POLYJET BEST PRACTICE:

FEA RESULTS IN COLOR 3D PRINTING

Stratasys®
3D Printers and Production Systems

SOFTWARE/PRODUCT/FINISHING

OVERVIEW

Finite element analysis (FEA) is a computer-based method of analyzing and simulating the behavior of components under a variety of conditions, including force, temperature, vibration and motion. FEA calculates displacements, strains, and stresses under internal and external loads. These predictions confirm if a design is suitable or if modifications are required to prevent failure.

FEA results are presented as on-screen, digital models with color mapping for a visual depiction of the effects of applied conditions (Figure 1). These models may also show the resulting change to a component's geometry as it deforms under the applied load.

To bring FEA results into the real word, PolyJet™ 3D Printers create physical models that retain the FEA color mapping (Figure 2). Rather than interpreting results from a computer screen, designers and engineers can visualize the analysis with models that are hand-held. The results can be printed in an "as-designed" or "load-deformed" state (Figure 3).

Common applications for 3D printed FEA results include:

- Design verification
- Failure analysis
- Material selection
- Design review meetings
- Marketing presentations

Finite element analysis yields better component performance. When coupled with PolyJet, design and material options become clearer, leading to better products.

Reference materials:

- Processes
  - Technical Application Guide: Multi-material Printing

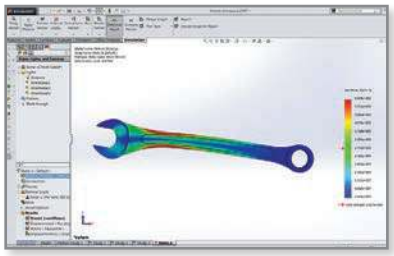

Figure 1: FEA results show areas of high stress (red) and low stress (blue).

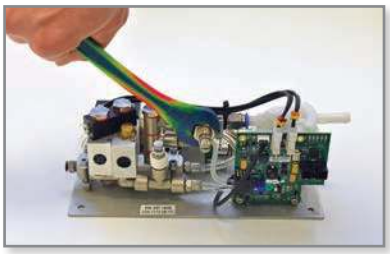

Figure 2: 3D printed PolyJet wrench with FEA color mapping.

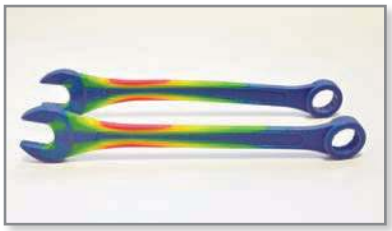

Figure 3: Printed FEA results for as-designed (foreground) and load-deformed states.

Figure 4: Output of a completed finite element analysis.

1. PROCESS

1.1. Perform FEA Calculation

STEP 1: Using available FEA software, import a CAD model, assign a material, define conditions and specify fixed positions.

NOTE: Please consult the FEA software's instructional guide for proper procedures.

STEP 2: Run the analysis (Figure 4).

STEP 3: FEA calculation procedure complete.

1.2. Create VRML Files

NOTE: The following procedures are for SolidWorks® software. However, the process will be similar for other FEA software programs. Please consult the appropriate user manuals for specific commands.

TIP: For 3D printed models with the predicted deformation from the loading conditions, select the ***Deformed Result*** option in SolidWorks before proceeding to STEP 1.

STEP 1: With the FEA results plot displayed, create the VRML for the first color range depicted in the color map. Do this by first selecting ***Plot Tools*** > ***Iso Clipping***.

STEP 2: Confirm that the ***Reverse clipping direction*** icon is not selected for Iso 1. Also confirm that the Iso 2 box is not selected.

STEP 3: Move the scroll bar for the Iso 1 value so that it includes all of the desired first-color results. With inactive, the display shows only the results above the selected value (Figure 5).

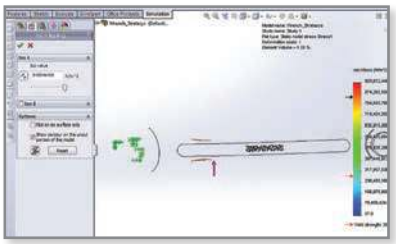

Figure 5: Iso clipping displays only the regions where values exceed the selection.

TIP: PolyJet will print discrete bands of color rather than gradient transitions. Determine the desired number of colors for the 3D printed model to clearly convey the FEA results.

TIP: When using the scroll bar to specify the value range, opt for a half-way point between two colors.

STEP 4: Click to confirm the selection.

STEP 5: Save the Iso clipping file as a VRML by selecting ***Plot Tools*** > ***Save As*** and then select the VRML file from the ***Save as type*** dropdown menu. This creates the first shell for 3D printing.

STEP 6: Repeat STEPS 1 – 5 for subsequent shell color ranges by using both Iso 1 and Iso 2 to create a value range (Figure 6).

For example, to create the second shell, use the Iso 2 scroll bar to set the lower limit. Leaving Iso 1 at its previous value, click the ***Reverse clipping direction*** icon so that only lower values are displayed. To create the third shell, toggle both Iso 1 and Iso 2 ***Reverse clipping direction*** icons and adjust the displayed value for Iso 1.

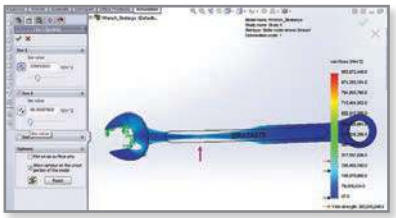

Figure 6: Combining Iso 1 and Iso 2 displays a range of values.

TIP: Always leave the lower limit value unchanged. If adjusted, some areas of the model may not be captured, which would result in gaps in the printed part.

STEP 7: After creating VRML files for all regions of the model, the VRML file creation procedure is complete.

1.3. Create STL Files

STEP 1: Open Materialize® Magics™ or any other STL manipulation program.

STEP 2: Import all Iso clipping files (VRMLs) created in section 1.2. ***Select File*** > ***Import Part***, select all files and then click ***Open***. When prompted, select ***OK*** (Figure 7).

STEP 3: After importing into Magics, there will be empty files that need to be unloaded. Click to view each file to see if it contains any elements of the model. Select all files with no content and then click ***Unload Parts***. When prompted with the option to save each file, select ***No to All***.

STEP 4: Now check the box for all of the files that remain to select them. Next, save the files as STLs using ***File*** > ***Save Part(s) As*** and select the STL format.

STEP 5: Create STL file procedure complete.

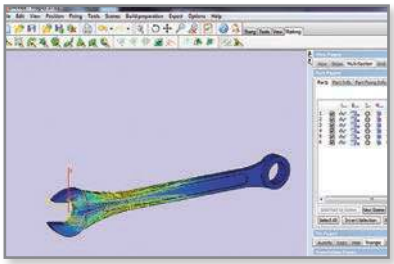

Figure 7: Display combines six VRML files that will be used to create STLs.

1.4. Print FEA Model

STEP 1: Open Objet Studio™ and import all of the STL files saved in section 1.3. Using the ***Insert Part*** function, select all of the STL files and check the ***Assembly*** box. Then click ***Insert*** (Figure 8).

STEP 2: Assign the desired material and color to each shell. Select a shell and then assign the color by selecting it from the material dropdown menu (Figure 9). Repeat as needed.

STEP 3: Complete the file preparation process using the standard PolyJet workflow.

STEP 4: Initiate PolyJet print job.

STEP 5: Print FEA model procedure complete (Figure 10).

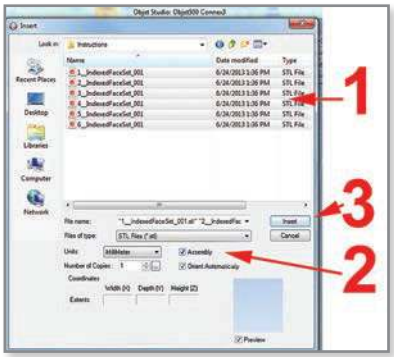

Figure 8: Import STLs into Objet Studio.

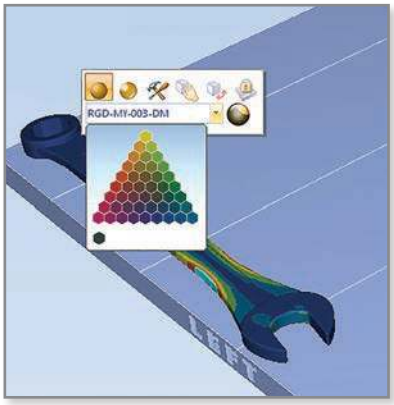

Figure 9: Assign colors by selecting a shell and choosing a color from the material palette.

Figure 10: PolyJet model for hands-on review of FEA results.

2. SAFETY

Observe manufacturer's recommendations for safety, material handling and storage. This information can be found in the Safety Data Sheet (SDS).

3. TOOLS & SUPPLIES

3.1. Software:

- FEA analysis program (SolidWorks or similar)
- STL manipulation program (Materialise Magics or similar)
- Objet Studio version 9.2 or later

3.2. Required Items

- PolyJet Connex™ 3D Printer
  - Connex3™ recommended. A Connex1™ or Connex2™ 3D Printer may also be used, but the color palette will be limited.

4. MATERIALS

These procedures are suitable for all PolyJet materials that are offered in multiple colors.

CONTACT:

To obtain more information on this application, contact:

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