Design, Analysis and Simulation of an Automotive Carbon Fiber Monocoque Chassis

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ABSTRACT

Figure 1: Formula Student Race Car

The purpose of this project is to design the monocoque chassis of Formula SAE or other race cars with composite material. Design of the chassis is very important because the weight and stiffness properties are directly related with the performance of the car and the safety of the driver.

In order to make the monocoque chassis stronger and lighter at the same time, a composite material made of carbon fiber was chosen. A composite material, a honeycomb sandwich construction was chosen. Nomex was chosen the core of the honeycomb sandwich structure and carbon fiber orientations were determined.

OBJECTIVES

Depending on the stiffness and light-weight of materials, we have done various processes such as:

- The determination of the carbon fiber orientations
- The determination of the core material
- The determination of the production method
- The determination of the tests to be applied and investigation of ASTM standards

HONEYCOMB SANDWİCH STRUCTURE

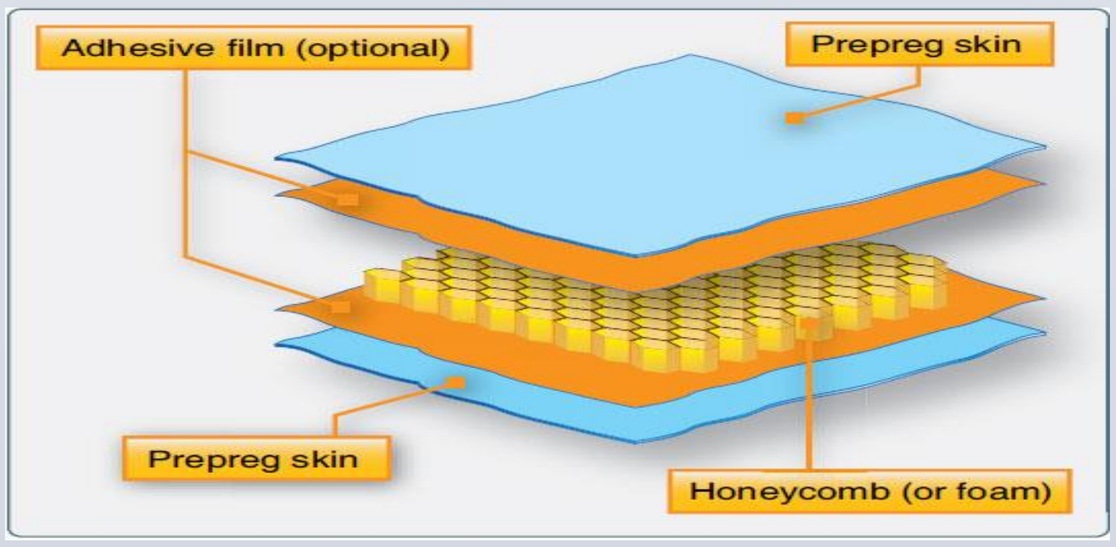

Figure 2: A Honeycomb Sandwich Panel

Honeycomb sandwich structures are natural or man-made structures that have the geometry of a honeycomb to allow the minimization of the amount of used material to reach the minimal weight and minimal material cost.

A honeycomb sandwich structure consists of two high strength face-sheets which are separated by the lightweight core as shown in Fig.2. The adhesives are used to bind the core and face-sheets.

DESİGN PROCEDURES

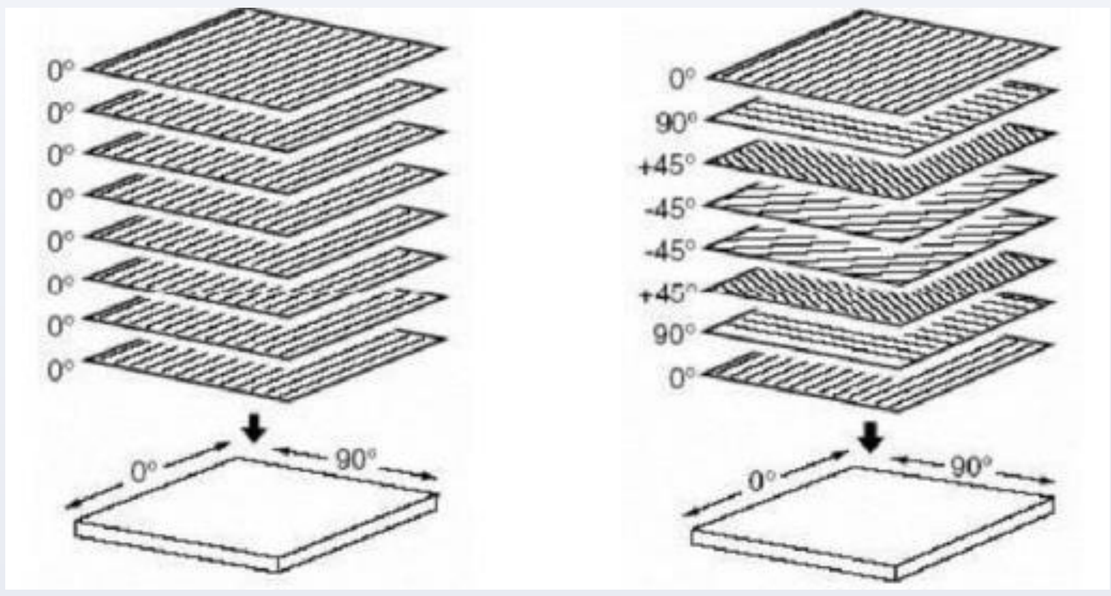

Figure 3: Combination of prepregs to form a laminate

A honeycomb sandwich structure was selected for the monocoque construction. This material included bi-directional woven carbon/epoxy fabric, unidirectional carbon/epoxy and Nomex honeycomb core.

The fibers provide strength in terms of orientation. In general, the fibers are placed in the load direction for optimum use of the composite. Bi-directional layers provide torsional stiffness and unidirectional layers provide longitudinal stiffness. For this reason, orientations have been chosen as both bi-directional and unidirectional carbon/epoxy. Two different sandwich configurations were ultimately chosen. In the final configurations, [F/03/F/core/F/03/F] has been used for the front bulkhead support region and [F_4/core/F_4] has been used for the side impact zones. In these layup descriptions, the 'F' refers to the bi-directional fabric and the '0' refers to the unidirectional tape and the subscript numeral refers to the number of layers.

Nomex honeycomb is a form of paper made of aromatic polyamide (aramid) fibers. Nomex honeycomb has fire retardance and formability properties.

Honeycomb is also the ideal material for energy absorption. The honeycomb core was selected 6 mm thickness.

CONCLUSIONS

This project provides a brief overview of the composite materials used for Formula SAE. Optimum material honeycomb sandwich structure was chosen among the composite materials. The most common material used in automotive and aerospace applications are the 'Nomex' aramid paper fiber core. The honeycomb geometry was modeled perfectly hexagonal. Durability is increased by using different orientations. In addition, weight is reduced by using fewer layers. The reason for the selection of this material is its both weight and stiffness. In this study, we have learned the importance of the core material and the layout of carbon fibers.

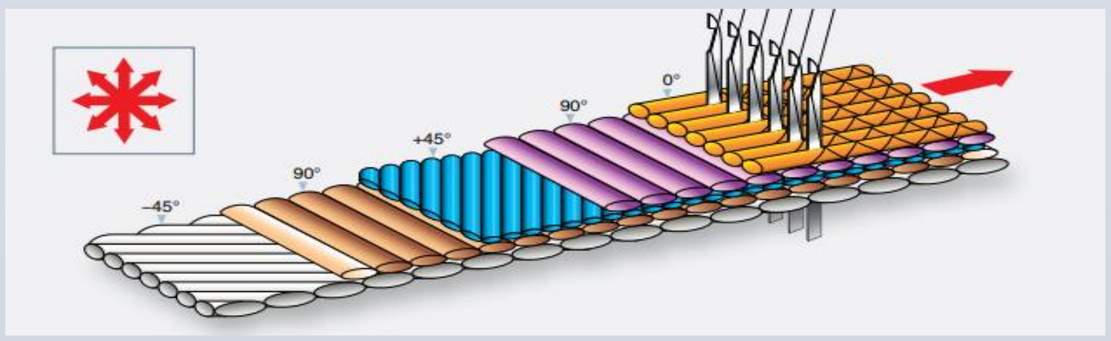

Figure 4: Orientations of Carbon Fibers

REFERENCES

- McDonald, M., Joyce, P., and Hamilton, L., Forero C., "Production of a Composite Monocoque Frame for a Formula SAE Racecar," SAE International, 2013-01-1173, 2013, doi:10.4271/2013-01-1173
- Louis A. Pilato, Michael J. Michno, '' Advanced Composite Materials,'' Springer Science & Business Media, 2013.