Honeycomb Integration into Rocket Airframes

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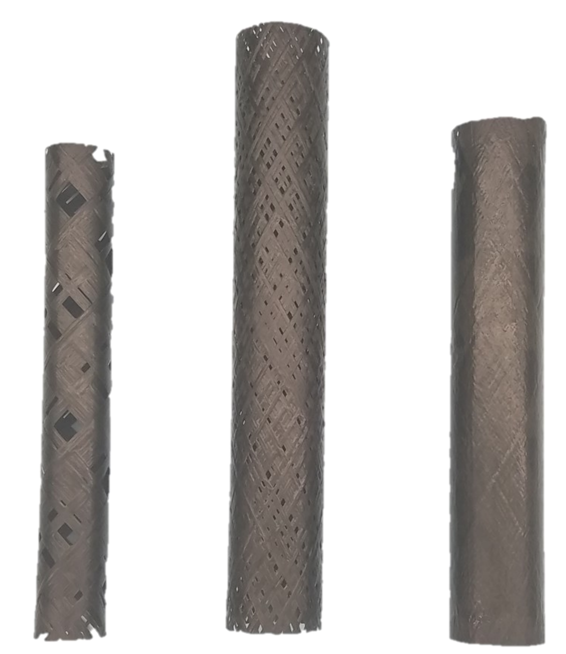
Abstract

This project's primary research goal is to develop a reliable method to design, manufacture, and test filament wound cylindrical shells for applications in rocket airframes. Currently, the design of shells relies on a complicated finite element analysis or empirically derived knockdown factors applied to analytical solutions. The scope of this research includes using both of these methods and comparing them to each other as well as experimental results. The current stage of the project is investigating cylindrical shell buckling of monocoque cylindrical shells under pure axial compression. The manufacturing of the shells is being performed with the assistance of Embry-Riddle Future Space Explorers and Developers Society, and the testing is being performed in Embry-Riddle's Materials Testing Lab. The end goal of the research is to publish the data and results in hopes of encouraging the design of safer and more efficient rocket structures in university built sounding rockets.

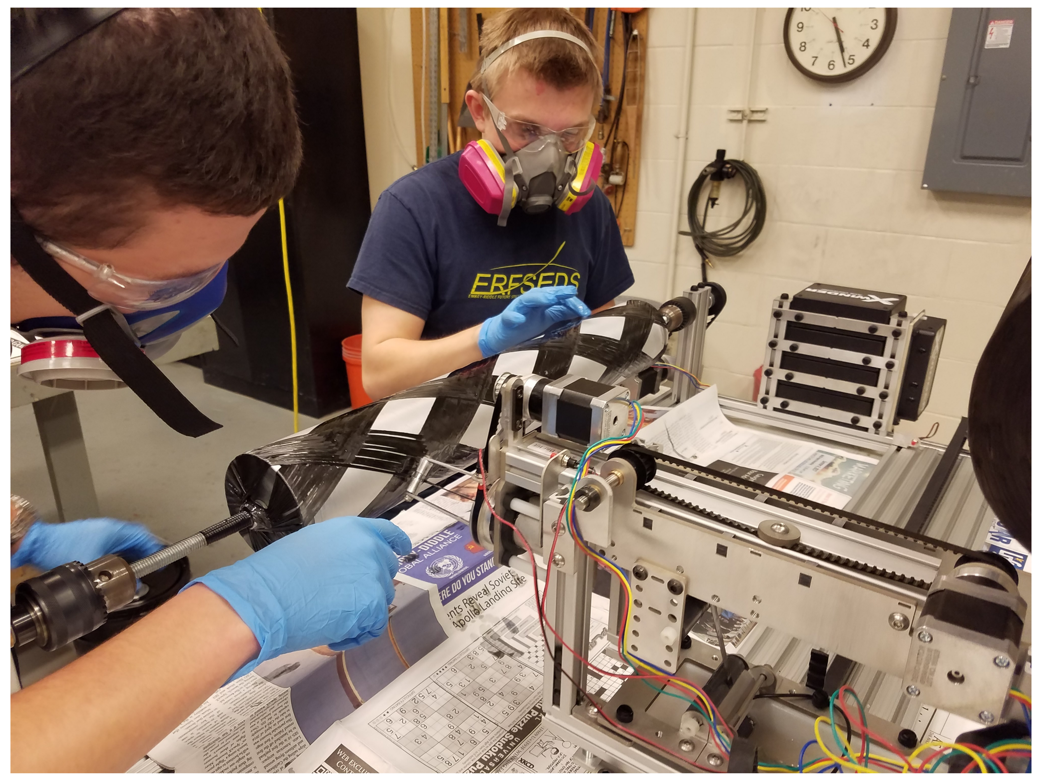
Conclusion

Despite setbacks in manufacturing pushing the project timeline back, a great deal of progress has been made developing a consistent manufacturing method for carbon fiber shells. As many goals of the project are yet to be completed, the project will continue over the Summer and into the next year, with the ultimate goal of advancing current manufacturing and analysis methods to develop safer launch vehicles.



Manufacturing Method

An Xwinder filament winder was used to manufacture the carbon fiber shells. Filament winding was selected as the manufacturing process in order to produce a consistent product; however, during the manufacturing, it became evident that the Xwinder did not produce a consistent product. A significant amount of time was put into modifying the Xwinder in an attempt to improve the results, but further modifications are required in order to obtain the desired consistency in manufacturing.



Analysis

After computing analytical and finite element solutions, a significant discrepancy exists between the two analysis methods. The greatest discrepancy being the dependence on length. The analytical solution, discussed in reference 1, yielded buckling loads which were highly dependent on the length of the shell. The finite element models, which were modeled in Nastran/Patran using QUAD4 shell elements, showed buckling loads which were mostly independent of the length.

Figure Number	Geometric Properties	Analysis Method	Critical Buckling Force (lbs)	Number of Axial Buckle Half-Waves	Number of Circumferential Buckle Waves

1	# Layers = 2
	Length = 6"
		Analytical Generalized case	35,782	7	5

		Finite Element	8,762	5	1

2	# Layers = 2
	Length = 24"
		Analytical Generalized case	649	13	5

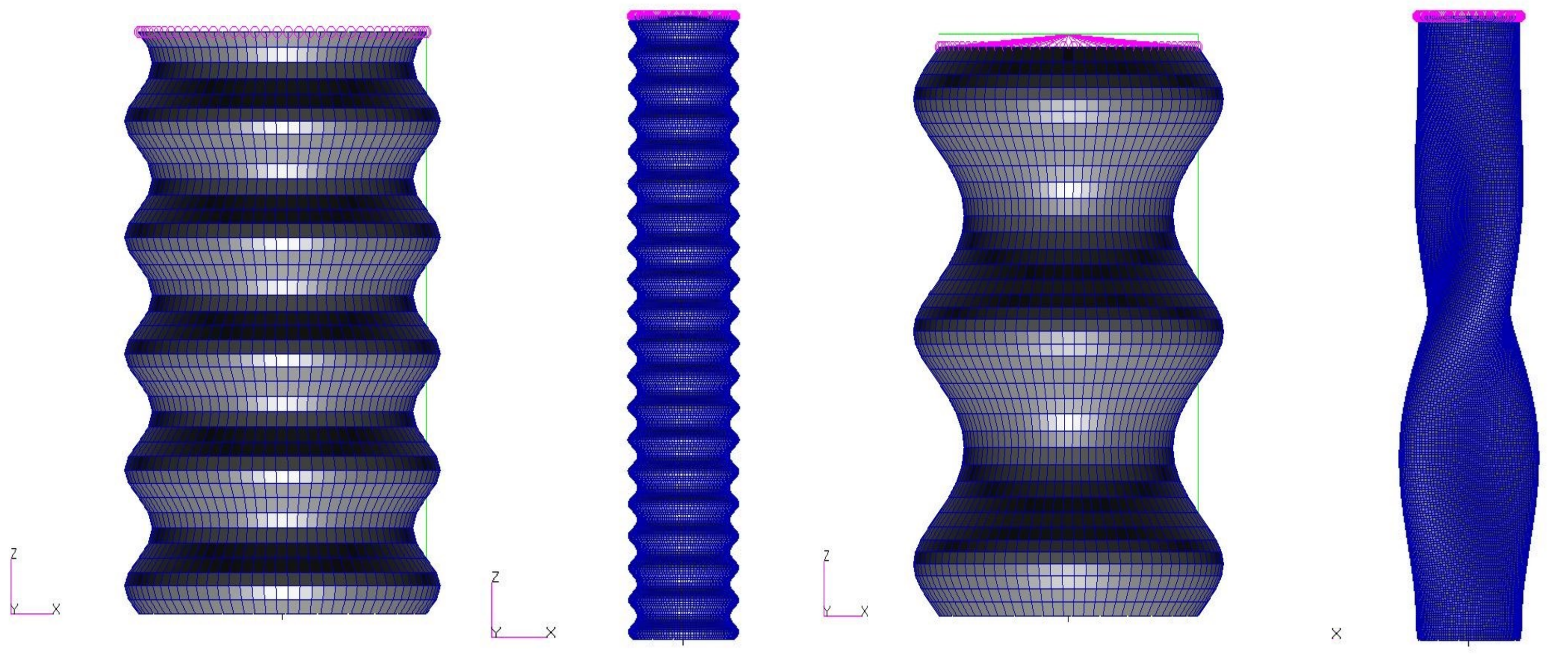
		Finite Element	8,749	19	1

3	# Layers = 6
	Length = 6"
		Analytical Generalized case	322,203	6	4

		Finite Element	99,175	3	1

4	# Layers = 6
	Length = 24"
		Analytical Generalized case	7,174	5	3

		Finite Element	97,296	1	2



Figures 1, 2, 3, 4 (left to right): Results of the finite element models

Acknowledgements:

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References:

1: Singer, J., Arbocz, J., Weller, T. (2002). *Buckling experiments: Experimental methods In buckling of thin-walled structures*. New York, NY: John Wiley and Sons Ltd