
APEX
ADDITIVE TECHNOLOGIES

CASE STUDY: Cool Moulds, Hot Results

Advanced Manufacturing

Injection Moulding Inserts (Cavities and Cores)

1. Can metal 3D printed tooling withstand the clamping pressure used in injection moulding?
2. Will conformal cooling channels leak?
3. Are conformal cooling channels beneficial?
4. Are the costs and lead times comparable to current traditional alternatives?
5. Will the inserts last for volume production runs?

To answer we set up a case study from design to commission.

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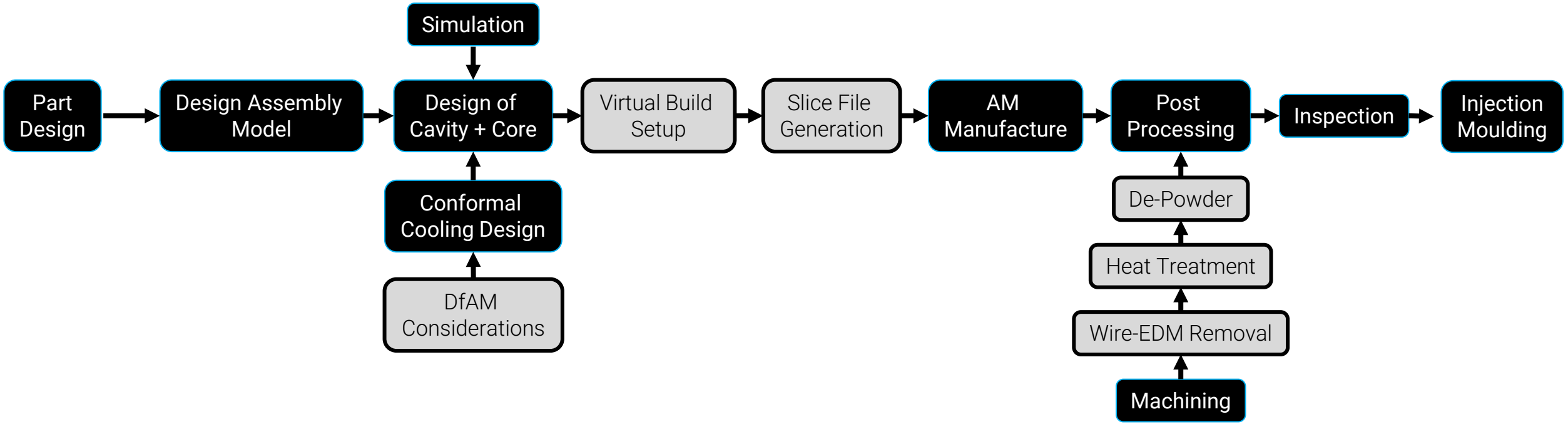
Workflow from Design to Commission



Covered in this Case Study

Not presented Here

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Part Design – A Simple Coaster

- The Coaster contains features which are challenging to manufacture with Injection Moulding
- The large variation in thickness leads to cooling rate variations which can result in **plastic flow, stress** and **warp** related issues
- Key dimensions include:
  - Coaster Thickness = 10 mm
  - Coaster Diameter = 95 mm
  - Minimum Thickness = 1.45 mm
  - Draft Angle = 1.5°

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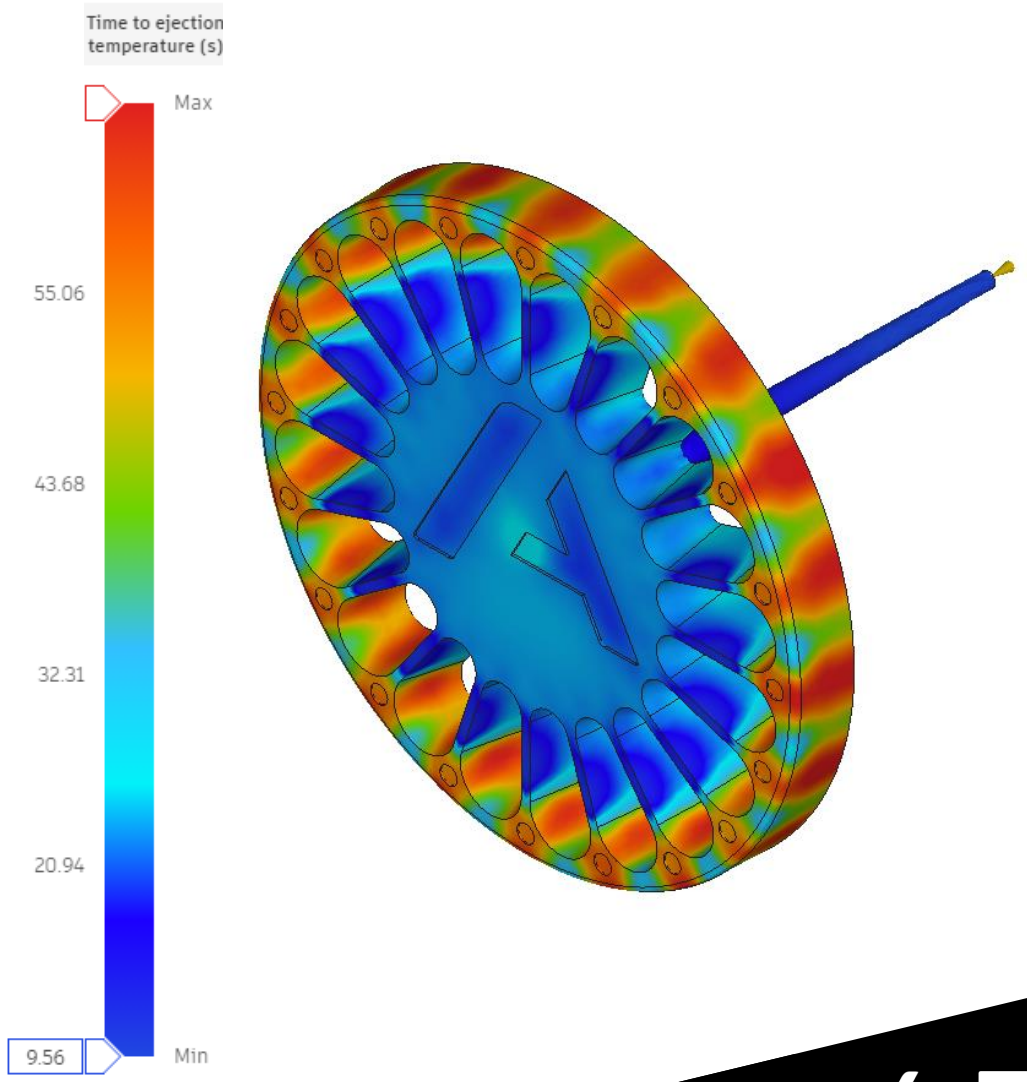
Injection Moulding Simulation

Time to Ejection Without Conformal Cooling

- The design and simulation were executed in Autodesk Fusion360, leveraging Autodesk's extensive library of plastic materials and processes.
- The simulation results predicted a time to ejection of **66.43seconds** for a PVC using default injection moulding settings.



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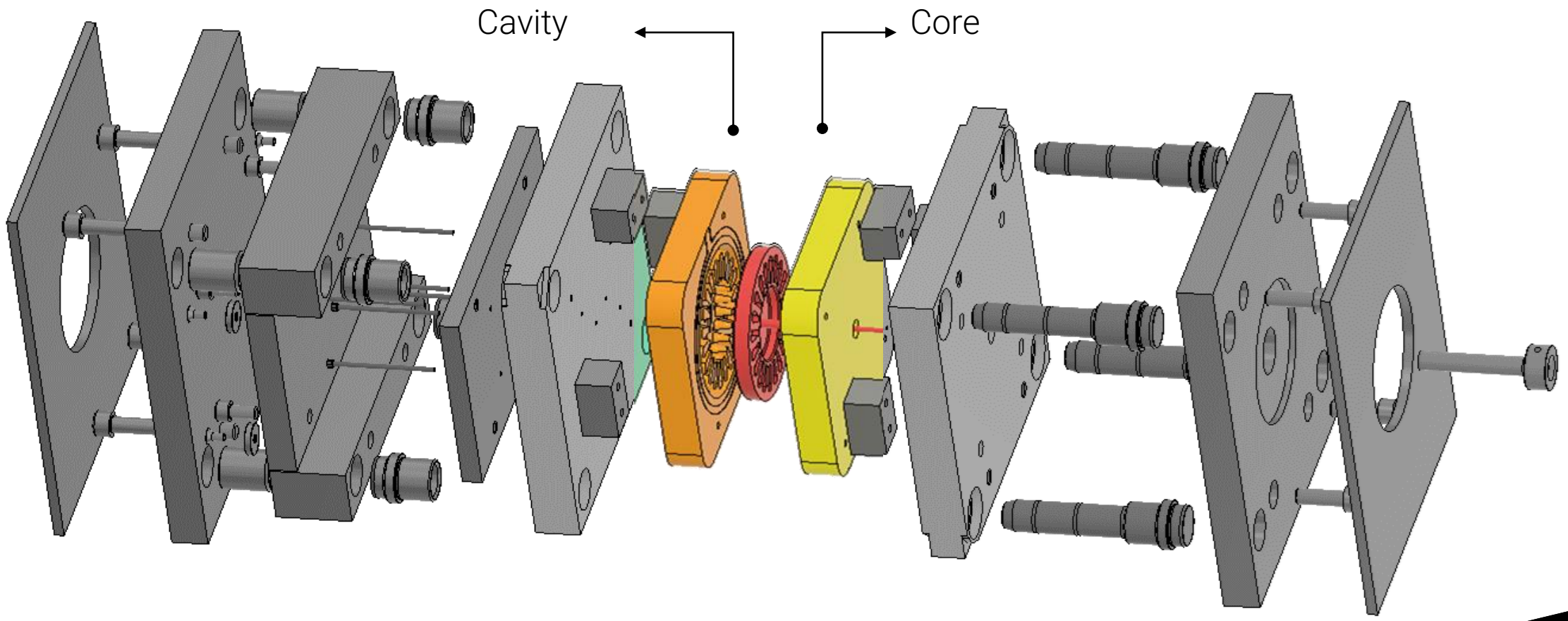
Design Assembly Model – Mould Inserts



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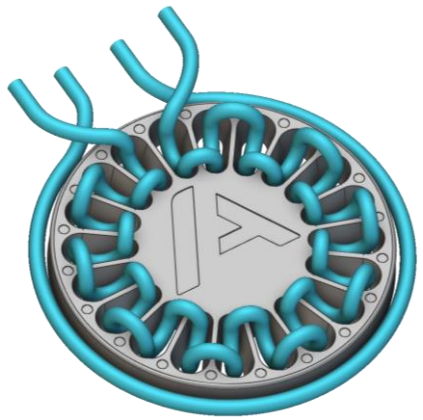
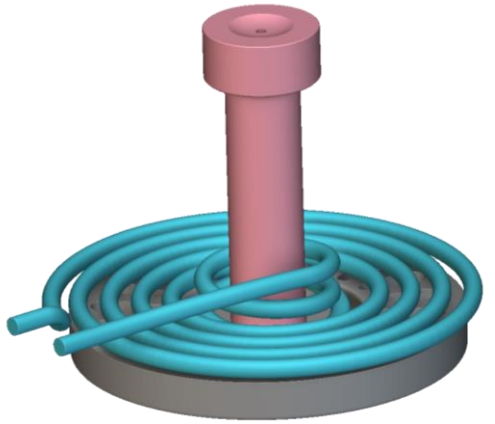
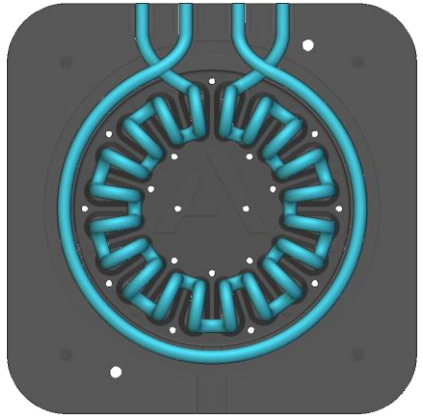
Cavity and Core Design

- The cavity contains two circuits, one to cool the circumference of the coaster and the other to control the temperature near the thin ribs
- The core contains a single circuit, which cools the back face of the part as well as a portion of the sprue
- The channels can better conform to the geometry of the coaster due to the unique capability of Additive Manufacturing (AM)







Cavity

Core

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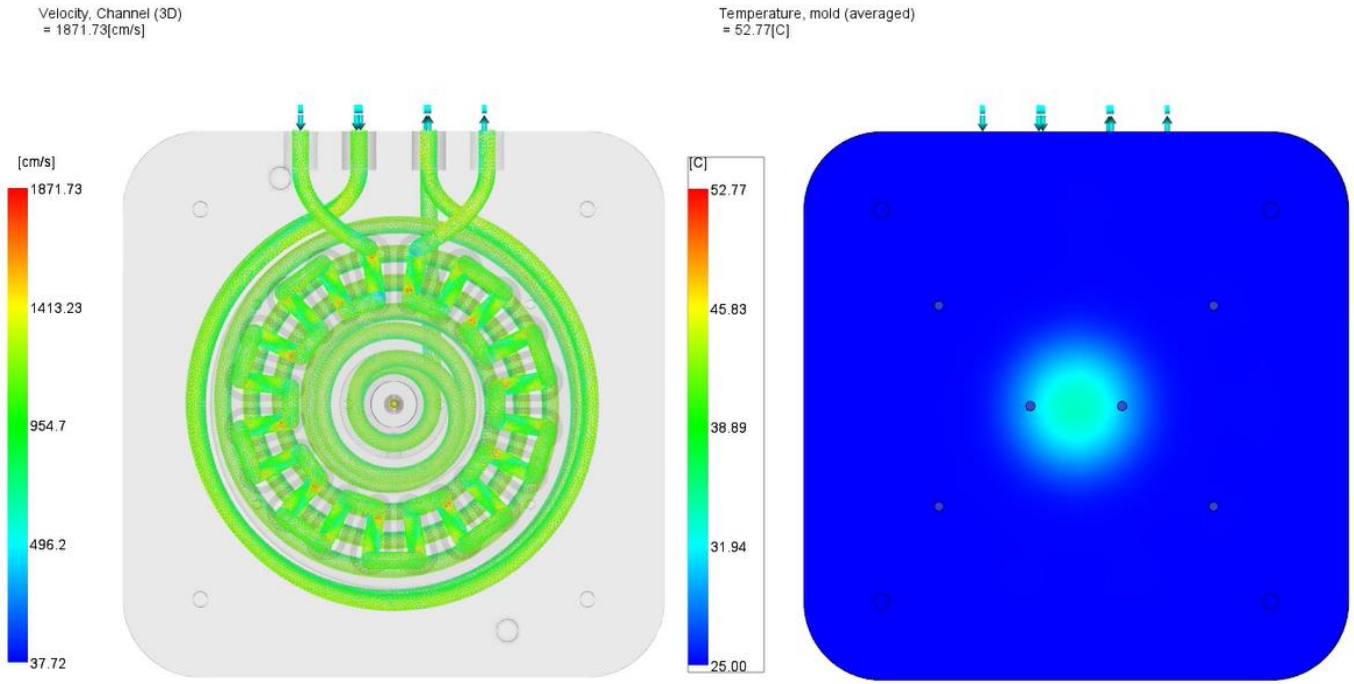
Conformal Cooling Simulation



- Material used PVC with a water temperature of 25ºC
- Predicted significant reduction in cycle time with conformal cooling strategy

	Without Conformal Cooling	With Conformal Cooling
Temperature at Flow Front (°C)	269.9	56
Predicted Time to reach ejection temp (s)	66.43	33
Max Sink Marks (mm)	0.0986	0.056
Total Deviation (mm)	0.5362	0.5081

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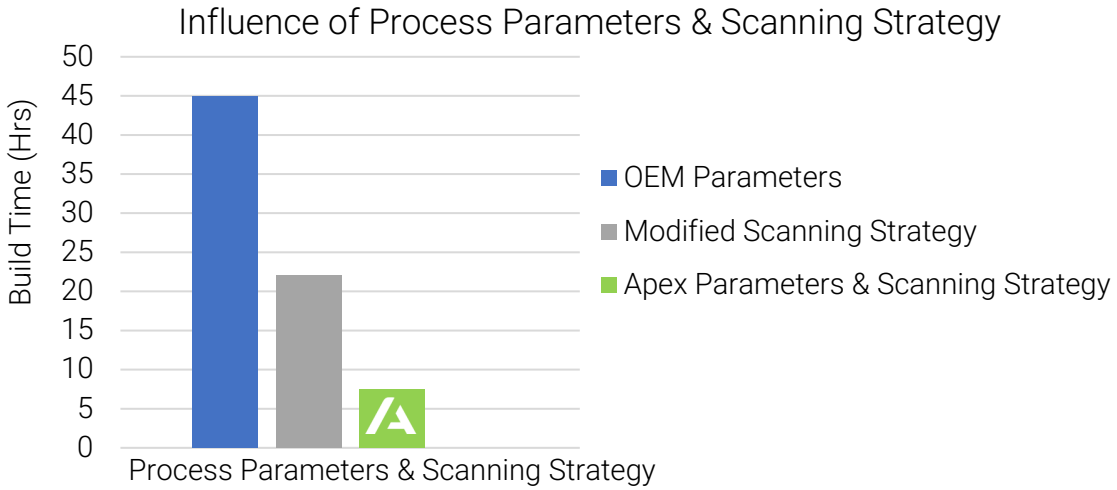
Injection Moulding Inserts (Cavities and Cores)

Apex's process parameters and scanning strategy achieves **83% reduction in build time**



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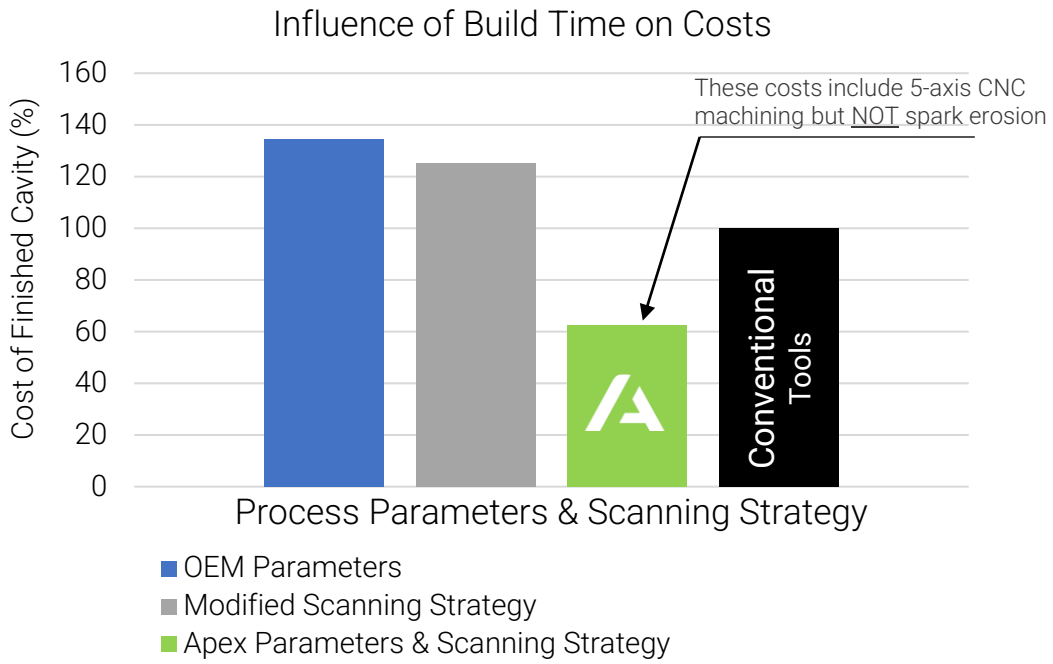
Injection Moulding Inserts (Cavities and Cores)

This reduction in build time, means a **40% reduction in tooling costs**



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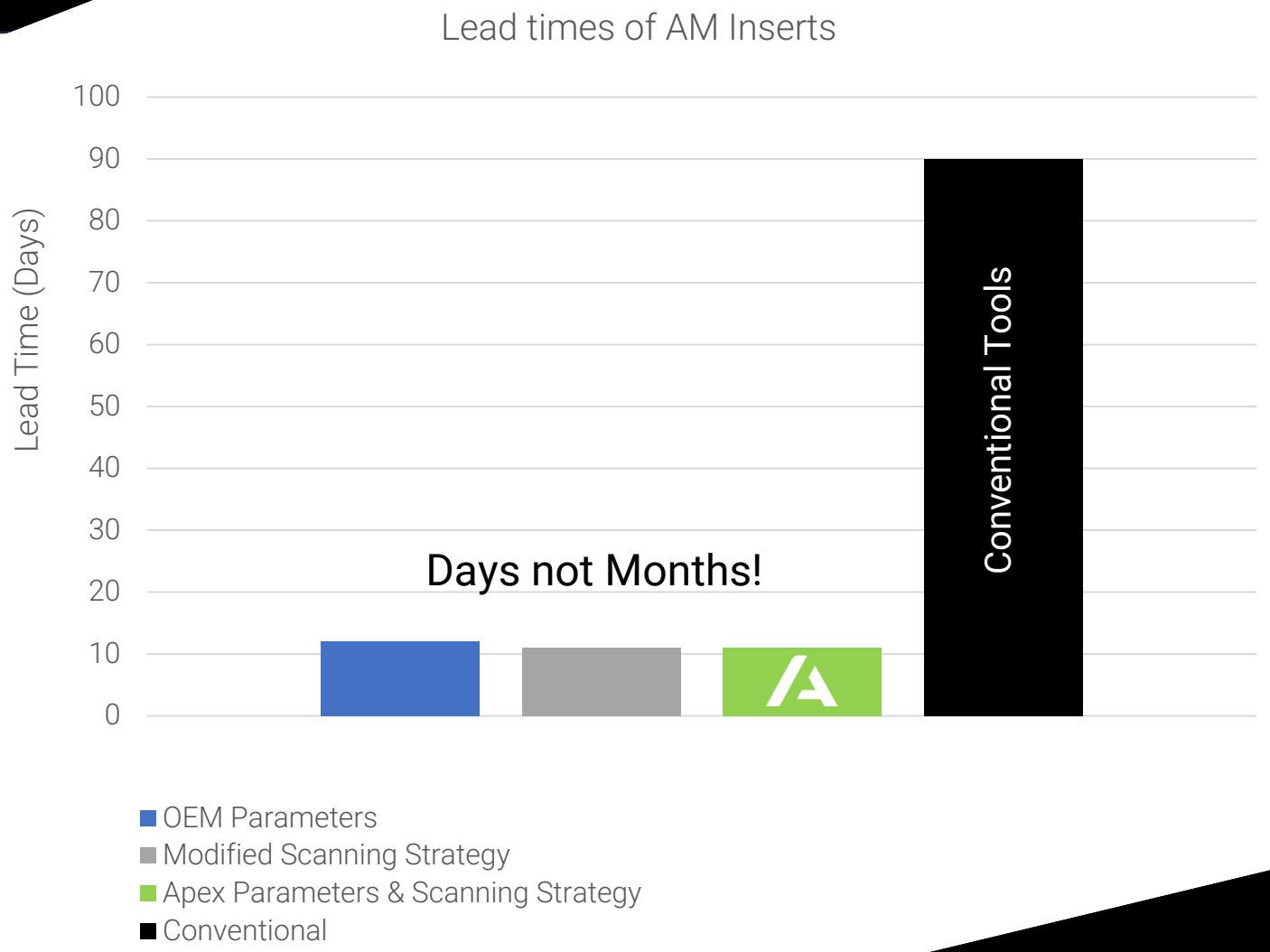
Costs vs Lead Times

- Apex's process parameters and scanning strategy achieves **83% reduction in build time**
- This means a **40% reduction in tooling costs**
- And a **lead-time of 12 Days** instead of 3 Months



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CASE STUDY: Cool Moulds, Hot Results

Injection Moulding

In Service Performance

- Conformal cooling resulted in a **47% reduction in actual moulding cycle time**
- **No leaks** were observed from the channels
- A **clamping pressure of 90T was used successfully** with a balanced shutoff between cavity and core

	Without Conformal Cooling	With Conformal Cooling
Predicted Time to reach ejection temp (s)	66.43	33.00
Actual Time to reach ejection temp (s)	66.00	32.00

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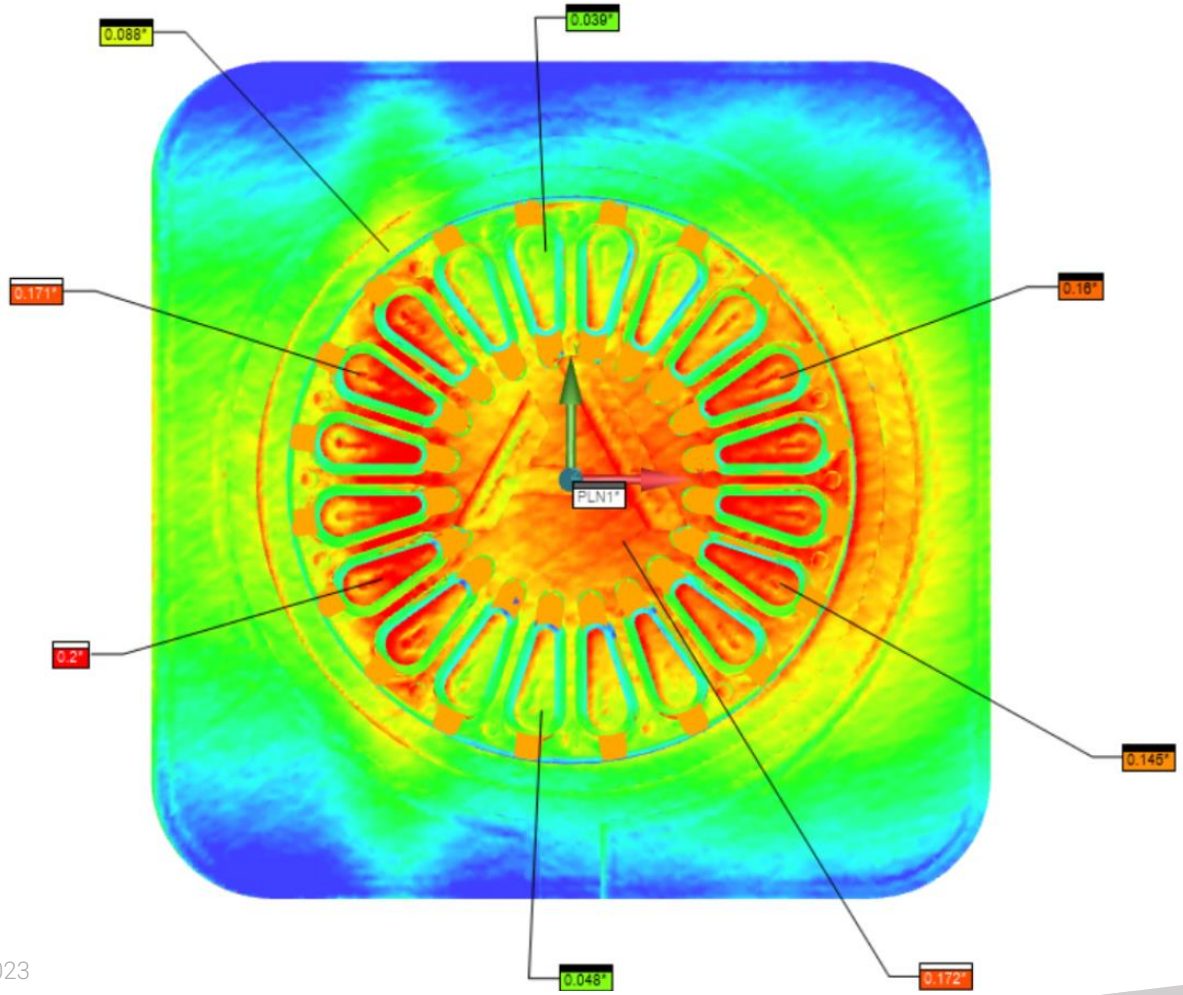
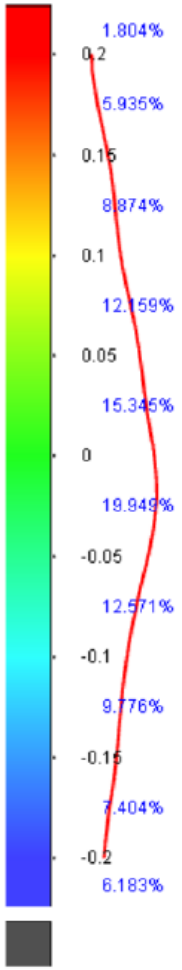
What are the Tolerances Achieved as Printed?

Printing Tolerances



Nominal CAD vs Printed Cavity



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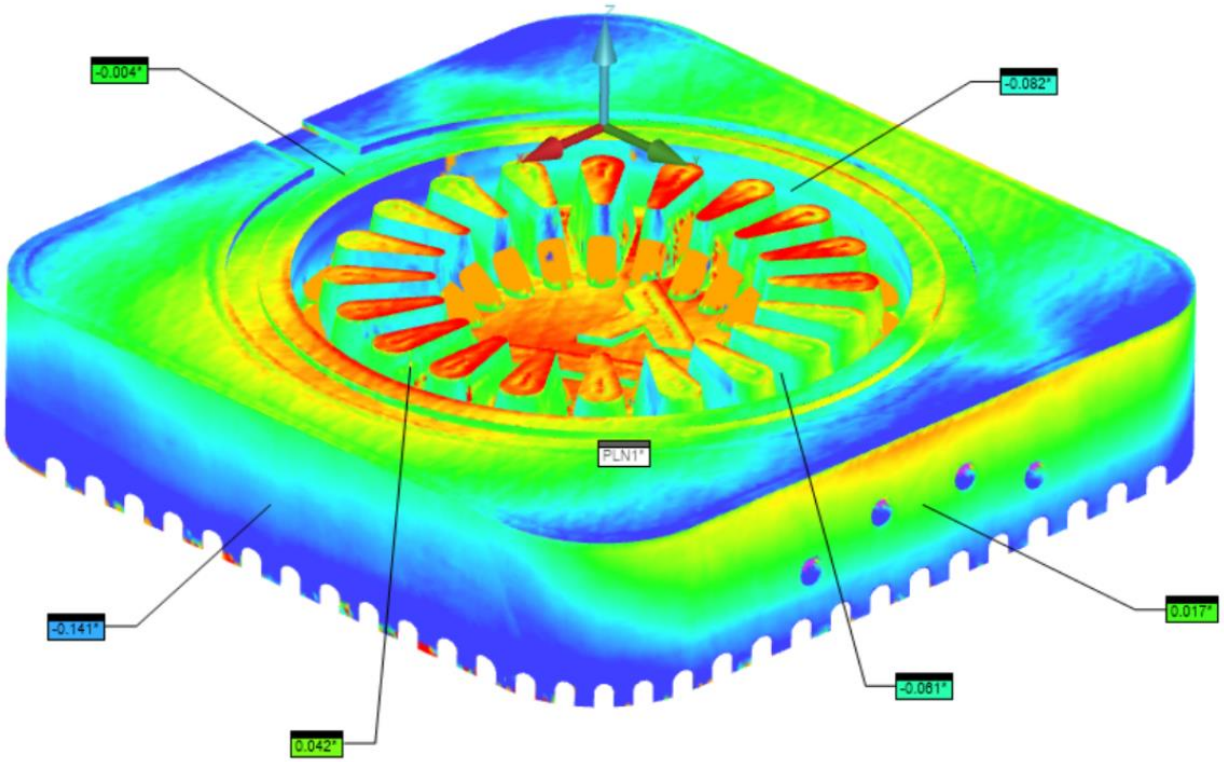
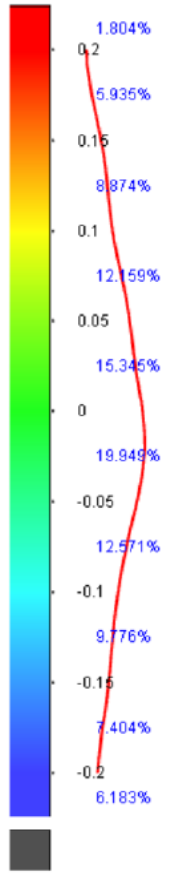
What are the Tolerances Achieved as Printed?

Printing Tolerances

Nominal CAD vs Printed Cavity





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Maraging Steel M300 – DIN 1.2709

Comparable to P20 and H13

Tool Steels

Chemical composition (wt. %)

C	Si	Mn	P	S	Mo	Ni	Co	Ti
≤ 0,03	≤ 0,10	≤ 0,15	≤ 0,01	≤ 0,01	4.9	18	9.3	1.1

Mechanical Properties

With according Heat Treatment	
Tensile strength (Rm) (MPa | ksi)	1,960 to 2,100 | 285 to 305
Yield strength ($RP_{0,2}$) (MPa | ksi)	1,880 to 2,020 | 273 to 293
Elongation (%)	4 to 8
Hardness (HRc)	51 to 55
Impact Toughness (ISO-V) (J)	16 to 20

Heat treatment

Solution annealing		
Temperature	min. 820 °C | 1,508 °F	Soaking time: 1h / air, gas

Precipitation hardening		
Temperature	min. 490 °C | 914 °F	Holding time: 6h / air

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The Hot Results!

1. Can printed parts withstand the clamping pressure?
   - Yes, Clamping pressure used was 90T
2. Will conformal cooling channels leak?
   - No leaks from conformal cooling channels
3. Are the costs and lead times comparable to current alternatives?
   - Apex inserts were 40% cheaper and delivered in 12days instead of 3 months.
4. Will the inserts last for volume production runs?
   - Hardness values can be tailored to requirements using the same material. We can provide a hardness from 38 HRC up to 55 HRC which is comparable to P20 and H13 tool steels

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