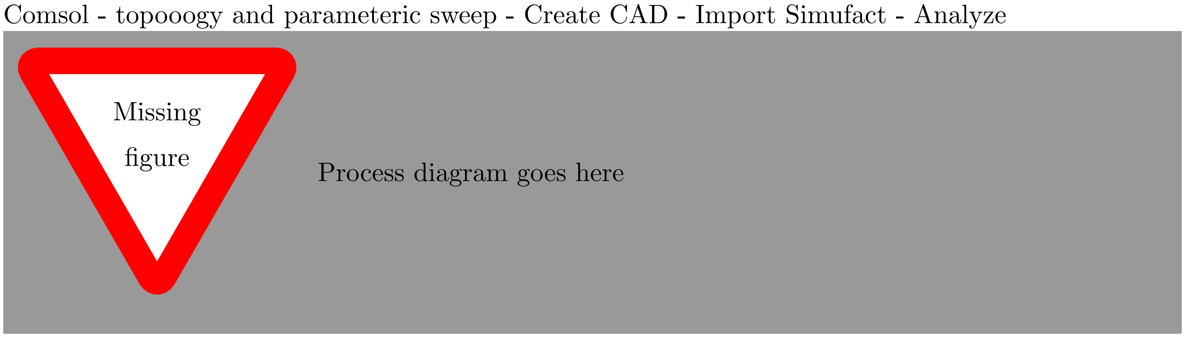
1 Introduction

To analyze the performance of different support structures created using topology optimization, a comparison study was made in which parts created by additive manufacturing were paried with different support structures. This study assumed that different structures will conduct heat energy differently, and thus some topologies might be more effective in removing heat faster from each layer as it is being melted, resulting in less thermal deformation. The geometries chosen for this study are the same geometries that were utilized in the thesis [Peihsu's thesis made]. These geometries were chosen for their ease of modeling, and also to provide a direct line of comparison between performances of support structure using topology optimization and support structures created using a lattice structure.

2 Process diagram

Comsol - topooogy and parameteric sweep - Create CAD - Import Simufact - Analyze



3 Comparison of topologies on simple geometries

3.1 Creating the simple geometry CAD

The components with simple geometries utilized in this study consist of a cube, three triangular components with different slopes, and three cylindrical components with different values of curvature. To reiterate, these components have the same dimensions that were used in the study of lattice support structure performance by Peishu . All of the CAD models used for the simple geometry study were created using FreeCAD, an open-source CAD software. All of the components were expoerted as .STEP files, and then they were merged with their corresponding support structures using the software nTop. The following section gives detail on the dimensions of the simple geometries, while a later section will explain the process of merging with the support structure.

reference peihsu's thesis here

3.1.1 Cubes

The first component analyzed was a simple cube, with side length of 30 mm. When imported into Simufact additive, the cube was placed above the base plate at a distance of 10 mm. The volume between the bottom surface of the cube and the base plate was used as the design space for the support structure using topology optimization.

Figure of cube component

3.1.2 Triangles

Three triangles with different slopes were used in this study. All triangular components used in this study consist of a base of 30 x 30 cm^2 with varying slopes and heights. The slopes used were slopes of 15°, 30°, and 45°. Figures of the triangular components are shown in below.

figure number

Figure of trianglular components.

3.1.3 Cylinders

Figure of cylindrical geometry

4 Design of support structure using topology optimization

4.0.1 Design domain

Explain here that the topology optimization is ran on a 2d space, and then extended to fill up the volume between the component and the base plate.

All of the design domains consisted of the volume directly underneath the components, which was placed at a height of HEIGHT above the base plate.

4.0.2 Mathematical model

4.0.3 Creating the support structure in COMSOL

rephrase this

5 Simulation of thermal expansion

The software utilized to simulate the manufacturing process is Simufact Additive version 2023.2. Simufact Additive is capable of simulation building process of additive manufacturing components, and coupling thermal and stress physics to predict the temperature values of the component throughout the building process and the total stresses, strains and deformations resulting from the manufacturing process.

In order to set up Simufact correctly, the building process and the building space geometry must be specified before each simulation. The building parameters and building geometries used in this study are the same that were used in the analysis of thermal deformation using lattice support structures done by Peihsy and al.

add reference here

5.1 Merging of part with support structure

Once the CAD file of the component and the support structure has been built, it is necessary to merge them together and import them into Simufact to undergo simulation of the manufacturing process. The software used for blending the component and its support structure is nTop . nTop's interface makes it very easy to merge the part, and also allows to blend the support structure and the component, which effectively creates a fillet between the nodes of both components to allow for a smooth transition between bodies. Of course, blending the component and the support structure in this manner would not give any benefit in a real manufacturing process, as the structure and the component would not be able to be separated easily. NEvertheless, this blend radius is benefitial for the simulation since it was observed that a direct union and import of the support strcuture + component in Simufact resulted in having very small gaps between the two pieces, resulting in a non manifold geometry that would cause the finite element model to have gaps between some of its nodes.

add version here

Missing figure

add figure of error / warning from Simufact due to import of structure with gaps. Two figures shoudl suffice here.

5.2 Import into Simufact and voxelization

Explain what this is and how it is done, and what the purpose of this is.

5.3 Convergence analysis

To make sure that the results of the simulation would not depend on the voxel density of the

6 Analysis of topology optimization on femoral component

Todo list