Thermal-Mechanical Analysis of Vertical Photovoltaic Arrays for Lunar Expedition

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A reliable power source is necessary for the successful construction of a long-term lunar base. An important constraint for the power source is its ability to be packed into a small volume for transport to the lunar surface. This project focuses on 10 kW class, deployable photovoltaic arrays for use near the Lunar South Pole. These arrays are projected be 16m in height and low mass, creating conditions for low fundamental natural frequencies and fast thermal response times. The Sun remains +/- 1.5 degrees from the horizon throughout the year at the Lunar South Pole. This type of illumination produces thermal gradients that induce unwanted structural bending and vibrational dynamics. This project develops a methodology for investigating coupled thermal-mechanical motions for single and multiple-part models. Building on work by Dr. Oliver R. Stohlman and later work by Mr. Jerry T. Haste, a Python code was created to dynamically exchange data between Abaqus and Thermal Desktop during an analysis. The approach allows for radically dissimilar structural and thermal meshes to be used for their respective analyses.

The objective of this project was to replicate previous data for a single-support seamless boom, provided by Mr. Jerry T. Haste, and produce new data for a multiple part model. The replicated data was conducted for an Aluminum 6061-T6 single support seamless boom which is 16m in length, has a 7.62cm outer radius, and has a 2mm wall thickness. The percent difference, comparing the C# and Python application, between the maximum tip deflection and the steady state deflection is between 2-3%. The multiple part model was a two part model consisting of a single-support seamless boom and a spreader bar. The single-support seamless boom is 16m in length, has a 7.62cm outer radius, and has a 2mm wall thickness. The spreader is 5m in length, has a 0.5m outer height, has a 0.5m outer width, and has a 2mm wall thickness. The spreader bar weight is approximately 86N which allows for a comparison with a single-support seamless boom with a distributed load of 80N on the top of the boom. The percent difference, comparing the simple and complex model, between the maximum tip deflection and the steady state deflection is between 4-8%. The addition of the spreader bar significantly changed temperature and deflection data, proving that the analysis of geometrically complex models is imperative to accurately gauging thermal-mechanical interactions.

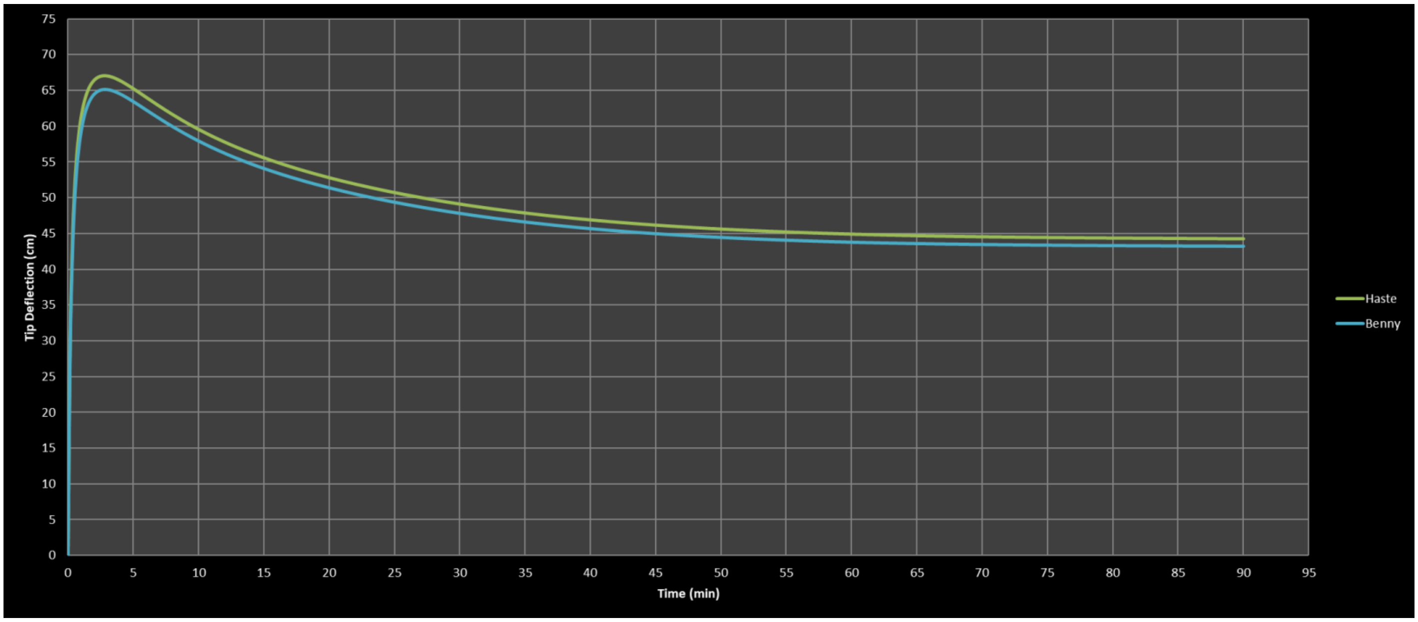

Figure 1: Tip Deflection Comparison of Single-Support Seamless Boom

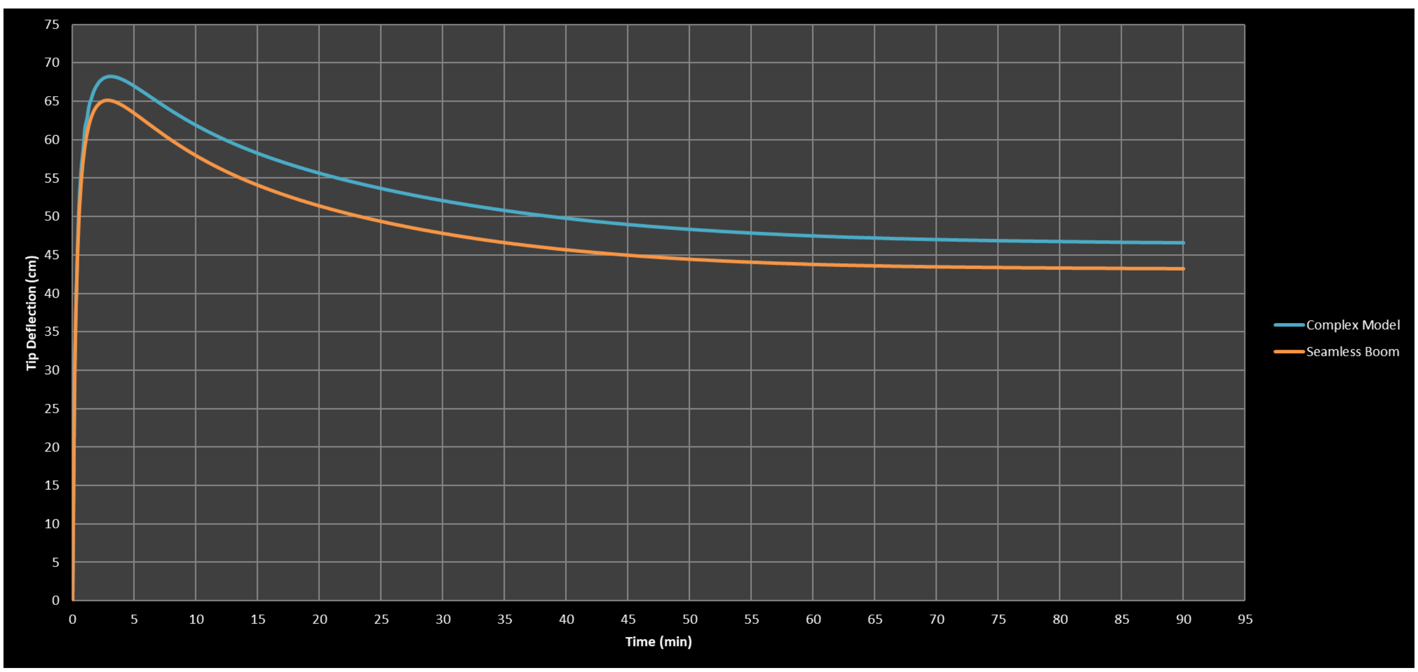

Figure 2: Tip Deflection Comparison of Complex Model & Single-Support Seamless Boom

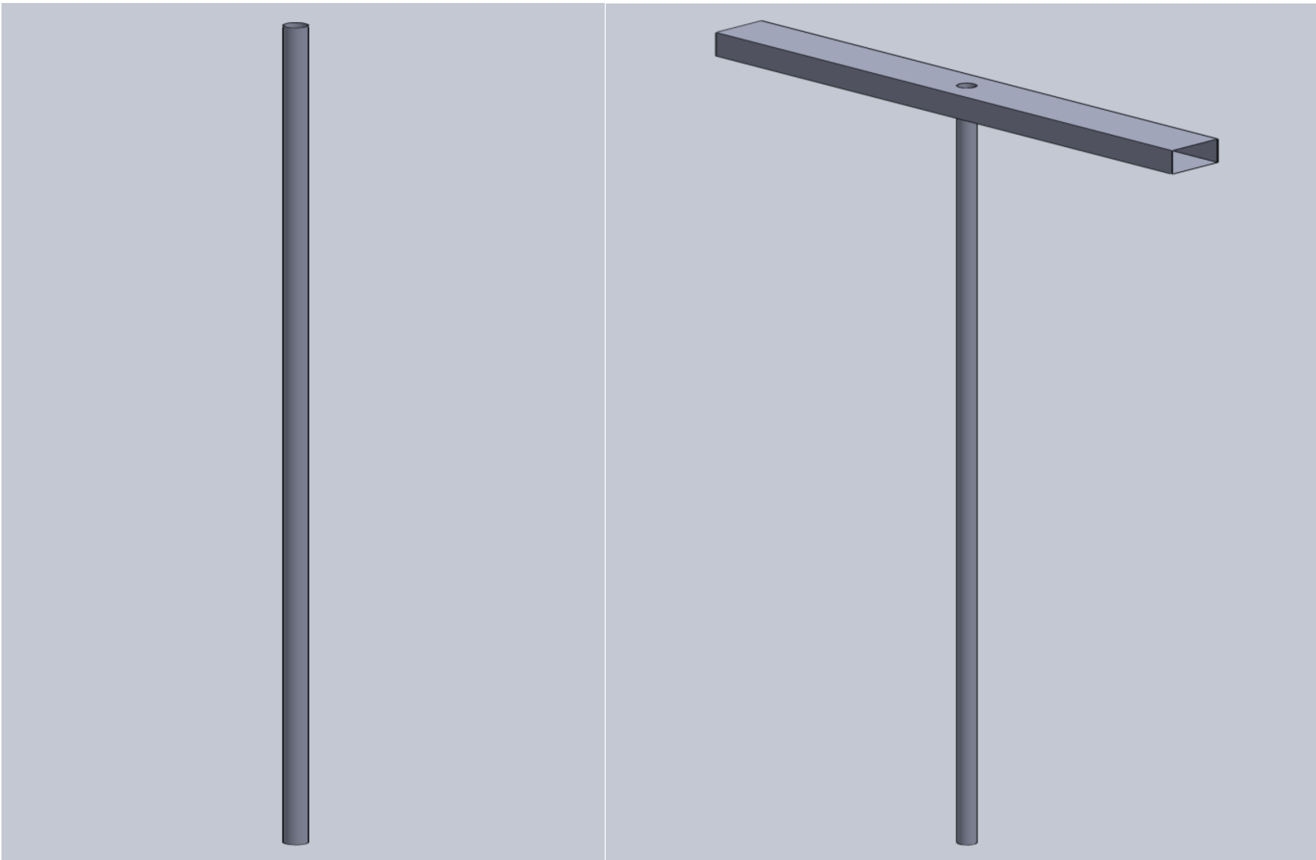

Figure 3: Model Comparison (Left: Single-Support Seamless Boom & Right: Multiple Part Model)