# Predicting Fiber Content by Mass in a Composite Material


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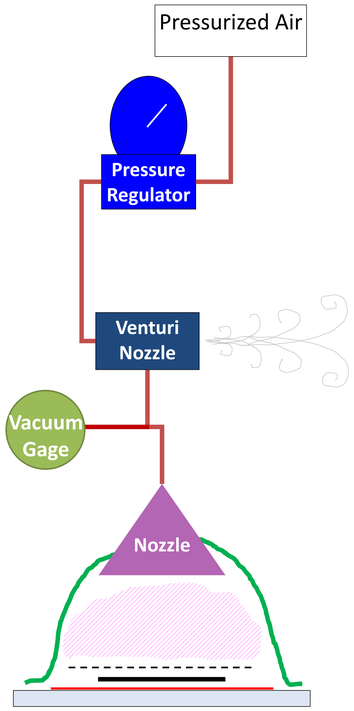
## Objectives

- Create an experiment to determine the mass content of a laminate composite after a layup has been performed under specific conditions.
- Determine important factors in a layup and discover any useful information that may aid in future layups.
- Find a mathematical model to describe the predicted content of a composite material.

## Apparatus




The apparatus was set up in the work area of the Human Powered Vehicle Team at the Student Innovation Center (SIC).
With this apparatus, inline pressurized air was fed through a positive pressure regulator, which regulated the pressure through a Venturi nozzle, creating a vacuum inside the vacuum bag.
The vacuum inside the bag forces the epoxy out of the impregnated fabric, through the peel ply (which acts as a cheese cloth), and into the batting, where it is soaked up.

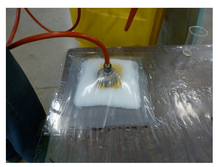
Although this apparatus functioned very well, it was very much the result of using available resources to make a cost-effective method of producing repeatable vacuum pressures, and had a number of shortcomings at all stages.

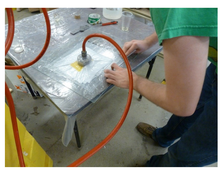
First, the inline air pressure would fluctuate as others used the resource and the compressor cycled. Next, setting the vacuum was somewhat imprecise, resulting in several minutes of epoxy pot life being wasted while fiddling with the regulator.

However, the most notable source of shortcomings came from the vacuum bag itself; small leaks were a constant problem, and identifying all of them was often difficult, sometimes impossible. The bag would also sometimes spontaneously fail in the middle of a trial, resulting in the need to repeat the trial.


## ABSTRACT

When analyzing composites, it is often necessary to have knowledge of the mass ratio between the matrix material and the fiber to compare theoretical results to analytical results. This experiment was conducted to give a prediction of the mass ratio for circumstances where data of initial and final weight is unavailable for this sort of analysis.
Carbon fiber and fiberglass were both chosen due to their common use and trials were conducted across three vacuum pressures, with three replicates per trial. For each trial, a small layup was performed on a pre-massed piece of fabric, with the fabric being massed again after the layup was complete. The data was then analyzed using MATLAB and Excel to obtain a visual representation and mathematical model respectively



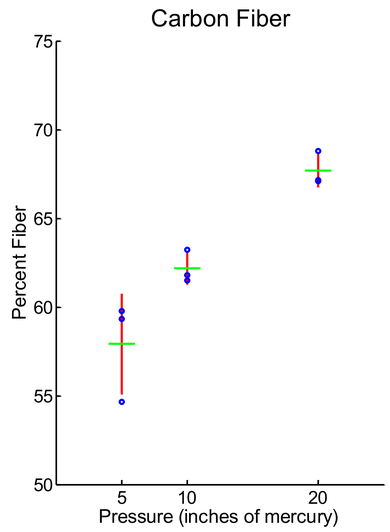
## Procedure

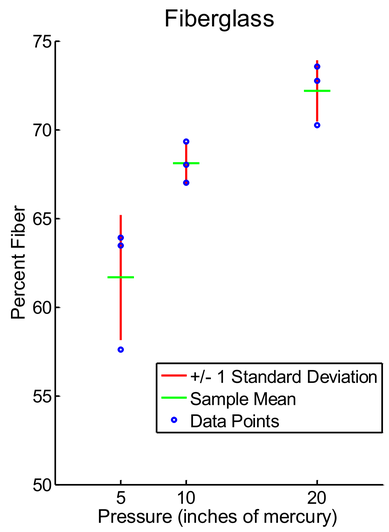
A DOE was performed using Minitab with the appropriate factors and levels. This DOE was used to determine the testing order for the individual trials.

For each trial, the appropriate materials were cut. The fiber being tested (either fiberglass or carbon fiber) would be massed on a small scale, and impregnated with double its mass in epoxy resin. The fabric was then laid on a glass plate covered in a release agent, and covered with peel ply and batting. An appropriate vacuum was then drawn using a vacuum bag, and the epoxy was left to cure for no fewer than four hours. At this point, the specimen was again massed.

Each trial was conducted in this manner, with the data being entered into Minitab. Data was then analyzed using MATLAB and Excel.

## Results




As expected, a higher vacuum pressure results in a higher fiber percent mass. When compared to carbon fiber, fiberglass allowed more epoxy to be drained from the composite. Furthermore, it was found that the variance was highest at the lowest pressure tested, possibly due to an increased sensitivity to other variables.

Near the pressures tested for these fibers, a reasonably good linear fit can be performed to predict the fiber content of a composite material knowing the vacuum pressure. It is likely that the percent content will approach some horizontal asymptote as the pressure differential approaches infinity.

During the course of the experiments it was found that the number of layers of material did not impact the percent fiber by mass, so it was omitted from the final trials

## Future Work

The most obvious extension of this work would be to increase the trial count, though some form of automation should be developed. It would also be prudent to test other fabric types, such as Kevlar and Zylon. Research could also be done under a more controlled environment (climate controlled, perfectly regulated pressure). Finally, investigation into the time dependency of the layups would be both useful and interesting.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