

Jigs and fixtures are just two examples of tooling devices that are used in a wide variety of manufacturing, assembly and inspection processes, across numerous industries.

Nearly as broad as the spectrum of applications is the range of methods used to make these tools. Traditionally, they are milled, molded, stamped and forged from many different types of material. With typical quantities of one to one hundred, these tools are not mass-produced but are usually hand-fabricated with manual or semi-automated processes.

PolyJet™ 3D Printing is a convenient alternative fabrication method for construction of jigs, fixtures and related tools used in departments such as engineering, R&D, testing, production, assembly, inventory, inspection and shipping (Figure 1).

Substituting PolyJet for traditional methods of fabricating jigs and fixtures substantially reduces lead time and cost, is simple, and virtually labor-free. With simplicity and speed, PolyJet jigs and fixtures improve manufacturing productivity, efficiency and quality.

PolyJet also creates new design opportunities. Jigs and fixtures can be designed for optimal performance and ergonomics since 3D printing places few constraints on a tool's configuration (Figure 2).

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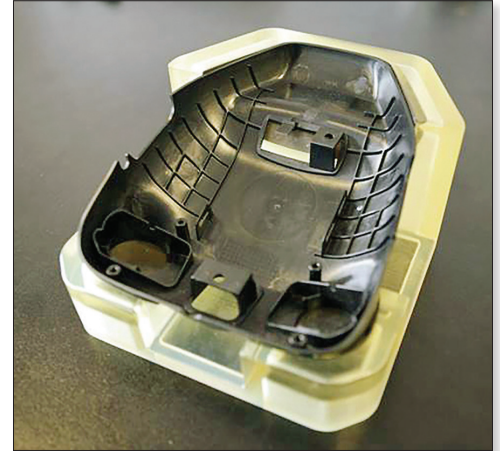


Figure 1: PolyJet assembly fixture for injection molded part (black).

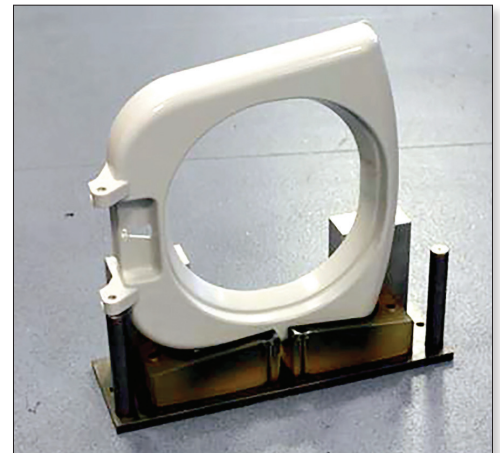


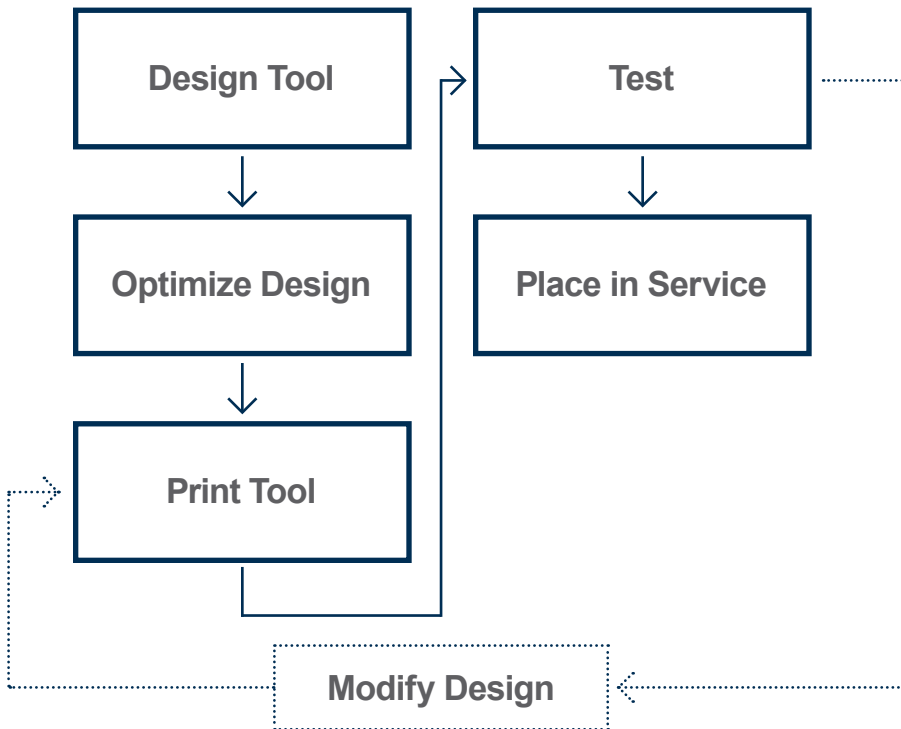
Figure 2: Locating fixture combines rigid and rubber-like materials.

Application compatibility:
(0 – N/A, 1 – Low, 5 – High)
PolyJet: Design (2)
FDM: Idea (2), Design (3), Production (5)
Companion and reference materials:

- Technical application guide
 - Document
- Application brief
 - Document
- Video
 - Commercial
 - Success story
 - How it's used

1. PROCESS OVERVIEW

Beyond substituting PolyJet for traditional fabrication processes, there are no other required modifications. However, design modifications that leverage 3D printing's capabilities are strongly recommended.



2. DESIGN FOR FUNCTION (CAD)

A simple approach to apply PolyJet to jig and fixture construction is to use existing designs and current design rules. However, this may be an inefficient approach that does not capitalize on the advantages of 3D printing. If left unchanged, the rules that govern designs for conventional processes are artificially imposed on PolyJet jigs and fixtures. These may negatively affect performance, time and cost.

Whenever time allows, it is best to start with a fresh design that builds from the design freedoms offered by 3D printing processes (Figure 3).

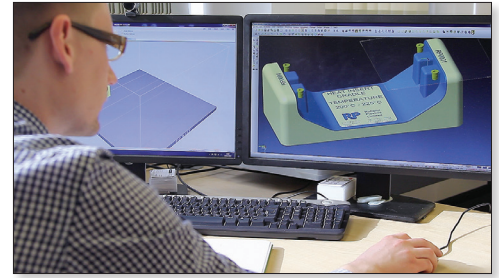


Figure 3: Design jigs & fixtures to maximize performance while minimizing time and cost.

2.1. Part consolidation

Convert assemblies into single parts. Often, jigs and fixtures are dissected into many components in order to make conventional manufacturing processes feasible and affordable.

If reproducing an existing tool, start with a redesign that consolidates as many components as possible into one piece (Figure 4). If designing a new item, create it as one piece. Use multiple parts only when it is advantageous to the operation of the jig or fixture.

Part consolidation has many advantages, including:

- Design for function.

Focus on the task that the tool will perform. Optimize the design for its function rather than the processes used to make it.

- Eliminate tolerance challenges.

Holding tight tolerances is costly but avoidable. If two mating parts are combined into one, all concerns and costs associated with controlling the tolerances are eliminated.

- Eliminate assembly time.

Tool assembly requires time. For one-off items like jigs and fixtures, perfect fits between parts are not guaranteed. Consolidate all parts into a single piece to eliminate the time needed for assembly.

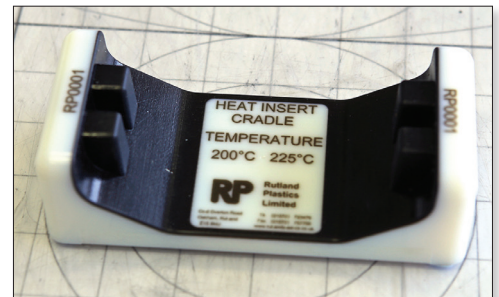


Figure 4: One-piece fixture is printed in a single operation.

2.2. Ergonomic design

For any hand-operated tool, or those that are frequently moved between work areas, ergonomic design is quite important. When designing new jigs incorporate ergonomics into the configuration (Figure 5). There will be little or no change in the cost and time to produce a lightweight, well-balanced, easy-to-handle tool.

Design the jig or fixture considering weight, balance and position of the tool for:

- Maximum technician comfort and ease of use



Figure 5: Vacuum tool for the calibration of 3D printers.

- Shortest process cycle time
- Easy access and storage

2.3. Integrated features

With traditional manufacturing processes, there is usually time and cost associated with every feature added to a part. This is typically not true with 3D printing.

In the design of a PolyJet jig or fixture, consider adding features that aid in its operation, improve performance, reduce build time and material consumption.

- Create multi-material tools.

If PolyJet Connex™ technology is available, add features with material properties that are different than those of the body of the jig or fixture. For example, combine rubber-like Tango™ materials with rigid materials to add soft-touch overmolding or anti-slip surfaces (Figure 6). Multi-materials also create high-contrast colors to increase the visibility of embellishments, such as text.

- Add embellishments.

Incorporate part numbers, storage locations, alignment arrows or usage guides directly on the tool (Figure 7).

- Add pockets, channels and holes.

Removing mass by coring out features in a jig or fixture will decrease weight and material consumption. This is an especially important modification for large, bulky tools.

For tools that will have hardware added, such as fasteners, inserts, RFID tags or sensors, create channels and pockets into which they will be placed. For example, create a hex-shaped hole for a nut so that a bolt can be mounted with one hand.

- Add chamfers and radii.

Jigs and fixtures that are made with conventional processes usually have sharp corners since it takes more machining time to avoid or remove them and the value is marginal. Since PolyJet print times will not increase, add chamfers and radii to improve function, make handling easier and increase worker safety.

- Add assembly features.

To simplify assembly of multi-piece jigs or fixtures, add locating features such as posts and holes, stand-offs and pockets, or guide rails and slots.

To ensure a good fit, increase the size and depth of the female feature by 0.1 mm (0.004 in). Also consider tapering the mating surfaces of

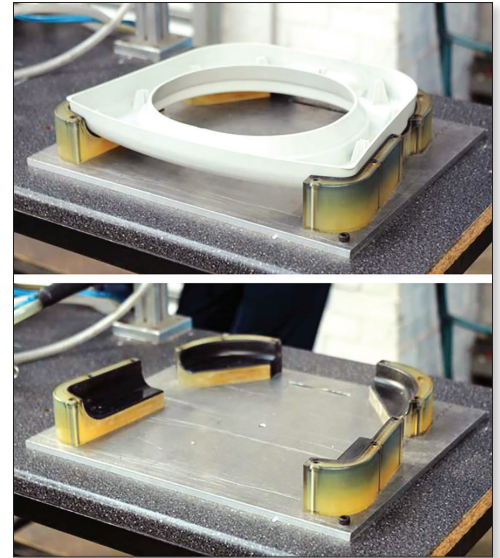


Figure 6: Assembly fixture uses multi-materials for non-marring, slip-free part holding.

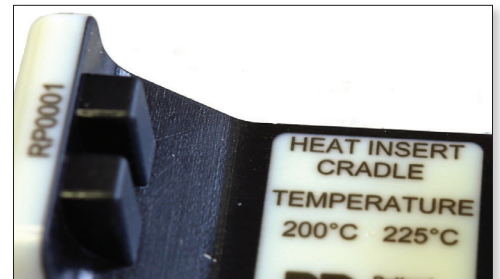


Figure 7: Add text embellishments for fixture identification and usage guides.

both the male and female locating features.

2.4. Design iterations

This design consideration is more of a reminder than a design technique. View each build as a prototype. Continue to revise the tool's design to optimize its performance.

Because PolyJet works directly from the CAD data, it is both quick and economical to build PolyJet tools. It is quite practical to gather feedback from the first iteration and make adjustments because of the speed of the process and elimination of overhead (e.g., detail drawings or purchase order approval). With a simple adjustment of the CAD model and a few minutes with Objet Studio™ to prepare the job, a new revision is ready to build.

Many businesses that use PolyJet to produce jigs and fixtures have found that they are able to improve their operations by implementing changes discovered after the tool has been put into service.

2.5. Optimize PolyJet performance

CAD design may also be used to improve dimensional accuracy while further decreasing build times.

- Offset surfaces.

For high-precision features, consider building a sample jig or fixture and inspecting it for adherence to dimensional requirements. If needed, offset the feature to compensate for the deviation.

Another option is to create a “material-safe” condition on critical features, such as surfaces that will have a tight fit between the tool and the part it cradles. Offset these surfaces by 0.2 mm (0.008 in). During post-processing (Section 6.2), adjust the feature with a light sanding.

- Split the CAD model.

To minimize build time and support material, consider splitting the fixture's CAD model into pieces that will be assembled and bonded after printing.

To reduce build time, split tall CAD models along the XY plane to create shorter sections. Use the same approach to reduce the amount of support material under features located at high Z elevations.

3. CAD DATA PREPARATION

3.1. Create multiple bodies.

If PolyJet's multi-material functionality will be used to create mixed material jigs or fixtures (Section 2.3), the CAD model must be split into discrete solid bodies so that materials can be assigned to each shell in Objet Studio (Figure 8). For details, see the Technical Application Guide: PolyJet Multi-material Printing.

3.2. Generate the STL file.

When the CAD design work is complete, save the model as an STL file. Make sure to adjust the STL file settings, such as chord height, so that small facets are created. This will produce smooth surfaces that require less post-processing when preparing the jig or fixture for service.

3.3. Analyze and repair the STL file.

The high resolution of the PolyJet process makes it more sensitive to the quality of the STL file than other 3D printing technologies. Slight overlaps or tiny gaps between facets will cause problems that affect tool quality.

Using a third-party application like Materialise® Magics or netfabb® Professional, analyze the STL file to detect errors. If the file requires repair, use the software's automated correction utilities.

Repeat the detection and repair process until all errors have been eliminated (Figure 9).

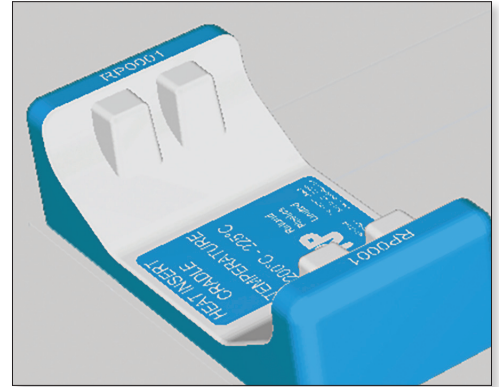


Figure 8: When printing with multi-materials, separate the CAD model into solid bodies for each material. Two materials, two bodies shown.

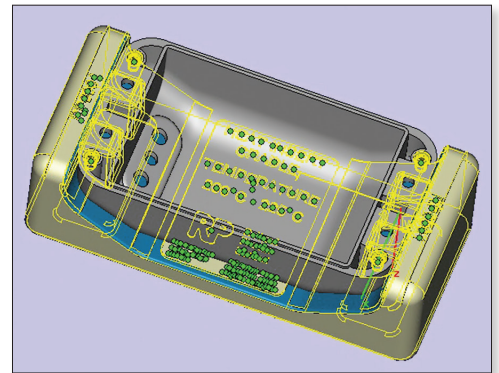


Figure 9: Using third-party software, analyze the STL file for defects and repair if needed.

4. FILE PREPARATION

Import the STL files into Objet Studio and prepare them for 3D printing.

4.1. Orient the STL files.

Orient the STL file to minimize build time and support material (Left click on part > Transform > Rotate) (Figure 10).

4.2. Select surface finish.

Select Glossy finish (Left click > Glossy).

The gloss finish yields a harder, more durable wear surface for jigs and fixtures.

4.3. Set printing mode.

Select High Speed for the printing mode to minimize build time.

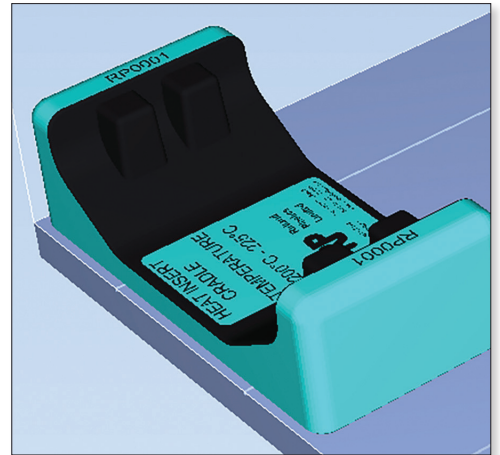


Figure 10: Orient the STL file considering both build time and the amount of support material.

5. MATERIALS

All PolyJet materials and Digital Materials may be considered for jig and fixture applications. Select a material based on the expected operating or loading conditions when it is placed in service.

Suggestions for Connex platforms:

- FC720 and TangoBlack™ (Figure 11).

FC720 is a cost-effective solution for jigs and fixtures with thicker wall sections (> 1.3 mm [0.05 in]). When TangoBlack is combined with the transparent FC720, text embellishments and similar features will be clearly visible (Figure 12).

Also consider Digital Materials that blend FC720 and TangoBlack, which offer hardnesses that range from Shore A 20 to 90.

- Digital ABS™

The Digital ABS family, the toughest, strongest and most durable materials, is recommended when a jig or fixture is subjected to high mechanical loads or impact force (Figure 13).

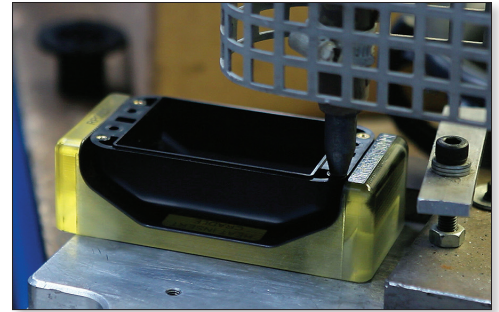


Figure 11: FC720 drill guide.



Figure 12: Combining TangoBlack and FC720 makes text stand out.

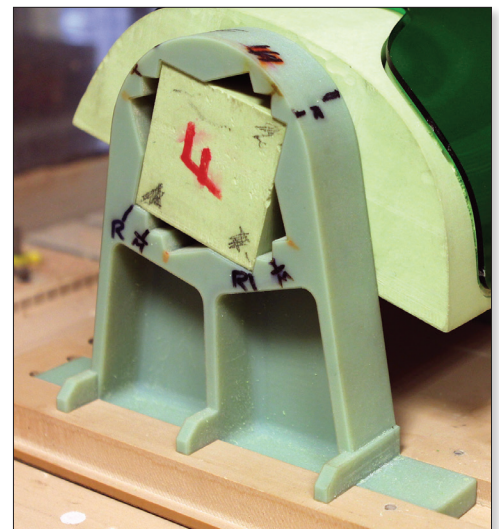


Figure 13: Fixture stand made with Digital ABS.

6. POST-PROCESSING

6.1. Remove support material.

On flat surfaces, simply scrape the support material from the jig or fixture using a putty knife or similar tool. For all other features, use a waterjet station to remove the support material.

6.2. Sand surfaces (optional).

If a material-safe condition was added to the CAD model (Section 2.5), test fit mating components and sand with 220-grit sandpaper as needed.

For most jigs and fixtures, the surface finish of a raw PolyJet part will be suitable. If smoother surfaces are needed, lightly sand with 220 grit sandpaper and then follow with 320 to 400 grit.

6.3. Insert hardware (optional).

Insert fasteners, RFID tags, sensors and other hardware into the receptacles added to the CAD model (Section 2.3). To bond the items to the PolyJet jig or fixture, use an adhesive, such as cyanoacrylate or epoxy.

6.4. Assemble components (optional).

If the CAD model was sectioned to decrease build time or material consumption (Section 2.5), mate the pieces and bond with cyanoacrylate or epoxy adhesive.

7. KEY PROCESS CONSIDERATIONS

Obstacle	Resolution			
	Design for PolyJet	Processing	Material Selection	Tool Orientation
Build Time	✓			✓
Material Expense	✓		✓	✓
Accuracy	✓	✓		
Material Properties			✓	

Table 1: Common obstacles and resolutions

7.1. Resolution details:

- Design for PolyJet:
 - Section tall objects to reduce height, which decreases build time.
 - Section objects to minimize supported features to decrease volume of support material.
 - Add stock to critical features and sand to obtain the desired fit.
- Processing:
 - Build a sample, measure and then adjust the CAD model.
 - Offset surfaces for a “material-safe” condition and then sand the features to obtain the desired fit.
- Material selection:
 - Select a PolyJet material for:
 1. Material properties suitable to the application.
 2. Material expense.
- Tool orientation
 - Orient with small Z height to decrease build time.
 - Orient to minimize the volume of support material.

8. TOOLS AND SUPPLIES

8.1. Required items:

- 3D CAD software
- STL repair software (e.g., Materialise® Magics or netfabb® Professional)

8.2. Optional items:

- Sandpaper
- Fastening hardware
- Adhesives

9. RECAP – CRITICAL SUCCESS FACTORS

9.1. Actions:

- Leverage design freedoms to optimize jigs and fixtures.
- Design jigs and fixtures to address unique characteristics of PolyJet.

9.2. Eliminate obstacles:

- Select PolyJet materials that have the required mechanical and thermal properties.
- Minimize build time through orientation and part splitting.



Figure 14: Heat-staked brass inserts in a plastic part held by a PolyJet fixture.



Figure 15: PolyJet 3D printed calibration fixture.

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