Sustainable Composite Manufacturing

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Project Introduction

Fiber metal laminates (FML), and composites in general, hold a prominent role and a promising future as materials used in the automotive and aerospace industries. This is due to the fact that they are customizable, lighter weight, and have improved mechanical properties compared to aluminum [1]. Since the standard synthetic fibers used in many of these composites are not reusable, recyclable, or biodegradable, this study investigates hemp fibers as a potential substitute for glass.

State of Knowledge

- Hemp is a strong and stiff plant fiber, making it an ideal composite reinforcement material [2]
- The main drawback to natural fibers is variability [2]

Relation Sustainable Mfg.

This work is inherently tied to material processing production, end of life recovery, and the supply chain since current composites lack recyclability [3].

Effects on the 3 pillars of sustainability:

[4]

- People – Higher demand for hemp creates jobs in rural areas
- Planet – Increased biodegradability
- Profit – Decreased cost in source material

Approach

- Fabricate 4-ply, unidirectional (90-0-90-0) glass (prepreg) and 4 and 5-ply epoxy/hemp (woven summercloth) composites, having similar fiber contents, in vacuum press
- Test glass and hemp fiber composites using 3-point bending and ASTM D790 standards
- Analyze the output data (displacement and force) by calculating stress and strain values

Results

Figure 4 and table 1 show that hemp has a lower Young's Modulus and tensile strength, respectively. These characteristics result in hemp having an earlier fracture point. Natural fibers, as opposed to synthetic, tend to have widely varying thicknesses, which plays an important role in the strength and ductility of a fiber.

Fiber Type	Ultimate Tensile Strength (MPa)	@ Strain of
Glass	726.793	0.02694
5-Ply Hemp	197.031	0.05023
4-Ply Hemp	171.056	0.03785

Table 1: Comparison of fiber flexural strengths


Figure 1: Max stress point of glass fiber


Figure 2: Max stress point of 5-ply hemp fiber

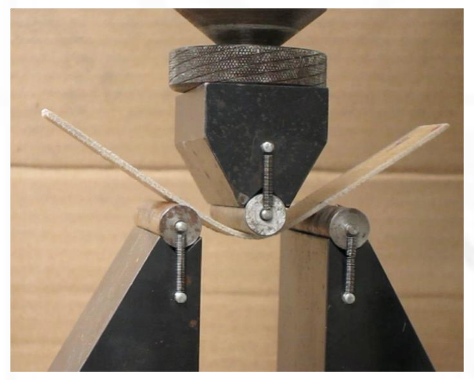
Figure 3: Max stress point of 4-ply hemp fiber

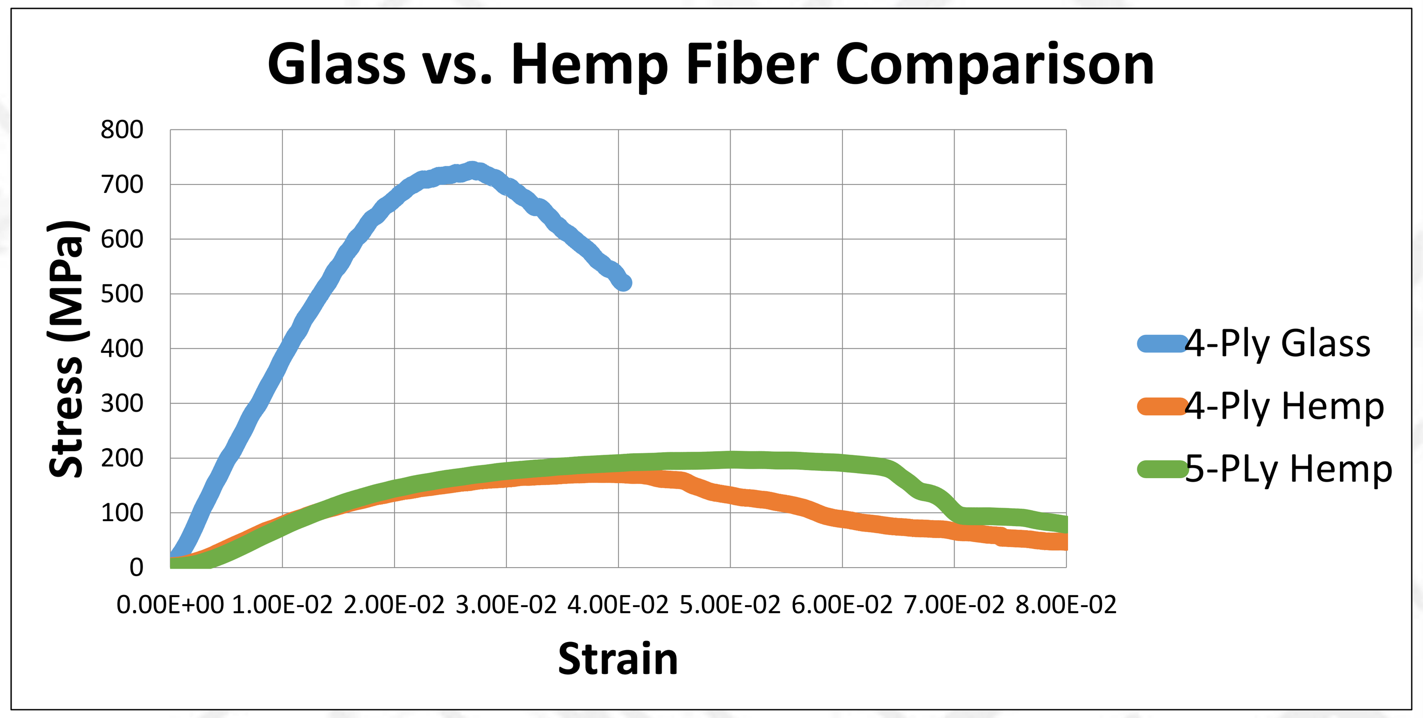

Figure 4: Overlaid stress-strain curves of glass and hemp fiber composites

Conclusions

Hemp fiber, though it greatly improves the flexural capabilities of pure epoxy, is biodegradable (when used in conjunction with a biodegradable matrix), and is less expensive than glass fiber, was found to have much less desirable mechanical properties than glass fiber (ultimate tensile strength and Young's Modulus). This shows that hemp may only be a suitable replacement in non-structural, low-load bearing applications to prevent early product failure and frequent replacement. Thus, further research is necessary to continue searching for appropriate, sustainable solutions.

Takeaways

- Gained a basic understanding of the requirements of a graduate research assistant and professor
- Learned about the manufacturing process and mechanical properties of advanced lightweight, layered composites
- Obtained hands-on experience in the production and testing of these composites
- Explored the sustainability-related issues with modern composites and potential alternatives to the standard synthetic fibers and epoxies

About Me

I am a chemical engineering student entering my senior year at California Baptist University in Riverside, CA.

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References

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