THE OHIO STATE UNIVERSITY

National Aeronautics and Space Administration

Biaxial Braid Flared Cone Structural Analysis

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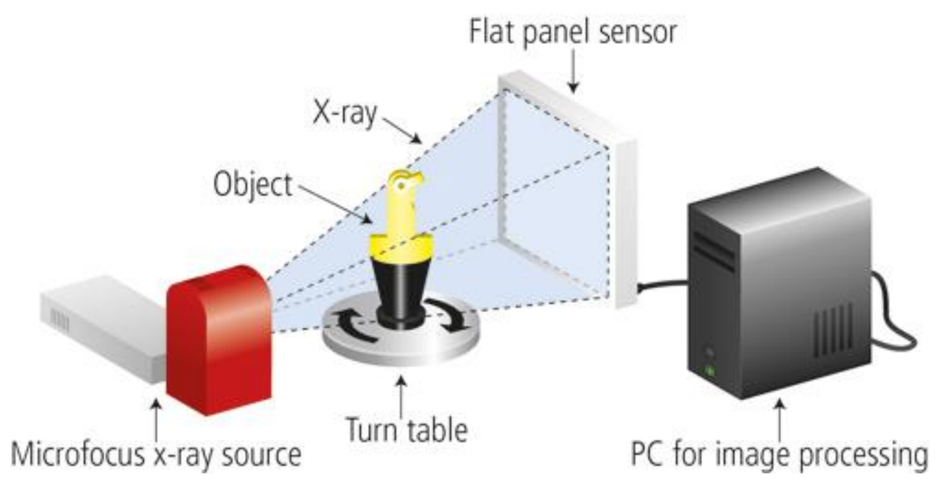
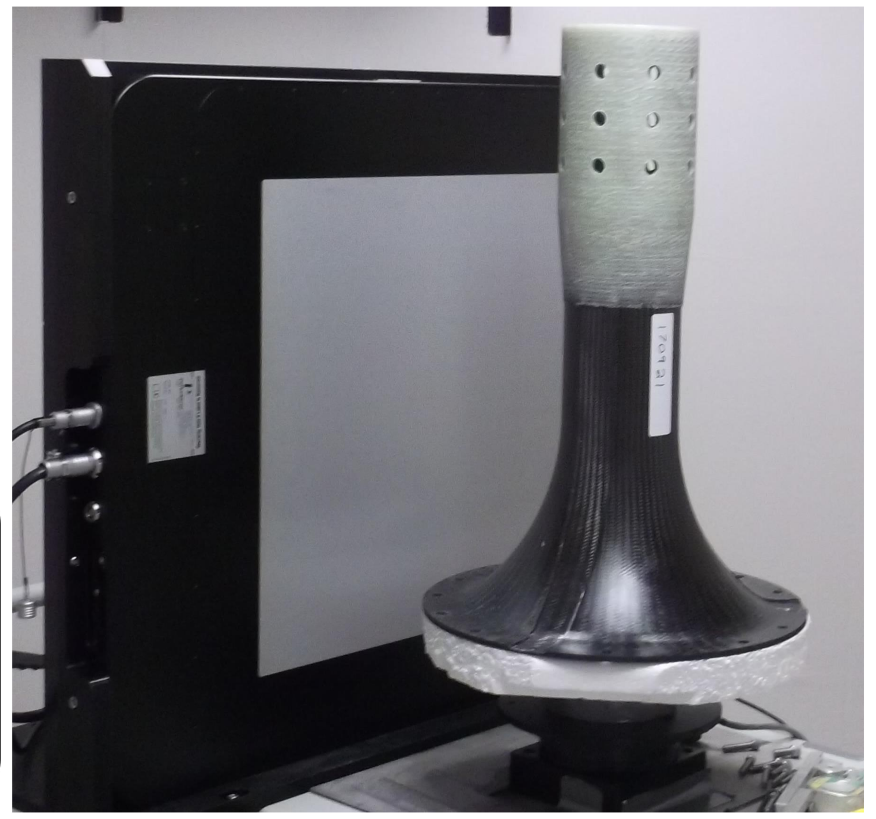
Introduction

Computed Tomography (CT) is a tool that can be used for structural analysis. CT data was taken for two flared cones with the same manufacturing process. These tubes were created from a biaxial braided composite made of T700 carbon fiber and E862 epoxy resin. One of the cones is shown in position to be scanned in the picture on the right below. The variation in reflectivity of the object allows for detailed imagery, as shown in the process to the left below. This CT data can then be used to analyze the properties of the scanned object.



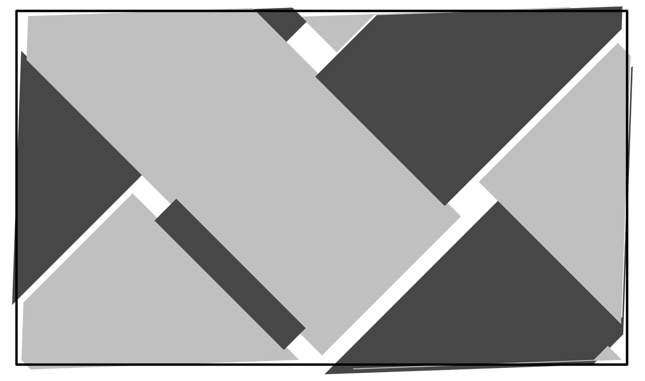


- X-ray image is taken by projecting the x-ray radiation through the object & capturing the signal using the sensor
- Multiple images are taken by programming the turn table to rotate by a set value after each time the x-ray signal is sent
- Variations within the object which cause reflections, absorption, or transmission losses of the x-ray radiation are detected by the sensor

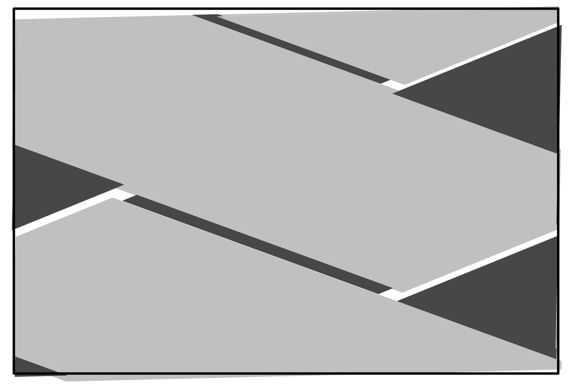
Image from: http://www.hamamatsu.com/us/en/community/xndt/app-industrial/industrial_ct.html

Objective

The objective of this analysis was to determine how both the thickness and biaxial braid angle changed throughout the part. In addition, a goal of this analysis was to find a method of performing the analysis that could be used for any future parts even if they are not also flared cones. Examples of the braid angles are shown below: the bottom, flared part of the cone was expected to have a braid angle of about ±70 degrees from the tow while the upper part of the cone was expected to have a braid angle of about ±45 degrees from the tow.



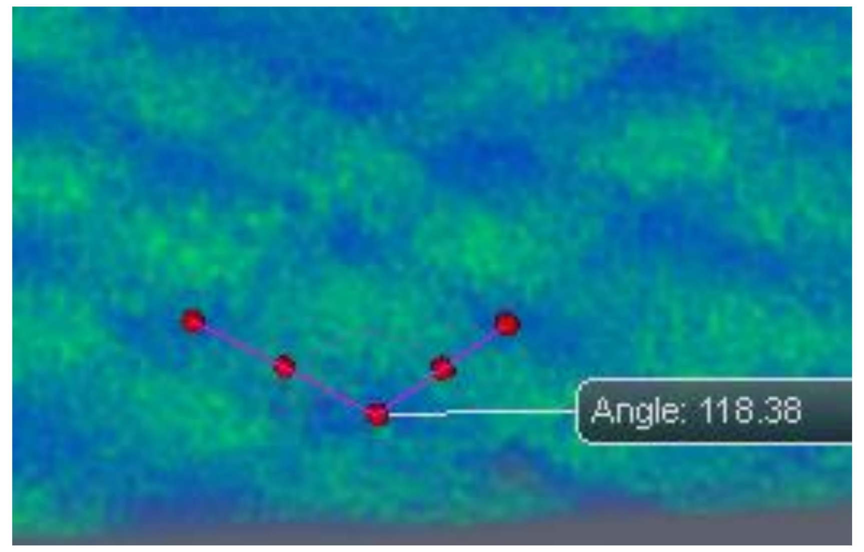
±45°

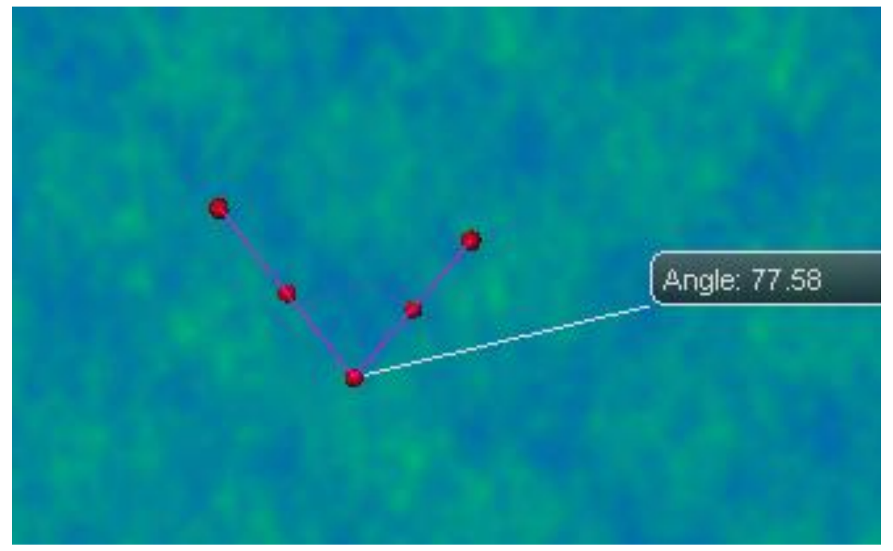


±70°

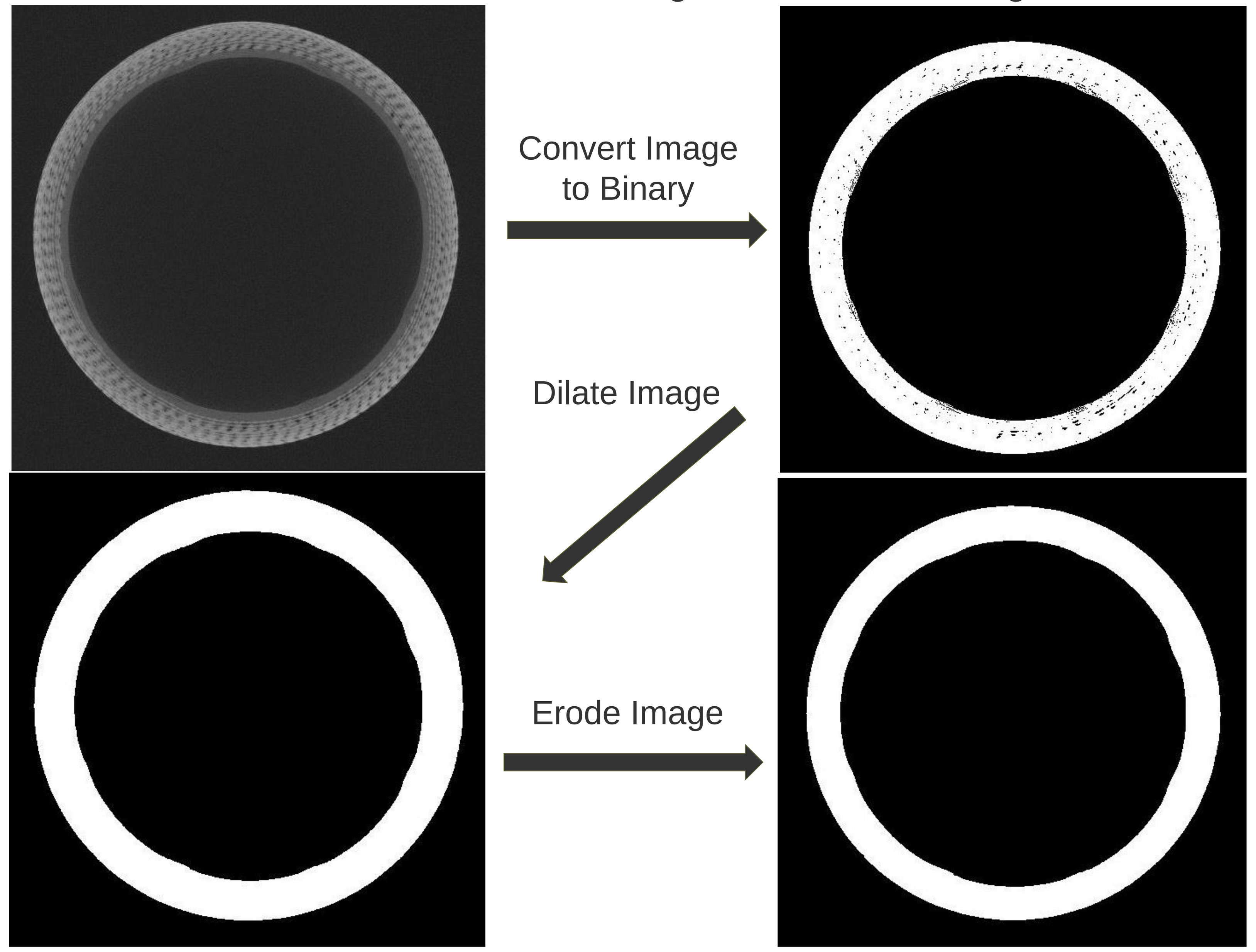
Methods

Two different software packages were used to analyze the data. Avizo 9.3 was used to take measurements of the braid angle throughout the part by constructing a visual 3D model based off of the CT data. Avizo's angle measurement tool was then used to find the braid angles throughout the part, and the coordinates of the vertex of the angle were recorded. Examples of angle measurements in Avizo are shown below (Note that the visual model is falsely colored for ease of viewing), and the braid angle data collected is shown on the right.



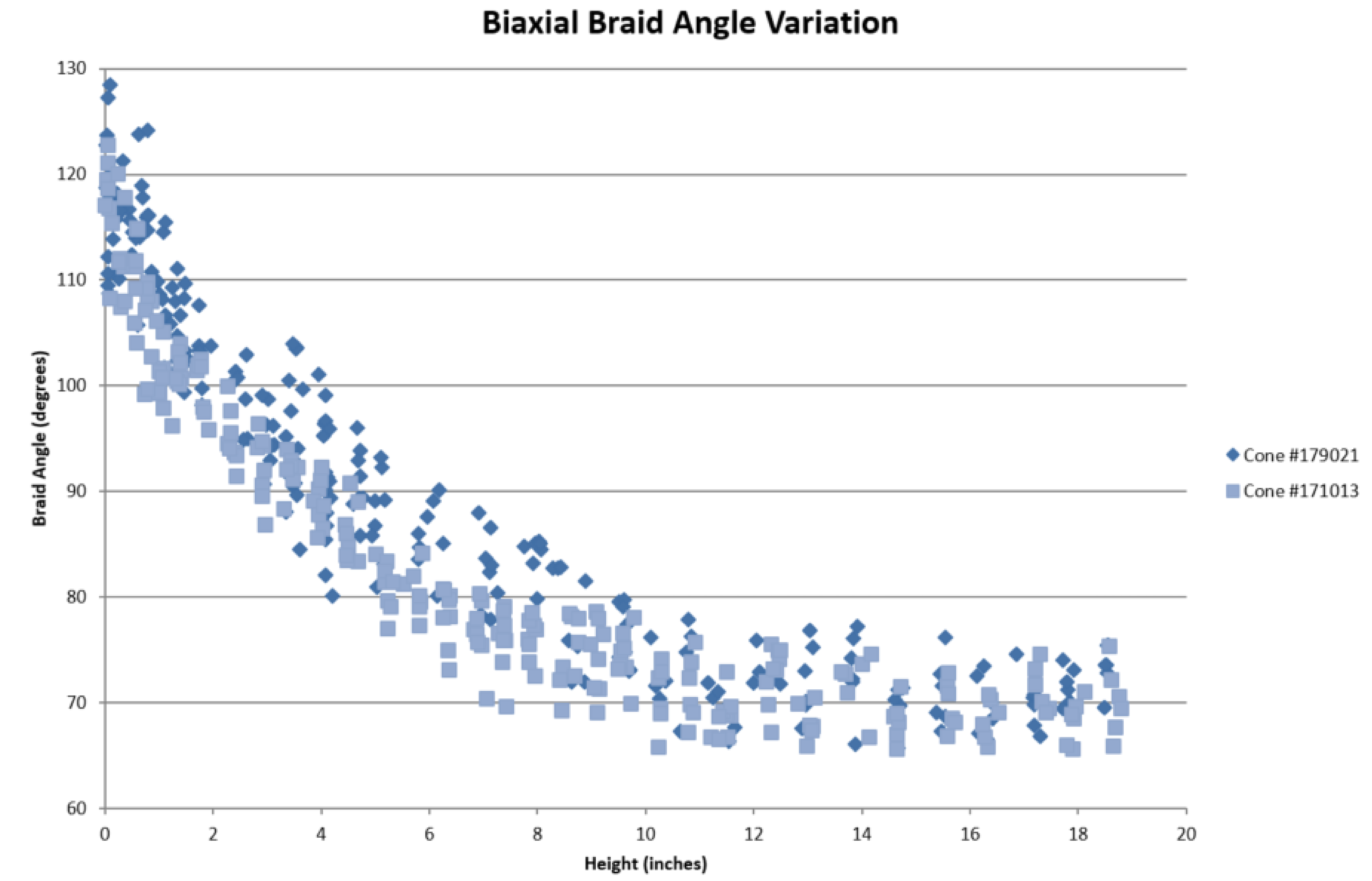


MATLAB was used to automatically measure the thickness of the cone throughout the dataset. For each picture (each representing about 1/300th of an inch in depth), eight measurements of the thickness were averaged. In order to ensure the most accurate measurements possible, the images had to be processed. First, each image was imported into MATLAB. Then, the image was converted to binary for simplicity of detection of material. Then, the image was dilated to fill in any 'holes' that were created in the binary image, mostly due to resin as seen in the first image. Finally, the binary image was eroded to ensure a return to the original size of the image.



Results

The braid angle for each cone started quite at around 120 degrees before dropping off first sharply but then gradually until the braid angle eventually levelled out at around 10 inches in height – or the height where the fiberglass first appears on the cone when measured from the bottom flange. The braid angle of the carbon fiber which was visible under the fiberglass was consistently about 70 degrees throughout the part of the cone wrapped in fiberglass. A graph of the data can be seen below.



The thickness of the two cones different significantly near the bottom flange of the cones but converge at about the halfway point between the bottom flange of the cone and the lowest reach of fiberglass on the cone. One cone was about 0.21 inches thick at the bottom while the other cone was only about .17 inches. Both cones levelled out at around .12 inches for the part that was purely carbon fiber, while the parts of the cones that were wrapped in fiberglass both had thicknesses of around 0.6 inches.