Service Module Panel Construction

Initial requirements called for M55J carbon fiber; however, after speaking with a sales representative at Toray, it was determined to be too expensive for our current budget. Purchase requirements dictated the customers buy at least one case of M55J weighing roughly 53 lbs. The cost of M55J is $255/lb, making a total purchase price of $13,515. Due to a readily available carbon fiber at the University of Idaho called HEX-613, correlations of material properties will be made between it and M55J. These correlations will give Team Impact an idea of how the test carbon fiber compares to the actual flight article.

Ensuring proper configuration of woven carbon fiber is crucial for producing maximum strength. The six layers of woven carbon fiber will be laid together as indicated by Figure 1. This quasi-isotropic configuration is suggested for improving multi-axial strength from Mechanics of Composite Materials authored by Robert M. Jones. The six layer application will be produced on both sides of the aluminum honeycomb panels. Team Impact will produce 6 panels, each cut to the dimensions of 7”X7”, for the testing at White Sands, NM.

![Figure 1: The six layers of carbon fiber will comprise of a twill woven quasi-isometric configuration for maximum impact strength.](image-url)
Carbon Fiber Setup

**Process A**

**Set up**

The setup will use a vacuum method to draw epoxy throughout the carbon fiber layout. This method is desired over others due to an even distribution of epoxy throughout the carbon fiber layout. It also reduces the mess of application experienced by other carbon fiber manufacturing processes.

The setup will consist of a large plastic sheet, four suction hoses, epoxy feeder line, flow max, suction manifold, suction pump, and cooling fan. As seen in Figure 2, the plastic sheet will overlap and contain all materials. A malleable sticky tape will then be used on the boarders of the sheet to create a vacuum seal. The malleable tape is needed to form seals around suction lines and feeder tube. The feeder lines will run to each corner of the setup, ensuring epoxy flows evenly throughout the vacuum bag. Vacuum tubes are routed to the manifold, where a single suction line connects the setup to a pump. The pump is separated from the vacuum manifold by a valve, giving the user the ability to maintain a complete suction once the vacuum is turned off.

Maintaining flow is accomplished by using a meshed plastic screen called flow max. It separates the suction bag, allowing epoxy to flow without obstruction throughout the contents of the bag. Seen in an exploded view on Figure 2, cotton swabs are secured to the suction lines preventing any obstructions from plugging the vacuum flow.

**Method**

The application of the epoxy requires a mixture ratio of 4:1, resin to hardener. Once mixed, the feeder line will be placed in the epoxy cup. The pump will then be turned on, drawing a vacuum in the system. Epoxy will begin flowing through the feeder line and spread evenly throughout the setup. Once the epoxy has reached all four vacuum lines, the valve will be closed and pump turned off. Closing the valve will ensure a constant vacuum during the eight hour curing time. Sufficient weight will be added to the carbon fiber articles to ensure proper lamination and removal of all air within the system.

**Conclusion**

After the eight hour curing time, the aluminum carbon fiber panels can be removed from the suction bag. Excess materials will be cut off with a band saw and the panel will be ready for testing.
Figure 2 Aluminum honeycomb and carbon fiber manufacturing setup seen from top and side views.
Process B

Due to concern for complete penetration of the epoxy through all six layers during the vacuum process, an alternative process of painting on the adhesive should be used.

Setup

The setup through this process depends solely on pressure to remove air bubbles. Wax paper, along with a release agent will be used as a base material during the process of adhere the carbon fiber together. This setup can be seen in Figure 3.

Method

The epoxy will use a ratio of 4:1, resin to hardener. The epoxy will be painted on to each individual carbon fiber sheet to insure complete penetration, therefore reducing any chances of voids. The bottom layer of carbon fiber will rest on the wax paper, while the entire assembly is built upon it. A sheet of wax paper will be placed on top, to separate the epoxy and weights. Sufficient pressure will be applied to the assembly to ensure removal of all air. The epoxy will be given eight hours to setup, and then the removal of pressure and wax paper can commence.

Conclusion

The final cleanup of the carbon fiber aluminum honeycomb panels will require cutting any excess resin or carbon fiber off. Once this material is removed, the panel will be ready for testing at White Sands, NM.

Final Thoughts:

After reviewing the methods available, I suggest using process b because it will drastically reduce any chance of voids forming in the laminated layers of carbon fiber.

-Matthew Mihelish