isThermaL

Overview
3D Printing
Additive Manufacturing

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Additive Manufacturing Machines

- **Laser-Sintering for Conformal Tooling**
- **Inserts Conformal Cooling Inserts & Components**
- **MS1 Maraging Steel**

- **Electron Beam Melting / Arcam MultiBeam™ technology**
- **Large parts / Built free of residual stresses**
- **Ti6Al4V (Titanium)**

- **Multi-Jet Fusion technology**
- **Nylon 12 parts**
- **Engineering-grade parts / up to 65% lower cost, 10x faster**

Metal Additive Manufacturing

EOS M280 Laser Powder Bed [DMLS]

- MS1 Maraging Steel
- Stainless Steel
- Aluminum
- Inconel
- Cobalt Chrome

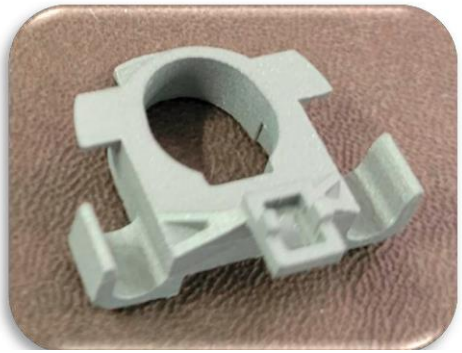
Automotive **Defense**

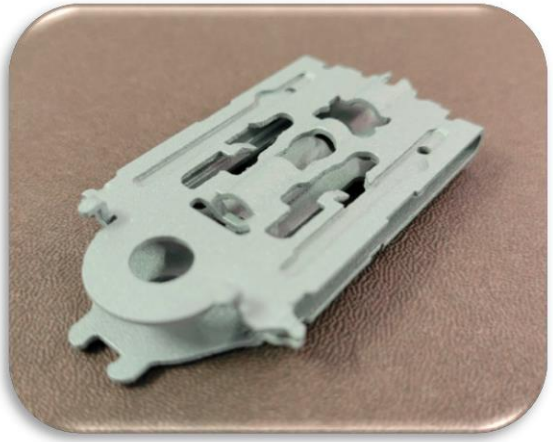
Aerospace **Industrial**

Metal Additive Manufacturing

EOS M280 Laser Powder Bed [DMLS]

- **Print Stamped, Cast, or Formed Parts**
- **No Tooling Investment**
- **Build Area 250mm x 250mm x 325mm**

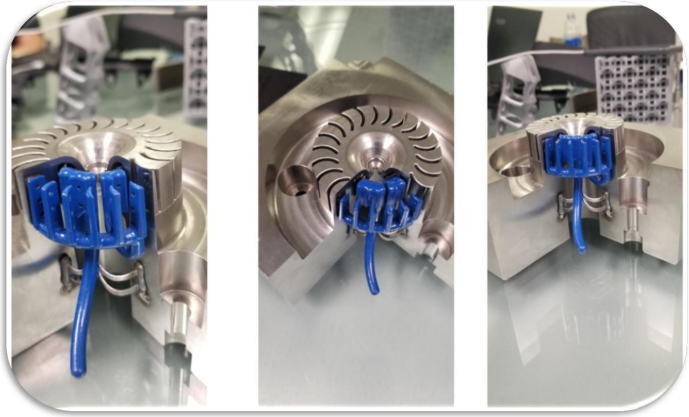


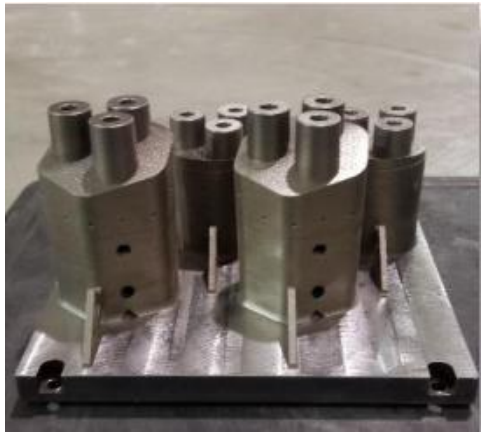


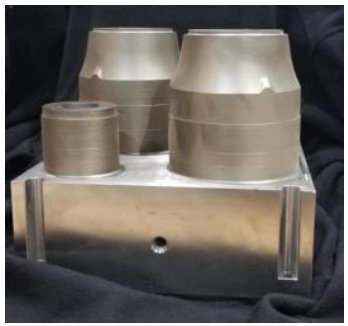
Metal Additive Manufacturing

EOS M280 Laser Powder Bed [DMLS]

- **Conformal Cooling Inserts**
- **Maraging Steel [MS1]**
- **34-36HRC As Printed,**
- **Heat Treat Up To 54-56HRC**
- **Can be Coated, Polished, Grained, etc.**







Metal Additive Manufacturing

Arcam
A GE Additive Company

Arcam Q20+ [EBM]

- **Electron Beam Technology for Titanium Builds**
- **Titanium Alloy Ti6Al4V**
- **No Residual Stress / Martensitic Structures**

Metal Additive Manufacturing

Arcam
A GE Additive Company

Arcam Q20+ [EBM]

- DfAM – Design for Additive Manufacturing
- Gives The Ability To Lighten Parts
- Material & Time Savings

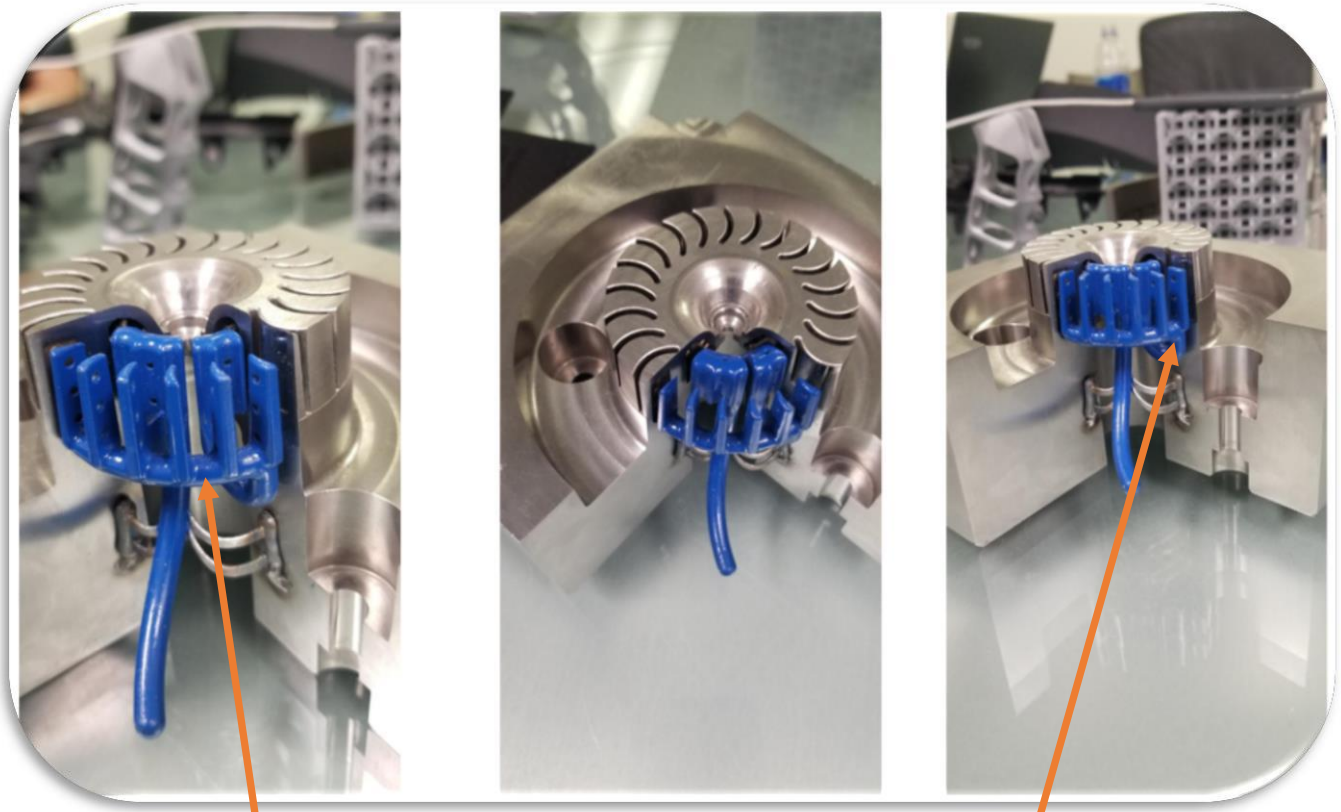
Before (Conventional Design)

Titanium

DfAM (Additive Manufacturing)

Titanium

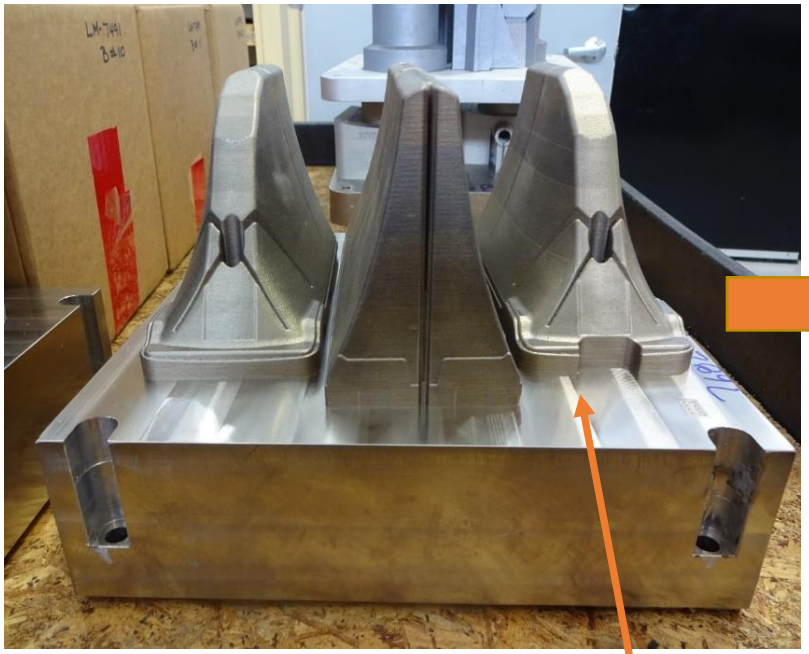
AM – Conformal Cooling Solutions



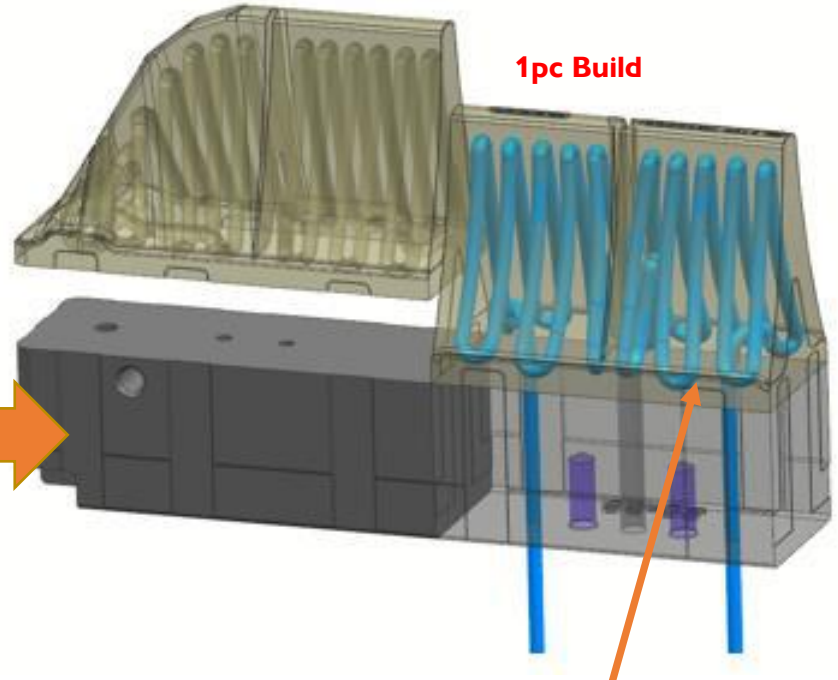
Blue Represents Conformal Cooling Channels
Not Possible with Conventional Machining

AM – Conformal Cooling Solutions

isThermaL Has The Ability To Use Both Conventional & Additive Manufacturing Saving On Time & Cost



Conventionally Machined Build Plate



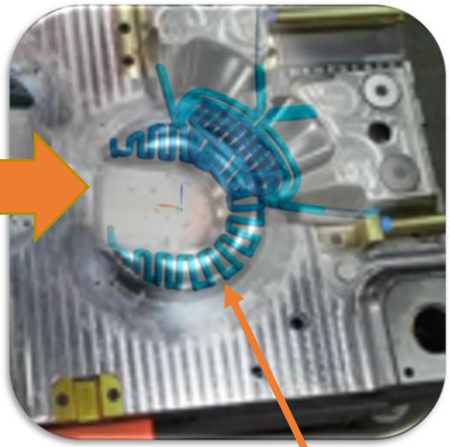
Additive Manufactured Tooling Printed On Top Of Build Plate With Conformal Cooling Channels

AM – Conformal Cooling Solutions

Multiple Inserts Which Utilized Conformal Cooling
Then Integrated Into Existing Tooling

Additive Manufacturing Inserts
(After Finishing)

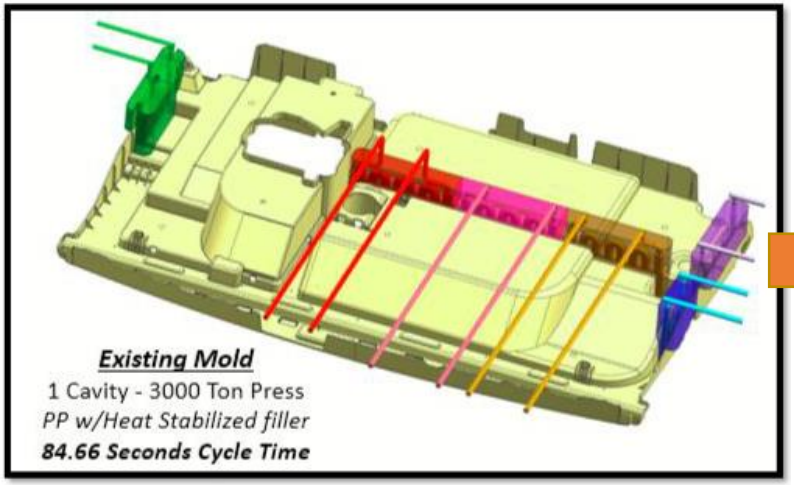
Implemented Into Tooling

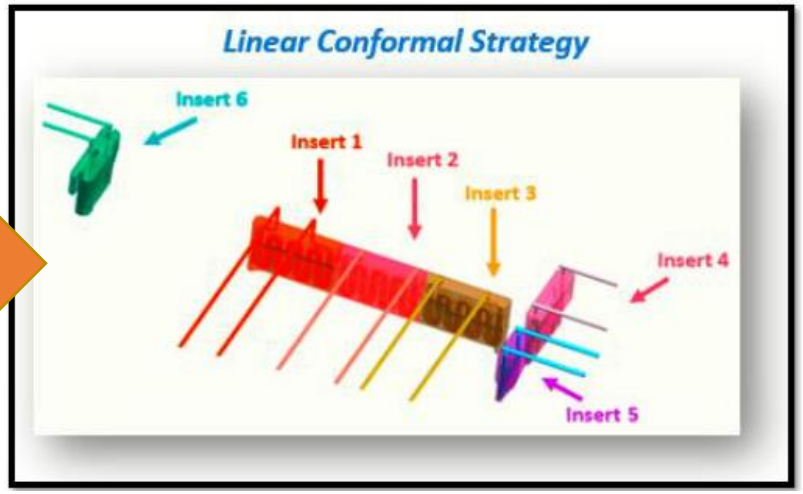


Conformal Cooling Channels Shown

AM – Conformal Cooling Solutions

Multiple Inserts Which Utilized Conformal Cooling Then Integrated Into Existing Tooling





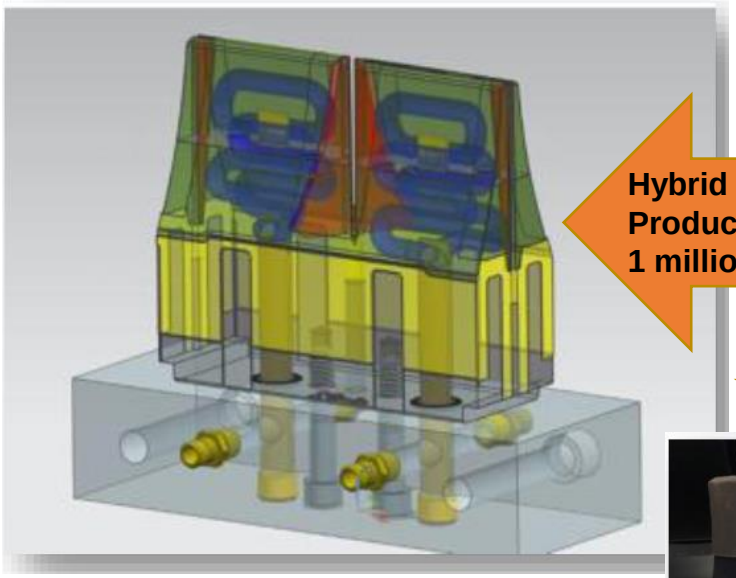
Existing Mold Inserts Modified For AM Targeting Hot Spots

Conformal Cooling Channels Integrated

Original Cycle Time: 84.66s
After Conformal Cooling Cycle Time: 33.7s

AM – Conformal Cooling Solutions

Additive Manufactured Inserts/Tooling Can Be Easily Repaired If Required



Hybrid Insert Produced over 1 million parts

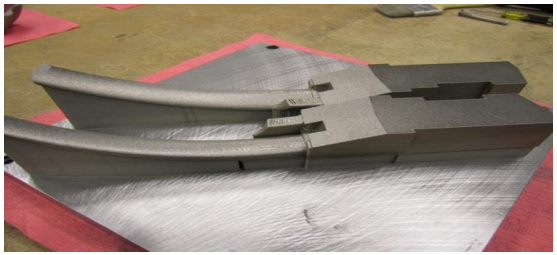
Mold Dmg From Incorrect Part Removal

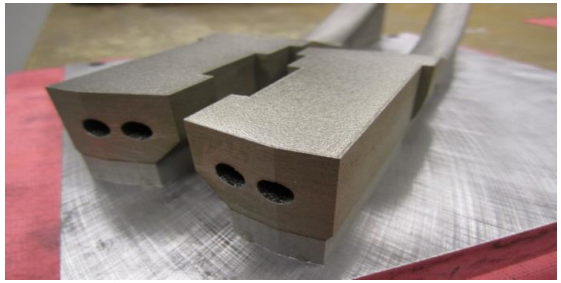
1 Week Repair!

AM – Conformal Cooling Solutions

Case Study 1 – Banana Core
AM Technology – DMLS – Maraging Steel [MS1]

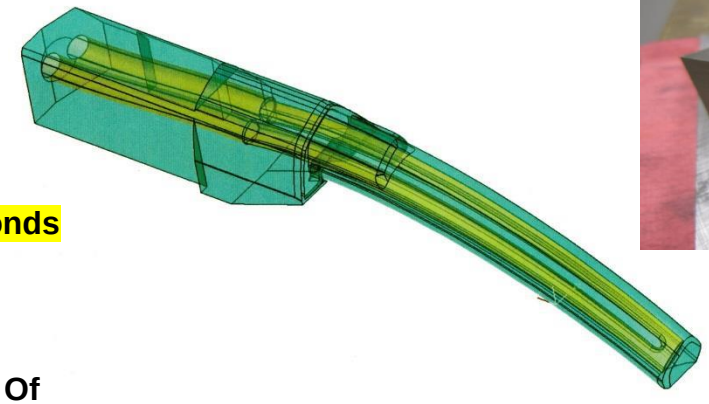
54% Cycle Time Reduction





"Banana core" geometry was redesigned with conformal cooling channels, grown using DMLS technology in order to extend cooling to the problem area of the mold, cooling the entire length.

Core Maintained 72˚F after 11 Hours Of Running Production
Zero Scrap Parts



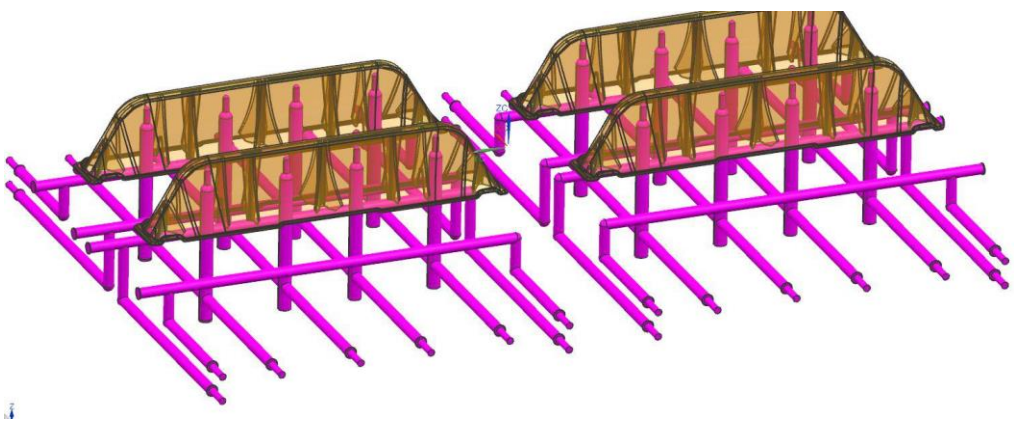
Cycle Time Reduced From 35 to 16 Seconds (54.3% Reduction)

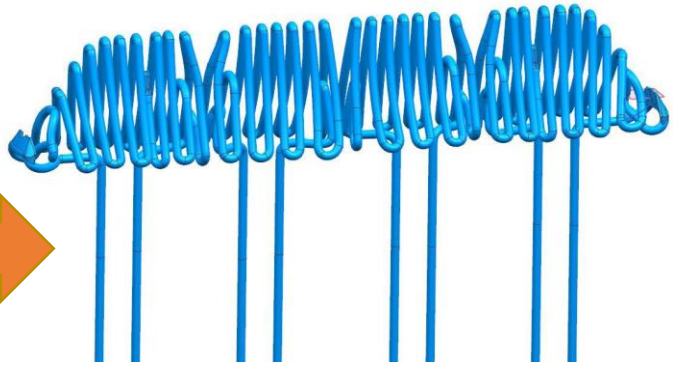
Total Savings:
19 Sec Cycle Reduction With A Demand Of 350,000 Parts Equated to a Total of 1,847 Hours Saved / 76 Days of Reclaimed Capacity

"The quoted cycle was 35 seconds, and we are making the handle in 16 by incorporating conformal cooling into the mold. Before we added the redesigned conformal core, it was not possible to run the tool after 12 shots. So, I would say we have achieved nirvana." - Customer Feedback

AM – Conformal Cooling Solutions

Case Study 2
AM Technology – DMLS – Maraging Steel [MS1]





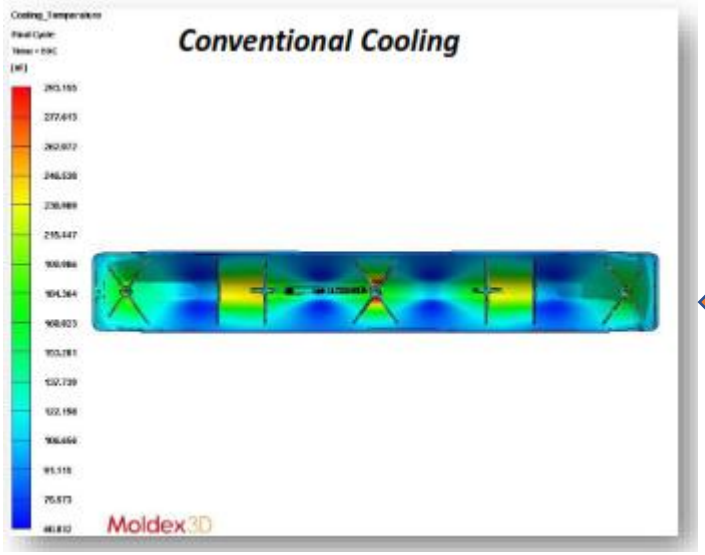
Existing Mold With Conventional Cooling
- **Cycle Time 78sec**
- **Part Distortion**
- **Excessive Scrap**

Conformal Cooling Utilized Into Inserts
- **Cycle Time 42sec**
- **Distortion Corrected**
- **Excessive Scrap Eliminated**

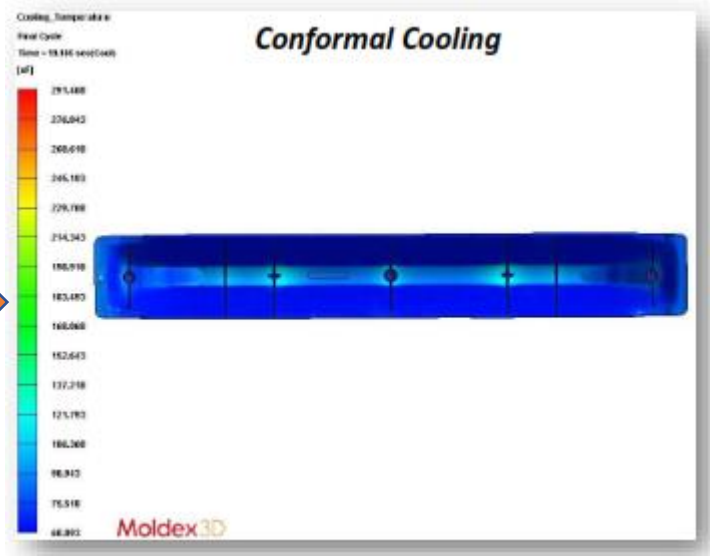
Cycle Time Reduced From 78 to 42 Seconds
(46.2% Reduction)

AM – Conformal Cooling Solutions

Case Study 2
AM Technology – DMLS – Maraging Steel [MS1]



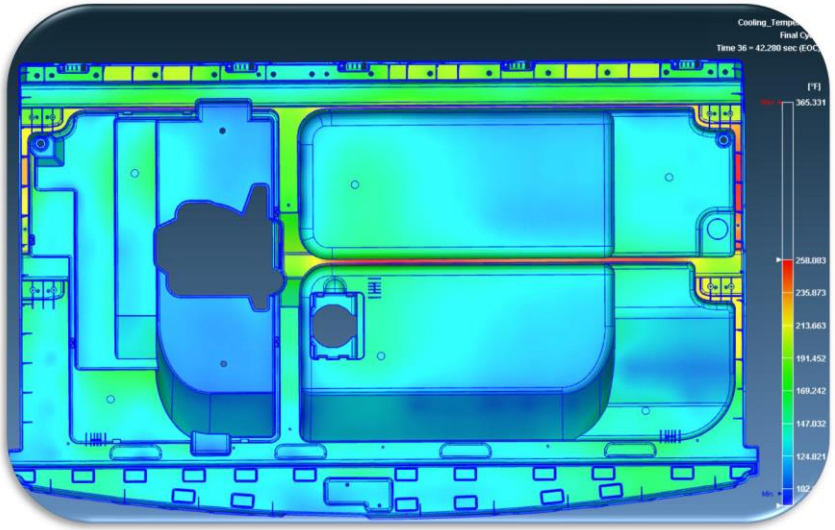
Analysis
Conventional Cooling
VS
Conformal Cooling



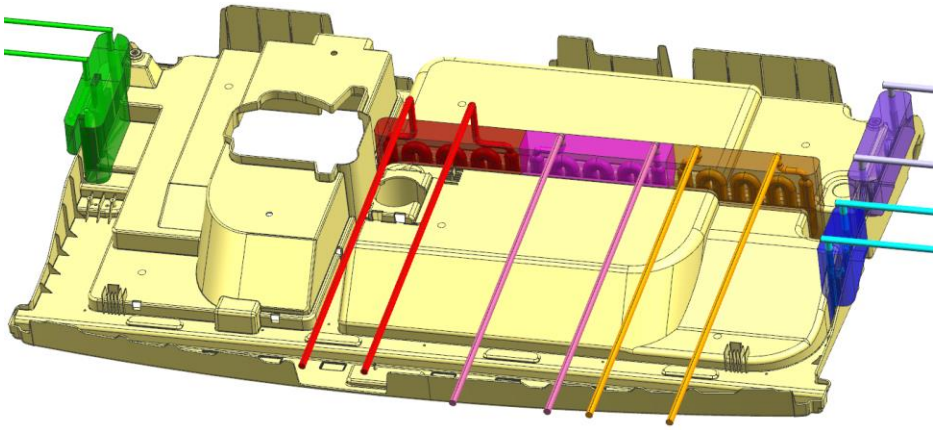
Cycle Time Reduced From 78 to 42 Seconds
(46.2% Reduction)

AM – Conformal Cooling Solutions

Case Study 3
AM Technology – 6 Inserts



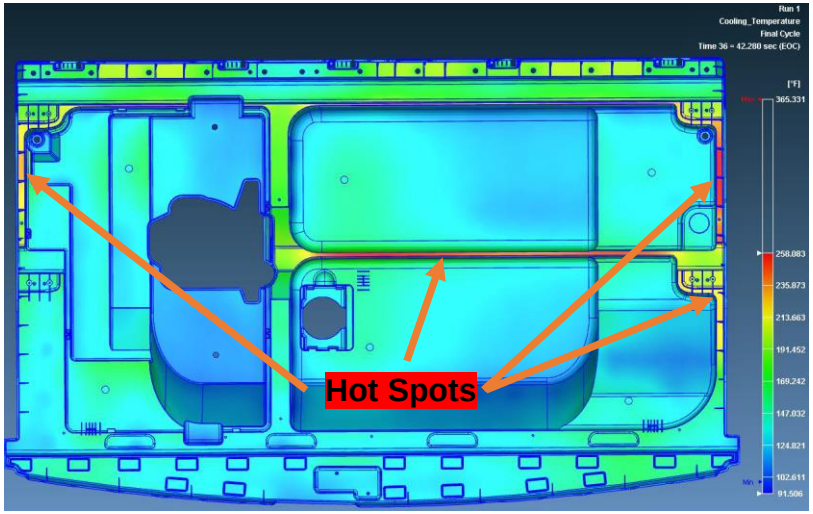
Existing Mold
- **6 Locations Show Excessive Heat**



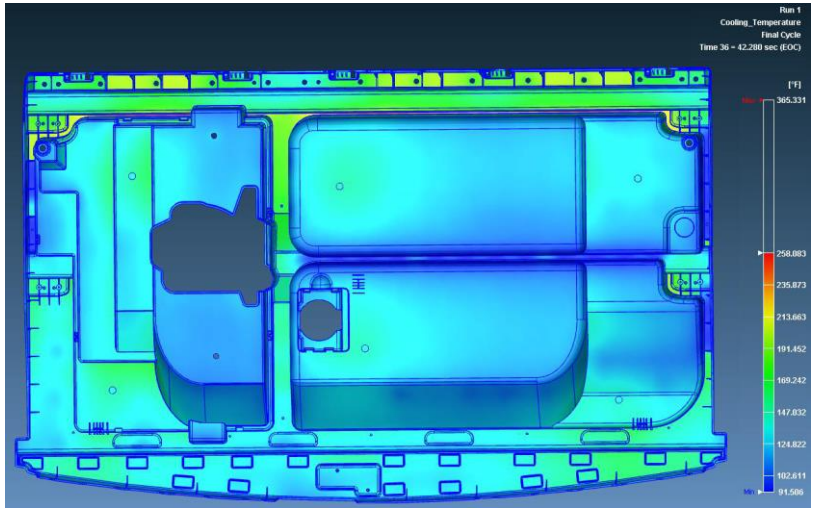
Proposed Conformal Cooling Target Areas
- **6 Inserts**

AM – Conformal Cooling Solutions

Case Study 3
Temperature – End Of Cooling Cycle



Existing Mold
- **6 Locations Show Excessive Heat**
- **Temp Avg: 141.29˚F**
- **Temp Max: 257.55˚F**
- **Temp Min: 99.47˚F**

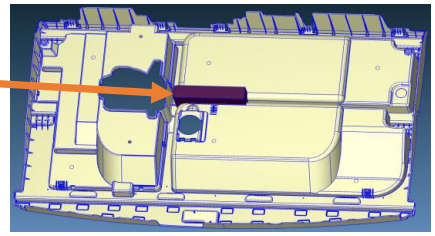


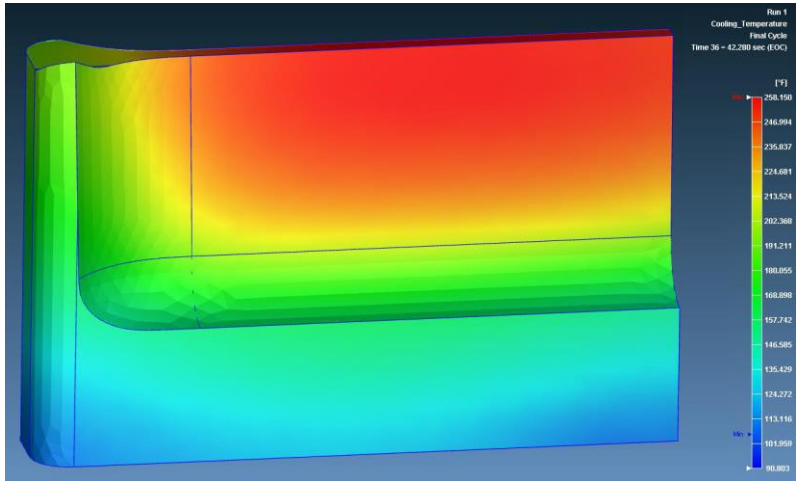
Conformal Cooling Design Integrated
- **6 Inserts**
- **Temp Avg: 131.92˚F**
- **Temp Max: 241.90˚F**
- **Temp Min: 91.51˚F**

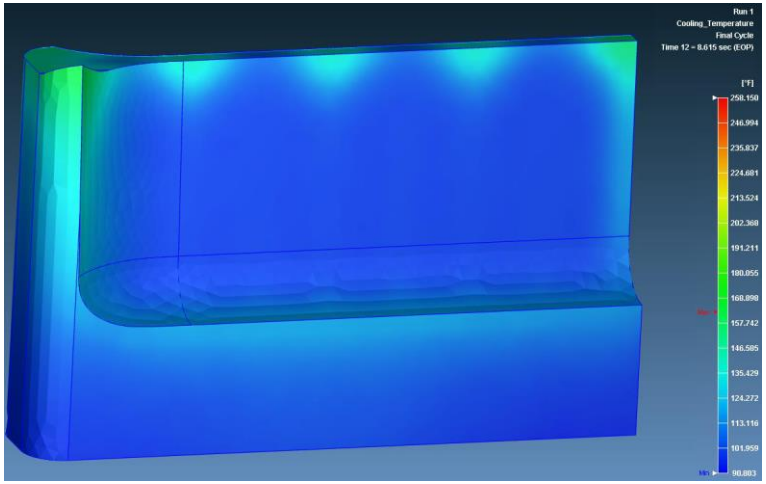
Temperature Improvement
9.37˚F (Avg) / 6.63%

AM – Conformal Cooling Solutions

Case Study 3
Temperature – Insert Review – Insert #1
Surface Temp – End Of Pack (8.614sec)







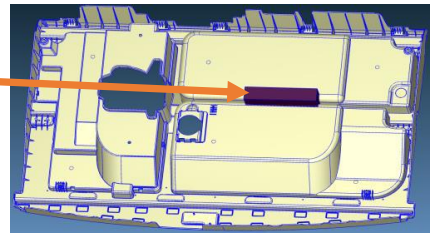
Existing Mold
- **Temp Avg: 178.84˚F**
- **Temp Max: 258.15˚F**
- **Temp Min: 106.13˚F**

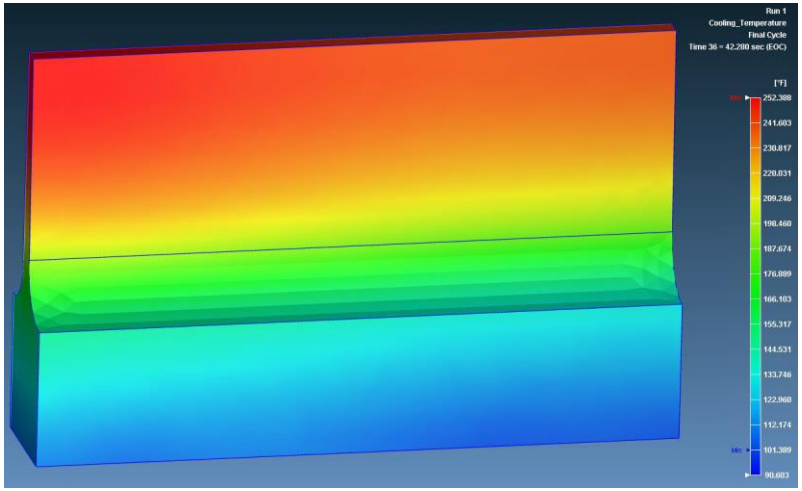
Temperature Improvement
76.46˚F (Avg) / 42.75%

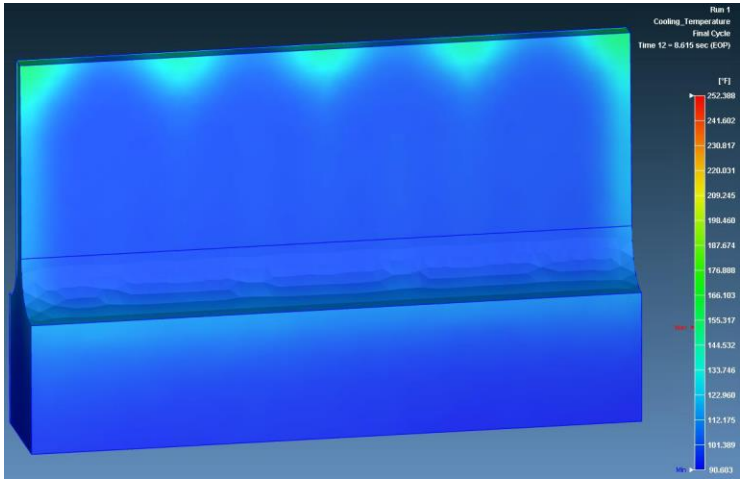
Conformal Cooling Design
- **Temp Avg: 102.38˚F**
- **Temp Max: 162.70˚F**
- **Temp Min: 90.80˚F**

AM – Conformal Cooling Solutions

Case Study 3
Temperature – Insert Review – Insert #2
Surface Temp – End Of Pack (8.614sec)







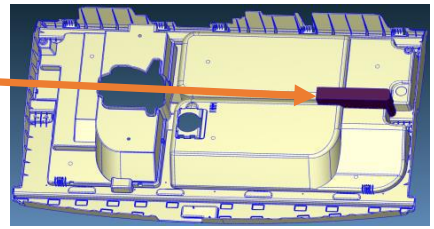
Existing Mold
- **Temp Avg: 171.98˚F**
- **Temp Max: 252.39˚F**
- **Temp Min: 101.17˚F**

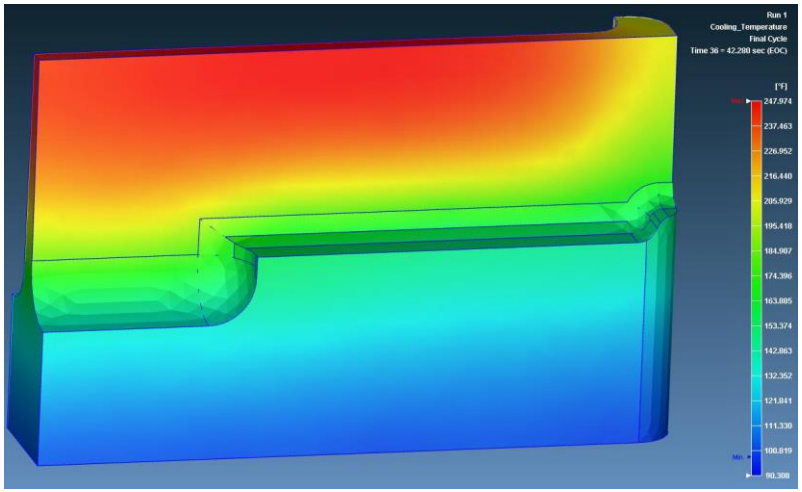
Temperature Improvement
71.90˚F (Avg) / 41.80%

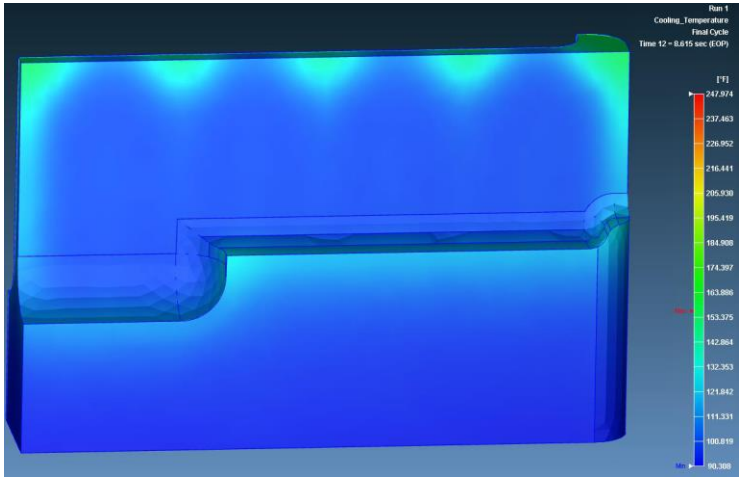
Conformal Cooling Design
- **Temp Avg: 100.8˚F**
- **Temp Max: 152.31˚F**
- **Temp Min: 90.60˚F**

AM – Conformal Cooling Solutions

Case Study 3
Temperature – Insert Review – Insert #3
Surface Temp – End Of Pack (8.614sec)







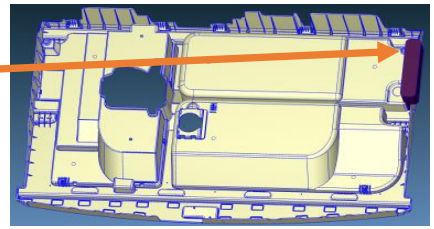
Existing Mold
- **Temp Avg: 161.07˚F**
- **Temp Max: 247.90˚F**
- **Temp Min: 97.99˚F**

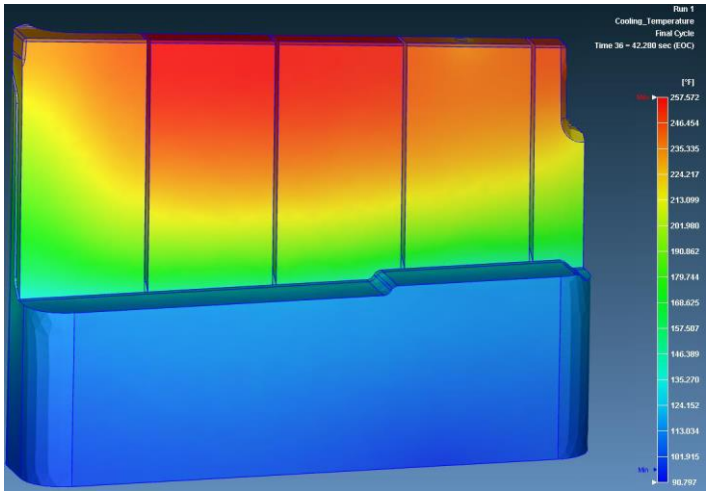
Temperature Improvement
60.98˚F (Avg) / 37.90%

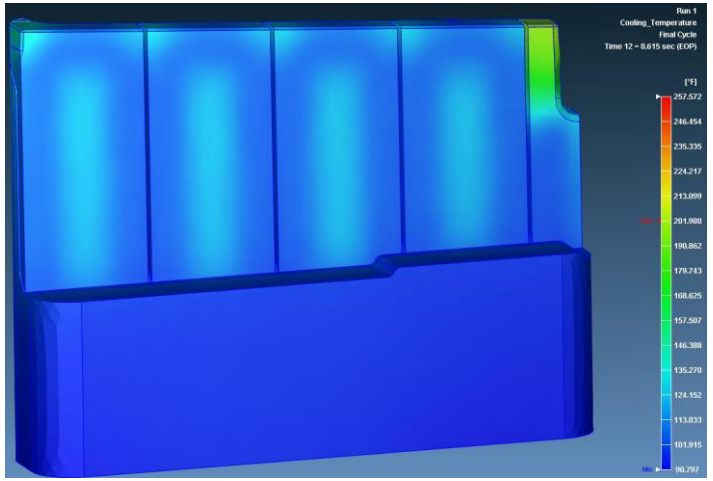
Conformal Cooling Design
- **Temp Avg: 100.09˚F**
- **Temp Max: 155.97˚F**
- **Temp Min: 90.31˚F**

AM – Conformal Cooling Solutions

Case Study 3
Temperature – Insert Review – Insert #4
Surface Temp – End Of Pack (8.614sec)







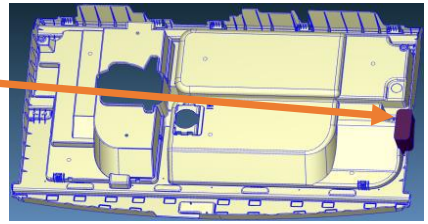
Existing Mold
- **Temp Avg: 168.21˚F**
- **Temp Max: 257.57˚F**
- **Temp Min: 96.24˚F**

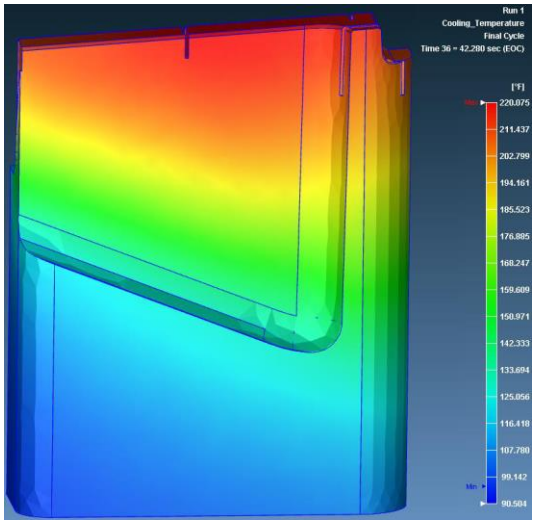
Temperature Improvement
62.90˚F (Avg) / 37.40%

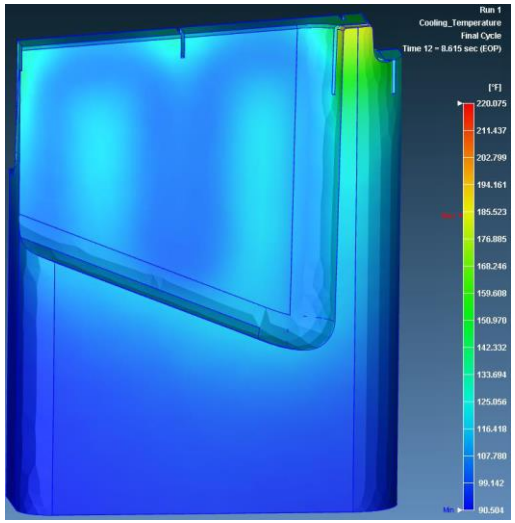
Conformal Cooling Design
- **Temp Avg: 105.31˚F**
- **Temp Max: 202.14˚F**
- **Temp Min: 90.80˚F**

AM – Conformal Cooling Solutions

Case Study 3
Temperature – Insert Review – Insert #5
Surface Temp – End Of Pack (8.614sec)







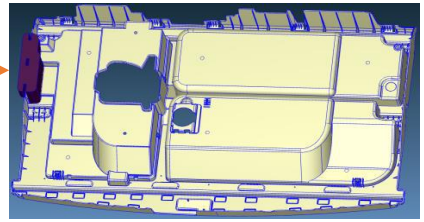
Existing Mold
- **Temp Avg: 143.62˚F**
- **Temp Max: 220.08˚F**
- **Temp Min: 96.02˚F**

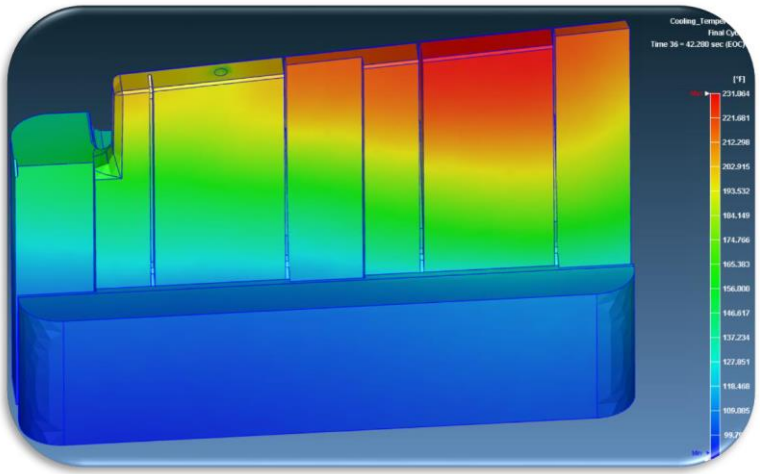
Temperature Improvement
41.65˚F (Avg) / 29.00%

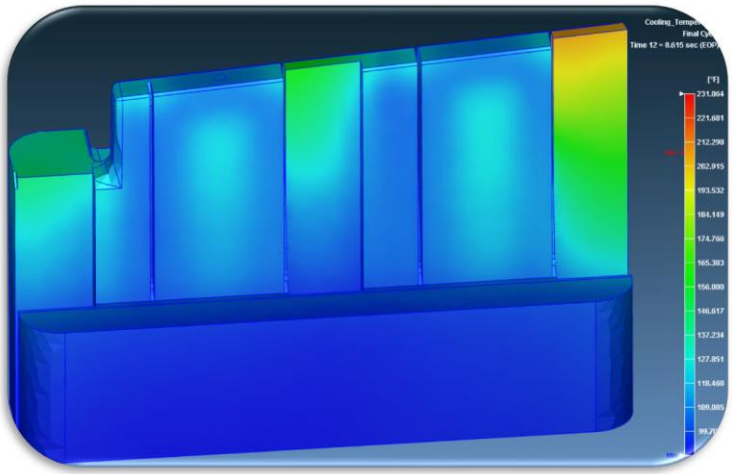
Conformal Cooling Design
- **Temp Avg: 101.97˚F**
- **Temp Max: 184.35˚F**
- **Temp Min: 90.50˚F**

AM – Conformal Cooling Solutions

Case Study 3
Temperature – Insert Review – Insert #6
Surface Temp – End Of Pack (8.614sec)







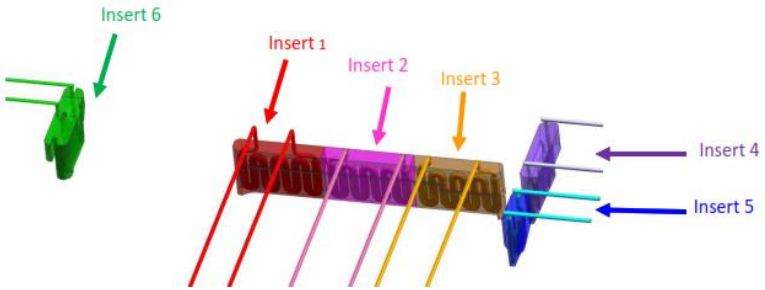
Existing Mold
- **Temp Avg: 136.98˚F**
- **Temp Max: 231.06˚F**
- **Temp Min: 92.78˚F**

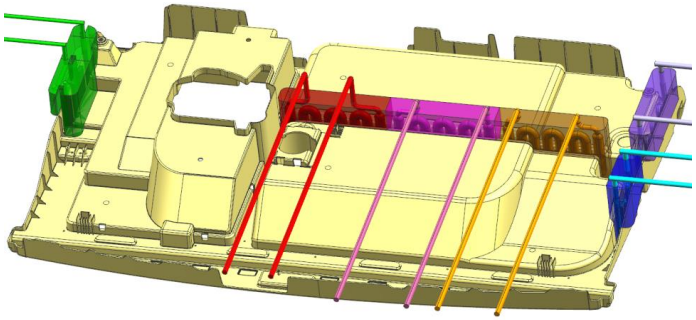
Temperature Improvement
30.34˚F (Avg) / 22.15%

Conformal Cooling Design
- **Temp Avg: 106.64˚F**
- **Temp Max: 208.26˚F**
- **Temp Min: 90.32˚F**

AM – Conformal Cooling Solutions

Case Study 3
Summary Of 6 Inserts



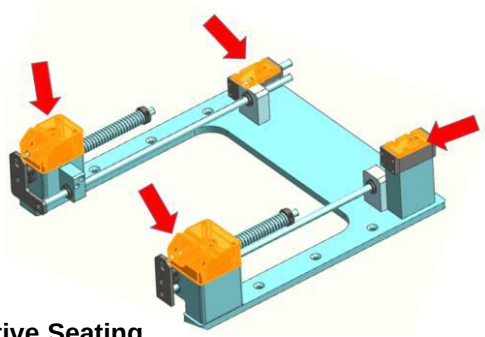


Previous Mold Cycle Time = 84.66 sec
After Conformal Cooling Design = 50.96 sec

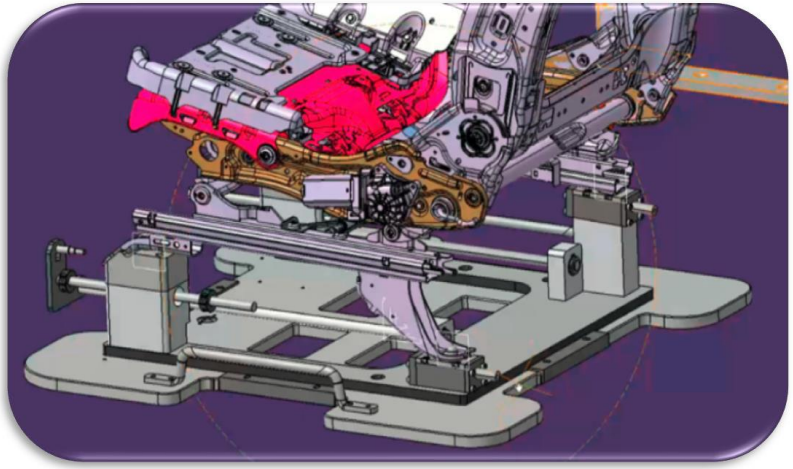
Cycle Time Reduction 33.7 sec
Cycle Time Improvement 39.8%

AM - Gauges & Fixtures

Hybrid Assembly



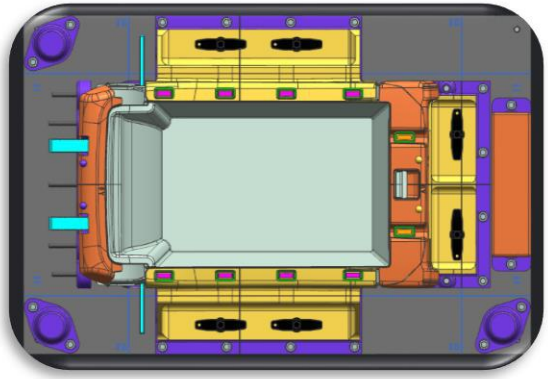
Automotive Seating

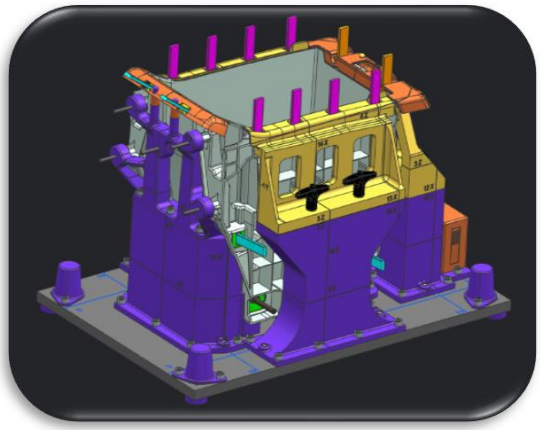


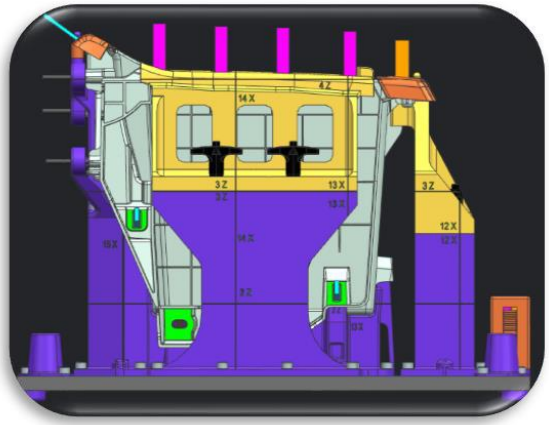
Bridging AM Metal & AM Polymer

AM - Gauges & Fixtures

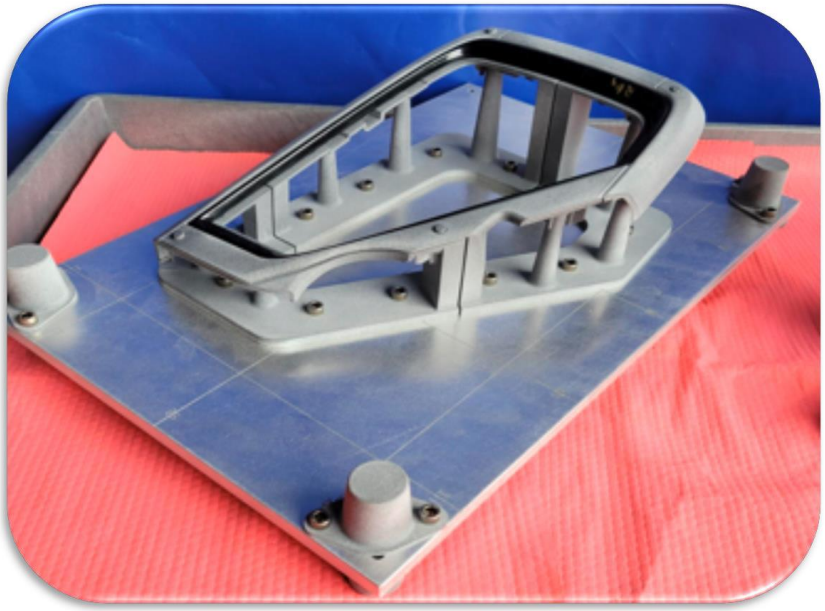
- Purple Represents Permanent Fixture Components
- Orange & Yellow Represents Modular Fixture Components To Be Loaded After Part Is Secured To The Cradle
- 1mm/3mm Scribe Line And Gap Check
- 5 Location Sheet Metal Alignment Pins





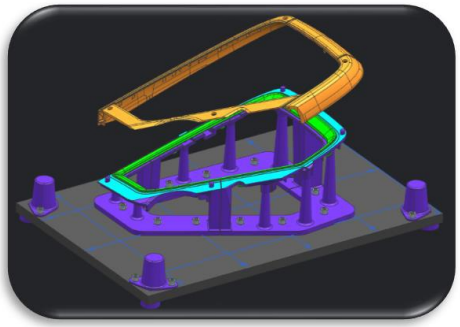


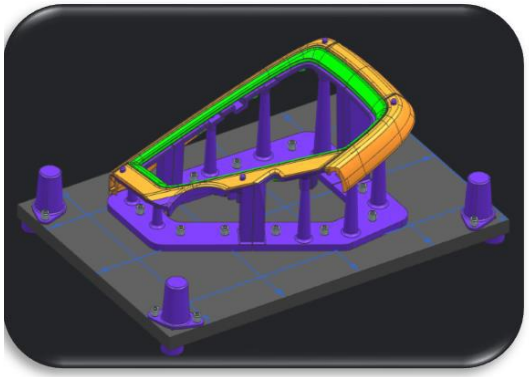
AM - Gauges & Fixtures



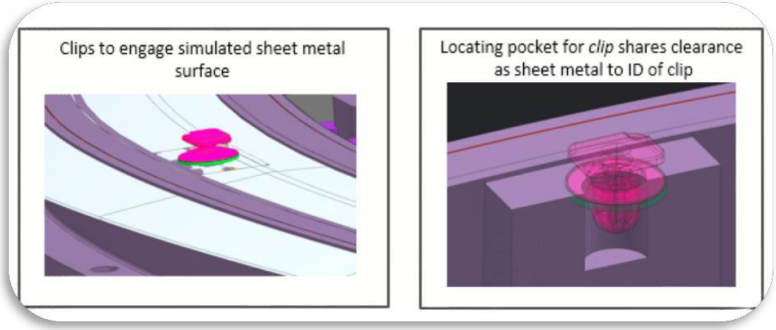
Bridging AM Metal & AM Polymer

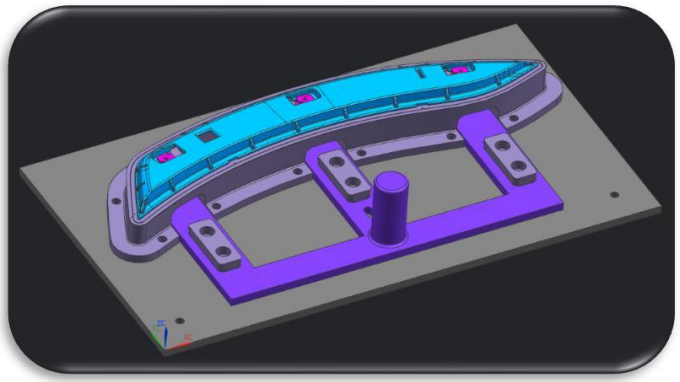
- **Purple Represents Permanent Fixture Components**
- **Orange Represents Modular Fixture Component For Gap Check To The Part**
- **3mm Scribe Line And Gap Check**

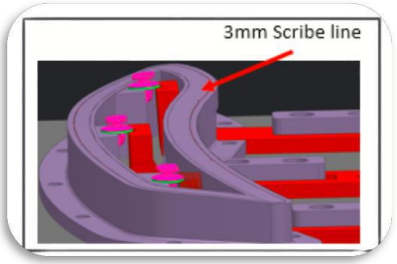




AM - Gauges & Fixtures







AM – Multi-Jet Fusion

HP-MJF 4210

- PA12
- Hardness Shore A:91 (Post Build)
- Surface Roughness (Post Build)
- Build Area 380mm x 284mm x 380mm

AM Material Properties / Build Resolutions

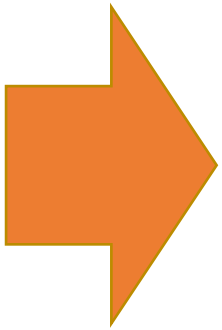
Material	Machine	Build Envelope	Particle Size	Layer Thickness	Hardness (Post Build)	Surface Roughness (Post Build)	Tensile Strength
PA12	HP4210	380 x 284 x 380mm	54µm	80µm	Hardness Shore A:91	Hardness Shore D:80	XY&Z: 48 Mpa

AM – Multi-Jet Fusion

HP-MJF 4210

- No Tooling Required = Fast Parts
- Multiple Designs and Iterations At One Time
- Up To 10x Fast And 50% Less Costly Than Conventional Processes
- Great For Complex Geometries Not Achievable By Conventional Methods
- Excellent Dimensional Accuracy And Fine Detail
- Prototype T Production Volume Output

How It Works

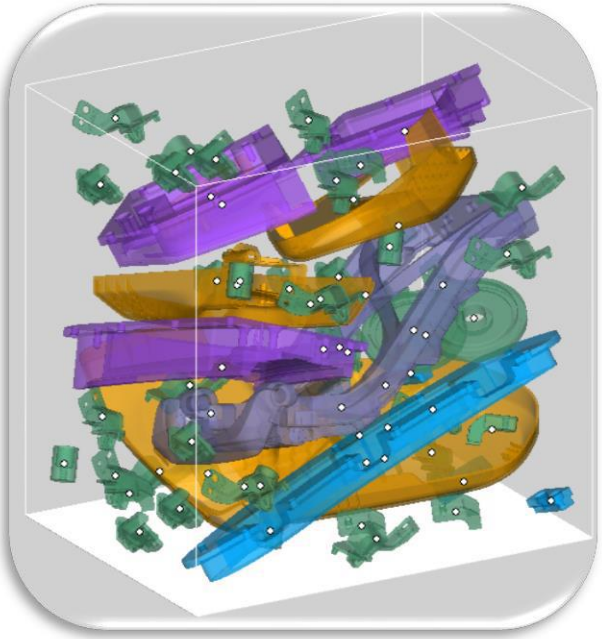


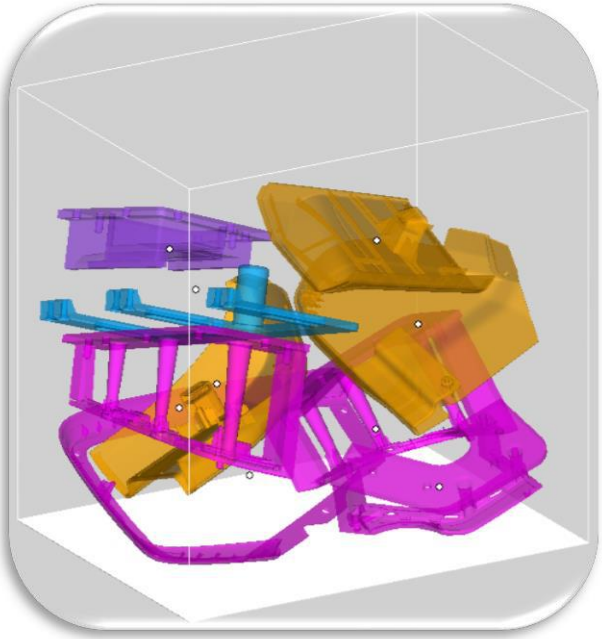
- Nylon powder is laid in a thin layer across the working area and is then scanned by the material coater carriage from top to bottom.
- The printing and fusing carriage with an HP thermal inkjet array and energy sources scans from right to left. Functional agents are printed in precise locations to define the part's geometry and properties and is then scanned by the printing and fusing carriage.
- After the work area is retracted, the material coater carriage scans in the reverse direction and the process is continued layer by layer until the part is completed. Once the part is completed, it is moved to post processing where it is bead blasted and finished.

AM – Multi-Jet Fusion

HP-MJF 4210

- **Multiple Build Configurations**
- **Fully Assemblies In One Print**
- **Typical Build Takes 20 Hours, Plus 30-40 Hours Cooling Time**

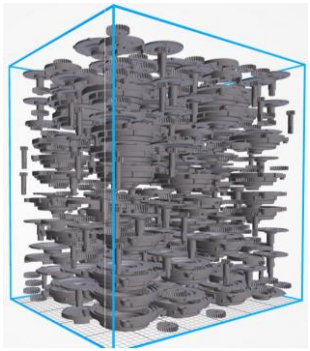




AM – Multi-Jet Fusion

HP-MJF 4210

- **Save Cost & Time**
- **Four Days - 60 Assemblies**



60 Complete Assemblies In One Build

Multi-Jet Fusion

$3,250.00
$54.16 Per Assembly
No Tooling Cost
8 Unique Parts
Delivery 4 Days

VS

Injection Molding

$59,275 Tooling
Additional Molding Costs
5 Injection Molds
Design Changes Extra Weeks To Mfg