SAPIENZA
UNIVERSITÀ DI ROMA

COURSE TITLE: **ADDITIVE MANUFACTURING AND PRODUCTION SYSTEMS**

GUIDED BY – Prof. ALBERTO BOSCHETTO

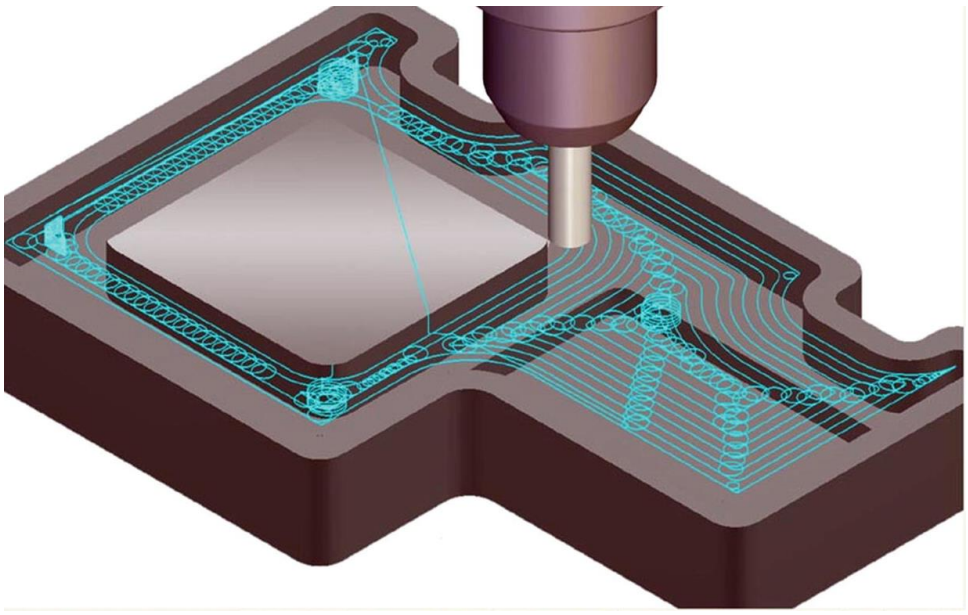
EXERCISE-2

COMPUTER AIDED MANUFACTURING

GROUP NAME: VALLURI

GROUP NUMBER: 10

VARUN YASHWANT RASALKAR **1921452**



COMPUTER AIDED MANUFACTURING

Part A

Exercise 2: Computer Aided Manufacturing

Part A

The components shown in Figg. 1 and 2 must be fabricated via 3 axix milling.
Select an adequate maching center, tools, raw material and fixturing system.
Use the CAM environment you can download at the link: https://mecsoft.com/demo-visualcadcam/
Other CAM software are admitted.
Remember that the suggested CAM is in demo mode an then you cannot save your work.
The files are given in STEP and STL formats. The object scales, the surface and tolerance requirements are reported in the appendix A.

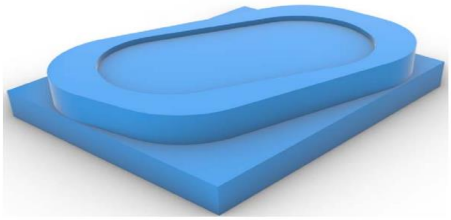


Figure 1

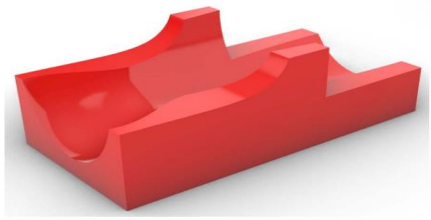


Figure 2

Report rules

- Motivate each choice and avoid theoretical digressions.
- Describe the macro-cycles (fixturing, zeroes, machining operations) and the micro-cycles.
- Develop the toolpath in VisualCADCAM and put in the report some representative screenshots (stock and zero, toolpaths in roughing and finishing operations, simulations).
- Report the production time and add indication of process design time and machine setup time.

Machine setup:

As per instructions we are using 3 axis milling machine which includes horizontal roughing and parallel finishing procedure in the suggested interface Mecsoft VisualCAM 2022. Both machining solid parts are ABS.

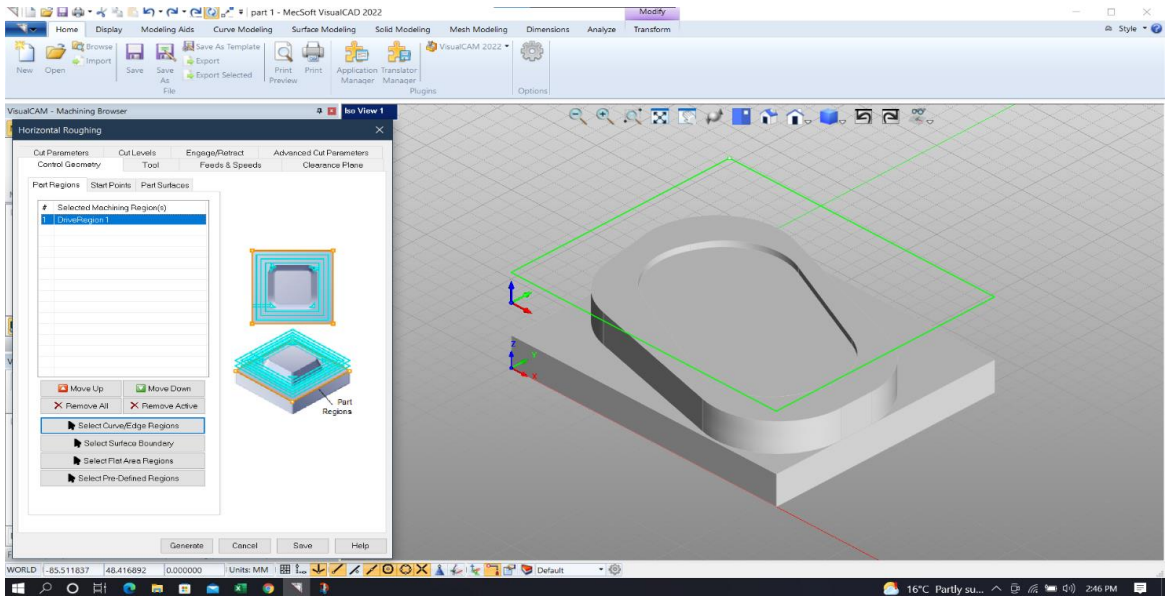


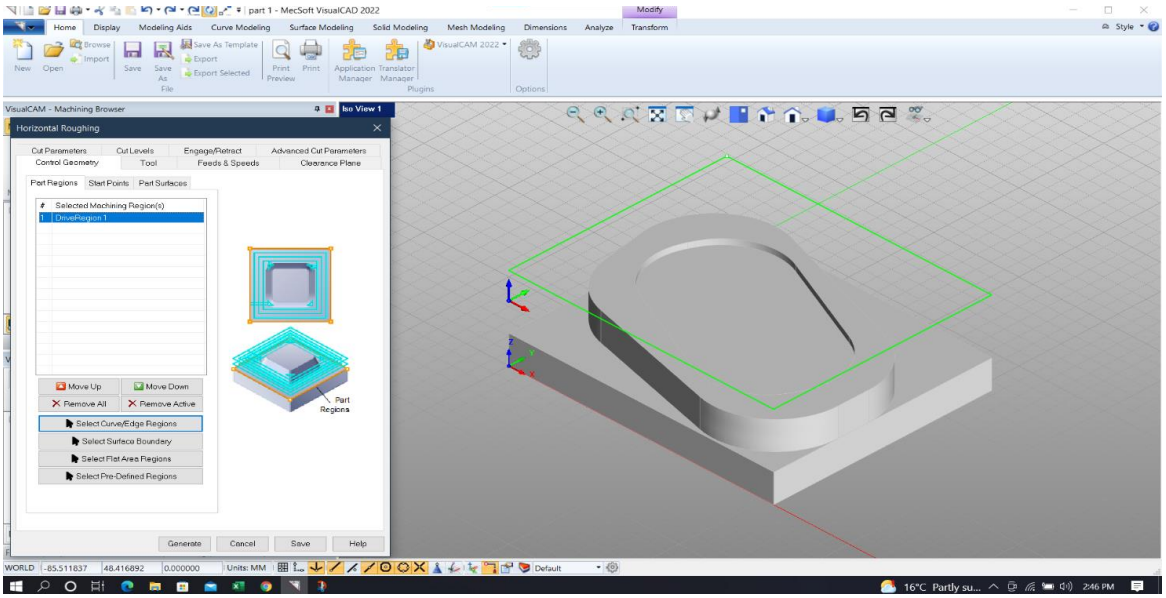
Figure:**1**

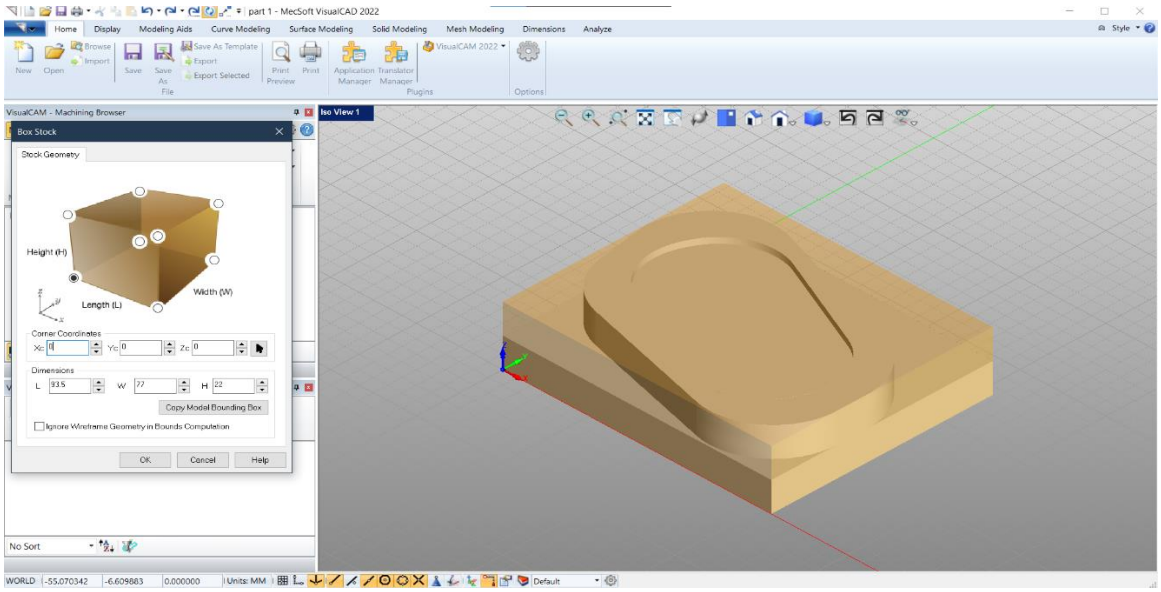
Scale:

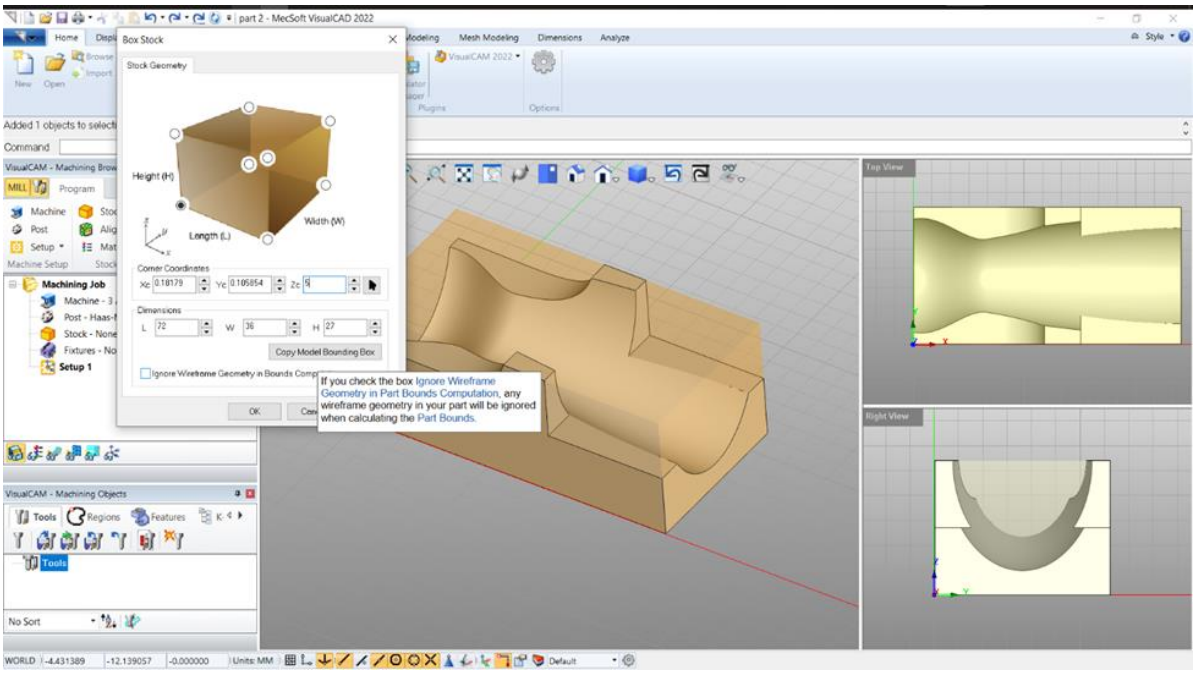
We uniformly Scaled the given parts as given in chart for part 1 and part 2 are 110% (1.1) and 90% (0.9) respectively.

Stock setup:

We are Setting up box stock

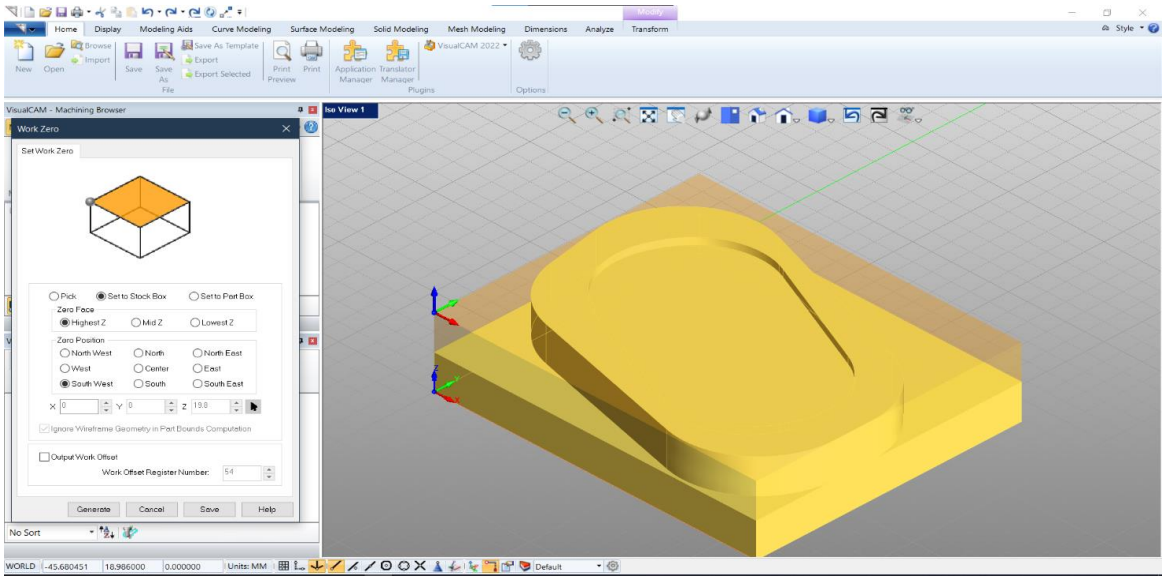


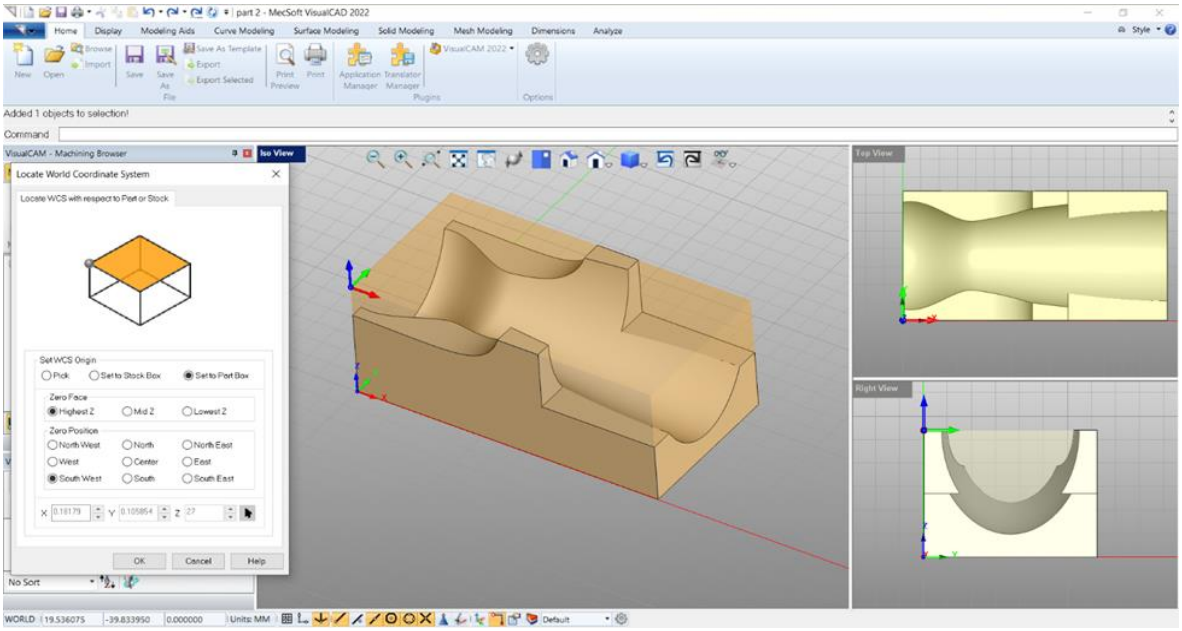




Work Zero:

Setting work zero as given in below

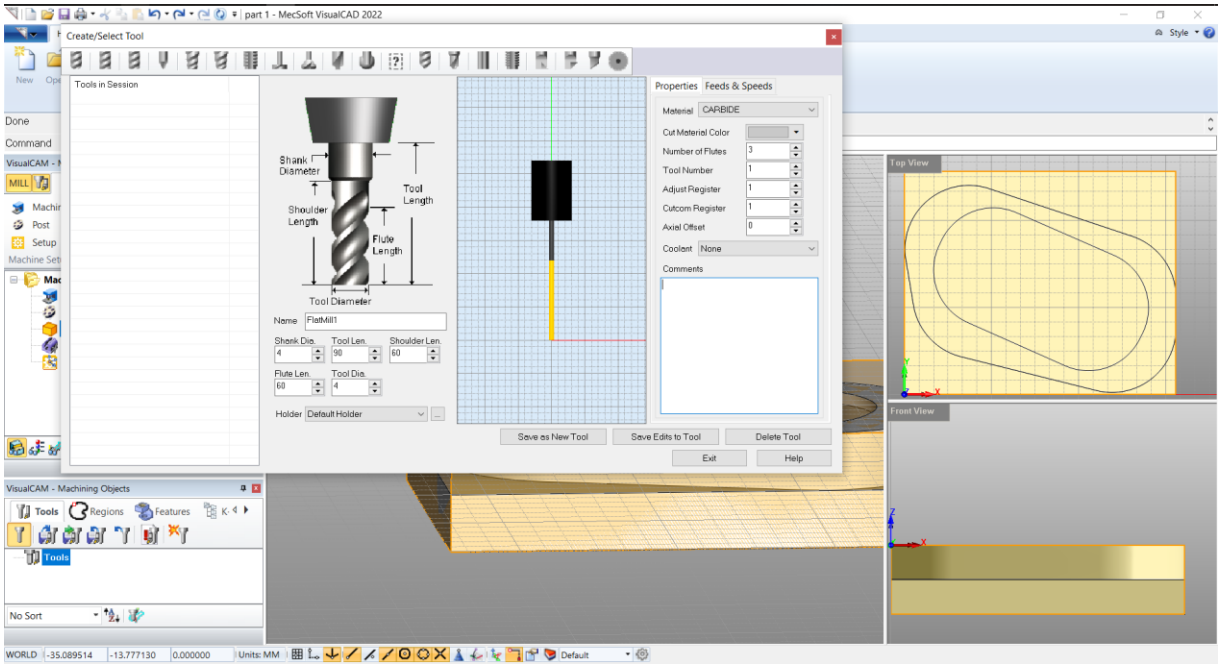




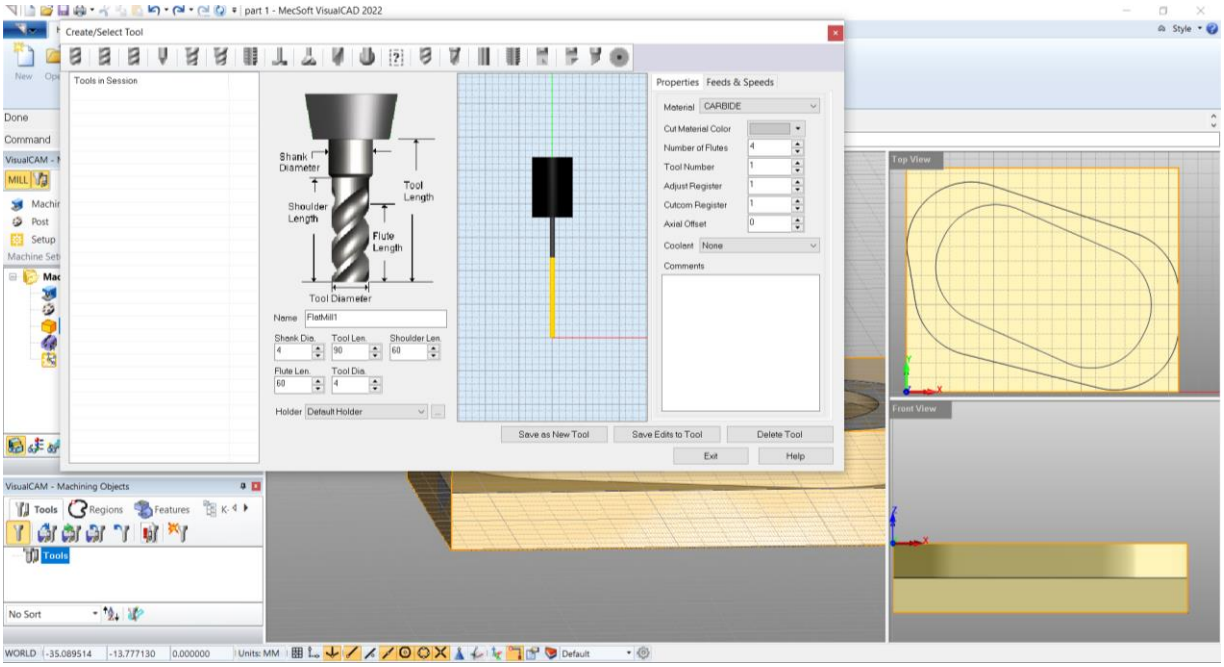
After work zero selecting perfect tool for roughing and finishing operations for both part 1&2

Tool selection:

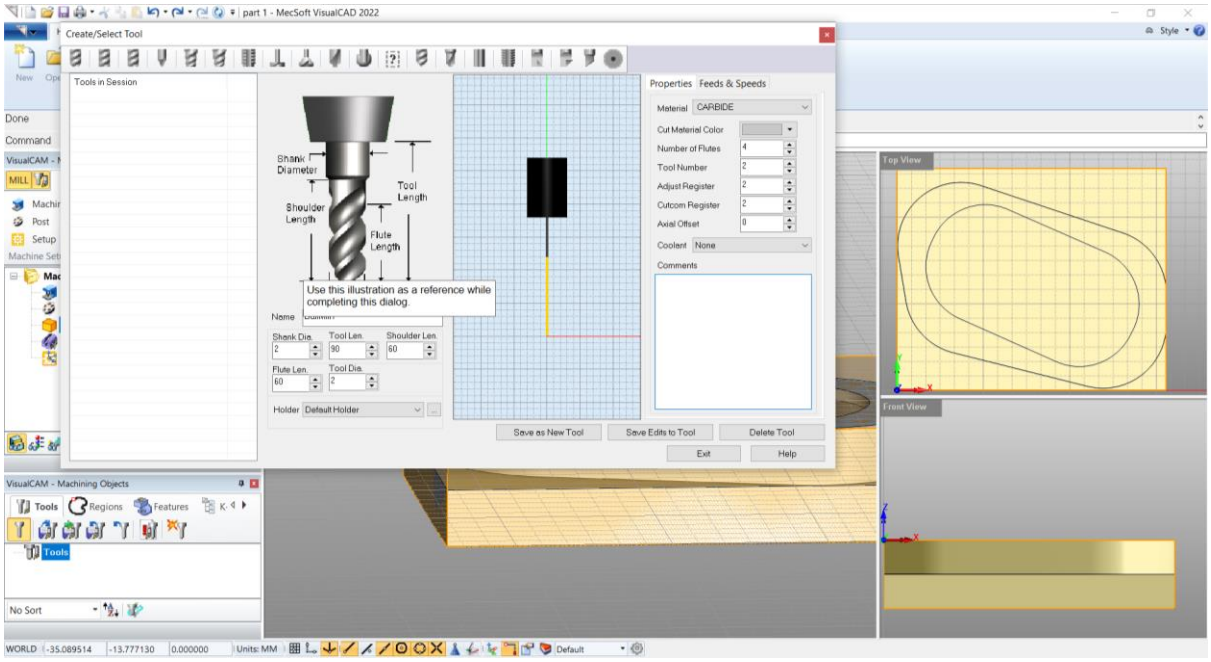
Carbide Tool 1 flat mill with 4mm diameter and 3 flutes



Carbide Tool 2 flat mill with 4mm diameter and 4 flutes

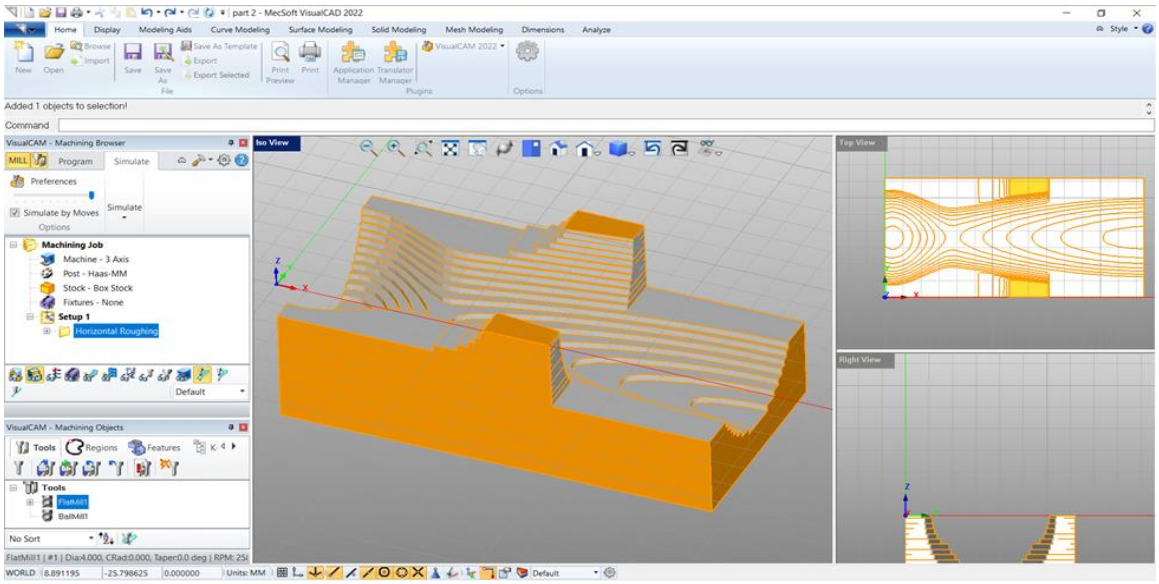


Carbide Tool 3 ball mill with 2mm diameter and 4 flutes



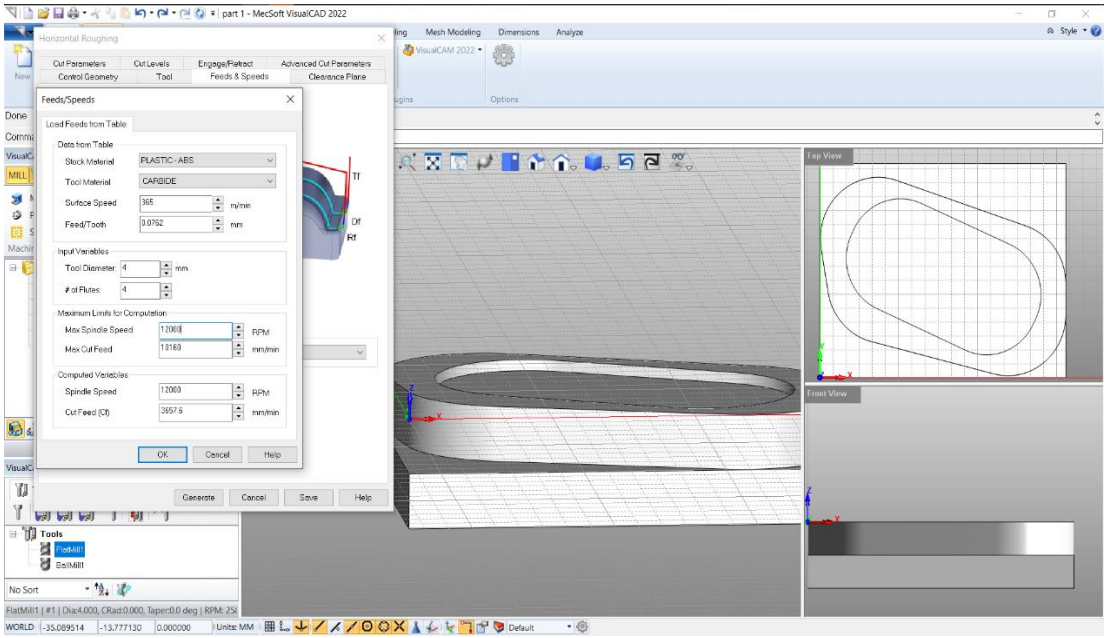
Horizontal roughing:

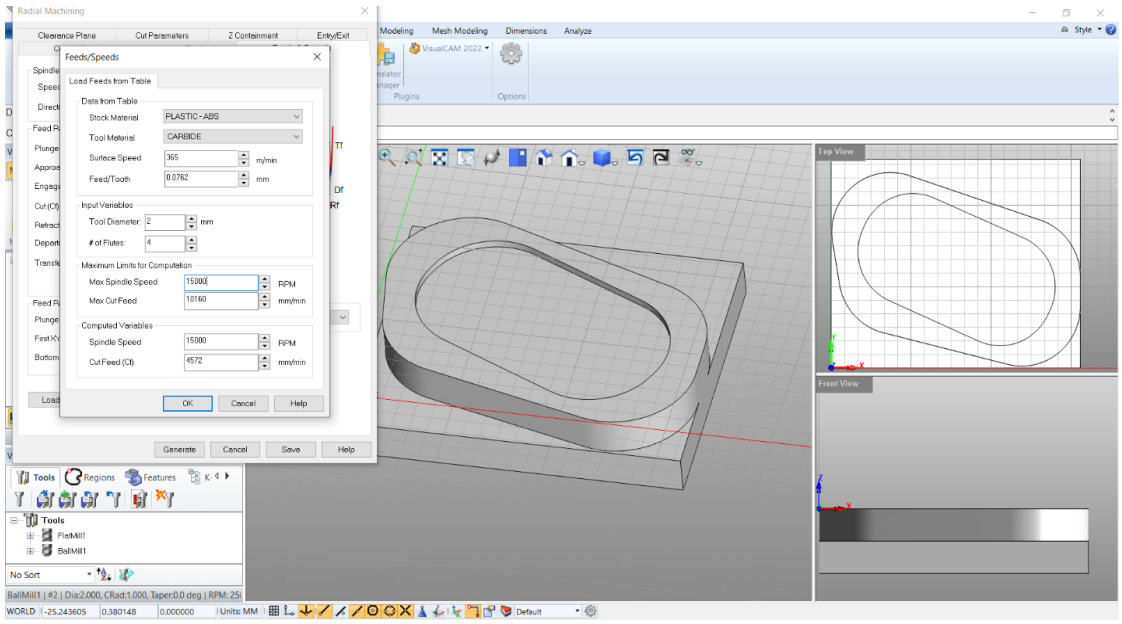
In horizontal roughing first we select the drive region to make sure that our tool doesn't move out of the stock this is done basically to make sure the tool doesn't hit the fixture, even though in the operation we aren't using any fixtures but me make sure the drive region is limited to stock. As shown in figure 1.

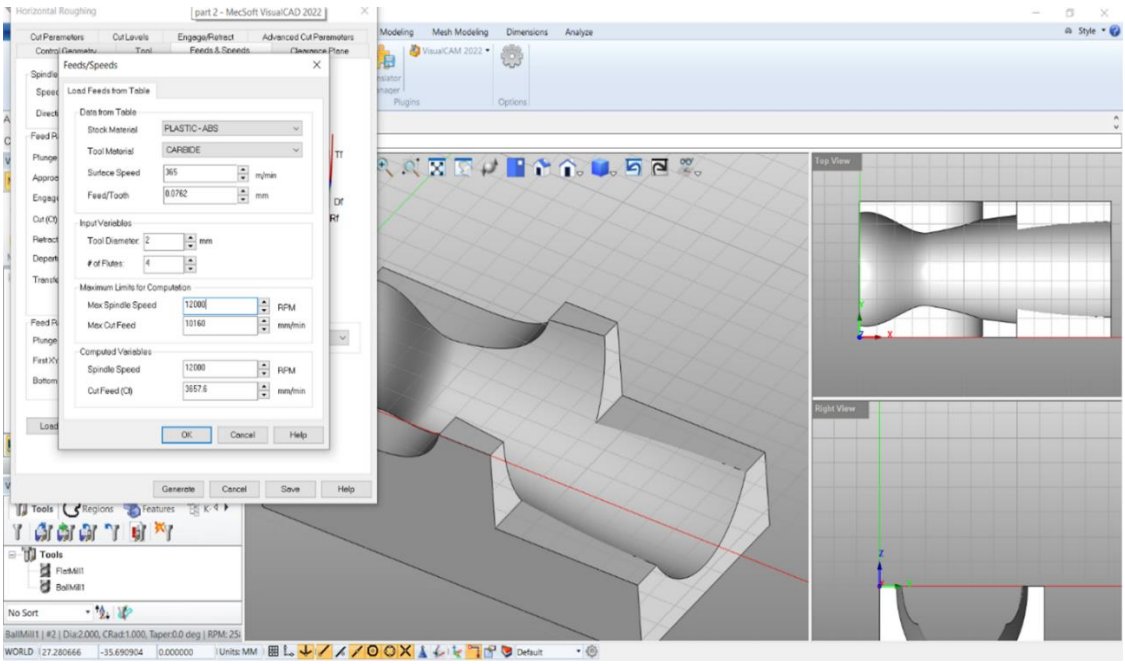


Feed and speed:

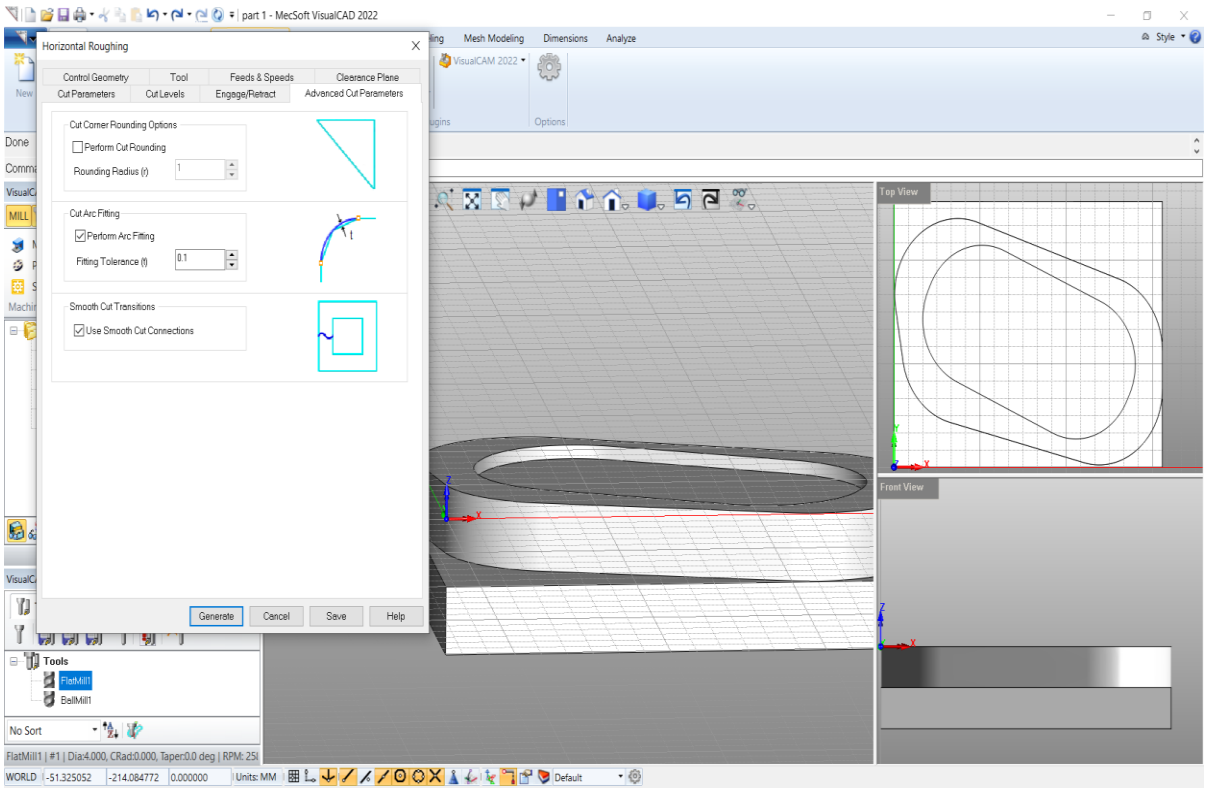
After the tool selection we tried with default values due to unsatisfactory outcome we customized the values to get optimal outcome.

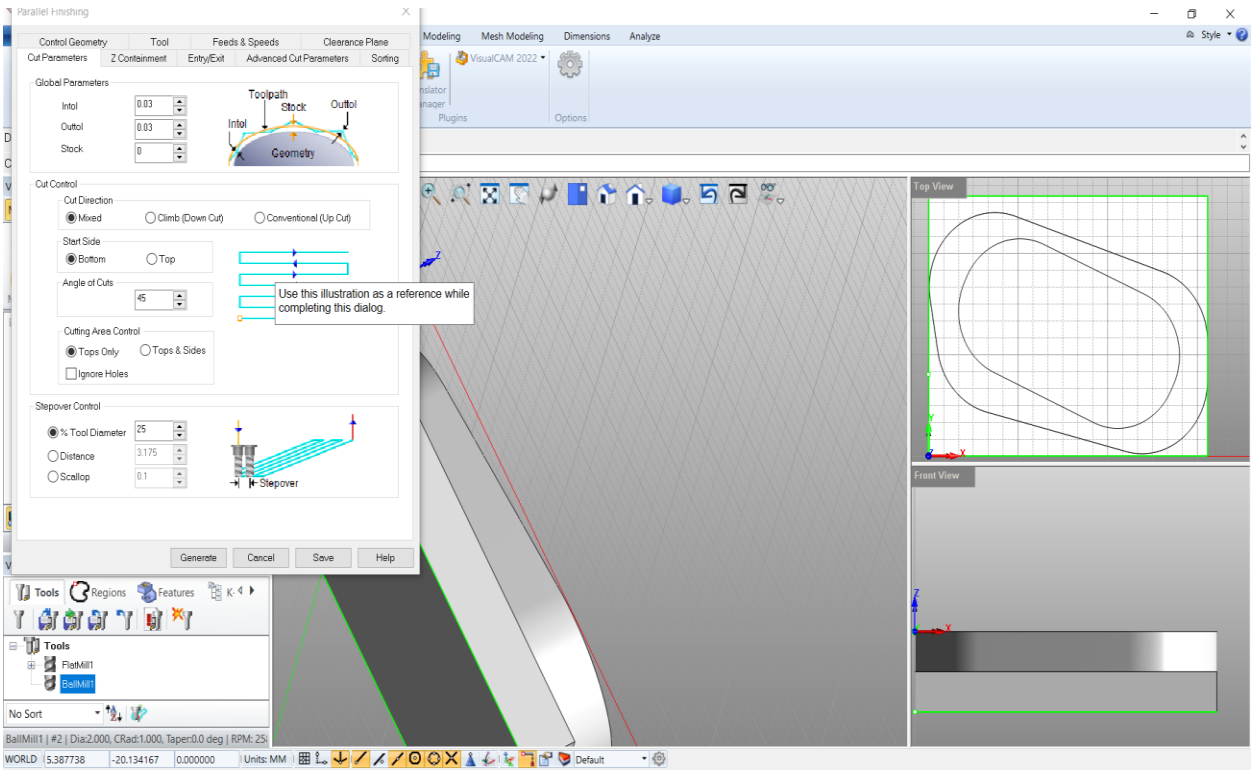


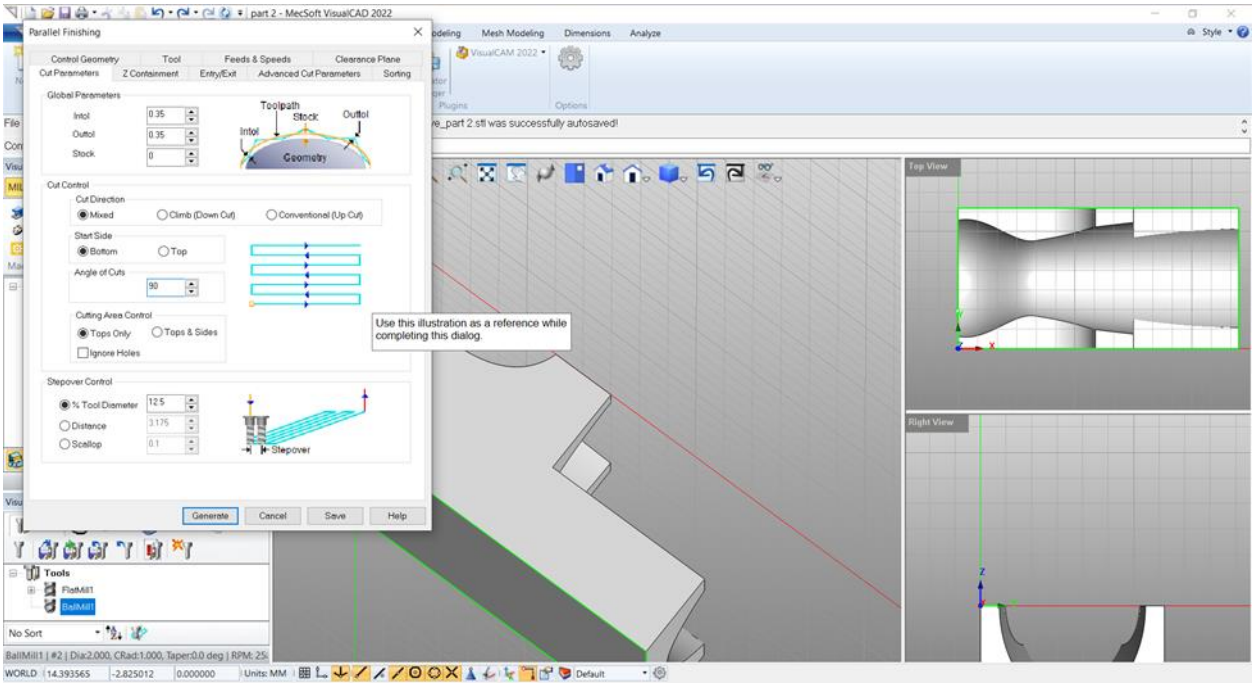


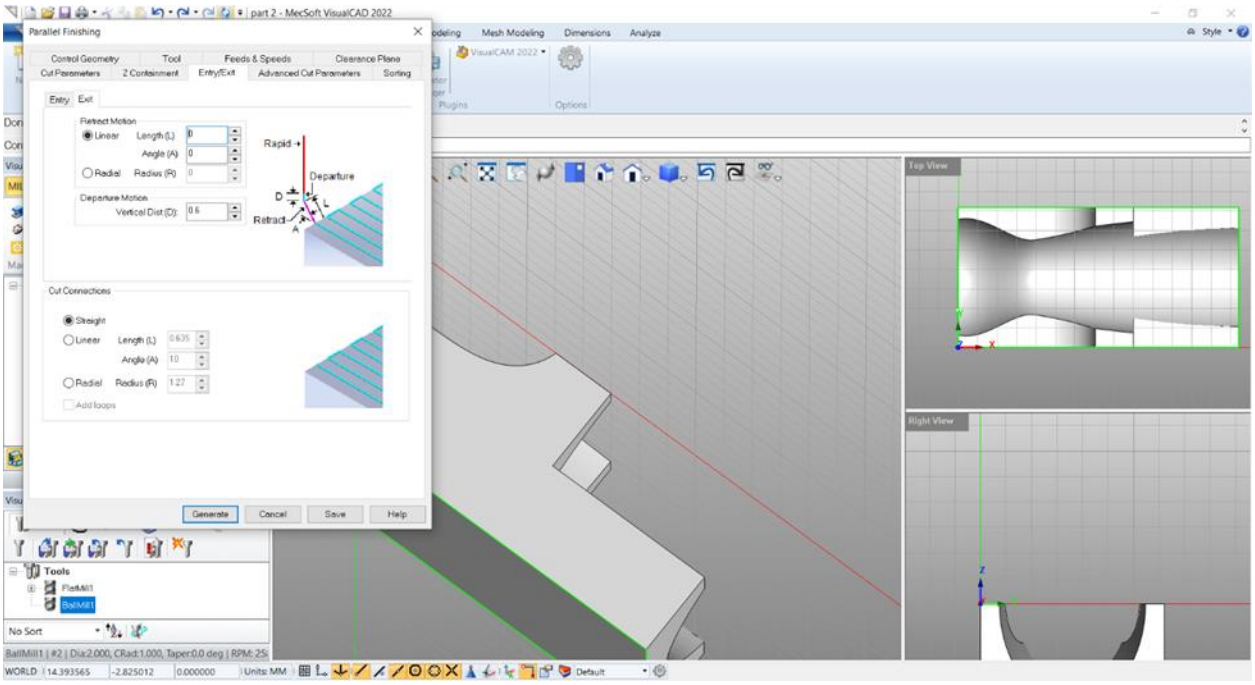


Cut levels and advanced parameters for roughness and tolerances of ABS material for better surface finishing.

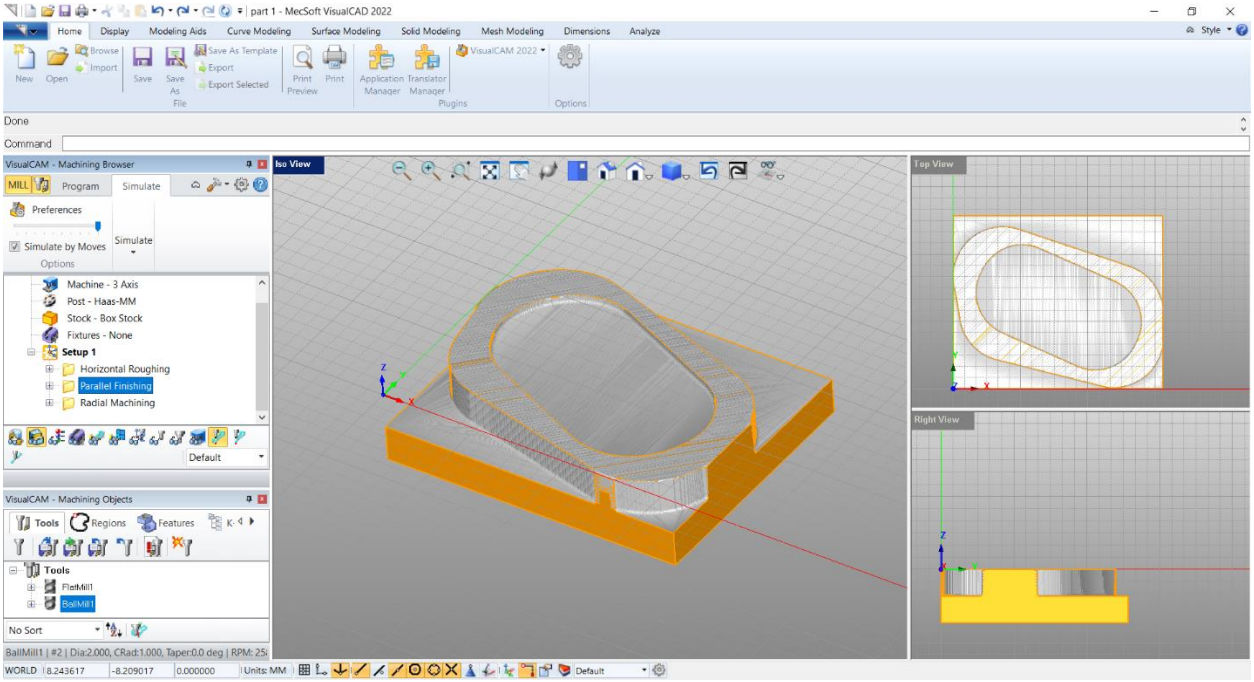

part 1 - MecSoft VisualCAD 2022
Horizontal Roughing
Control Geometry
Tool
Feeds & Speeds
Clearance Plane
Cut Parameters
Cut Levels
Engage/Retract
Advanced Cut Parameters
Cut Corner Rounding Options
Perform Cut Rounding
Rounding Radius (r)
Cut Arc Fitting
Perform Arc Fitting
Fitting Tolerance (t)
Smooth Cut Transitions
Use Smooth Cut Connections
Generate
Cancel
Save
Help
Top View
Front View
Tools
FlatMill1
BallMill1

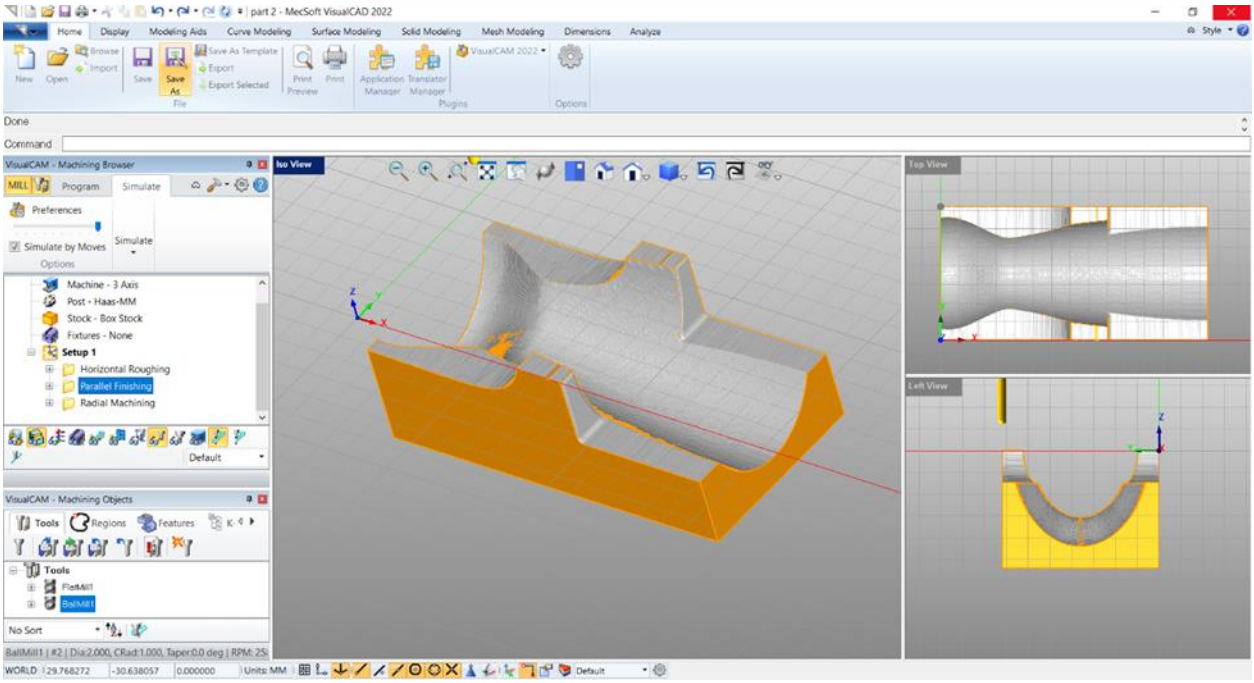

Parallel Finishing
Control Geometry
Tool
Feeds & Speeds
Clearance Plane
Cut Parameters
Z Containment
Entry/Exit
Advanced Cut Parameters
Sorting
Global Parameters
Intol
Outtol
Stock
Toolpath
Geometry
Cut Control
Cut Direction
Mixed
Climb (Down Cut)
Conventional (Up Cut)
Start Side
Bottom
Top
Angle of Cuts
Use this illustration as a reference while completing this dialog.
Cutting Area Control
Tops Only
Tops & Sides
Ignore Holes
Stepover Control
% Tool Diameter
Distance
Scallop
Stepover
Generate
Cancel
Save
Help
Top View
Front View
Tools
FlatMill1
BallMill1


part 2 - MecSoft VisualCAD 2022
Parallel Finishing
Control Geometry
Tool
Feeds & Speeds
Clearance Plane
Cut Parameters
Z Containment
Entry/Exit
Advanced Cut Parameters
Sorting
Global Parameters
Intol
Outtol
Stock
Toolpath
Stock
Outtol
Intol
Geometry
Cut Control
Cut Direction
Mixed
Climb (Down Cut)
Conventional (Up Cut)
Start Side
Bottom
Top
Angle of Cuts
Cutting Area Control
Tops Only
Tops & Sides
Ignore Holes
Use this illustration as a reference while completing this dialog.
Stepover Control
% Tool Diameter
Distance
Scallop
Stepover
Generate
Cancel
Save
Help
Tools
FlatMill1
BallMill1
No Sort
Top View
Right View

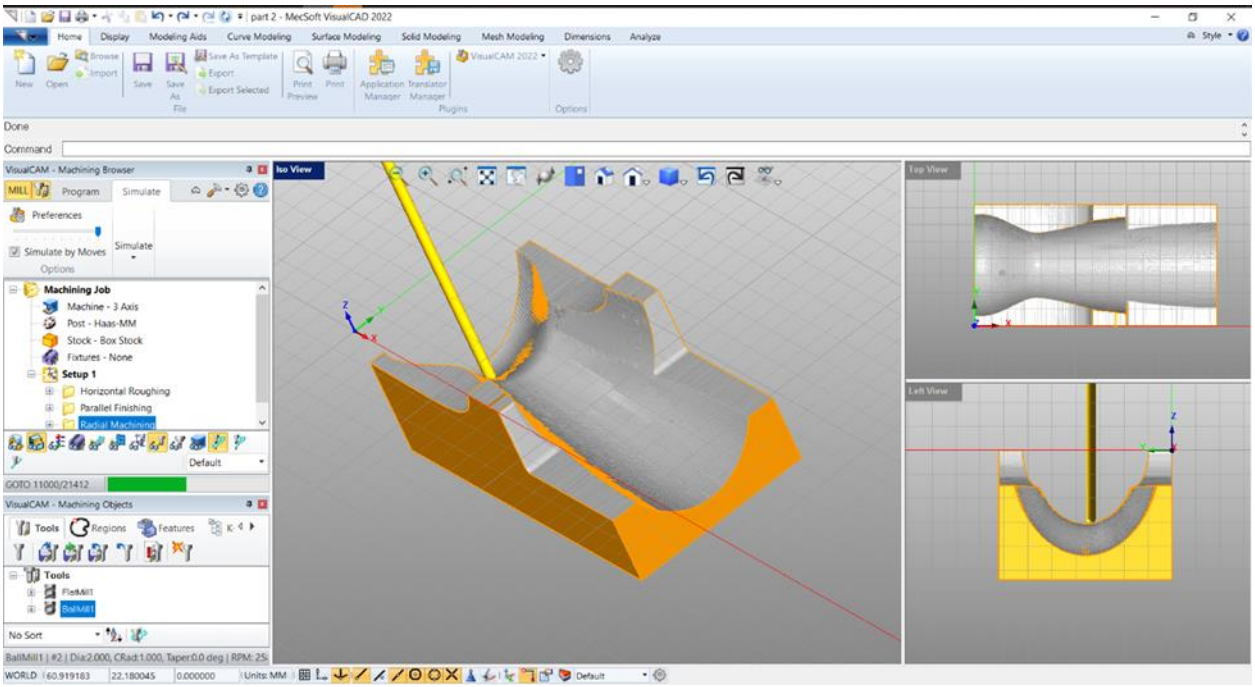

part 2 - MecSoft VisualCAD 2022
Parallel Finishing
Control Geometry
Tool
Feeds & Speeds
Clearance Plane
Cut Parameters
Z Containment
Entry/Exit
Advanced Cut Parameters
Sorting
Entry
Exit
Retract Motion
Linear
Length (L)
Angle (A)
Radial
Radius (R)
Rapid
Departure
Retract
Departure Motion
Vertical Dist (D)
Cut Connections
Straight
Linear
Length (L)
Angle (A)
Radial
Radius (R)
Add loops
Generate
Cancel
Save
Help
Tools
FlatMill1
BallMill1
No Sort
Top View
Right View

After horizontal roughing selecting parallel finishing for better finishing as shown in below figure





After parallel finishing considering radial machining



Total time taken for the machining process is given below

for part 1

Machining Operations Information

Mops Information

Name	Status	Tool	Tool #	Cut Feed	Spindle Speed	# of GOTOs	Machining Time
Setup 1							
Horizontal Roughing	Clean	FlatMill1	2	3657.60 mm/...	12000 RPM	7646	11.29 min
Parallel Finishing	Clean	BallMill1	1	3657.60 mm/...	12000 RPM	9387	5.10 min
Radial Machining	Clean	BallMill1	1	3657.60 mm/...	12000 RPM	21960	12.19 min
						Setup-total	28.58 min

Print

OK Cancel Help

Operations	Time (Hours)
Process design	0.10
Machine setup	0.20
Micro cycle	0.15
Macro cycle	0.40
Stock setting	0.10
Zero setting	0.10
Total machining time (production)	0.28

So total time taken for one part (1) is 2.21

Raw material for one part = 127 grams

Cost of experienced CAM operator per hour = 15 euros

Total cost of time = 2.21 x 15 = 33.25 euros

Cost of raw material (ABS) for 1 part = 0.19 euros (1kg = 1.5 euros)

Total cost per part = 33.44 euros

Total time taken for machining part 2

Machining Operations Information

Mops Information

Name	Status	Tool	Tool #	Cut Feed	Spindle Speed	# of GOTOs	Machining Time
Setup 1							
Horizontal Roughing	Clean	FlatMill1	1	3657.60 mm/...	12000 RPM	11066	10.10 min
Parallel Finishing	Clean	BallMill1	2	3657.60 mm/...	12000 RPM	8514	3.78 min
Radial Machining	Clean	BallMill1	2	4572.00 mm/...	15000 RPM	21412	3.73 min
						Setup-total	17.62 min

Operations	Time (Hours)
Process design	0.10
Machine setup	0.20
Micro cycle	0.10
Macro cycle	0.40
Stock setting	0.10
Zero setting	0.10
Total machining	0.17

So total time taken for only one part (2) is 2.1 hours

Raw material for one part = 34 grams

Cost of experienced CAM operator per hour = 15 euros

Total cost of time = 2.1 x 15 = 31.5 euros

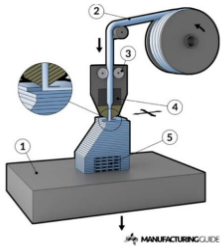
Cost of raw material (ABS) for 1 part = 0.051 euros (1kg = 1.5 euros)

Total cost per part = 31.5 euros

Total time and cost for machining 10 parts (both part1&2):

PART 1	CAM(TIME)	CAM COST (EUROS)
P1	2.21	33.44
P2	4.42	66.88
P3	6.63	100.32
P4	8.84	133.76
P5	11.05	167.2
P6	13.26	200.64
P7	15.47	234.08
P8	17.68	267.52
P9	19.89	300.96
P10	22.1	334.4

PART 2	CAM(TIME)	CAM COST(EUROS)
P1	2.1	31.5
P2	4.2	63
P3	6.3	94.5
P4	8.4	126
P5	10.5	157.5
P6	12.6	189
P7	14.7	220.5
P8	16.8	252
P9	18.9	283.5
P10	21	315



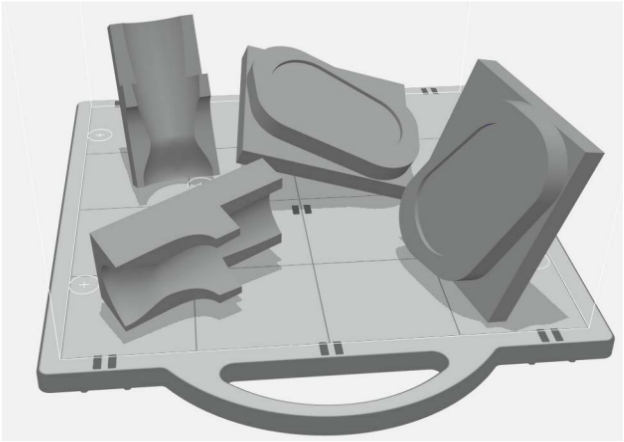
Exercise 2: Computer Aided Manufacturing

Part B

Both the previous components must be fabricated via Fused Deposition Modeling.
Select an adequate machine.
Use the software Grabcad (Figure 3) you can download at the link:
https://grabcad.com/it/print
As before, pay attention to the specfications in accordance with the Table I in the appendix A.
Find best orientation and strategies to obtain a fast fabrication.
In order to predict attainable roughness use the Boschetto-Bottini models.

Report rules

- Motivate each choice and avoid theoretical digressions.
- Orient the part and motivate this decision.
- Choice adequate values for processing parameters for reasonable processing time
- Report the production time and add indication about setup and postprocessing times.



3D Printer Machine Selection:

We are selecting Stratasys F900 due to its widely usage in FDM market and accuracy.

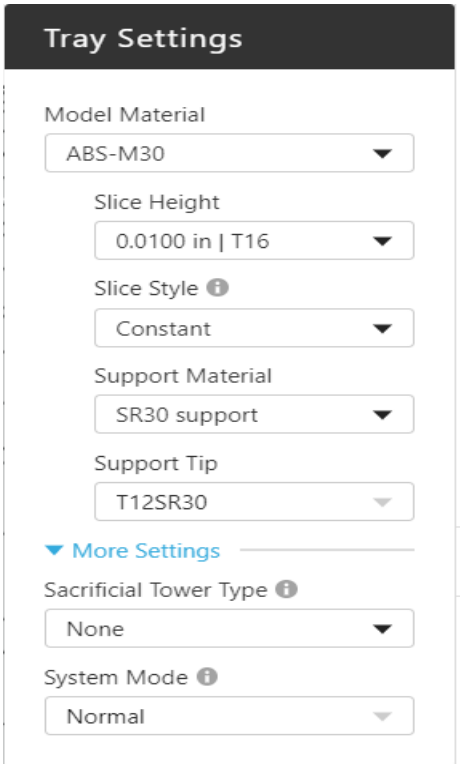
Model Material:

The considered printing material is ABS also known as acrylonitrile butadiene styrene; ABS is one of the most versatile materials available for 3D printing today. ABS comes in the form of a long filament wound around a spool. The 3D Printing process used with ABS is the FDM (Fusion Deposition modelling) process where material is heated and squeezed through a fine nozzle to build your design in 250-micron layers.

3D printing Process Includes,

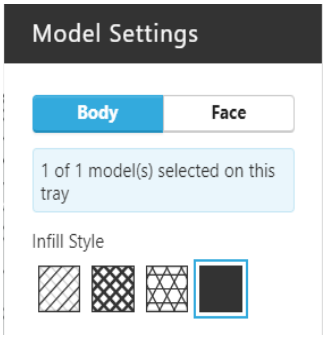
Tray Setting:

According to the printer we are considering Slice height as 0.254 mm for better surface finish

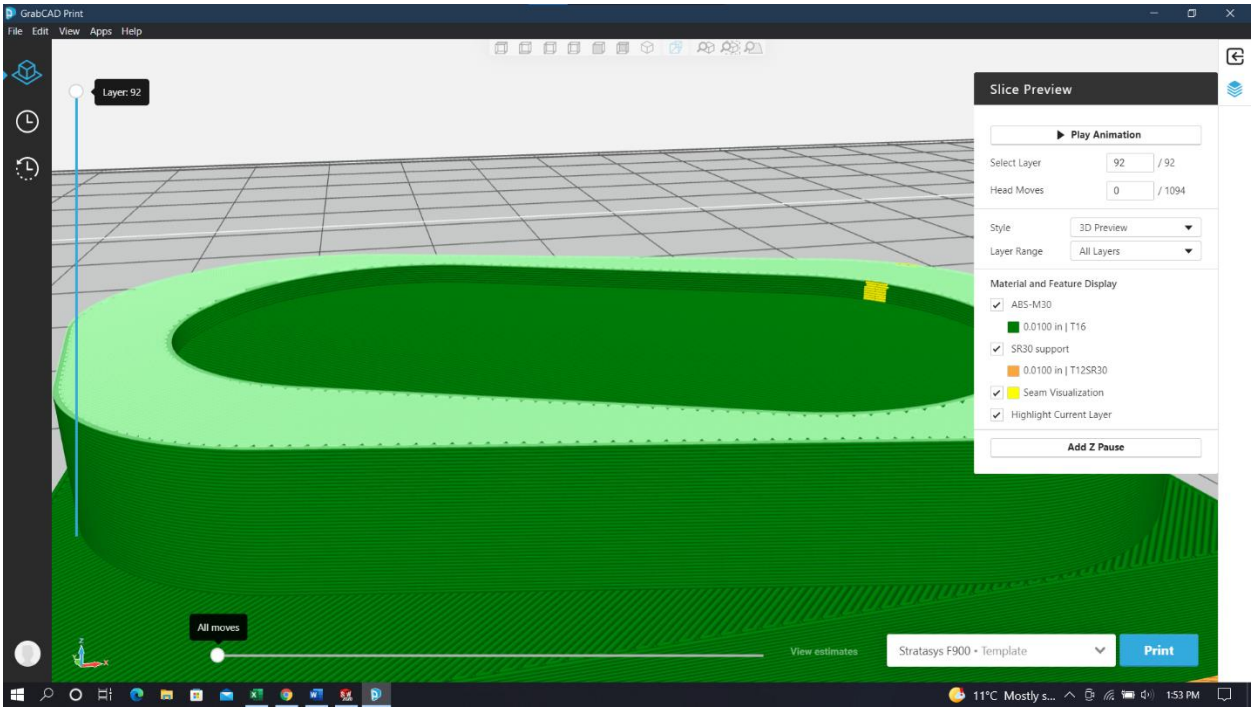


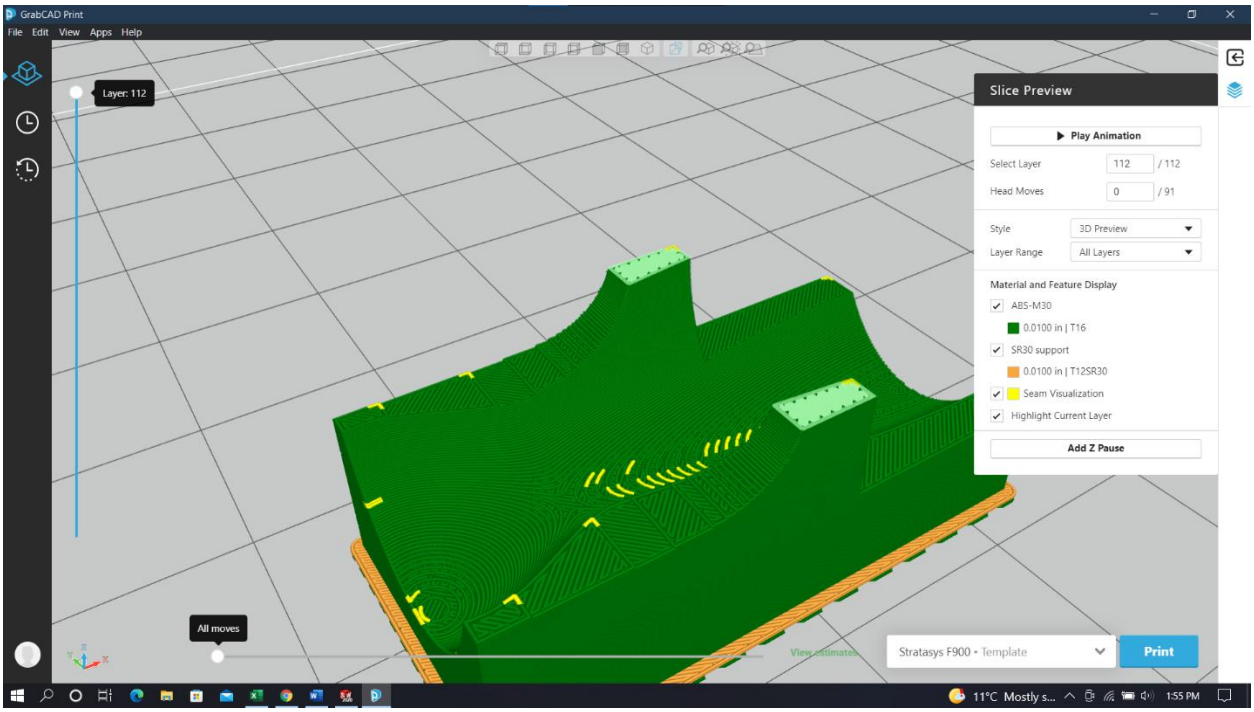
Model settings:

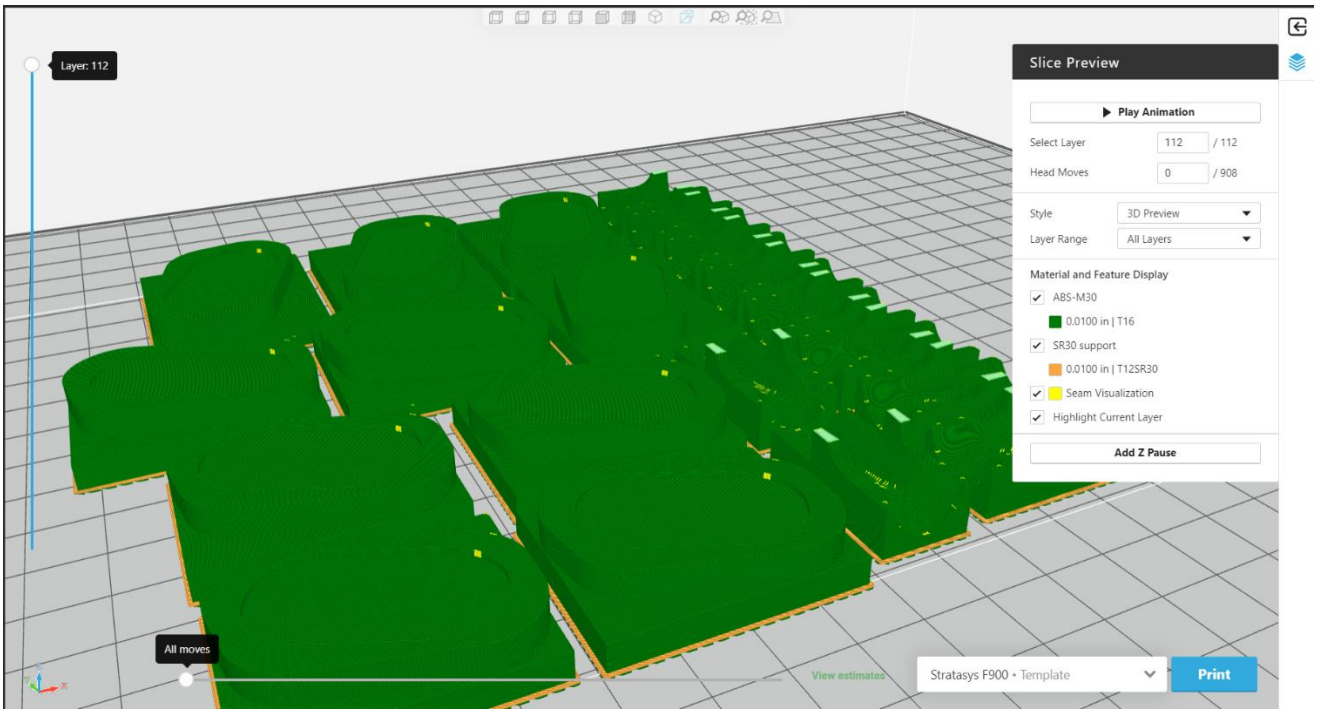
The body of both part 1 and part 2 both require better structural integrity, so we selected solid model



Part 1 & part 2 slicing preview of all 20 parts of part 1 &2:







Support settings:

As we set support style in basic also base style is both model and support and self-supporting angle is 45 degrees, industrially it may vary for better surface finish and time consumption.

Orientation:

Orientation of model is default 90 degrees, but it can be changed for better outcome.

Post Processing:

The support layer present under both part 1 and part 2 can be removed by chipping and the printed part does not support the required roughness to compensate that the part is subjected to ABS acetone Vapor smoothing. The part is subjected to acetone fumes, the surface layer of the part gets melted due to acetone and the gap between the overlapped layers is filled with the melted material of the subsequent layers.
Therefore, the required surface roughness is achieved. The part should not be subjected for more time in acetone fumes else the dimensional deformation occurs; it must be given the required dwell time.

Total cost and time taken for printing part 1 & 2

Operations	Time (Hours)
Process design	0.10
Printer setup	0.10
Micro cycle	0.15
Macro cycle	0.30
Stock setting	0.10
Zero setting	0.10
Production time	26.39

PART 1	3D PRINTING(TIME)
P1	4.2
P2	8.4
P3	12.6
P4	16.8
P5	21
P6	25.2
P7	29.4
P8	33.6
P9	37.8
P10	42

Total time taken to produce per part 1 = 3.8

Cost of raw material per part 1 (0.127 kg) = 0.254 euros (1kg = 2 euros)

Cost of 3D printing operator per hour = 10 euros (Don't need to be experienced)

Total time = 10x 3.8 = 38

Total cost = 38.254 euros

PART 2	3D PRINTING(TIME)
P1	2.8
P2	4.8
P3	6.8
P4	8.8
P5	10.8
P6	12.8
P7	14.8
P8	16.8
P9	18.8
P10	20.8

Total time taken to produce per part 2 = 2 hours

Cost of raw material per part 2 (0.038 kg) = 0.076 euros (1kg = 2 euros)

Cost of 3D printing operator per hour = 10 euros (Don't need to be experienced)

Total time = 10x 2 =20

Total cost = 20 euros

Total Time for printing all 20 parts (part 1&2) is about 55.7hours

Total time and cost for machining 10 parts (both part 1&2):

PART 1	3D PRINTING(TIME)	3D PRINTING COST (EUROS)
P1	4.2	38.25
P2	8.4	76.5
P3	12.6	114.75
P4	16.8	153
P5	21	191.25
P6	25.2	229.5
P7	29.4	267.75
P8	33.6	306
P9	37.8	344.25
P10	42	382.5

PART 2	CAM COST(EUROS)	3D PRINTING COST (EUROS)
P1	31.5	20
P2	63	40
P3	94.5	60
P4	126	80
P5	157.5	100
P6	189	120
P7	220.5	140
P8	252	160
P9	283.5	180
P10	315	200

Technology comparison

Part C

Technology comparison:

According to the below given data in table and graph, we did not find breakeven point, both technologies have their own advantages and disadvantages, there are some sensitive parameters taken consider in both preprocessing and postprocessing.

PART 1&2	CAM COST(EUROS)	3D PRINTING COST (EUROS)
P1	64.94	58.25
P2	129.88	116.5
P3	194.82	174.75
P4	259.76	233
P5	324.7	291.25
P6	389.64	349.5
P7	454.58	407.75
P8	519.52	466
P9	584.46	524.25
P10	649.4	582.5