Design for Additive Manufacturing
Metal & Multi-Jet Fusion (MJF)

20 Dec 2021

Fusion 360 Generative Design Workshop

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1. What is Generative Design

- Generative design - create parts that would otherwise be too difficult or costly to justify with traditional manufacturing methods.
- Software tools to create highly-optimized parts backed by complex computational simulations.
- Built to withstand specific loads and user-defined constraints.
- Generate parts only put material where it's needed, resulting in parts that are as much lighter - yet equally strong - than conventional designs.

Engine Mount

Skateboard Truck

2. Generative Design - Terminology

- Generative design requires that we approach a model differently than a traditional design.
- Information to be provided:
  - Initial shape of design (Starting shape)
  - what materials we want (PA12, SS316L)
  - how the part interacts with its surroundings (Loading & Constraint)
  - what geometry it must keep (Preserve geometry)
  - what geometry it must avoid (Obstacle geometry)
  - Design objectives (Minimize mass, Factor of safety, etc.)
  - Manufacturing method (3D printing)
- Once software has all the parameters, it can go to evaluating large number of possible cases and presenting us with best options.
2. Generative Design - Terminology

- **Preserve geometry**: what geometry needs to stay behind
  - These will be things like bushings or areas for mounting to other components in an assembly.
  - This geometry also gets utilized to apply any loads or constraints that drive the design.

- **Obstacle geometry**: what geometry needs to avoid
  - Geometry needs to be created for the shelf and for the hardware connecting the bracket to the shelf.
  - Tools used to install or remove the fasteners cannot be blocked by the Generative Design results.
  - Not only will the hardware itself be represented, but areas for the installation tools will also be modeled.
3. Printer Specification

**Metal 3D Printer**
- Build volume: 100 x 100 x 80 mm
- ± 0.2% with ± 0.05 mm minimum
- Wall thicknesses down to 0.15 mm
- Needs to have support

**Nylon 3D Printer**
- Build volume: 332 x 190 x 248 mm
- ± 0.3% with ± 0.2 mm minimum
- Wall thicknesses down to 0.6 mm
- Self-supporting nature
  - Freedom to print complex and intricate geometries
  - Enables to print assemblies in single, continuous pieces
**Import Data**

- To use online Fusion 360:
  - [https://fusion.online.autodesk.com](https://fusion.online.autodesk.com).

- Data uploading
  - Show the Data Panel

- After creating your folder, then Upload the X_T file

- Right click the uploaded file and select “Create Fusion Design” to create a Fusion360 model

- Double click the created Fusion 360 model at Data Panel to open it

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**Preserve Geometry**

- Change Workspace to “Generative Design”
- Click “Create Study”

- Define Preserve Geometry
  - Ribbon “DESIGN SPACE” > “Preserve Geometry”
  - Select preserve geometry by selecting Body4, Body5, Body9 and Body11 from “Model Components” > “Bodies”
4. Fusion 360 with Generative Design - Workflow

**Obstacle Geometry**

- Define Obstacle Geometry
  - Ribbon “DESIGN SPACE” > “Obstacle Geometry”
  - Select obstacle geometry by selecting Body6, Body7, Body8 and Body10 from “Model Components” > “Bodies”

**Starting Shape**

- Define Starting Shape
  - Ribbon “DESIGN SPACE” > “Starting Shape”
  - Select starting shape by selecting Body13 from “Model Components” > “Bodies”
Constraints

4. Fusion 360 with Generative Design - Workflow

- Define the constraints on preserve geometry
  - Click the “eye” of the Obstacle Geometry, Starting Shape and Unassigned Geometry, so that they are invisible.
  - Only Preserve Geometry is visible.

- Ribbon “DESIGN CONDITIONS” > “Structural Constraints”

- Click to select the 4 cylindrical surfaces of the holes for the fasteners to passing through the bracket into the wall.
  - Type = Fixed
  - Deactivate “Uz”
    - => only fixes in X and Y axes.
  - Click “OK”

- Click to select the 2 back faces of the vertical preserve geometry, which will contact the wall.
  - Type = Fixed
  - Only activate “Uz”
  - Click “OK”
Define the loading on preserve geometry
- Ribbon “DESIGN CONDITIONS” > “Structural Loads”
- Type = “Force”
- Select the top face of horizontal preserve geometry that is furthest away from the wall.
- Magnitude = 25 lb force
- Click “OK”

Define the design objectives
- Ribbon “DESIGN CRITERIA” > “Objectives”
- Check ON “Minimize Mass”
- Safety Factor = 4
- Click “OK”
Define the manufacturing method
- Ribbon “DESIGN CRITERIA” > “Manufacturing”
- Check ON “Additive” only
- Check ON “Include all six directions”
  - To get more design alternatives

(Assuming using MJF540 for 3d printing)
- Overhang Angle = 90
- Minimum Thickness = 1
- Click “OK”

Define the materials
- Ribbon “Materials” > “Study Materials”
- Methods = “Additive”
- If there is any materials in this study, then:
  - Right click > Select “Delete”
Materials

- Library = “Fusion 360 Additive Material Library”
- Click the folder “Plastic”
- Drag and drop “HP 3D HR CB PA 12 (with HP Jet Fusion 580 Color 3D Printer)” to the upper area of “Add Materials from Libraries Below”
- Click “Close”

Generate Designs

- Generate designs: Pre-Check > Previewer > Generate
**Generate Designs**

4. Fusion 360 with Generative Design - Workflow

- Generate designs > Pre-check
  - Ribbon “GENERATE” > “Pre-check”
  - A “green” tick => everything OK

- Generate designs > Previewer
  - Ribbon “GENERATE” > “Previewer”
  - Drag the slider to preview outcomes

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**Generate Designs**

4. Fusion 360 with Generative Design - Workflow

- Generate designs > Generate
  - Ribbon “GENERATE” > “Generate”
  - Check ON the related Study
  - Click the “Generate 1 Study” button

- The analysis study is then sent to the cloud.
- “Job Status” dialogue is shown.

- Can exit Fusion 360.
- Enter Fusion 360 later to check the generated designs.

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**Explore Generative Results**

### 4. Fusion 360 with Generative Design - Workflow

- Ribbon “EXPLORE”
- Select the various display modes:
  - Thumbnail View
  - Properties View
  - Scatter Plot View
  - Table View

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- Click “Recommendation settings” button to fine-tune the displayed results
- Explore the recommended outcome by clicking one of the converged result
Select the “Stress View” to check the stress level of the result.

To export the outcome:
- Select “Design from Outcome”
- Create editable CAD model
- Select “Mesh Design from Outcome”
- Create mesh file for 3d printing