Stratasys

Technology And Applications

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We help our customers to growth up.

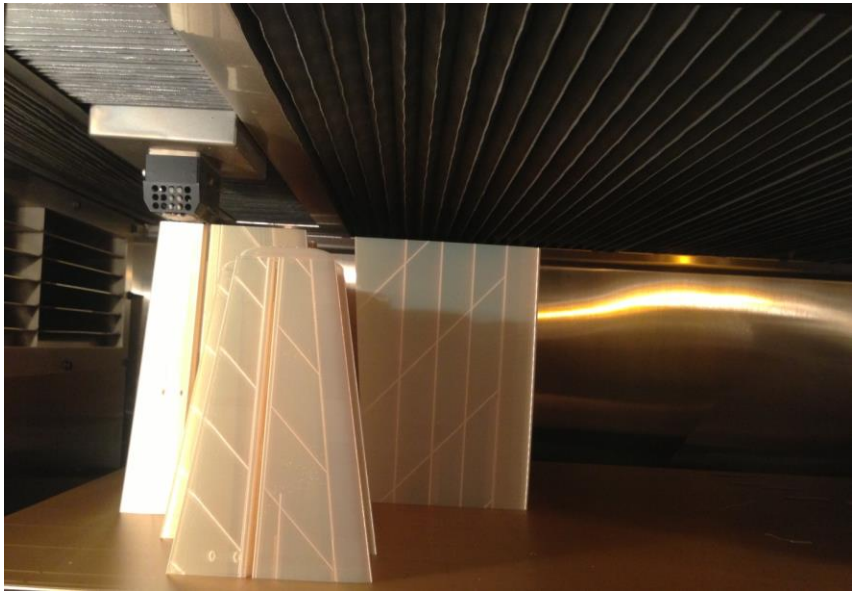
Emanuele D'Addario
DDM Business Development

Agenda

- Introductions
- What Is FDM?
- Applications
- Software Introduction
- Special Questions

What Is FDM?

- Technology
- Materials
- Machines



FDM Material Value

- Production Grade Thermoplastics
  - Excellent Mechanical And Thermal Properties
  - Capable Of End-use Part Production
- High Accuracy
  - Stable Material Properties Lead To Accurate Parts
  - Accuracy Up To +/- .089 mm Or +/- .0015 mm Per mm
- Stable Materials
  - Accurate Assessment Of Design, Regardless Of Environment
  - Accurate Functional Testing Over Time
- Repeatability
  - Stable And Predictable Materials For Repeatable Results
  - Enables DDM (Direct Digital Manufacturing) Applications

Fortus 900MC

- 914mm X 610mm X 914mm Build Area
- Widest Range Of Thermoplastics
- Three Layer Thicknesses
  - 0.178mm
  - 0.254mm
  - 0.330mm
- Good Accuracy And Repeatability
  - ± 0.090 mm Or ± 0.0015mm/mm

Standard Materials

ABS-M30

- 6 Colors Available
- Great For
  - Prototypes

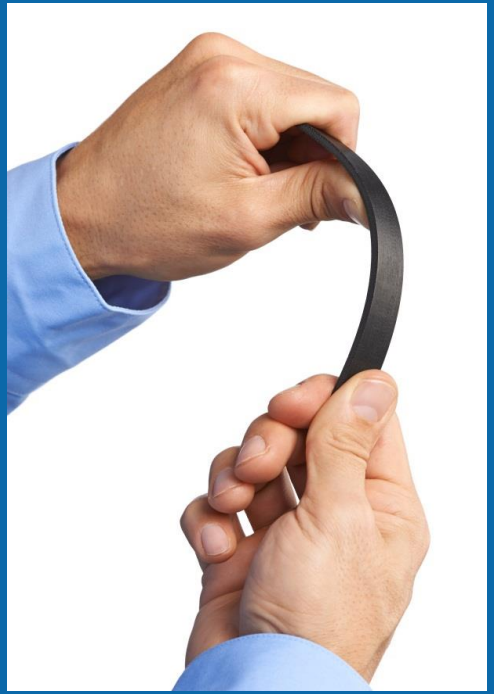
ABS-ESD7

- Electrical Conductivity
- Great For
  - Electrical Assembly Tooling

ASA

- UV Resistant
- Best Material For Light Weight Parts
- Great For
  - Parts Exposed To Sunlight

Engineered Materials



Nylon 12

- Most Flexible FDM Material
- Highest Impact Resistance
- Great For
  - Shop Floor Tooling
  - End Use Parts

PC-ABS

- Good Ascetics
- High Impact Resistance
- Great For
  - End Use Parts
  - Assembly Fixtures

Engineered Materials

PC

- High Tensile And Flexural Strength
- Moderate Heat And Chemical Resistance
- Great For
  - High Requirement Prototypes
  - Manufacturing Tools
  - Wind Tunnel Testing

PC-ISO

- Good Ascetics
- High Impact Resistance
- Great For
  - End Use Parts
  - Assembly Fixtures

Performance Materials

PPSF

- Highest Chemical Resistance
- High Temperature (189C HDT)
- Great For
  - Chemical Exposed Parts
  - Special Applications

ULTEM 9085

- High Strength
- High Temperature (153C HDT)
- FST And V-0 Rating
- Great For
  - Manufacturing Tooling
  - End Use Parts

Performance Materials

ULTEM 1010

- High Stiffness
- High Chemical Resistance
- High Temperature (213C HDT)
- Biocompatibility (ISO10993)
- Food Grade (NSF-51)
- Low Thermal Expansion (47 Mm/(M·°c))
- Great For
  - High Temperature Applications
  - Composite Tooling
  - End Use Parts

Applications

- Functional Prototypes
- Metal Forming Tools
- Thermoforming Tools
- Casting
- Composite Tooling
- Jigs and Fixtures
- Wind Tunnel Testing

Functional Prototypes

Traditional Use Of All Additive Manufacturing

- Use The Final Production Material
- Quickly Produce And Test Designs
- Reduce Time To Market
- Fully Functional Parts

End Use Parts

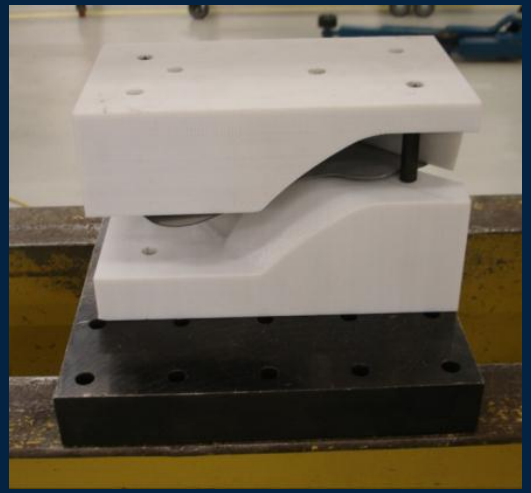
Great for

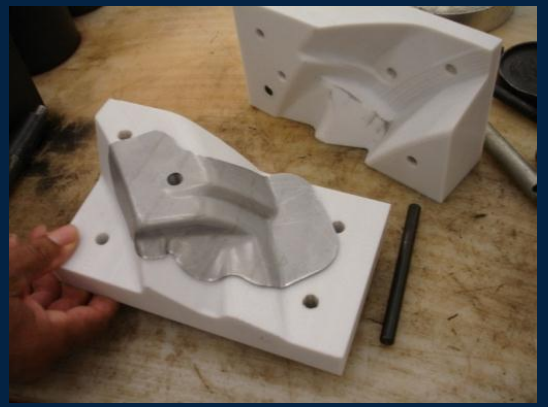
- Bridge To Production
- Bridge To End Of Life
- Customized Products
- Short Production Runs
- Otherwise Impossible Components

Metal Forming Tools

Process

- Tool Design
- Build Tool From Suitable Material
- Finish Tool As Desired
  - Important For Thicknesses Less Than 2mm
- Form Metal Directly On FDM Tool
- No Need To Catalog Tool
  - Quick To Reproduce





Metal Forming Tools

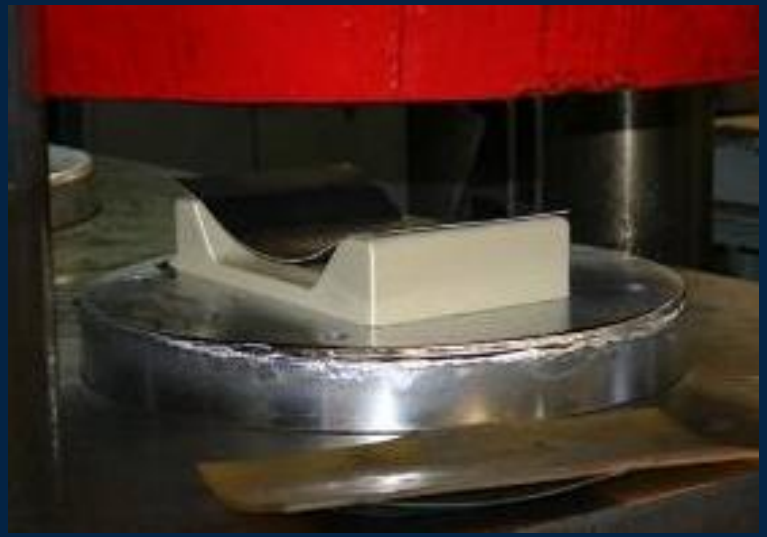
Limits

- Maximum Compressive Strength Varies By Material
  - ABS ~ 200 Bar
  - PC ~ 400 Bar
  - Ultem9085 ~ 900 Bar
- Great For Short Runs Of Parts
  - 1-100 Parts
- Tested With Multiple Processes
  - Hydro Forming
  - Stamping
  - Stretch Forming
  - Rubber Pad Press

Metal Forming Tools

Design Considerations

- Spring Back Is Less Than Steel Tooling
- Only Put Material Where You Need It
- Deep Draws May Require Intensifiers



Vacuum Forming Tools

Process

- Design Tool
  - No Need For Drilling Air Passages
- Build Tool
- Finish As Desired
  - Thin Sheets Could Show FDM Patterns
- Produce Parts

Vacuum Forming Tools

Limits

- Temperature Limits Depend On Material
  - ABS– 95c
  - PC– 138c
  - ULTEM 9085 – 153C
  - ULTEM 1010 – 214C
- Great For Short To Medium Runs
  - 1-1,000
- Cycle Times Are Increased Vs Metallic

Vacuum Forming Tools

Design Considerations

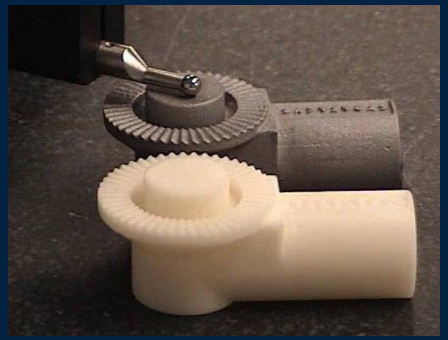
- General Tooling Design
- Natural Porosity Saves Time/Money
  - Vacuum Passages Are Set In Insight
- Vacuum Will Flow In Z More Than X-Y

Investment Casting

Process

- Produce Patterns Directly From FDM
- Finish As Desired
- Add FDM Part To Tree
- Coat With Ceramic Burn Out FDM Part
- Clean Out Ceramic Pattern
  - Ash Content Is ~3% By Weight For ABS
- Produce Metal Part

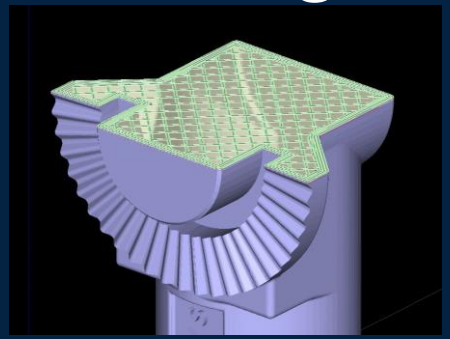
Investment Casting

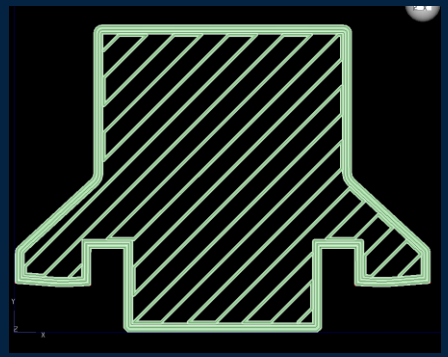


Limits

- Very Small Parts Are Better Produced With Wax
- Burn-out Process Is Different Than Melting Wax
- Best For 1-100 Parts

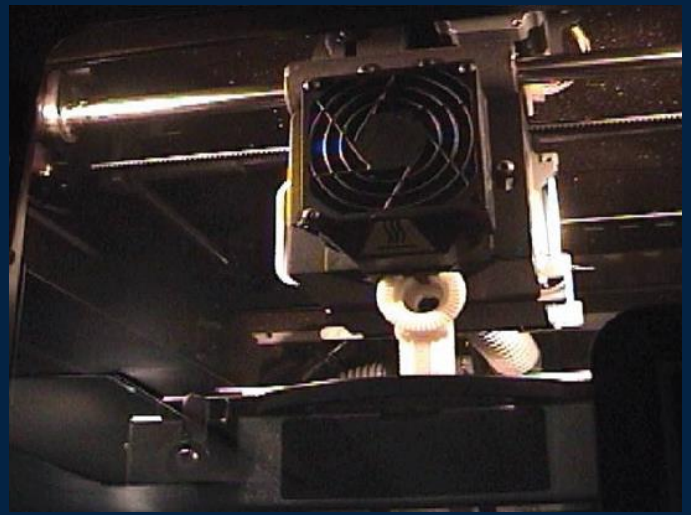
Investment Casting





Design Considerations

- Parts Should Be Built As Light Weight As Possible
  - Use Insight To Control Density
  - Less Material = Less Ash To Clean Out
- ASA Or ABS Should Be Used



Sand Casting

Process

- Produce Needed FDM Component
  - Match Plates
  - Split Patterns
  - Loose Patterns
  - Core Boxes
- Use Pattern To Create Sand Casting Mold
- Create Metal Parts

Sand Casting

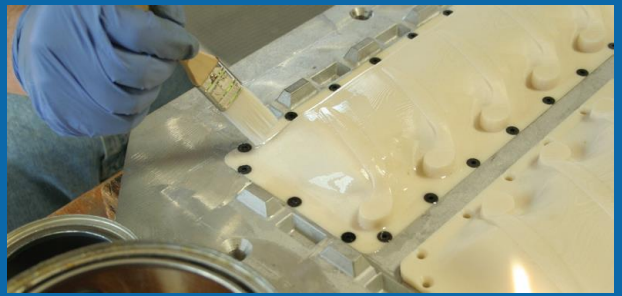
Limits

- Size Limited By FDM Build System
  - Models Can Be Joined To Overcome This
- Compaction Pressure Below 200 Bar For ABS
  - Higher With Other Materials
- Best For Low To Moderate Volumes
  - 5,000+

Sand Casting

Design Considerations

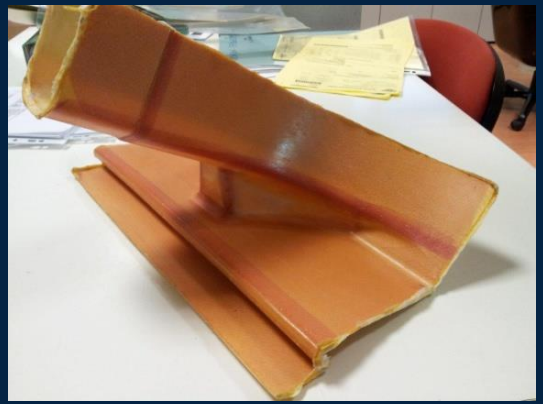
- Correct Material For Compressive Force
  - ABS ~ 200 Bar
  - PC ~ 400 Bar
  - ULTEM 9085 ~ 700 Bar
- Use FDM For The Complex Areas Of Patterns
  - Mold Inserts
- Finish FDM To Reach Required Surface Finish



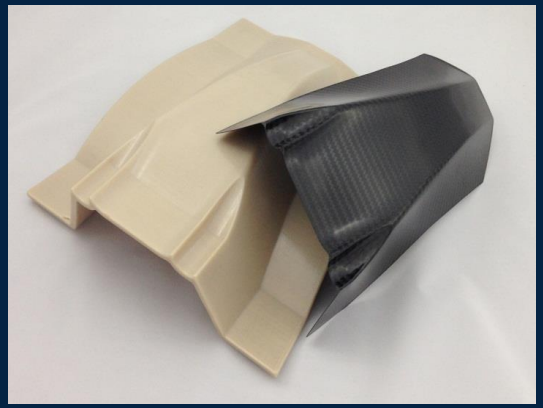
Composite Tooling

Process

- Design Tool
- Build FDM Tool
- Finish And Seal Tool
- Apply Release Agent
- Produce Parts
- Repeat



Composite Tooling



Limits

- Temperature Limits Depend On Material
  - ABS – 95C
  - PC – 138C
  - Ultem 9085 – 168C
  - Ultem 1010 – 214C
- Full Autoclave Pressure Is OK
- Thermal Expansion Of FDM Materials Must Be Considered
- Great For Short To Medium Runs
  - 1-100 Parts

Composite Tooling

Design Considerations

- Thin Tools Work Well With Envelope Bagging
  - Offsets Should Be Made In Insight
- CTE Of Materials Are Listed On Data Sheets
- Only Put Material Where Needed
  - Less Material = Less Time And Cost

Soluble Cores

Process

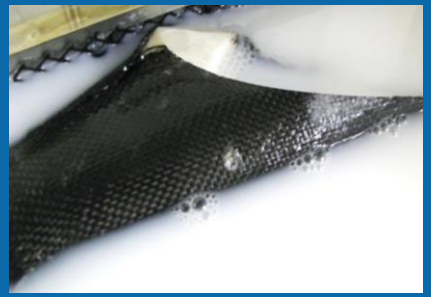
- Design Core Based On Internal Geometry
- Smooth And Seal Core
- Lay-up Composites And Consolidate
- Dissolve Core In Cleaning Tank
- Trim And Polish Finial Part As Desired

Soluble Cores

Limits

- Temperature Limits Depend On Material
  - SR30 – 80C
  - SR100 – 120C
- Full Autoclave Pressure Is OK
- Thermal Expansion Of FDM Materials Must Be Considered
- Great For Short To Medium Runs
  - 1-100 Parts

Soluble Cores



Design Considerations

- Design Internal Geometry Instead Of Tooling
- Optional
  - Design Flow Passages For Wash-Out
- Use CAD Data To Design Trim Tools

Jigs and Fixtures

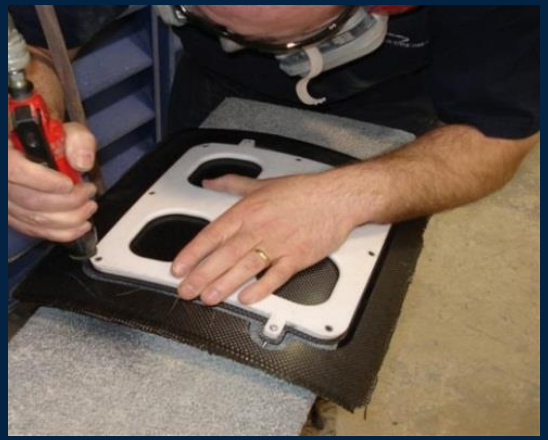
Process

- Used In Many Different Ways
  - Test Fixtures
  - Holding
  - Automation
  - Quality Control

Jigs and Fixtures

Limits

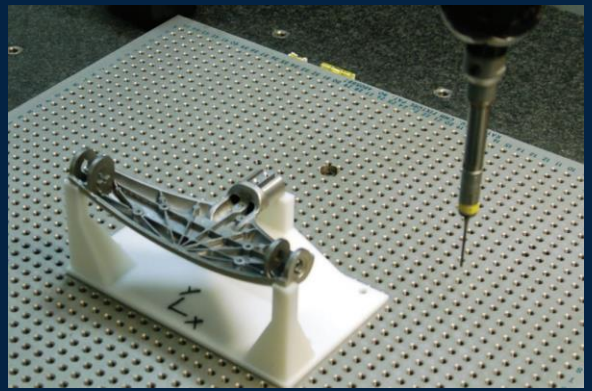
- Limits Are Defined By Material Data Sheets
  - Temperature
  - Strength
  - Stiffness

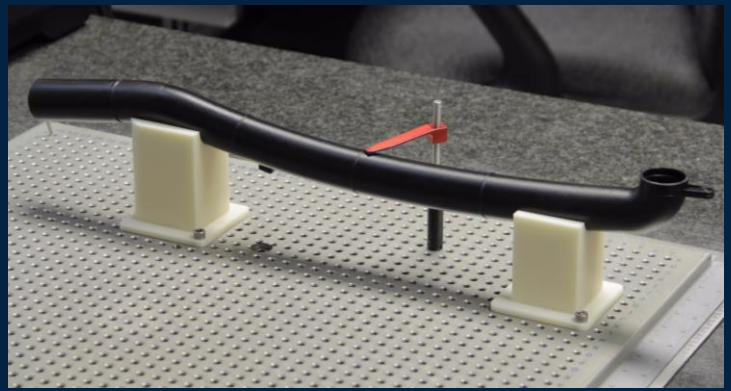


Jigs and Fixtures

Design Considerations

- Only Put Material Where It Needs To Be
- Design For Function
- Wear Surfaces Can Be Coated Or Platted To Increase
- Can Be Machined To Achieve Tighter Tolerances

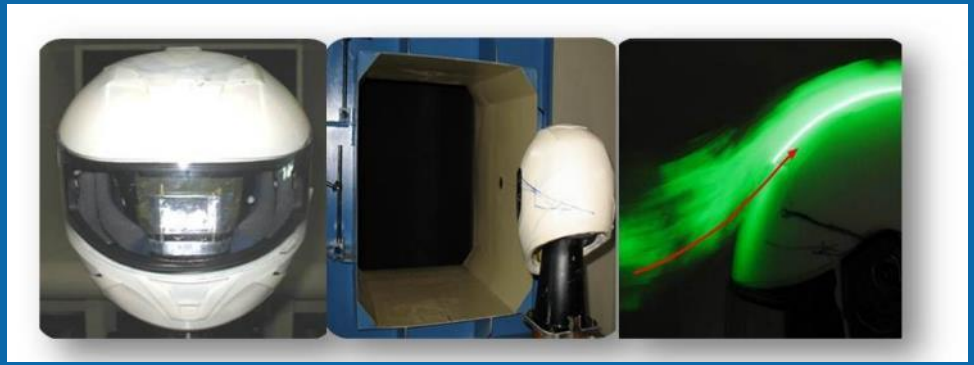




Wind Tunnel Testing

Process

- Design Component
- Build
- Finish As Needed For Surface Quality
  - Sanding, Painting, And Epoxy Fillers
- Test Components
- Repeat As Needed



Wind Tunnel Testing

General Considerations

- Low Speed Wind Tunnels
  - Ultra Sonic For Short Times
- Flexural Modulus Of Materials Should Be Noted

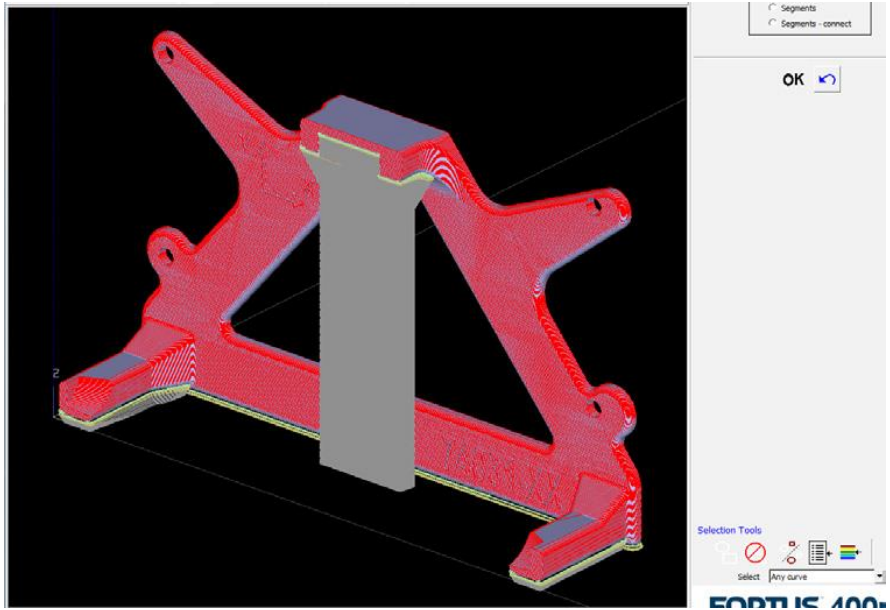
Wind Tunnel Testing

Design Considerations

- Parts should be built for best surface finish
  - Thin Layers
  - Proper orientation
- All Material Data Sheets Have Flexibility Data
- Insert Stiffeners In Long, Thin Features

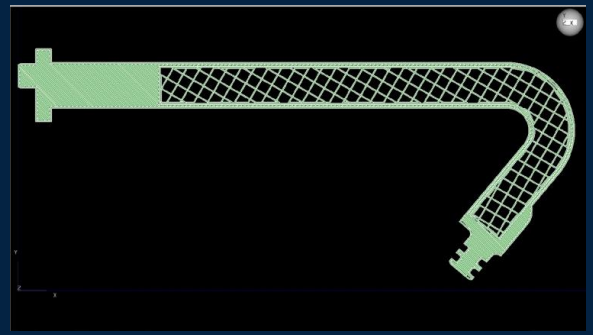
Software Introduction

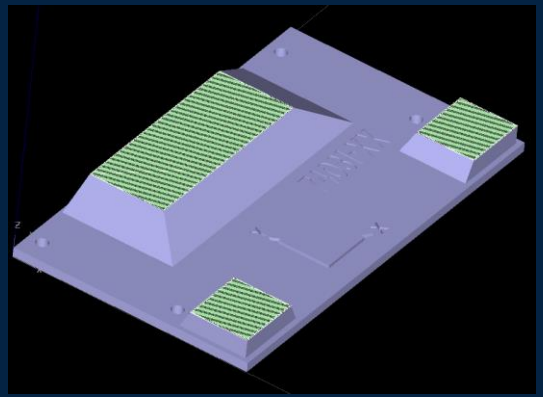
- Basic Overview
- Different Build Styles
- Design for FDM



Basic Overview

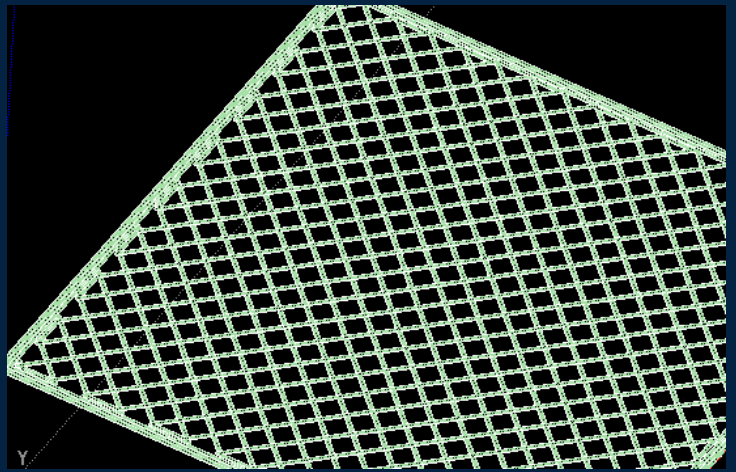
- Insight Software
- Basic Functions
  - Orientate Part
  - Slice
  - Support
  - Build!
- What It Shows
  - Model And Support Material
  - Toolpaths
  - Build Times And Material Usage





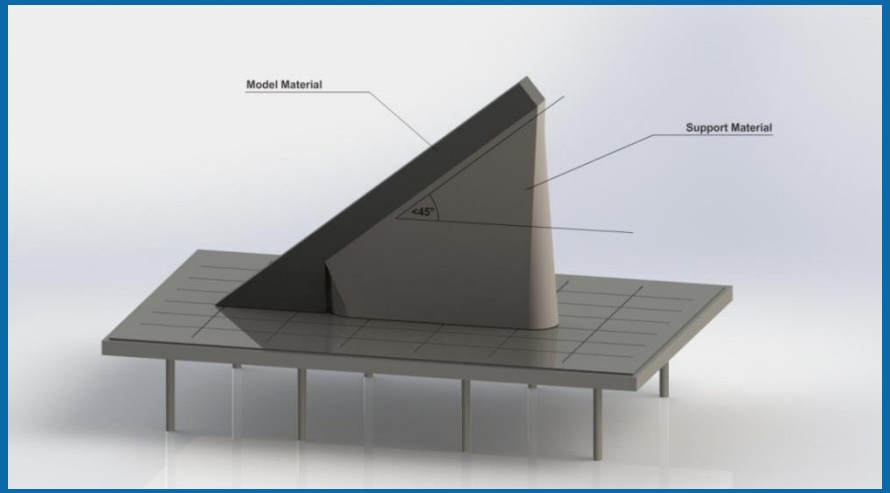
Build Style Differences

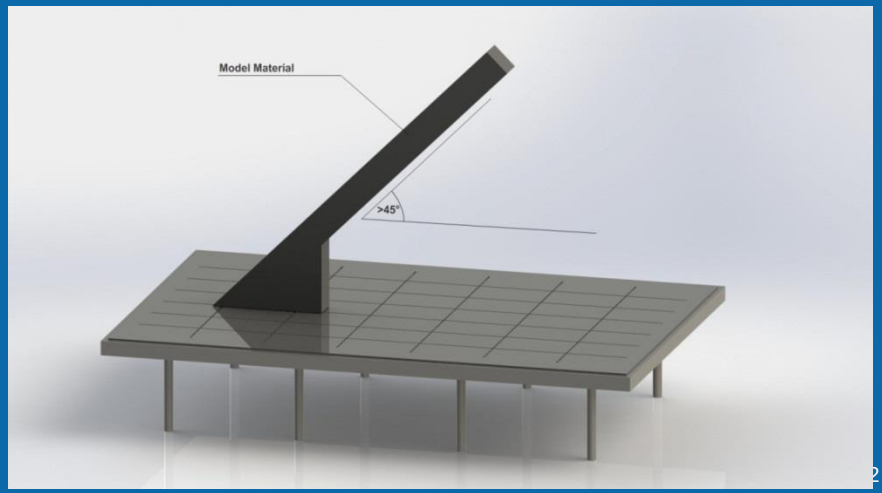
- Solid
- Sparse
- Sparse Double Dense
- Inverted Materials



Design For FDM

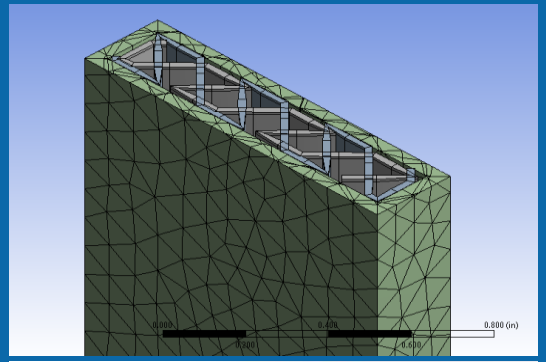
- Self Supporting Angles
  - 45 Degrees
- Thin Walled Tubes
  - Why Offsetting In CAD Is A Challenge
- Thin Walled Tooling

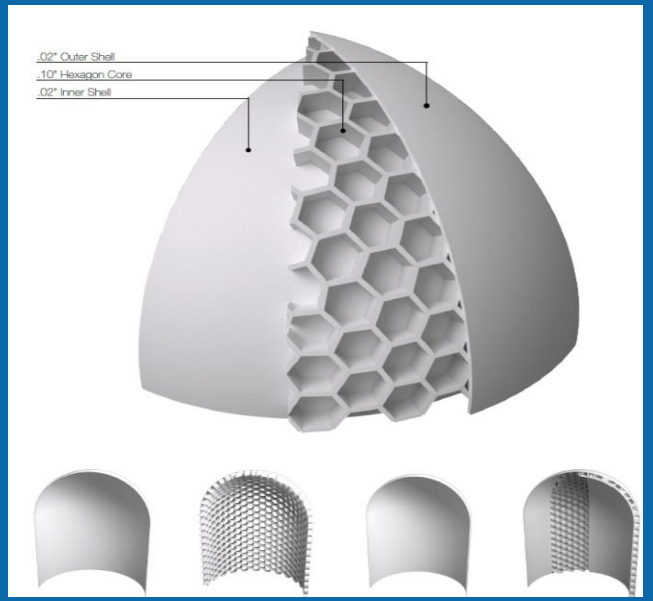




Design for FDM

- Add Material Only Where Needed
- Topology Optimization Results Can Now Be Produced
- Complexity Does Not Add Cost





Design for FDM

End Of Arm Tool Example

- Remove Unnecessary Mass
- Create Self-Supporting Angles
- Optimal Mass Distribution
  - Hollow Interior
- Integrated Vacuum Passages