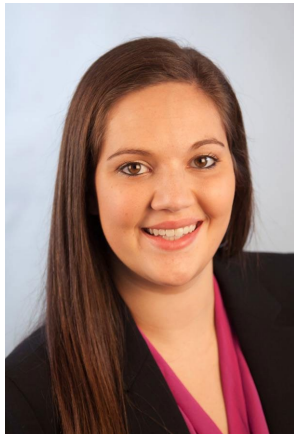
Virtual Design Review #1

Air Force Research Lab (AFRL)
Polymer Infiltration Device

Haimowitz, Jenkins, Kent

The Team

Catherine Kent
Lead ME/Research Coordinator



Emily Stern
Lead Technologist

Michael Haimowitz
Team Leader

James Jenkins
Geometric Integrator

Project Brief

- Design a device to infiltrate additively manufactured open-celled lattices of varying geometries
- Device will permeate lattice structure with a polymer infill
- Deliver device to AFRL

Project Objective

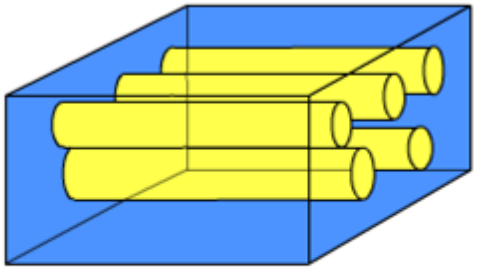
- Create a device prototype
- Device must fill a lattice of variable shapes, sizes, materials, and cavity structure
- Device must be able to completely fill the lattice structure without porosity
- Device must be compatible with current AFRL equipment

Purpose for Project

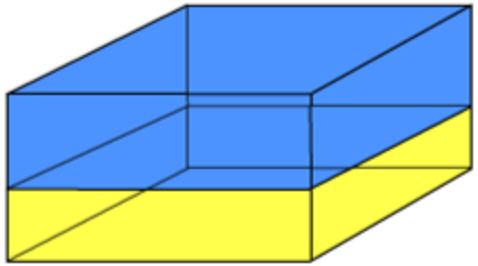
- Filled lattices be used to tailor the mechanical response of a warhead payload
- Lattices will ultimately be infiltrated with high explosive
- Eliminate air voids to limit hot spots in explosive composite
- Verify Rule of Mixtures is valid for filled lattices

Rule of Mixtures

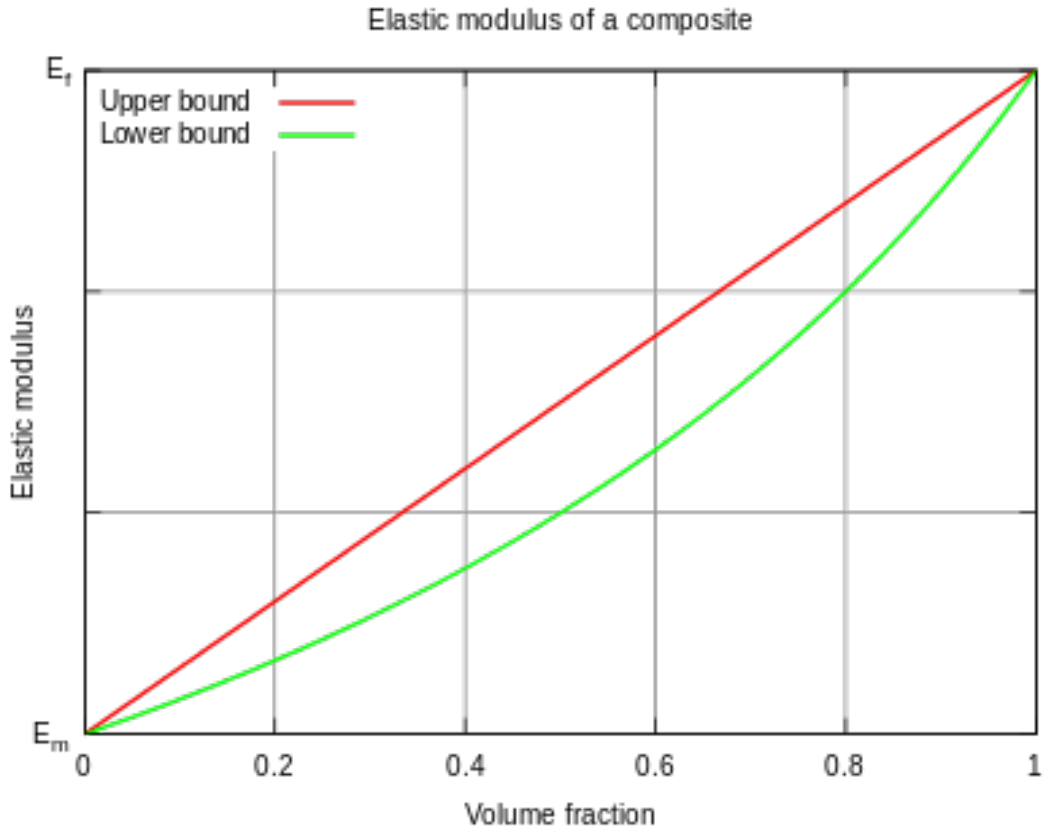
Upper and lower bound of some mechanical properties of composites can be predicted using the mechanical properties of the constituents.



Composite material showing aligned fibres within the matrix



The approximation used in the Rule of Mixtures



Rule of Mixtures - Assumptions

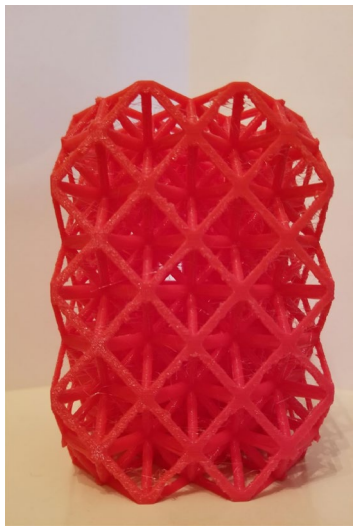
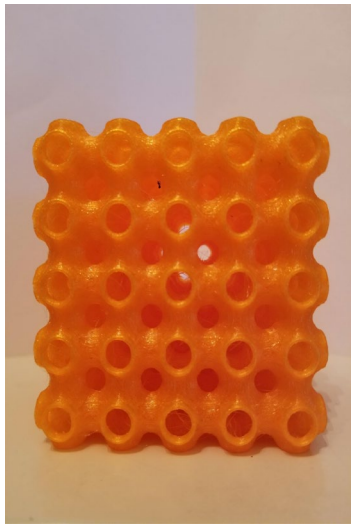
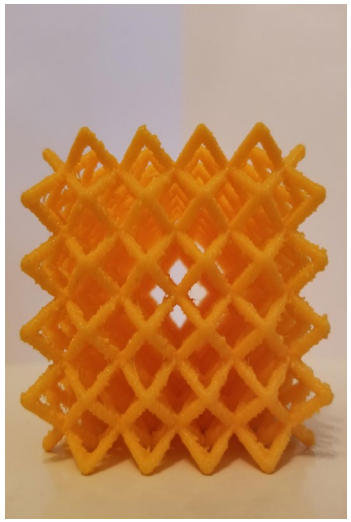
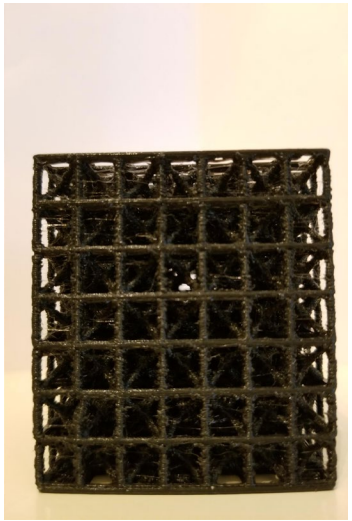
1. Uniform distribution throughout the matrix.
2. Perfect bonding between fibers and matrix.
3. Matrix is free of voids.
4. Matrix free of residual stresses.
5. Equal Strain Assumption:
    a. The strain found in the composite, the matrix, and the fibers are all equal.

Detailed Scope - Project Description

- Design and build a prototype to infiltrate open-cell lattice structures with silicone
- Evenly fill the lattices
- Eliminate air voids
- Validate the effectiveness of the prototype

Detailed Scope - Assumptions

- Geometries used will be only cubes and cylinders


- Homogenous material for filling lattices
  - Sylgard 184 Silicone

Detailed Scope - Project Goals

- Design a device that will completely fill a variety of lattice structures with silicone
- Create a functional prototype
- Analyze filled lattice to verify removal of cavities
- If possible, test the device using silicone mixed with interstitial solids

Detailed Scope - Market

- Aerospace
  - Airfoils
  - Landing gear
- Military-Industrial
  - Munitions
  - Personnel Protection

- Automotive
  - Body
  - Cooling Systems
- Construction
  - Higher strength-weight ratio support structures

Detailed Scope - Stakeholders

- Eglin Air Force Base
  - Dr. Philip J. Flater
  - Air Force Research Lab

Dr. Philip J. Flater

- FAMU-FSU College of Engineering

Dr. McConomy

Dr. Hellstrom

Dr. Shih

Customer Needs

Information Provided	Verbalized Need	Interpereted Need
"Ensure uniform distribution of polymer infill while eliminating air voids/porosity for a variety of bulk shapes."	Lattice must be infiltrated with silicone without voids	Fills lattices with specifed polymer
		Fills lattices without porosity
	Can fill multiple lattice geometries	Fills small cube, large cube, and cylindrical lattices
		Specimens unconstrained in height
		Specimens constrained by length and width

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Customer Needs

Information Provided	Interpereted Need
"Validate infiltration effectiveness."	Ensure a working prototype
"Be compatible with AFRL processes and equipment."	Use standardized equipment and methodology
	Use standardized parts
"Provide user and safety manuals."	Provide guidelines to operate protoype and display safety hazards

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Functional Decomposition

- Contain fluid
- Transfer fluid
- Purge air out of fluid
- Purge air out of lattice
- Isolate lattice
- Fill lattice
- Extract filled lattice

Summary

- Customer needs and the scope of the project have been defined to include the polymer infiltration of a variety of lattices for use in warheads.
- The team seeks to design a polymer infiltrator, build a prototype, and verify the effectiveness of the prototype.

Going Forward

- Research current methods
  - How can they be improved
  - Can we integrate current ideas into prototype
- Create preliminary designs
  - Bill of materials
  - Prototype ideas
  - Solidworks simulations
- Get supplies for prototype
- Build prototype

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Questions?