Computational analysis of frp composite under different temperature gradient

P.Gunasekar¹ S.Manigandan₂

¹,² Asst professor, Department of Mechanical Engineering, Sathyabama University, India

Abstract. Composite material strength depends on the stiffness of fiber and the resin which is used for reinforcement. The strength of the laminate can be increased by applying good manufacturing practices. The strength is directly depending on the property of resin. The property of the any compound subjected to changed when they exposed to the temperature. This paper investigates the strength of laminate when they subjected to different temperature gradient of resin while manufacturing. The resin is preheated before adding hardener with them. These types of laminate reinforced with resin at different levels of temperature 20c, 40c, and 60c. These different temperature resin are used for reinforcement and the specimen tested. The comparative results are made to find how the stiffness of laminate changes with respect to the thermal property of resin. The results are helpful to obtain high strength laminate.

1. Introduction
Recent years, quick advance in construction materials skill have enabled civil engineers to attain impressive gains in the economy and safety. The earliest FRP materials used glass fibers rooted in polymeric resins that were made available at World War II. The combination of high-strength, stiffness structural fibers with low cost and lightweight. The environmentally challenging polymers resulted in composite materials with mechanical properties and durability superior than metals. Fiber materials such as boron, carbon, and aramid, were used in space exploration and air due to its higher strength, higher stiffness, and lower density. Stable cross-sectioned FRP composite are produced for use in the construction industry for building bridge and other superstructures. Recent research on pultruded FRP shapes is very high.

The natural fiber composites are promising as reasonable alternatives to glass-reinforced composites. Natural fiber composites such as hemp fiber-epoxy and china reed fiber-PP are predominantly striking in automotive applications because of lower cost density. The natural fibers conventionally have been used to fill and reinforce thermosets; have attracted better concentration due to super recyclability behavior. Natural fiber composites are also claim to tender environmental reward such as lower greenhouse gas emissions, lowest pollutant emission and enhanced energy recovery.

1.1 FRP on Polyester Resin
Polyester resin reinforcement with natural fibers like coconut fibers are exhibits higher tensile strength and light weight, it can easily deform to high strain values due to its high flexibility stamina. The reference paper predicts that sisal-glass composite were undergone high compression and poor tensile under dynamic loading. It also pragmatic that the tensile properties are superior compare to the sisal-
glass matrix. Fiber reinforced composites create average impact to temperatures when the thermal source involved. Form [1][2] as the temperature increases, the impact strength of the composites decrease steadily [6-8]. The bagasse fiber has been reinforced with polyester resin in addition to its mechanical properties were distinguished. It is observed that tensile property is increasing with increase in proportion of polyester.

Experimental Details

1.2 Materials

Raw materials used in this experiment is:
- Glass Fiber and Jute -Polyester
- Accelerator
- Catalyst

Jute Fiber: Jute is a lengthy fiber, spongy in nature it can be spin into coarse and strong threads. It is produced from genus corchorus plant. Jute is one of the finest and lowest cost natural fibers, and it’s only to cotton in amount bent and mixture of uses. Jute fibers are contains mostly of the plant materials such as cellulose.

Glass Fiber - Polyester: Glass Fiber Reinforced Polyester is reinforced polymer completed of a plastic matrix reinforced by glass fiber. Fiber glass is a light weight, strong, and robust.

The composite laminate specimen’s are geared up using the hand layup technique and the specimen is investigation in ASTM standards. The simplest technique of manufacturing adapted to laying down bidirectional, a liquid thermosetting resin is worked into the reinforcement by hand with a brush or roller. The process is frequent number of times alike to the number of layers required for the final composite. Resin and catalyst agents are pre-mixed and usually designed to harden at room temperature. The major advantage of this process is its great flexibility and cheap. The prepared specimen is tested for the mechanical strength.

2. Results and discussion

For this research we have opted, four specimen of same property.
Specimen 1 Glass fiber with polyester resin at room temperature
Specimen 2 Glass fiber with polyester resin preheat 28 C
Specimen 3 Glass fiber with polyester resin preheat 32 C
Specimen 4 Glass fiber with polyester resin preheat 35 C

The specimens are tested and the results are compared with each other to find the best optimized process for making the laminate.
Table 1. Stress comparison table

| Material                | S-I  | S-II | S-III | S-IV |
|-------------------------|------|------|-------|------|
| Ultimate/ Break Load    | 8    | 9.75 | 11.7  | 12.0 |
| Disp at Fmax (mm)       | 13   | 14.2 | 17.04 | 19.5 |
| Max. Disp (mm)          | 15   | 16.9 | 20.28 | 22.5 |
| Area mm²                | 63.7 | 63.7 | 63.7  | 63.7 |
| Ult. Stress (Mpa)       | 218  | 233  | 279.6 | 327.0|
| Yield stress (Mpa)      | 125  | 135  | 162   | 187.5|
| YS/UTS Ratio            | 0.29 | 0.35 | 0.42  | 0.4  |
| Elongation              | 0.16 | 0.21 | 0.252 | 0.2  |

Table 2. Stress comparison table

| Material                | S-I  | S-II | S-III | S-IV |
|-------------------------|------|------|-------|------|
| Ult/Break Load          | 0.4  | 0.45 | 0.5175| 0.52 |
| Disp at Fmax (mm)       | 2.5  | 2.8  | 3.22  | 3.25 |
| Max. Disp (mm)          | 3.5  | 3.9  | 4.485 | 4.55 |
| Area                    | 63   | 63   | 72.45 | 81.9 |
| Ult. Stress             | 9    | 12   | 13.8  | 11.7 |

Table 3. Stress comparison table

| Material                | S-I  | S-II | S-III | S-IV |
|-------------------------|------|------|-------|------|
| Ultimate Stress (Mpa)   | 218  | 233  | 279.6 | 327.0|
| Expt. Ultimate Stress (Mpa)| 220  | 233  | 249   | 258.0|
| Maximum Displacement    | 15   | 16.9 | 20.28 | 22.5 |
| Expt. MaxDisp           | 16.9 | 16.9 | 15.3  | 16.3 |
| Expt. Ultimate Stress (Mpa)| 7.5  | 11   | 13    | 12.5 |
| Ultimate Stress (Mpa)   | 9    | 12   | 13.8  | 11.7 |
| Maximum Displacement    | 3.5  | 3.9  | 4.485 | 4.55 |
Expt. MaxDisp 3.5 3.9 10.2 14

Figure 1. Ultimate stress vs Displacement

Figure 2. Stress vs Yield stress

Figure 3. Stress vs strain

Figure 4. Strain validation
3. Conclusion

All the four types of specimen tested for the mechanical behaviour and their results are plotted above. The comparative data’s and plot shows that the behaviour of the laminate is very good and superior as the temperature of the resin changes.

The results predict that as the temperature of the pre mixing increases the strength of the fiber is increased significantly. It also concluded that the strength of fiber is depending on the resin temperature.

References

[1] Gunasekar, P., Manigandan, S., Anderson, D., &Devipriya, J 2017 Evaluation of Fe-Epoxy metal nanocomposite in glass fiber and Kevlar. International Journal of Ambient Energy.

[2] Puck, A., H. Schürmann 1988 Failure analysis of FRP laminates by means of physically based phenomenological models, Composites Science and Technology.

[3] S. Manigandan 2015 Computational Investigation of High Velocity Ballistic Impact Test on Kevlar 149, Applied Mechanics and Materials.

[4] Sriramula, Srinivas, Marios K. Chryssanthopoulos 2009 Quantification of uncertainty modelling in stochastic analysis of FRP composites, Composites Part A: Applied Science and Manufacturing.

[5] Karbhari, V. M 2003 Durability gap analysis for fiber-reinforced polymer composites in civil infrastructure, Journal of composites for construction.

[6] Rahimi, Hamid, Allan Hutchinson 2001 Concrete beams strengthened with externally bonded FRP plates, Journal of composites for construction.
[7] S. Manigandan 2015 Determination of Fracture Behavior under Biaxial Loading of Kevlar 149, Applied Mechanics and Materials