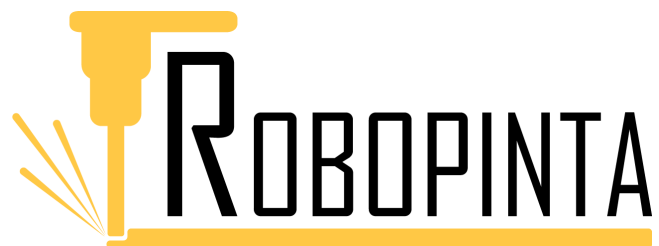
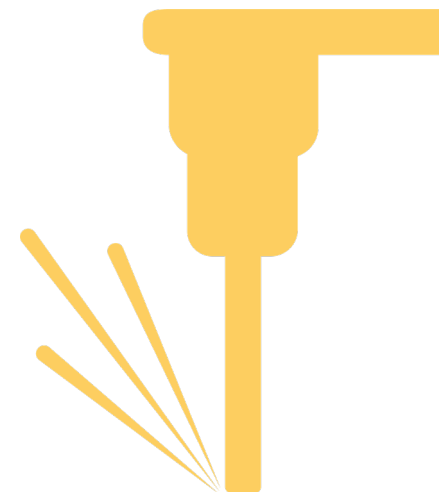


From 3D Printing to a Finished Product

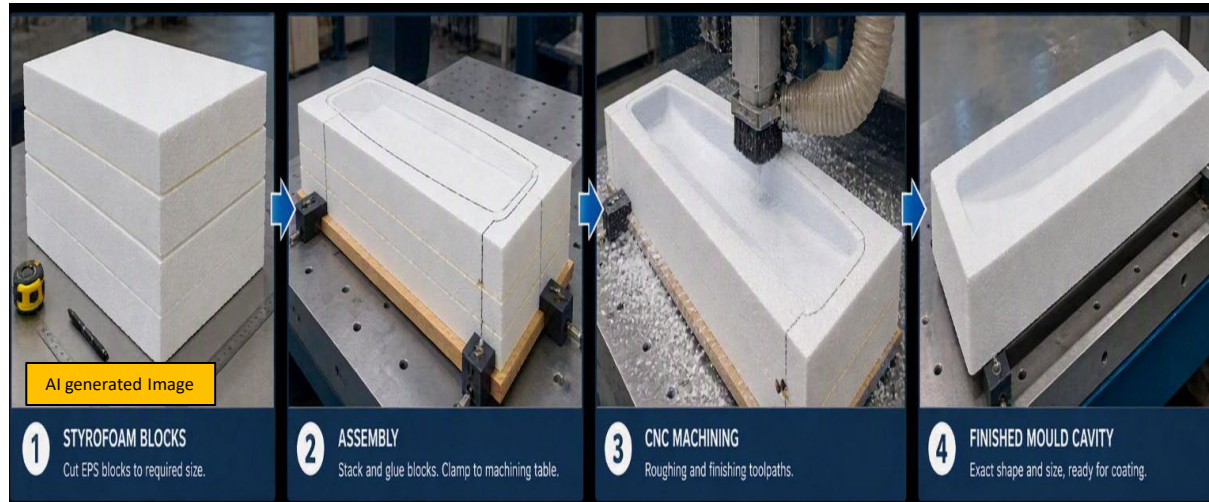
Case Study: Printing and Machining a Composite Mould

Manoj Sharma, RDI Expert



Scope

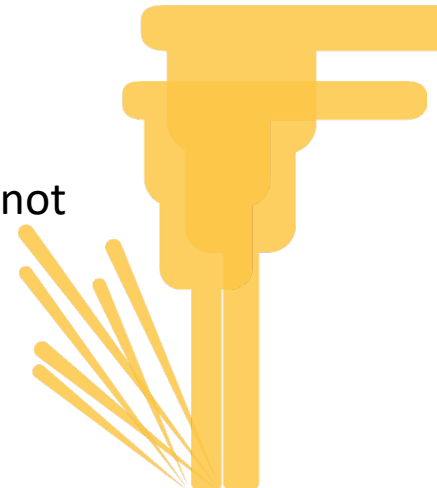
- Print the large scale composite mould and machine the surface to the dimension.
- Sanding and Coating for the required surface finish.



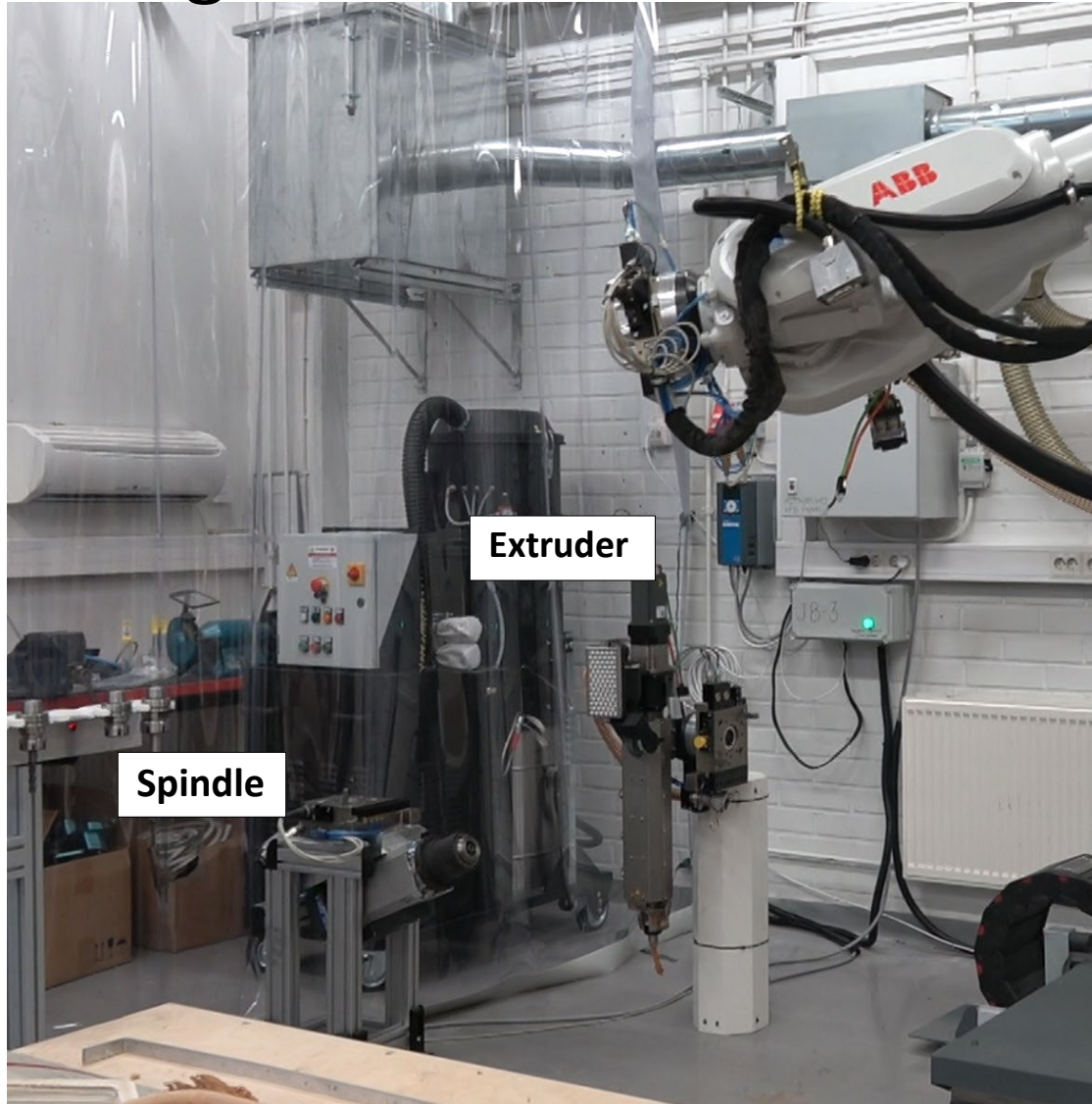
Why

- Problem
 - The conventional mould making method is long, dusty, labour intensive, high material consuming, not recyclable.
- Motivation

The goal is to combine the speed of Additive Manufacturing with the accuracy of CNC Machining



Large scale additive manufacturing (LSAM) – since June 2022



Robot ABB IRB6700

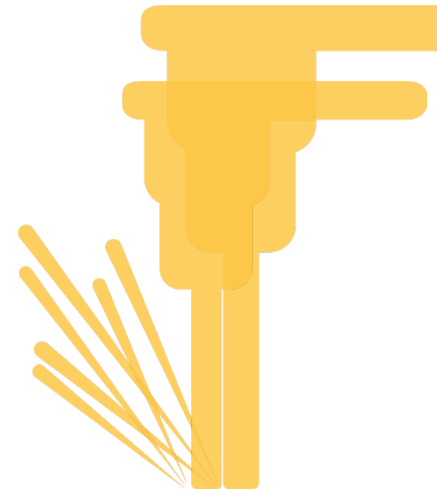
- 175kg / 3.05m
- TrackMotion IRBT6004, 2,7m
- 2-axis workpiece positioner IRBP A500
- ATC 170Kg

Extruder for printing CEAD E25

- 80-400°C
- Throughput 5-12 kg/h
- Nozzles – 2-18 mm
- Material dryer/feeder 50-185°C, 100 l

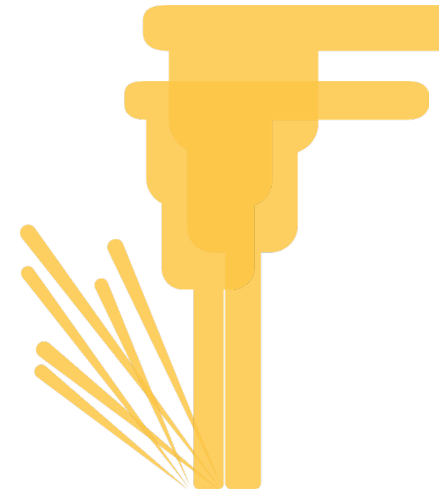
HSD Spindel

- Max 11kW
- Max 24000 rpm
- Air Cooled



Conventional Method in use

- Typical workflow is
 - CAD Design>Machining of large blocks to Near-Shape>Surface Preparation>Manual composite layering>Curing
- Challenges in Conventional method
 - Very long lead times
 - Labour intensive
 - Dusty work and health challenges
 - Heavy PPE gear for workers all the time
 - Multiple materials used are not easy to recycle



The Additive Method

- Typical Workflow

- CAD Design>Slicing>Toolpath Generation>Printing>Machining>Tool Gel coating

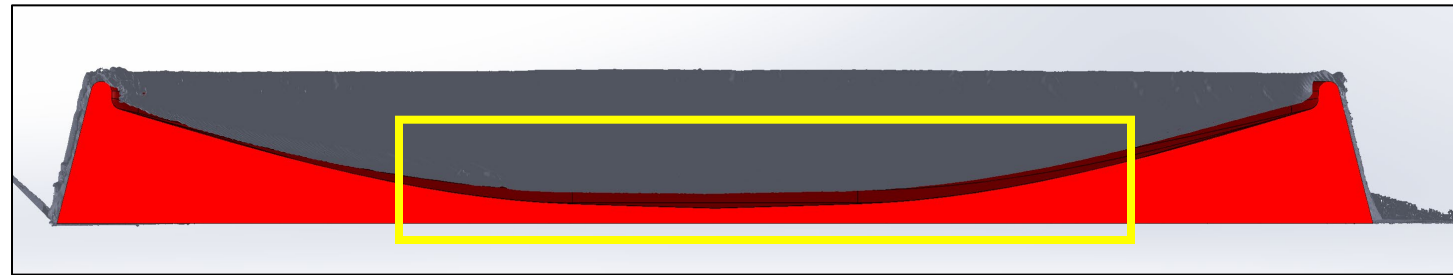
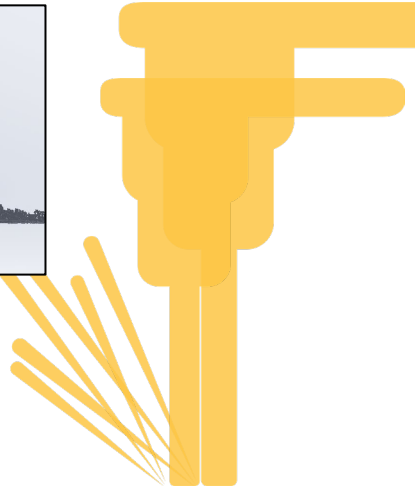
- Advantages

- Faster developments
- Fully automatic and hence less laborious
- Easy, quick and cheap to implement modifications
- Sustainable
- Recyclable material



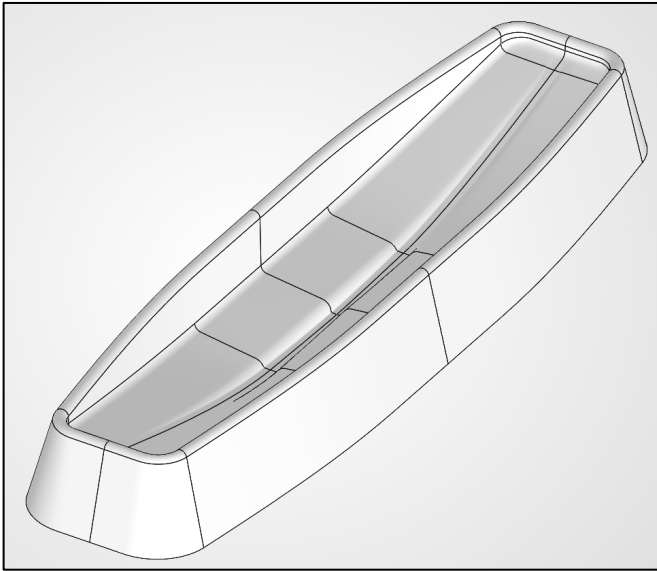
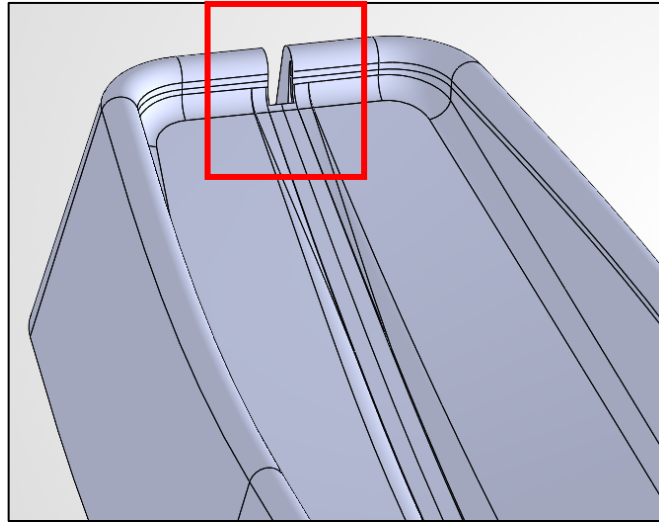
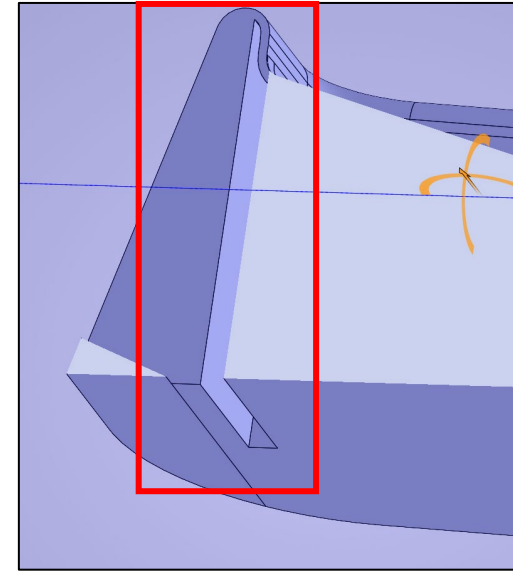
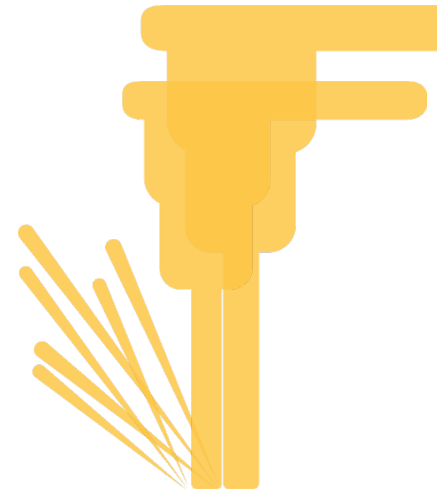
- Challenges

- Thermal Distortions
- Shrinkages on cooling
- Not all shapes and sizes can be printed
- High Initial cost



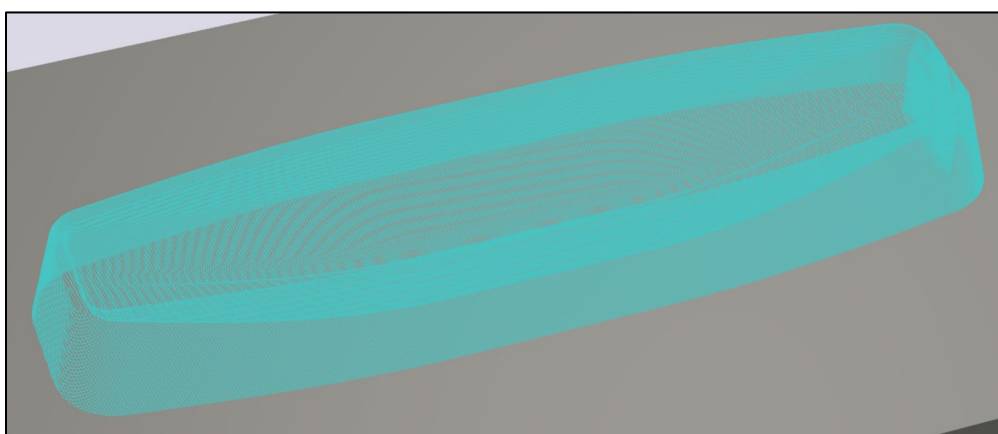
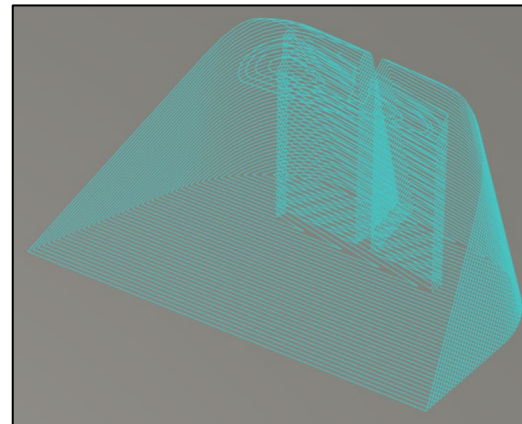
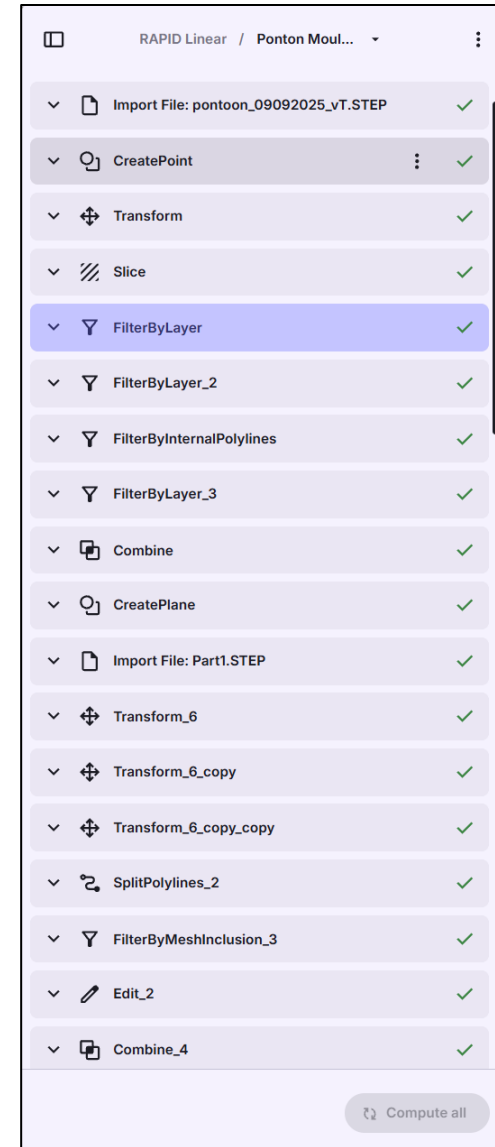
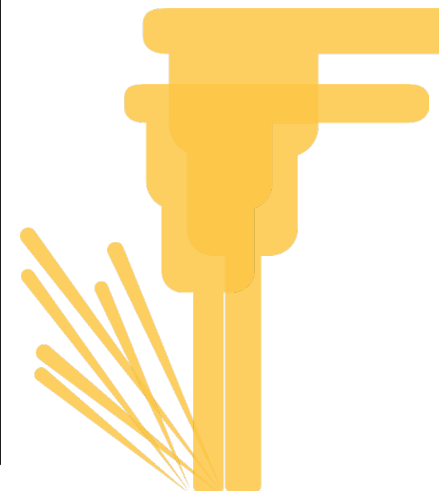
Design Phase

- The Surface of CAD model of the Product is converted to a mould surface.
- Not all designs are printable, so modifications needed to make it printable are implemented
- The CAD model are modified to compensate shrinkages and distortions



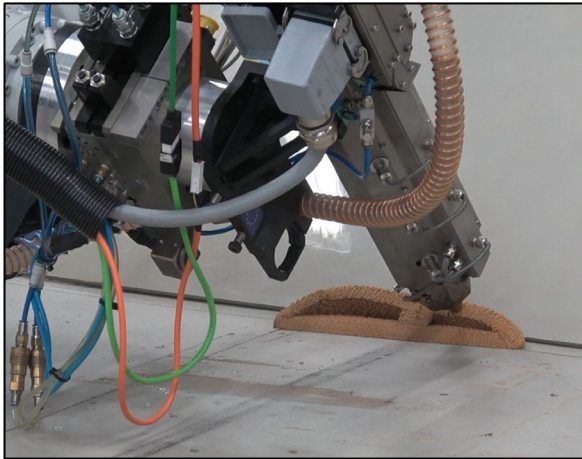
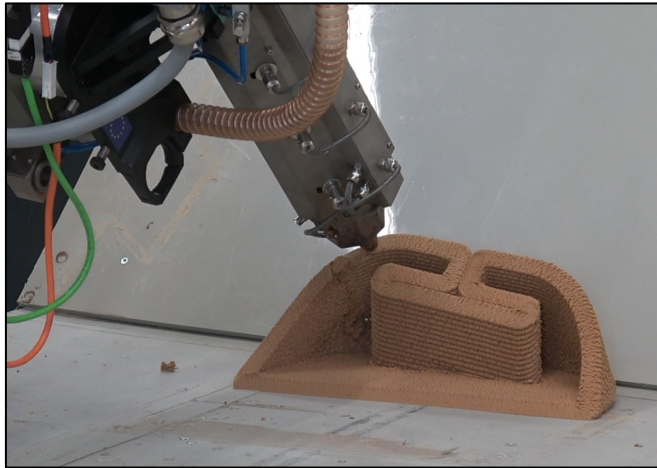
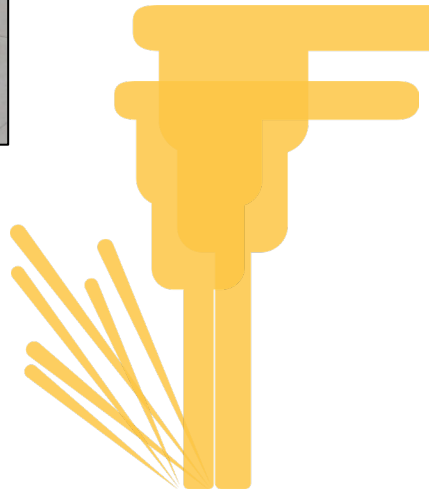
Slicing and Toolpath Generation

- Slicing software are used to slice and generate toolpath. Software example is Ai Build, Adaone
- A product can be printed with many strategies like Horizontal or Angular. Large models are mostly sliced Angular
- The Sliced polylines are converted in Toolpath and then simulated for finding possible ambiguities.



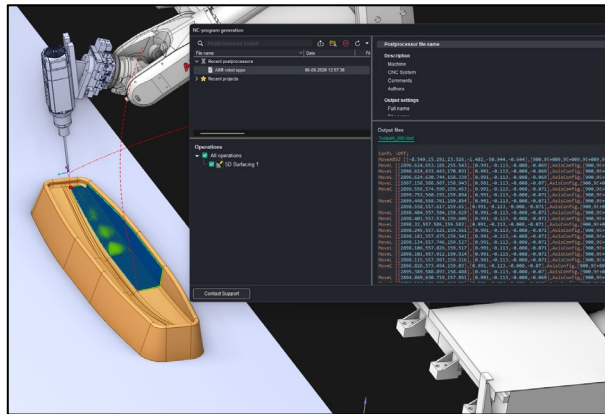
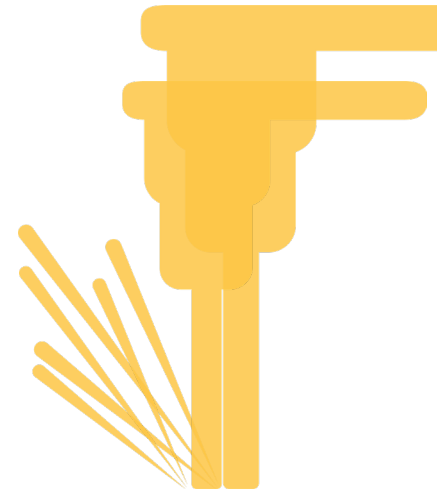
Printing

- Robot mounted extruder is used to print the part, method called Fused Granule Fabrication (FGF)
- Target is to extrude enough material to have enough stock for machining



Machining to the dimension

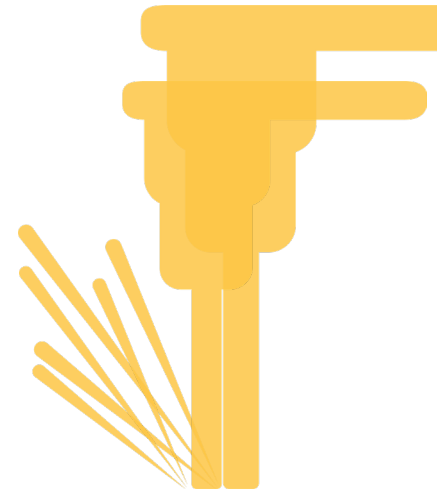
- CAM Software to generate machining path are used.
- Roughing passes and then Finishing passes. Roughing and Finishing passes can be multiple.
- With our motor size, we could go 30mm/s and depth of cut of 2.5mm. Above that, the vibrations reaches to unhealthy levels.



Challenges

- Challenges with Machining

- Lower stiffness of the robotic arm than the CNC machines
- Over-machined part recovery is almost impossible
- Final wall thickness in warpage/distorted moulds can be inconsistent

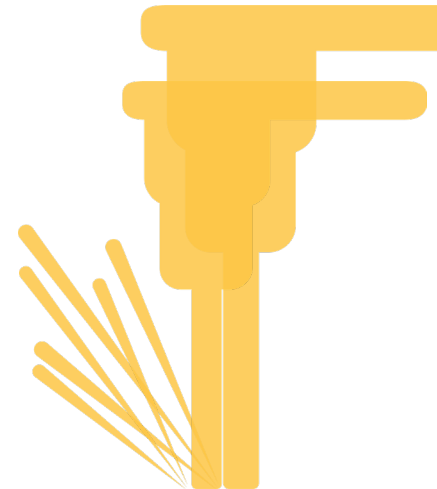


Industrial Applications

- Wide application Industry are
 - Marine
 - Aerospace
 - Research and Development-Rapid tooling & prototyping

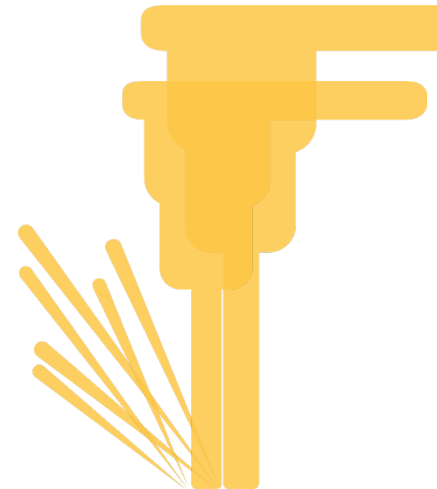
The Future

- Heating/cooling control of printings process
- Digital twin for automated quality control
- Strategies to integrate shape distortion compensations into design phase



Conclusion

- Lesson Learnt are
 - Not everything can be printed
 - Thermal Distortion, shrinkage and warpage are bigger villain than we think
- Achievements
 - Additive method reduces development time
 - Reduces material waste to fractions compared to Conventional method
 - High quality is achievable
 - Most thermoplastic composites are recyclable



Thank You!

