Explorations in Vibrational Testing and Quasistatic Behavior of Additively Manufactured Lattice Structures

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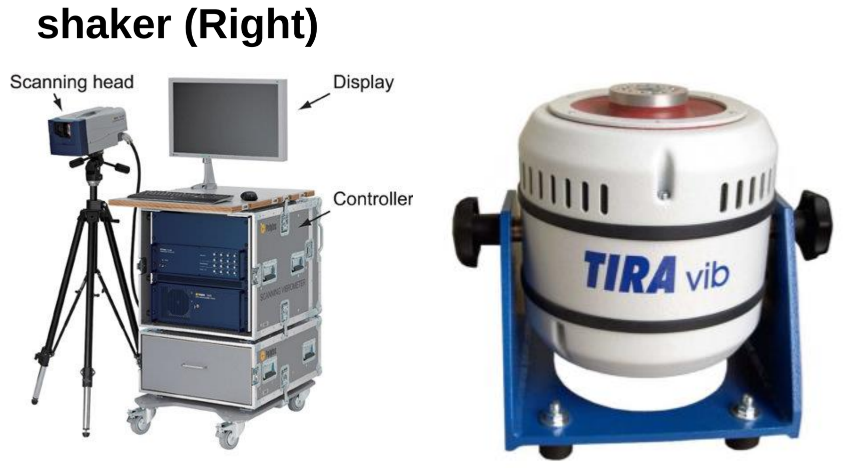
Background & Motivation

- Additive manufacturing allows for previously unachievable designs with traditional manufacturing techniques to be produced at a rapid rate
- In the academic environment, there is a great deal of quasistatic (tension & compression) plastic research
- The dynamic behavior of additively manufactured parts, however, is still developing and has great potential for a variety of applications. These include
  - Printing with mixed materials

  - Printing with different print parameters such as: infill percentage, infill patterns, retraction rate, print speed, and print head temperature
- This research aims to better understand how these materials work with one another and how to print them properly.
- Through this understanding we hope to find ways to better print prosthetics, prototype parts, and component parts all together

Preliminary Ideation

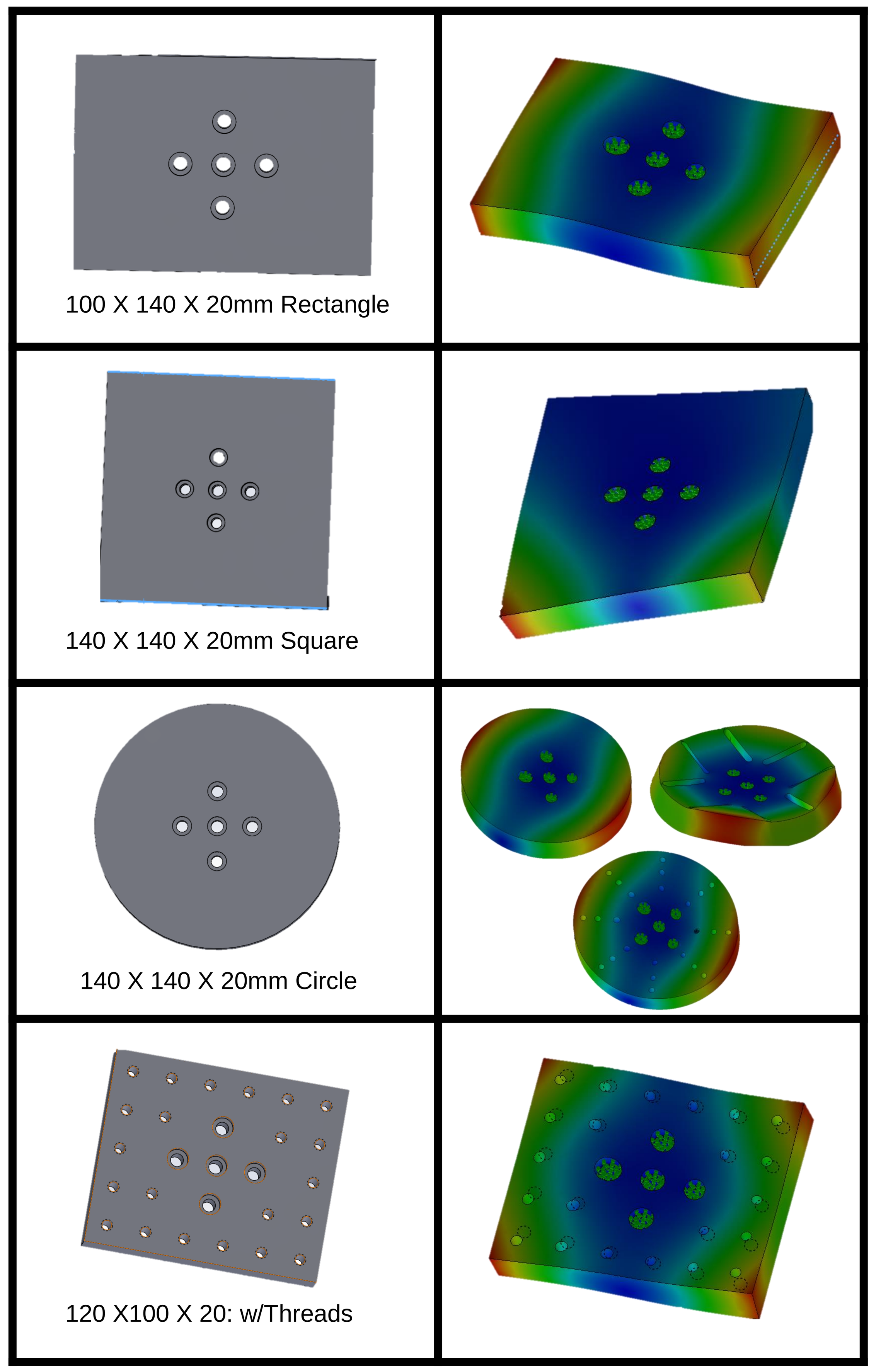
- In order to study the dynamic profile of 3D printed components, a vibration fixture was needed
- Utilizing the two systems below a Laser Doppler Vibrometer (Left) and a single axis shaker (Right)



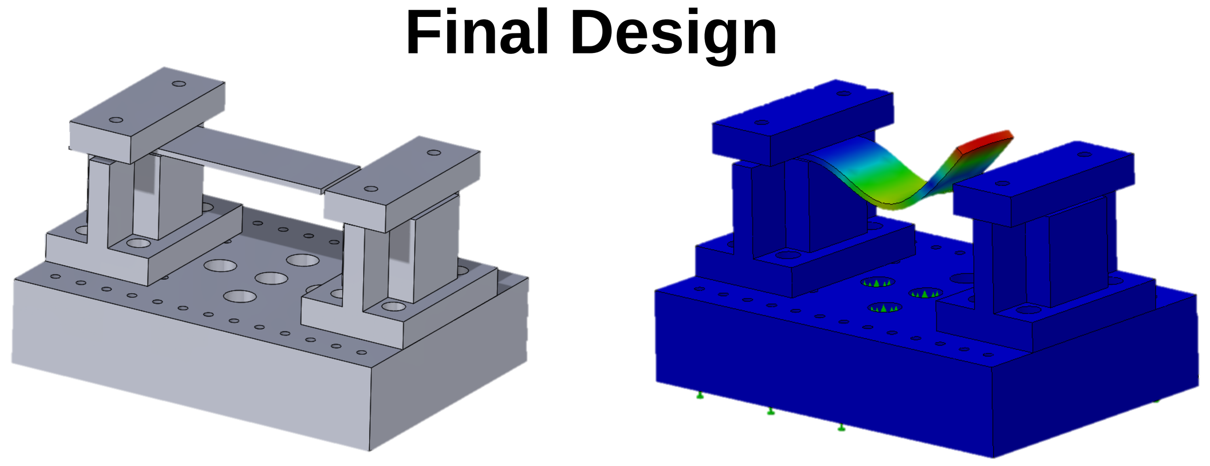
- The system needed a way to secure samples, excite them, and measure the surface velocity

Simulating Different Fixture Designs in FEA

- To achieve the desired measurements, different fixtures were designed in CAD and simulated using FEA to determine if the fixture could perform under the frequencies created by the exciter
- The proposed geometries are shown (left) and their resulting FEA (right). Blue shows low displacement and red shows large displacement at their natural displacement



Final Design



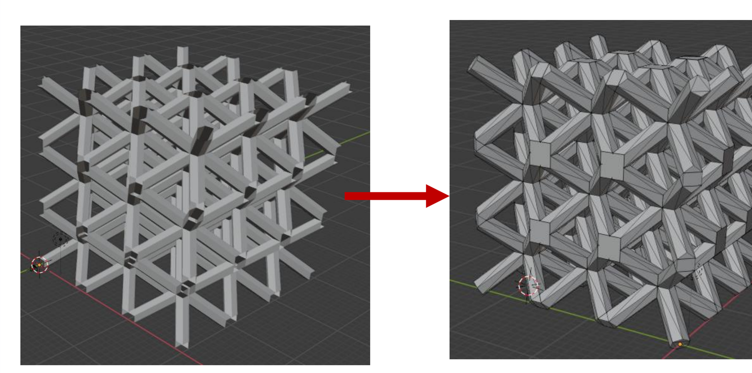
Fused Deposition Modeling (FDM) of Lattice Structures

- Lattice structures are a unique shape that allows for immense strength at a very small surface area and low mass
- Selective Laser Melting (SLM) and stereolithography (SLA) printing are the primary means for manufacturing lattice structures.
- Fused Deposition Modeling (FDM) created structures have less publications due to the difficult nature of printing

Goal: Develop a way to use FDM printing to print flexible polyurethane lattices

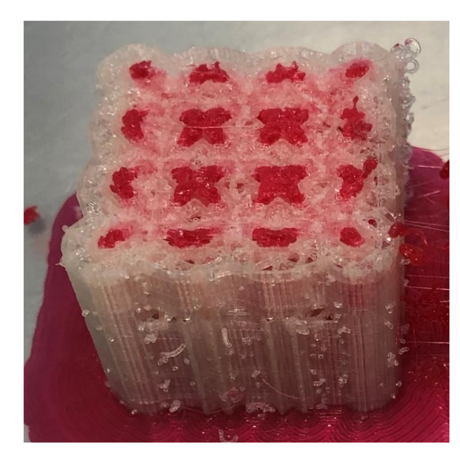
Solution: Lattices have tight geometries which presents challenges when utilizing a printer that builds layer by layer. The solution is using a water-soluble support structure (PVA) to aid in the printing of the lattice structures

MATLAB® blender

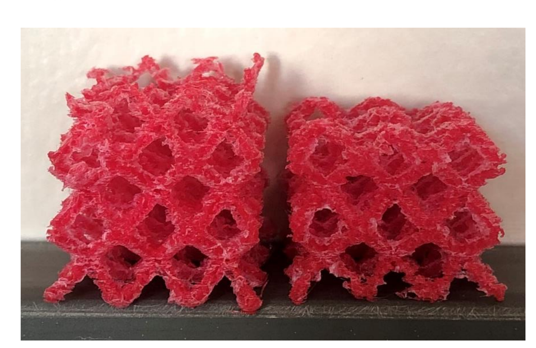


- Utilize a MATLAB lattice generator to create stl files
- Clean up the geometry and join the vertices using Blender

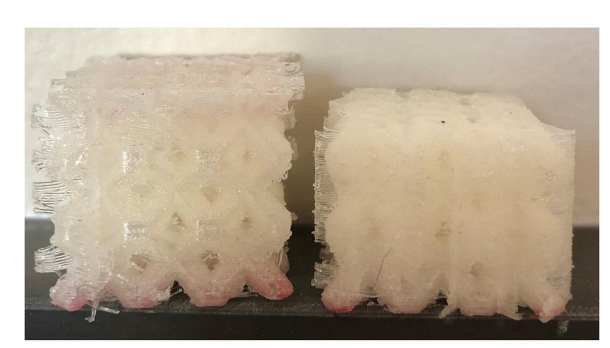
- Challenges:
  - Many challenges were presented through the printing process which are highlighted below
  - A proper lattice with its PVA support material is shown (right)



Retraction distance determines how far the filament is removed from the extruder head. Varying this helped in preventing the extruder head from clogging, but resulted in extra stringiness (right)



Under-extrusion results from clogging of the extruder head and an improperly calibrated retraction distance and standby temperature (results above)

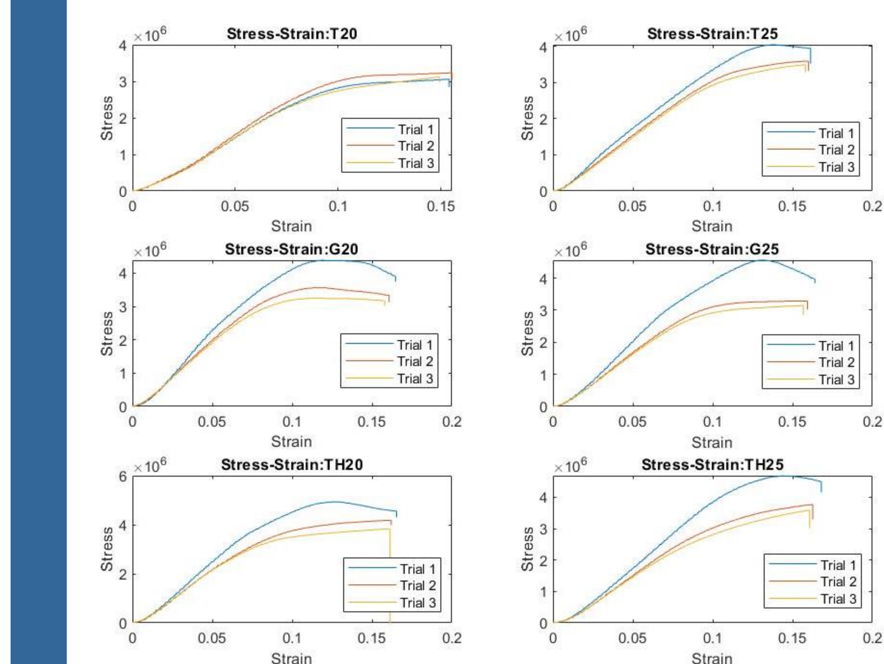


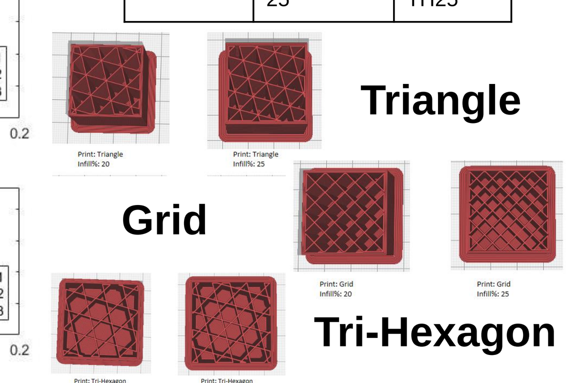
If the print head becomes completely clogged, no TPU extrudes. However, the PVA still does, resulting in hollow water-soluble shells (above)

Data Processing

- Due to print times and variations in printer settings, there was not enough time this summer to create a full set of testable lattices
- Gained experience in bulk data processing in MATLAB by running compression tests on cubes of varying infill geometries and infill percentage.
- Once printer and variables have been defined, there will be quick turn around on data processing
- Below are the stress strain curves from compression tests for 6 different samples

Print Pattern	Infill Percentage	Name
Triangle	20	T20
	25	T25
Grid	20	G20
	25	G25
Tri-Hexagon	20	TH20
	25	TH25





Future Work

- Continue fine-tuning the printer parameters to consistently produce lattices
- Have the vibration fixture machined and begin set-up of entire testing system
  - Mounting the exciter to the floor
  - Creating mount for LDV
- Plan to independent study with Dr. Murray next semester to continue efforts on both projects

Acknowledgements

I would like to thank Dr. Murray for not only being an unbelievably helpful, encouraging, and knowledgeable mentor, but also for showing me that engineering is so much more than technical knowledge.

I want to thank my family and friends at Marquette and Missouri for guiding and supporting me to become the person I am today

This project was funded by Dr. Zurcher and the Honors Program and Ms. Jamiola and The Opus College of Engineering SURF Program