# Effect Of Curing Cycle And Evaluation Of Mechanical Strength Of Banana/Epoxy Polymer Composite

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***Abstract— Composite of banana fiber reinforced with Epoxy resin is manufactured by conventional hand layup method, to study Effect of curing temperature with curing time period on composite material and also optimization of curing temperature and curing time period, Gray relation analysis has been carried out to optimize different mechanical strength such as tensile strength, flexural strength, inter laminar shear strength.***

***Keywords: Banana/epoxy, curing, Fabrication, Hand layup, Gray relation analysis.***

## 1. INTRODUCTION

Composites are inherently available or are engineered by fusing 2 or more materials with significantly different physical and chemical properties that remain different at the micro or macro level within the final structure. Basically, divided into two types of materials: matrix and reinforcement, the matrix to resist the surrounding environment mechanical and environmental damage, to maintain its relative position, and reinforcement gives special mechanical properties, such as strength, dielectric, stiffness, etc. and physical properties.

## 2. LITERATURE REVIEW

**T. Ota1 & T. Matsuoka et al:** In this study, a droplet test was conducted to determine the effect of post-cure conditions on the interfacial properties of glass fiber/vinylester resin composites. The droplet samples were post-cured at (80°C) for 4 hours to 24 hours. Post-cure conditions PC-8h and PC-16h improved interfacial shear strength (IFSS) compared to PC-4h. Post-cure PC-24h reduced IFSS compared to PC-16h.**(1)**

**Rami J.A. Hamad ,M.A. Megat Johari et al:** This research gives the results for experimental research on the cause of increased temperatures for mechanical properties of FRP bars and the concrete materials.The results revealed that the FRP bars undergo considerable diminution of the mechanical characteristics upon exposure for increased temperatures of up to 450°C at which the GFRP and BFRP becomes melt and lose total tensile strength.At a crucial temperature about 325°C, the FRP bars loses its tensile strength and elastic modulus around 55% and 30% respectively. **(2)**

**B.Mahasenadhipathi Rao & O.Vasudeva Reddy et al:** In this work, fiberglass/epoxy resin and carbon fiber/epoxy resin with 80% of fiber and 20% of matrix composite rods are produced by using pultrusion technology. Both samples were rod-shaped and subjected to impact testing, chemical absorption and tensile testing at different temperatures below room temperature. Analytical values determines that the as temperature decreases, the energy absorption of both composites increases. In experiment result we observed that the rate of chemical absorption is more in carbon fiber composite than the glass fiber composite (carbon and glass both composites are dipped in different solutions under controlled environment.**(3)**

## 3. METHODOLOGY

- Material selection
- Development of experimental plan using design of experiment (DOE) technique
- Cutting of woven Banana fiber to required dimension
- Calculation of requirement of material to prepare single laminate
- Preparation of laminate using hand layup process
- Curing of laminate at different temperature using microwave oven
- Preparation of specimen for different testing as per the ASTM Standards
- Mechanical strength evolution of specimen by different test(tensile,flexural,ILSS)
- Gray relation analysis

### 3.1 MATERIAL SELECTION

The selected materials and their properties for making Banana/epoxy laminate are shown in table 1.

| **Reinforcement** | **Matrix material** | **Hardner** |
|---|---|---|
| Banana of 360 GSM bidirectional woven roving | Epoxy resin(LY556) [Aralide] | Hardner(HY951) [Arudur] |
| Density of fiber $\rho_f$ =1.35 g/cc | Density of Epoxy resin $\rho_r$ =1.15-1.20g/cc | |
| Young's modulus of banana fiber 3500MPa or 3.5GPa | | |

**Table No:1 Material and Their Properties**

### 3.2 FABRICATION OF LAMINATE STRUCTURE

The laminates of thickness 2mm are prepared using the hand layup technique. The preparation of laminates procedure is given below,

- The fiber layers are marked and cut to the size of 15 X 15 cm. shown in figure 4.1.
- Weight of single ply is measured using electronic weighing machine.
- The number of ply required for laminate preparation is calculated.
- The resin(epoxy(LY556)[Aralide]) and hardner((HY951)[Arudur]) are taken in a flask as per calculation and mixed.
- A layer of resin is applied on the tile and then the lamina i.e. single ply is placed on the applied resin. Then again a layer of resin is applied on the surface of the fiber and then next layer is placed on the previous layer. The procedure is continued till the laminate structure of 2mm thickness is built as shown in figure
- The prepared laminates are then placed in the microwave oven
- The laminate structures are cut as per ASTM standard.

(a) (b) (c)

Figure no.1: a)Cured laminate b)Prepared test specimen for Tensile and Flexural test c)Prepared specimen for ILSS test

### 3.3 TENSILE TEST

ASTM D3039 standard is used for the tensile testing. Tensile test was done on 10kn capacity computer controlled UTM, in R&D Centre GND college Bidar.


**(a)** **(b)**

**Fig: 2 Tensile Test Setup.**

### 3.4 FLEXURAL TEST

ASTM D2344 standard is used for the flexural testing of laminate structure. Flexural test was done on 10kn capacity computer controlled UTM, Flexural test was done on 10kn capacity computer controlled UTM, in R&D Centre GND college bidar.

**(a)** (b)

**Fig: 3 Flexural Test Setup.**

### 3.5 INTER LAMINOR SHEAR STRENGTH (ILSS) TEST

ASTM D2344 standard is used for the Inter laminar shear strength testing of laminate structure. ILSS test was done on 10kn capacity computer controlled UTM, Flexural test was done on 10kn capacity computer controlled UTM.


**(a)** **(b)**

**Fig:4 ILSS Test Setup.**

## 4 RESULTS AND DISSCUSSION

### 4.1 TENSILE TEST

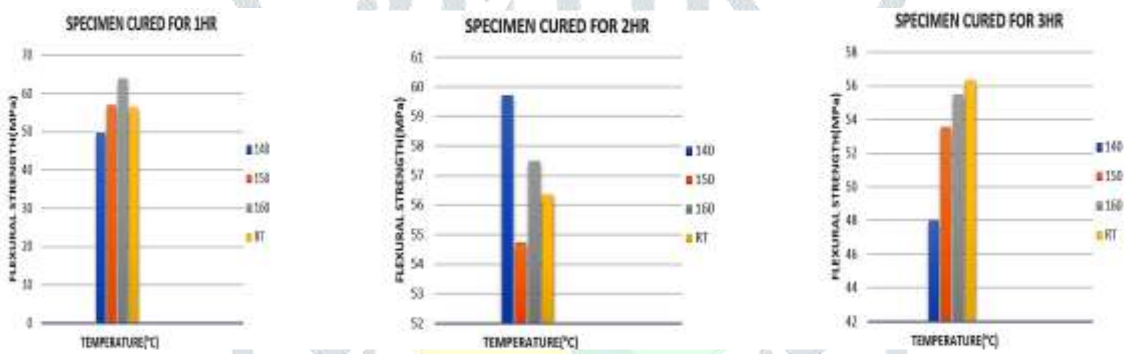

**(a) (b) (c)**

**Fig: 5 UTS of A Specimen Cured At 140 150 160°c Temperature for 1hr 2hr 3hr Time Period.**

The above figures 5(a) 5(b) 5(c) shows that, specimen cured for different temperatures(140 150 160 °C) and different time period(1,2,3 Hrs) and compared with specimen cured at room temperature.

- The ultimate tensile strength of 1Hr cured specimen at 140°C,150°C,160°C,and at room temperature are 32.256MPa, 40.103MPa, 26.597MPa, 32.069MPa respectively. Among 150°C temperature cured specimens gives maximum ultimate tensile strength.
- The ultimate tensile strength of 2Hr cured specimen at 140°C,150°C,160°C,and at room temperature are 32.771MPa,36.878MPa,40.030MPa,32.069MPa respectively. Among 160°C temperature cured specimens gives maximum ultimate tensile strength.
- The ultimate tensile strength of 3Hr cured specimen at 140°C,150°C,160°C,and at room temperature are 30.571MPa,32.037MPa,34.234MPa,32.069MPa respectively. Among 160°C temperature cured specimens gives maximum ultimate tensile strength.

### 4.2 FLEXURAL TEST




**(a) (b) (c)**

**Fig: 6 Flexural Strength of a Specimen Cured At 140 150 160°c Temperature**

**For 1hr 2hr 3hr Time Period.**

The above figures 6(a) 6(b) 6(c) shows that, specimen cured for different temperatures (140 150 160 °C) and different time period(1,2,3 Hrs) and compared with specimen cured at room temperature.

- The Flexural strength of 1Hr cured specimen at 140°C,150°C,160°C,and at room temperature are 49.724MPa, 56.894MPa, 63.740MPa, 56.348MPa respectively. Among 160°C temperature cured specimens gives maximum flexural strength.
- The Flexural strength of 2Hr cured specimen at 140°C,150°C,160°C,and at room temperature are 59.70MPa, 54.732MPa, 57.484MPa, 56.348MPa respectively. Among 140°C temperature cured specimens gives maximum flexural strength.
- The Flexural strength of 3Hr cured specimen at 140°C,150°C,160°C,and at room temperature are 47.128MPa, 53.564MPa, 55.492MPa, 56.348MPa respectively. Among room temperature cured specimens gives maximum flexural strength.

### 4.3 ILSS TEST


(a) **(b) (c)**

**Fig: 7 ILSS of a Specimen Cured At 140 150 160°c Temperature for 1hr 2hr 3hr Time Period.**

The above figures 7(a) 7(b) 7(c) shows that, specimen cured for different temperatures(140 150 160 °C) and different time period(1,2,3 Hrs) and compared with specimen cured at room temperature.

- The ILSS of 1Hr cured specimen at 140°C,150°C,160°C,and at room temperature are 16.146MPa, 23.133MPa, 12.630MPa, 21.42MPa respectively. Among 150°C temperature cured specimens gives maximum ILSS strength.

- The ILSS of 2Hr cured specimen at 140°C,150°C,160°C,and at room temperature are 9.766MPa, 14.813MPa, 18.667MPa, 21.42MPa respectively. Among room temperature cured specimens gives maximum ILSS strength.
- The ILSS of 3Hr cured specimen at 140°C,150°C,160°C,and at room temperature are 18.03MPa, 14.846MPa, 13.183MPa, 21.42MPa respectively. Among room temperature cured specimens gives maximum ILSS strength.

## 5. GREY RELATION ANALYSIS

For the gray relational examination, the test data, the measurement parameters of the quality attributes, are first standardized to the range in the vicinity of 0 and 1. This procedure is called gray relation generation. In view of the stabilized test data, the gray correlation coefficient were determined to represent the correlation among the expected experimental data and present test data. In general gray relational level is established by taking the average of gray relational coefficients match up to the chosen responses. General execution of performance characteristics of a multi-reaction procedure depend on the considered gray level of association. This method transforms the multi-reaction procedure optimization dilemma into solitary reaction improved/optimized dilemma, and the purpose of function is the overall gray relation degree/grade.

| Exp. No | Normalized Values | | | Grey Relational Coefficient | | | Grey Grade | Rank |
|---|---|---|---|---|---|---|---|---|
| | Tensile | Flexural | Ilss | Tensile | Flexural | Ilss | | |
| 1 | 0.5809 | 0.1562 | 0.4770 | 0.5440 | 0.3720 | 0.4887 | 0.4682 | 7 |
| 2 | 0.5428 | 0.7568 | 0 | 0.5222 | 0.6727 | 0.3333 | 0.5093 | 4 |
| 3 | 0.7057 | 0 | 0.6185 | 0.6294 | 0.3333 | 0.5672 | 0.5099 | 3 |
| 4 | 0 | 0.5878 | 1 | 0.3333 | 0.5481 | 1 | 0.6270 | 2 |
| 5 | 0.2387 | 0.4577 | 0.3770 | 0.3964 | 0.4797 | 0.4452 | 0.4404 | 9 |
| 6 | 0.5972 | 0.3874 | 0.3802 | 0.5538 | 0.4493 | 0.4465 | 0.4832 | 6 |
| 7 | 1 | 1 | 0.2143 | 1 | 1 | 0.3888 | 0.7962 | 1 |
| 8 | 0.0054 | 0.6234 | 0.6657 | 0.3345 | 0.5703 | 0.5993 | 0.5013 | 5 |
| 9 | 0.4345 | 0.5034 | 0.2557 | 0.4692 | 0.5017 | 0.4018 | 0.4575 | 8 |

**Table No:2 Grey Relation Analysis Table**

## 6. CONCLUSION

From the experimentation of Tensile, Flexural, ILSS, for different cured temperature (140,150,160 $^0$C) and time (1,2,3 Hr) we conclude that

- The maximum ultimate tensile strength is obtained for 150 $^0$C temperature at 1 Hr time period cured specimen i.e, 40.103 MPa
- The maximum flexural strength obtained for 160 $^0$C at 1 Hr time period cured specimen i,e. 63.740 MPa
- The maximum Inter laminar shear strength obtained for 150 $^0$C temperature at 1 Hr time period cured specimen i.e, 23.133 MPa
- The optimized results using grey relation analysis is 160 $^0$C at 1 Hr time period cured specimen

### 6.1. SCOPE FOR FUTURE WORK

- The heat absorption of laminates in microwave oven can be studied by using differential scanning calorimeter(DSC)
- The mechanical strength (fatigue, fracture, impact, compressive) can be studied.
- Surface Morphology of failed surface can be studied by using scanning electron microscope

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