Welding 3D Printed Structures for Composite Sacrificial Tooling

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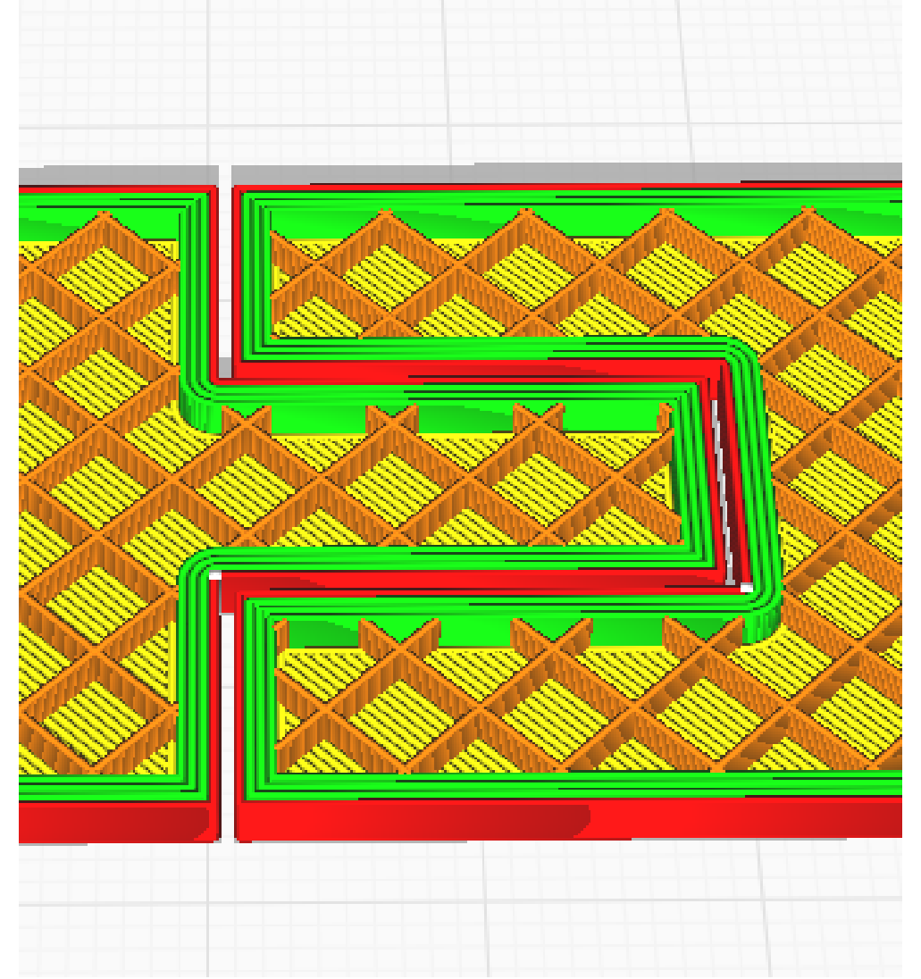
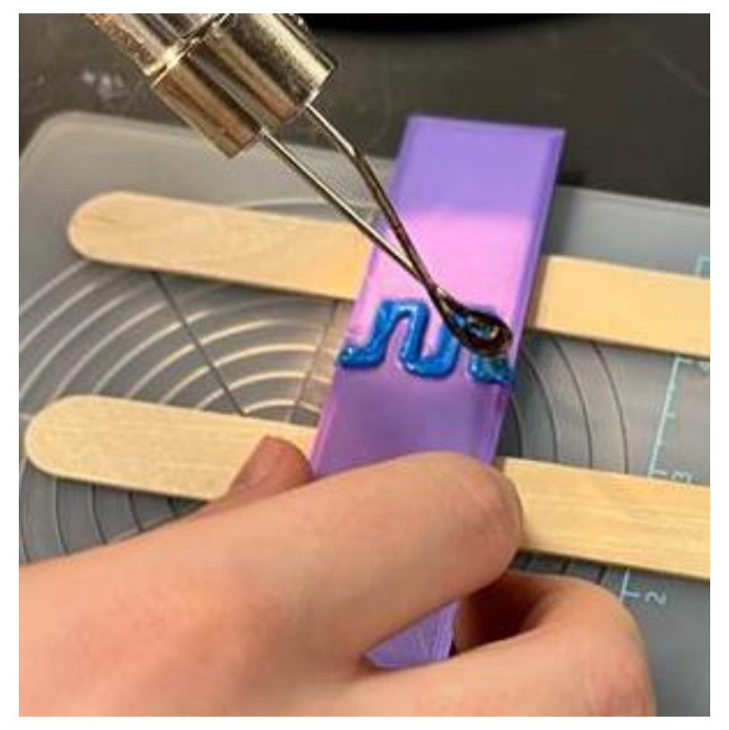
A previous study demonstrated the ability to effectively weld 3D printed structures together for tensile applications. The purpose of this study was to determine the welding characteristics required to achieve effective performance in flexural applications. 3D printing has become a manufacturing method that more parts are being designed for production. The nature of 3D printing poses challenges for adequate strength in desired directions and the ability to create significantly large parts. Effective welding of multiple parts would allow for designable solutions to these issues.

The creation of tooling for composite processing is an expensive and time-consuming process that requires skilled labor and precision equipment. Rapid prototyping may take weeks to source tooling, rely on simple geometry substitutes, or utilize 3D printing for a visual (not structural) representation. The use of 3D printing as a scaffold or tooling surface has been used successfully on large scale parts by sacrificing part resolution. Effective part sectioning and structural welding of 3D printed structures could result in an inexpensive and fast method for prototyping tooling that allow for precise, complex composite part production.



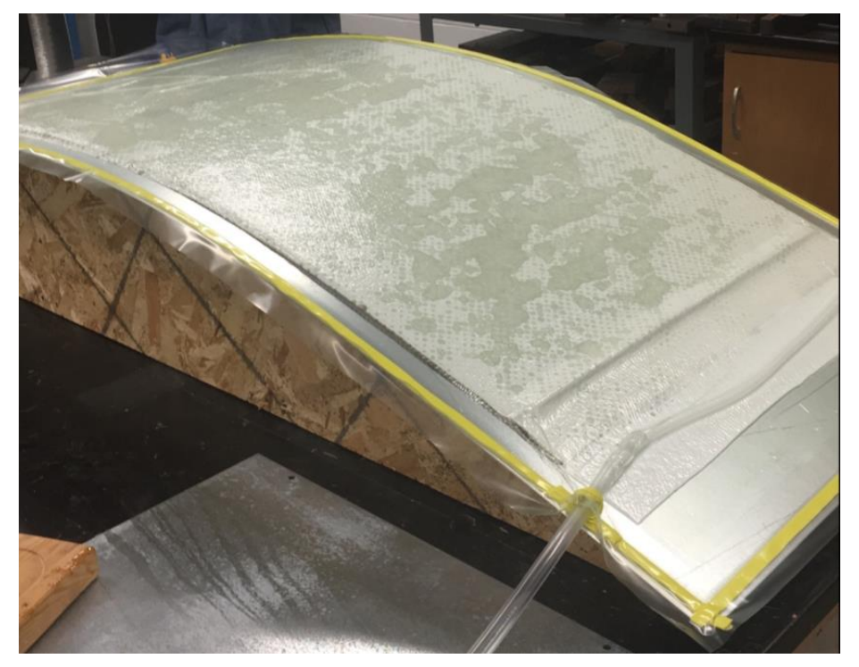


Background

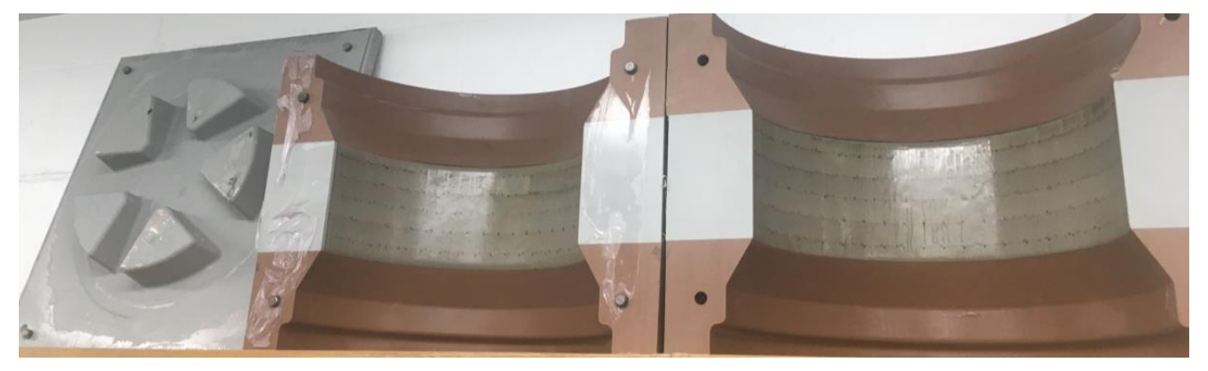
Composite tooling for property characterization and panels is typically a simple, flat surface. If curvature is needed, tooling may need to machined or if the curvature is gradual a thin sheet of metal could be clamped to a tool form. As complexity increases, the time and expense of tooling can dramatically increase.

Simple ⟷ Complex

Flat Parts on a Flat Table

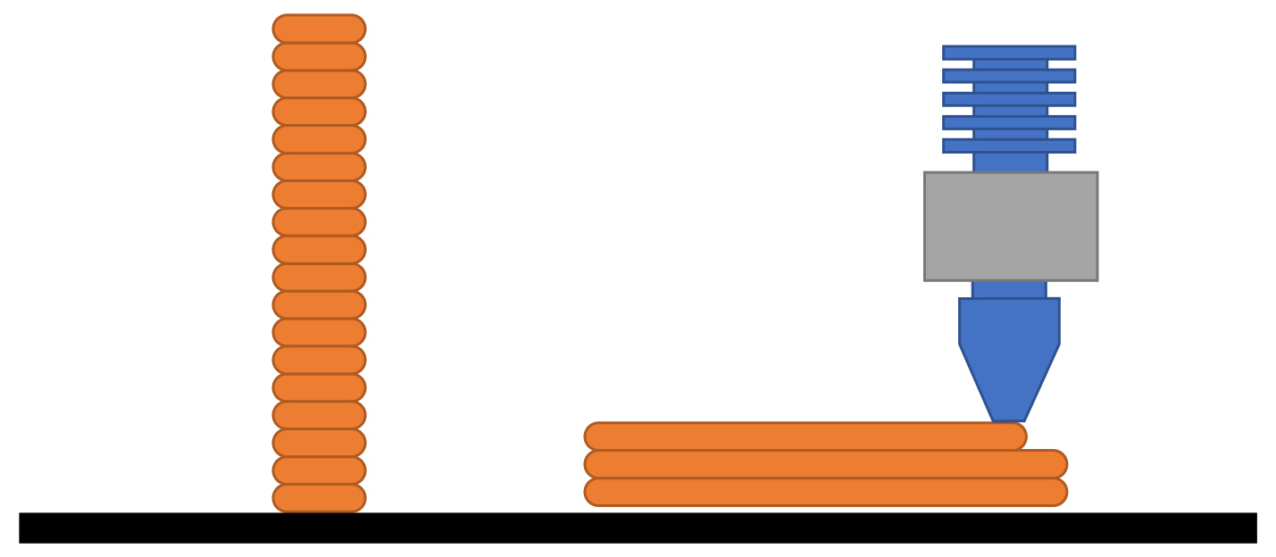


Curved parts on a thin sheet of metal clamped to a wooden Form

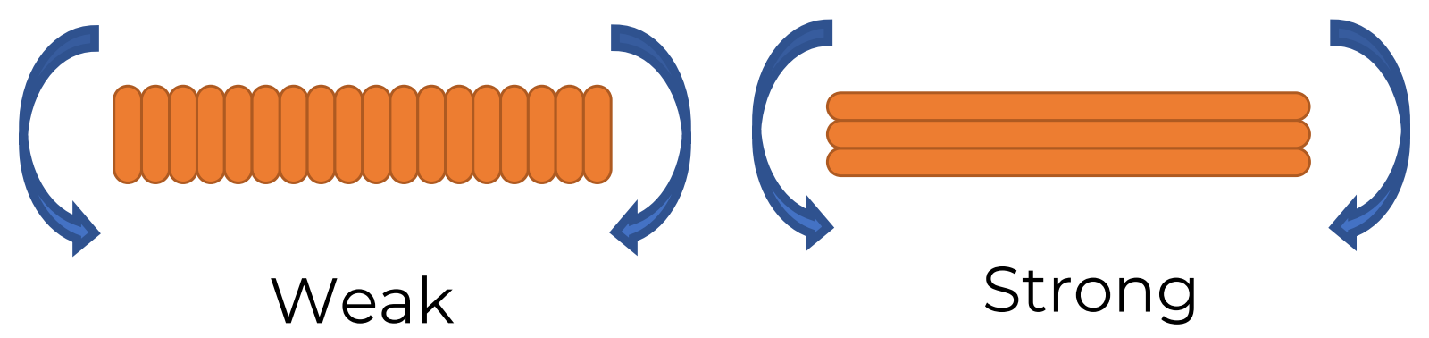


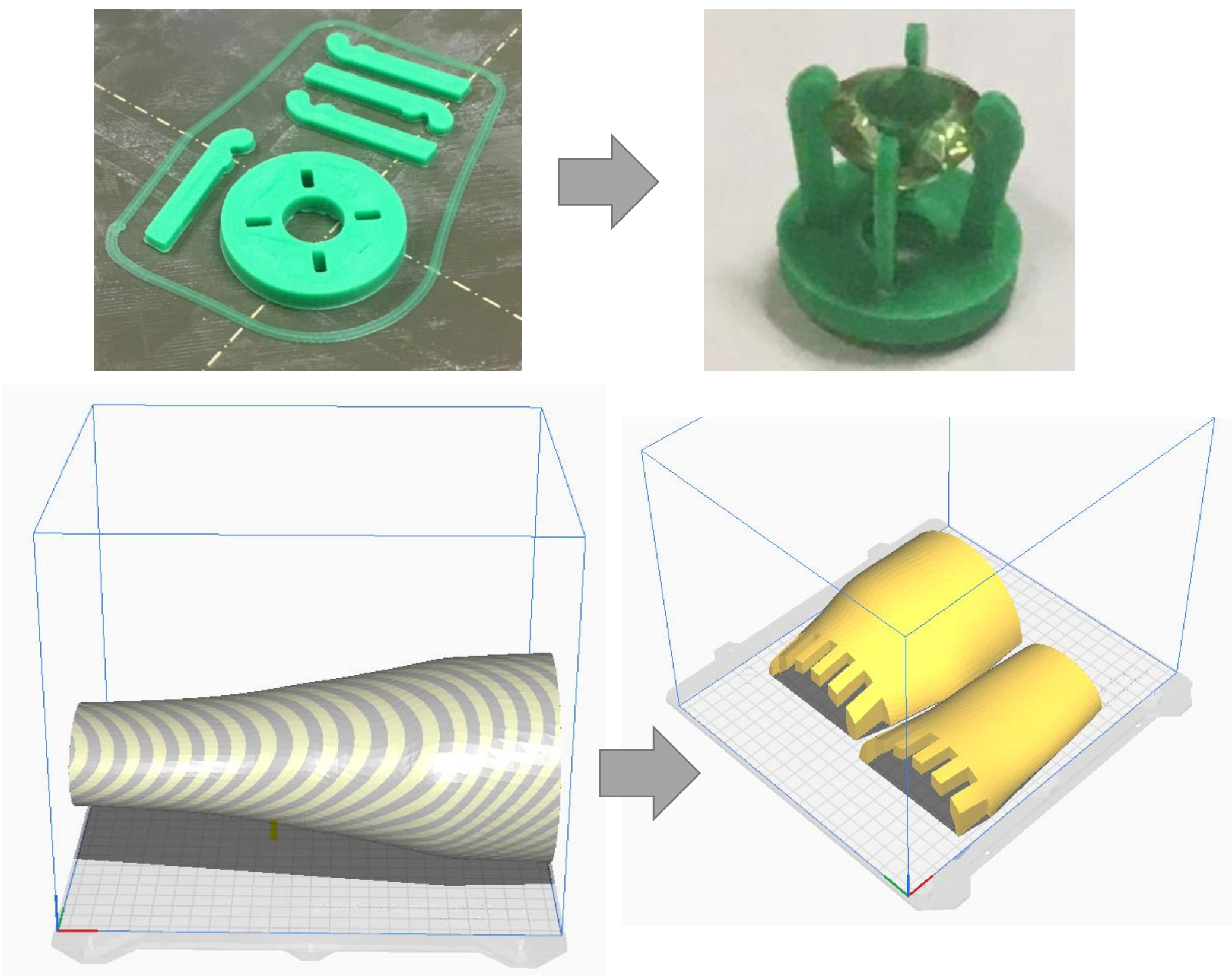
Complex Geometry Parts with machined, multi-cavity tooling

3D printing offers the ability for designers to create complex geometry parts that may be difficult if not impossible to create with traditional manufacturing methods.



3D printing also opens doors for those without equipment or manufacturing skills to create unique and complex items.

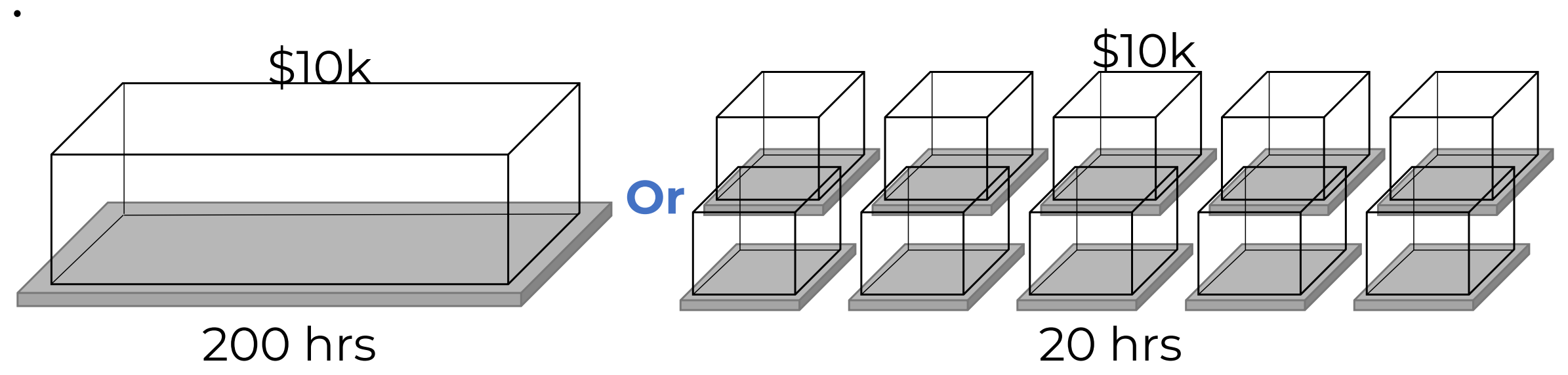




The ability to 3D print multiple sections in their preferred strong plane to create a welded assembly of 3D printed parts would mitigate many issues with 3D printing design.

The ability to section big parts into smaller sections would allow for large 3D printed parts to be generated.

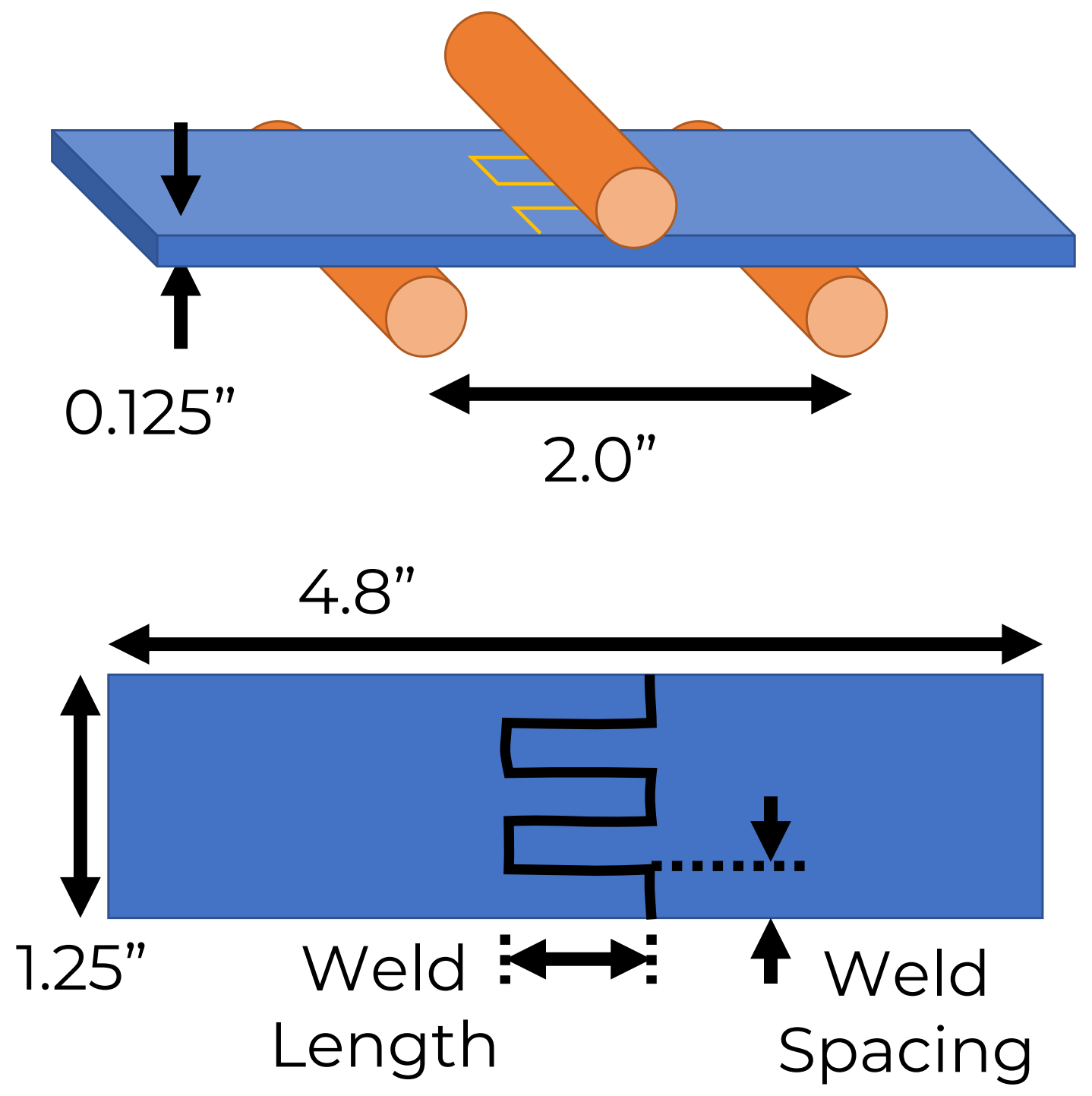
One large printer may be the same cost as 10 smaller printers. If 10 printers are making a section of a big part at the same time, then it would be 10 times faster than creating it on a big printer.



As 3D printed parts increase in size, the possibility of a misprint increases due to build plate levelness, heating consistencies, robustness of equipment, and build plate debonding.

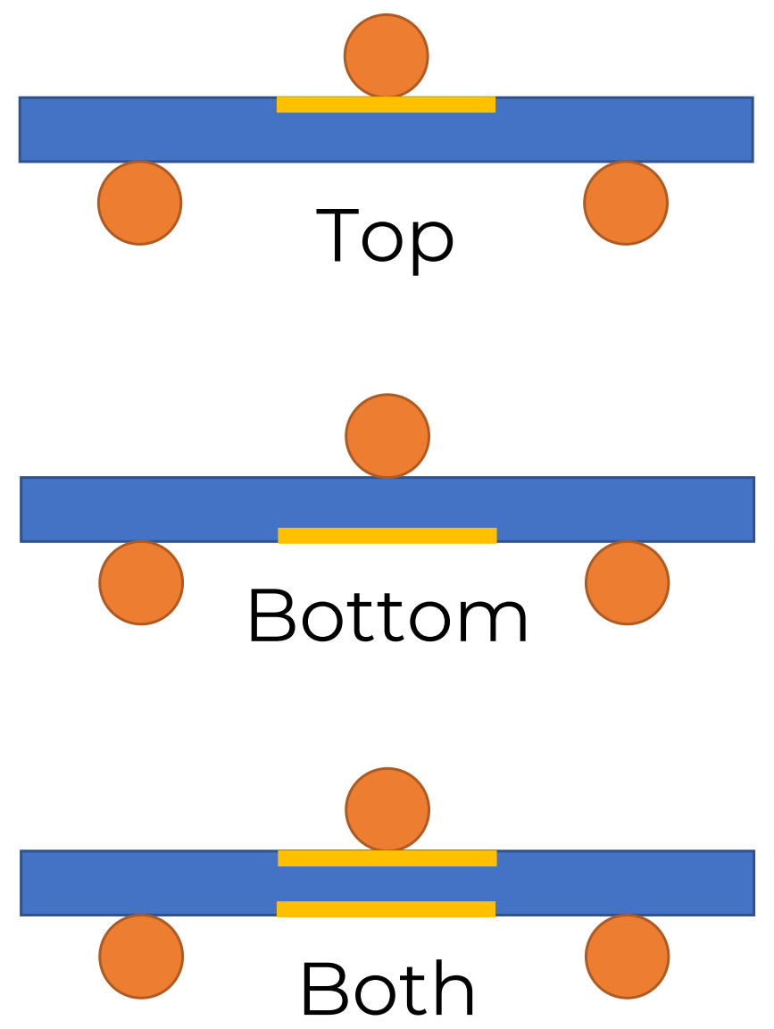
Experimental Setup

Flexural specimens were 3D printed with no welds and used to determine a baseline target for a welded joint. A 16:1 span to thickness ratio was used for the 3-pt flexural testing.



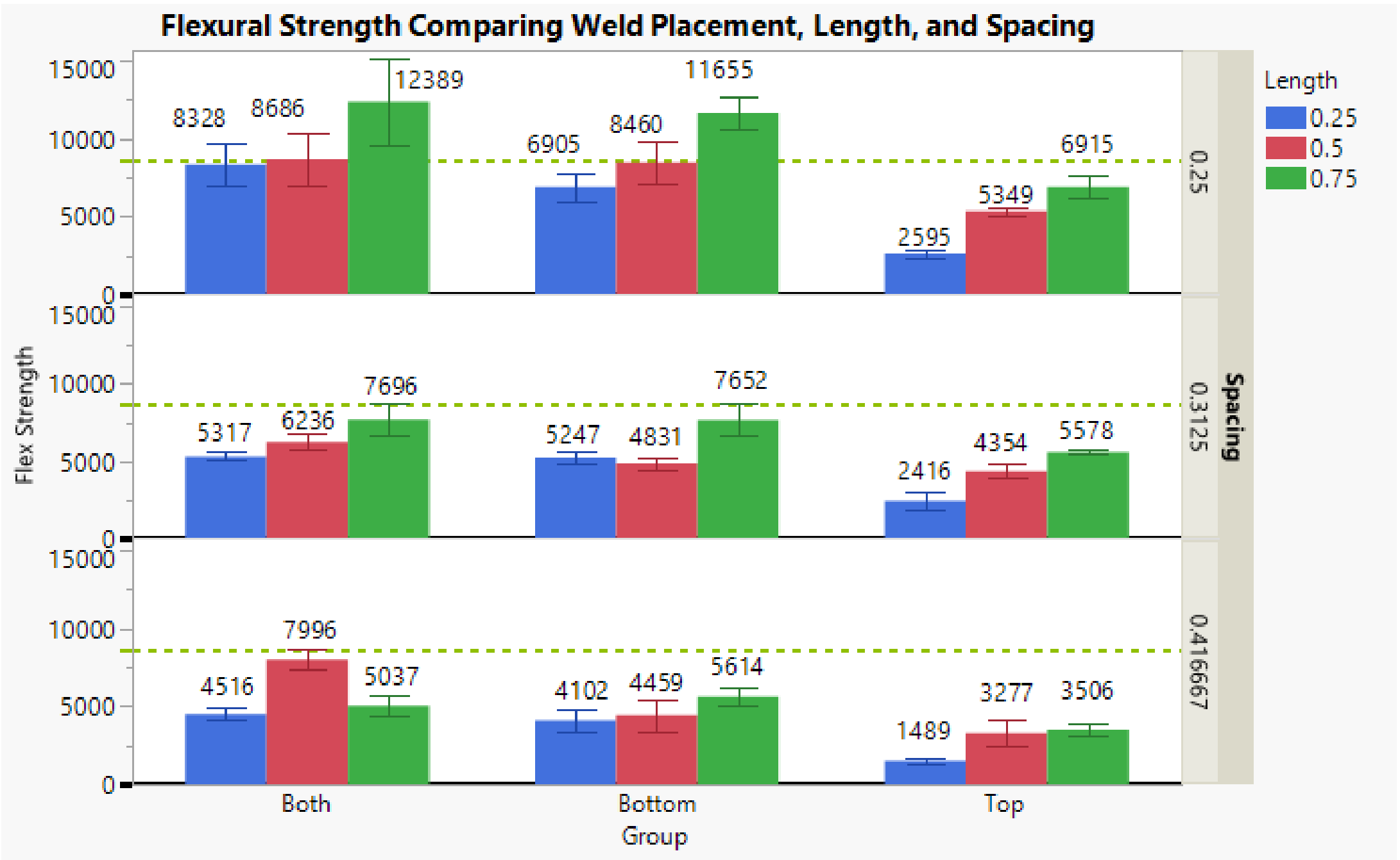
Weld length, weld spacing, and weld placement were tested as shown in the below Table. Each grouping had 5 replicate test specimens. 45 specimens per spacing; 135 total tests.

		Spacing		
		0.25"	0.3125"	0.4167"
Weld Length	0.25"	Top	Top	Top
		Bottom	Bottom	Bottom
		Both	Both	Both
	0.50"	Top	Top	Top
		Bottom	Bottom	Bottom
		Both	Both	Both
	0.75"	Top	Top	Top
		Bottom	Bottom	Bottom
		Both	Both	Both



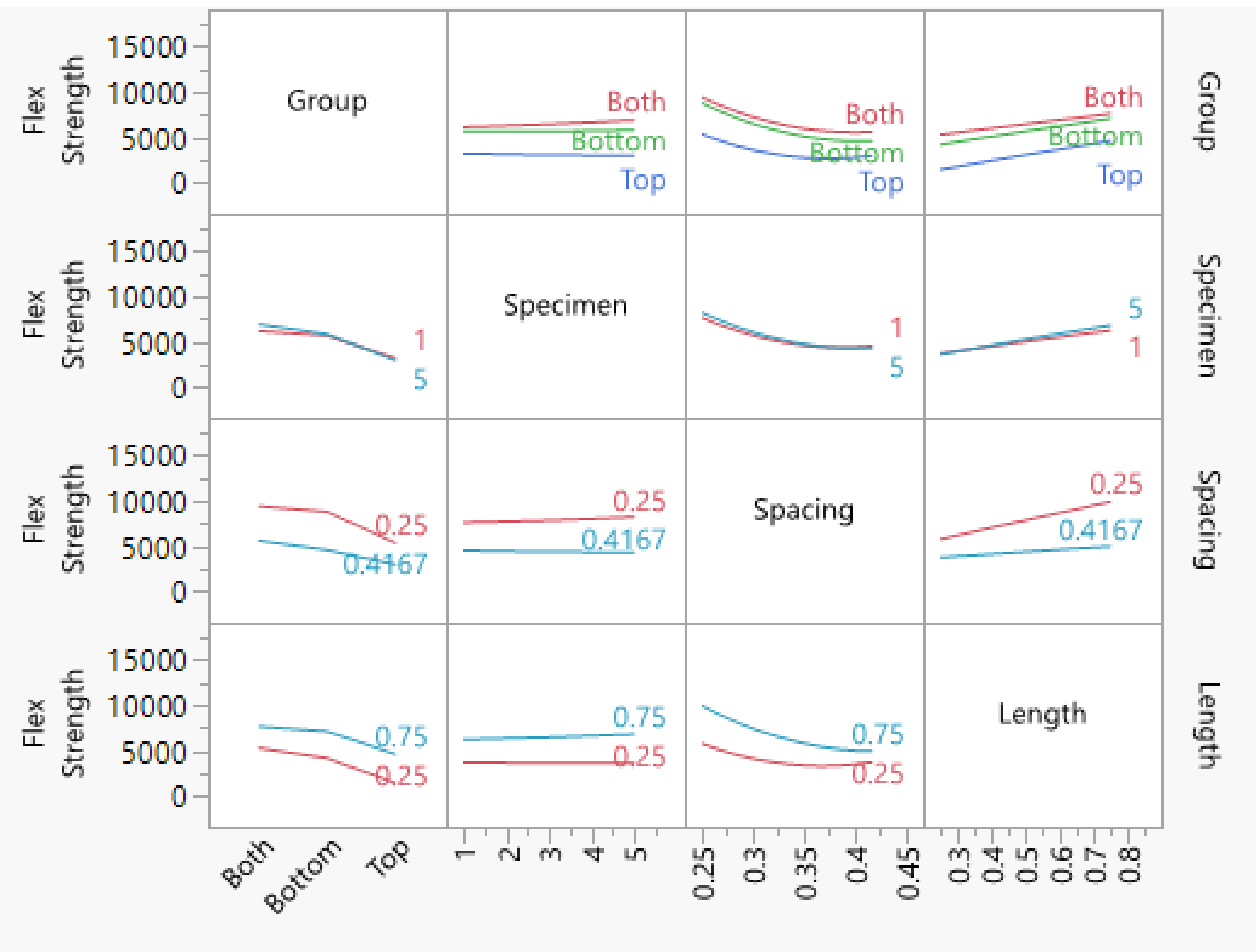
Results

It was determined that a weld length of 0.75" and a weld spacing of 0.25" exceeded the target if the weld was placed on the tensile side of the flexure.

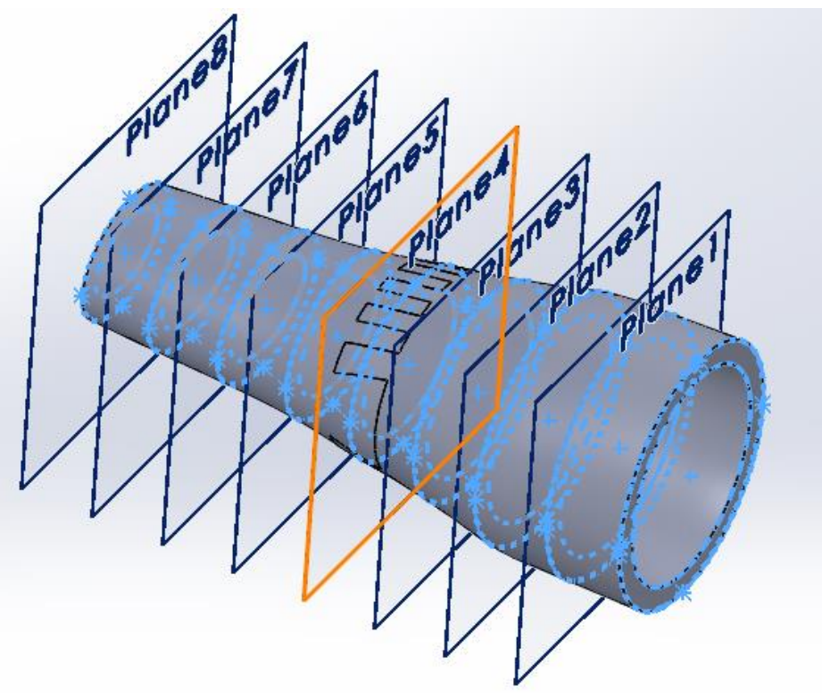


Breaking load increased as the spacing decreased, as the weld length increased, and if it was placed on the tensile side.

Not all parts will have the ability to weld on the inside of a joint.



As a proof of concept, a student arm was modelled by measuring the principal axis of ellipses at inch increments and modelled in Solidworks to create a 3D printed part welded together from 4 pieces.



Future Work

Additional considerations include determining if this is true for all fill levels, what thickness is required to resist deformation under vacuum, and how to program an auto generated puzzle piece parting of a large structure.

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