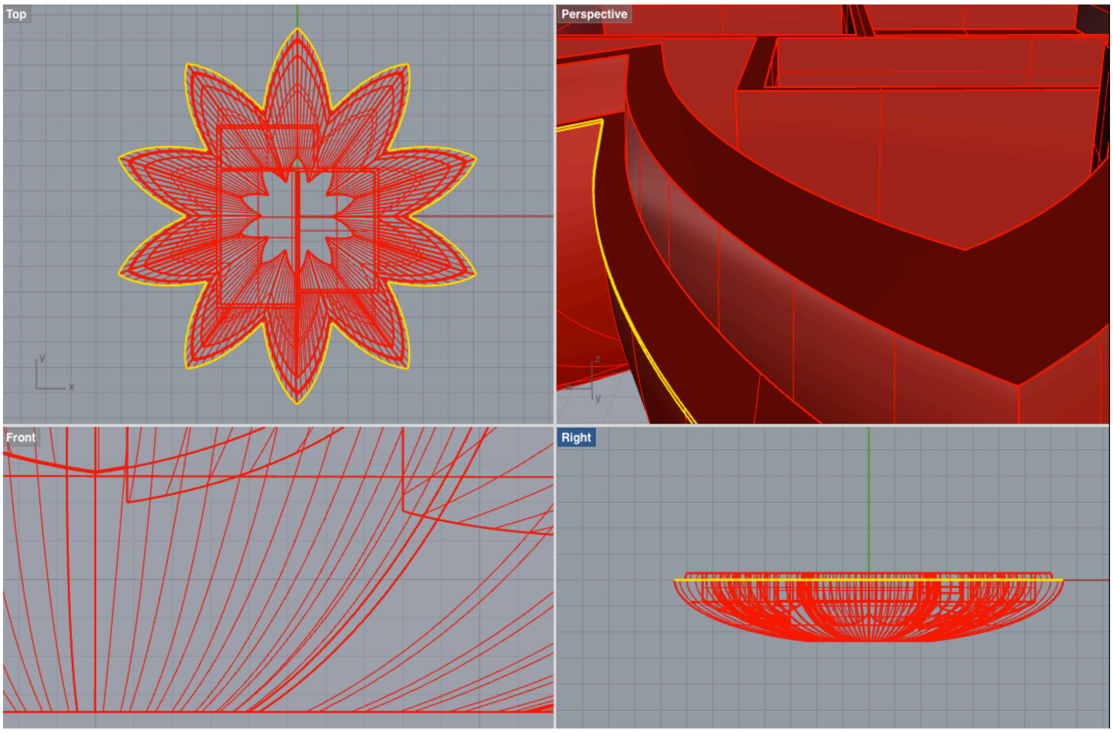
Now select all and Join 155 surfaces joined into 3 open polysurfaces – bottom, the boxes and the outside shell.

Edit Split (the outside shell) – select the cutting object (the red line at the bottom and the upper rim) – Enter. Then the bottom faces and uneccessary top faces can be selected separately and deleted.

Bottom:



Top faces, by rim:



Then select all – Ctrl A and Join. This joins the 3 surfaces into one open polysurface.

This completed the modeling of the flower and its two parts.

The bottom part is to be 3D-printed and the top part will be cast from casting resins and clear urethane liquid rubber compound, that will be pigmented with Ignite® Fluorescent Color Pigments.

Mould design

The moulds were made, first as square solid boleans from the original flower forms, top and bottom parts. Image.

Then I redesigned them in such a way that they became circular with many small opening for pouring the resin. I also added runners on the sides to facilitate the flow of the resin. Image.

3D Printing

I decided to print the bottom parts for the flower form, but also did one transparent print for the top part. The material is PLA (polylactic acid) which is a bio-degradable polymer that can be produced from lactic acid, which can be fermented from crops such as maize (https://en.wikipedia.org/wiki/Polylactic_acid).

The printing procedure was as follows:

The Rhino 3dm file is saved in the .stl format for 3D printing, file type binary. It is then opened in the MakerBot software, move to platform and rotate the object 180 degrees on the x-axis and 90 degrees on the z-axis. Settings – chose Standard for quality. OK. Make sure that the right printer is chosen, in this case Replicator2. Then file – export. A printfile is created, that can be previewed. Slider can be moved to see how the model builds up. Presets can at this stage be adjusted. I did make some changes as some of the areas did not seem to be supported properly (with clicking bridges). Did another print preview and this seemed to have fixed the problem. Make sure SD-card is moved from the printer to the external ScanDisk drive. Export Now. Chose the right removable disk, the file now prints to file. Remove the disk from the external drive and insert in slot on the printer. Replace the paper on the printing surface if needed. Lightly sand the surface of the paper. On the printer menu chose: Build from SD, by pressing M softly. Then chose the file (which would normally be on top of the file list). The printer moves the table up and starts by heating the plastic – up to 215 degrees. Then printing commances. Printing time: 6h and 19 minutes.

During printing some filaments printing the support became lose and the printing had to be stopped. The filament were glued in place with a gluegun and the printing resumed. The printing did not complete successfully as during printing the thread came lose and the model was divided into two, when handled. I fixed some minor issues in the design and had another attempt at printing. This went well and the piece printed was complete and solid.

The cutting of the mould on the Shopbot

Chosing a tool –
The tools in common use in top boxes, the special tools in the other boxes.
Lining the wax block with supporting bits of wood
Turning the machine on (with key and door closed), fan goes, then press the blue button. Move it away from the working are with the arrow buttons.
Create a base for the cutting material and secure it with screws into the sacrificial layer underneath. - image
Also lists around it – image

Load the stl file on the computer (wall) in PartWorks 3D.
Calculating toolpaths – first set the position, xy, and height, set edges to 0.1 – apply and next. Chose tools: a four flute 1/8 inch for the roughing and for the finishing.
Bull noses are better to refine the cut.
Two Collet Wrenches are used to change the tool and the collet has to be changed if the tool demands it. It needs to be freed from the chuch by pushing it slightly to one side.
If PartWorks 3D various setting are inserted or adjusted – images.
The roughing and the finishing paths are saved onto work-station, that controls the machine.
Then the tools is changed and secured in the right chuck and the z, x/y is set for the job.
The various settings in the Shopbot control interface are set – images.
Then the roughing toolpath is loaded and the spindle speed checked. Before starting the key to the machine is turned to engage the machine. Pressing the green start button starts the rotation of the acting part of the machine. It has to warm up until the box gets warm, this is to extend the life of the various machine parts. As I used the same tool for roughing and finishing, no tool exchange took place, the finishing toolpath was loaded and the mould finished. cu

Mould and preparation for casting

I cut acrylic sides to frame the wax model – as is had holes on all sides (material limitations), that needed to be closed – image.

I then calculated the volume in preparation for mixing the Oomoo*25.
In Rhino select Analyse – mass properties – volume.
Part1: Volume = 346331.63 (+/- 0.079) cubic millimeters
Part2: Volume = 467414.903 (+/- 0.017) cubic millimeters
In total: 813746 cubic millimeters. Converting this to liters makes 0.81

Oomoo25 mould was used to create the mould.

Programming

I adopted my code from the networking session code, by taking out the code relevant to the input board, because on the boards that I am using for the final project, the input (from the phototransistor) and the output (speakers) are on the same board. The resulting code was:

sketch_flower2sound | Arduino 1.6.1

sketch_flower2sound

```
int analogPin = 3;

int val = 0;           // variable to store the value read

int digitalPin = 1;     // potentiometer wiper (middle terminal) connected to analog pi

// lightval = 500

void setup() {
  // set the data rate for the SoftwareSerial port

  pinMode(1, OUTPUT);


}

void loop() {
  // put your main code here, to run repeatedly:
    val = analogRead(analogPin);    // read the input pin
    if (val<512){
      beep(1000,250);}
      else {
      beep(500,500);}

   delay(1000);

}


void beep(int frequency, int duration) {
   // Sound beep delay
  for (int i=0; i <= duration; i++){
  digitalWrite(1, HIGH);
  delayMicroseconds(frequency); // Approximately 10% duty cycle @ 1KHz
  digitalWrite(1, LOW);
  delayMicroseconds(frequency);
   }

   }
```

When having established that the code worked, that the phototransistor was reading light and an output (beep) was established from the speakers, I employed Arduino mapping (http://www.arduino.cc/en/Reference/Map) and entered the following line to the code:

val = map(val, 0, 1023, 0, 255);

This established a mapping function that enables sound of different frequency to be produced according to the variable input (light). The resulting code was:

sketch_flower2sound_mapping | Arduino 1.6.1

sketch_flower2sound_mapping

```
int analogPin = 3;

int val = 0;           // variable to store the value read

int digitalPin = 1;     // potentiometer wiper (middle terminal) connected to analog pin 3

// lightval = 500

void setup() {
  // set the data rate for the SoftwareSerial port

  pinMode(1, OUTPUT);


}

void loop() {
  // put your main code here, to run repeatedly:
    val = analogRead(analogPin);     // read the input pin
    val = map(val, 0, 1023, 500, 2000);

      beep(val,500);

   delay(1000);

}


void beep(int frequency, int duration) {
   // Sound beep delay
  for (int i=0; i <= duration; i++){
  digitalWrite(1, HIGH);
  delayMicroseconds(frequency); // Approximately 10% duty cycle @ 1KHz
  digitalWrite(1, LOW);
  delayMicroseconds(frequency);
   }

   }
```

The sound varied in frequency when the flower2sound was exposed to infra-red LED light.

Mesh Mixer..... check