International Journal of Multidisciplinary Research and Modern Education (IJMRME)
ISSN (Online): 2454 - 6119
(www.rdmodernresearch.org) Volume I, Issue I, 2015

THE EFFECT OF CARBON POWDER ON GLASS FIBER REINFORCED COMPOSITES

D. Manikandan*, P. Dhinakaran**, P. Arunkumar* & A. Dinesh Kumar***

* Assistant Professor, Department of Mechanical Engineering, Srinivasan Engineering College, Perambalur, Tamilnadu, India.

** Assistant Professor, Department of Mechanical Engineering, Dhanalakshmi Srinivasan Engineering College, Perambalur, Tamilnadu, India.

*** Assistant Professor, Department of Mathematics, Dhanalakshmi Srinivasan Engineering College, Perambalur, Tamilnadu, India.

Abstract:

Composite laminates plays a major role in automobile and aerospace applications due to its low weight and high strength. Many researches are trying to improve the strength and toughness of composite laminates using different types of fibers and resin combinations. In addition to this, fiber laminate are integrated with the fillers of fine micro or nano sized particles. These fillers are the key element in increasing the aspect ratio of fiber\Resin laminate, which leads to further increase the strength and toughness of the structure. In our project, the carbon fine powder of 300 mesh-sized of particles at different weight fractions (5%, 10%) were added with Glass fiber polyester resin matrix for making test specimen. The computerized UTM machine was utilized to test. The test results of carbon powder reinforced glass fiber laminate were compared with 100% resin-0% fiber and 40% resin-60% fiber laminates. We observed that mechanical properties of carbon powder reinforced Glass fiber polyester resin composite increases with increase of percentage carbon powder content. We also observed that as carbon powder increases beyond 10 %, the mechanical properties were decreased.

Key Words: Woven Fiber / Resin Laminates & Carbon Powder.

1. INTRODUCTION:

Fiber-Reinforced composites materials consist of fibers of high strength and modulus embedded in or bonded to a matrix with distinct interfaces between them. In this form, both fibers and matrix retain their physical and chemical identities. Yet they produce a combination of properties that cannot be achieved with either of the constituents acting alone. In general, fibers are the principle load carrying members, while the surrounding matrix keeps them in the desired location, acts as a load transfer medium between them, and protects them from environmental damages due to elevated temperatures and humidity. For example: The most common form in which composites are used in structural application is called as laminates. It is obtained by stacking a number of thin layers of fibers and matrix, and consolidating them into the desired thickness. Fibers orientation in each layer as well as the stacking sequence of various layers can be controlled to generate a wide range of physical and mechanical properties for the composite laminates.

2. MATERIALS:

Major constituents in a fiber-reinforced composite material are the reinforcing fibers and matrix, which act as a binder for the fibers. Other constituents that may also be found are coupling agents and coatings are applied on the fibers to improve their wetting with the matrix as well as to promote bonding across the fiber-matrix interface. Both in turn promote a better load transfer between the fibers and the matrix. Fillers are used with some polymeric matrices. Primarily to reduce cost and improve their dimensional stability. Manufacturing of a composite structure starts with the incorporation of a large number of fibers into a thin layer of matrix to form a lamina (ply). The thickness of a lamina is usually in the range of 0.1-1mm. If continuous (long) fibers are used making the lamina they may be arranged either in unidirectional orientation (i.e., all fibers in one direction), in a bidirectional orientation (i.e., fibers in two directions, usually normal to each other), or in a multidirectional orientation (i.e., fibers in more than two directions). The figure 1 shows different orientations of fiber. The bi-or multidirectional orientation of fibers is obtained by weaving or other process used in the textile industry. For a lamina containing unidirectional fibers, the composite material has the highest strength and modulus in the longitudinal direction of the fibers. However, in the transverse direction, its strength and modulus are very low. For a lamina containing bidirectional fibers, the strength and modulus can be varied using different amounts of fibers in the longitudinal and transverse directions. A lamina can also be constructed using discontinuous (short) fibers in a matrix. The discontinuous fibers can be arranged either in unidirectional orientation or in random orientation. Discontinuous fiber-reinforced composites have lower strength and modulus than continuous fiber composites. However, with random orientation of fibers it is possible to obtain equal mechanical and physical properties in all directions in the plane of the lamina. The thickness required to support a given load or to maintain a given deflection in a fiber reinforced composites structure is obtained by stacking several laminas in a specified sequence and then consolidating them to form a laminate. Various laminas in a laminate may contain fibers either all in one

3. MANUFACTURING METHODS OF COMPOSITES:

There are many methods available for manufacturing composite material. Some of the advanced methods are discussed in this chapter. The most common methods by which the composites of various types are explained below.

(a) Pultrusion Process
(b) Resin Transfer Moulding Process
(c) Hand Lay-Up Technique
(d) Compression Moulding Process

4. HAND LAY-UP PROCESS:

Resins are impregnated by hand into fibers which are in the form of woven, knitted, stitched or bonded fabrics. This is usually accomplished by rollers or brushes, with an increasing use of nip-roller type impregnators for forcing resin into the fabrics by means of rotating rollers and a bath of resin. Laminates are left to cure under standard atmospheric conditions [5].

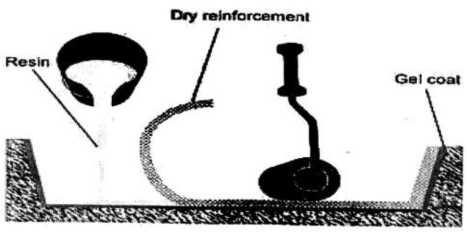

Figure (1): Hand Lay-Up Process

5. FIBERS:

Fibers are the major constituent in a fiber reinforced composite material. They occupy the largest volume fraction in a composite laminate and share the major portion of the load acting on a composite structure.

6. MATERIAL SELECTION AND SPECIMEN PREPARATION MATERIALS:

Glass fiber, Polyester resin, corresponding catalyst and accelerator such as Ethyl-Methyl Ketone and cobalt were obtained from M/s Leo chemicals Nagarcoil, and carbon powder of 300 mesh size (i.e. 45 μm) was obtained from Universal Scientific Lab Madurai.

7. SPECIMEN PREPARATION

A combination of hand lay-up and compression molding method were used to prepare the glass fiber reinforced polyester composite samples. A measured quantity of polyester resin mixed with a catalyst and accelerator for rapid curing was poured on a pre-weighed amount of glass fiber mat, which was placed in a mould. The mould was coated with a semi-permanent, polymer mould release agent, or wax. After pouring the resin, each layer was left for a few minutes to allow the resin to soak into the fiber mat. Trapped air was gently squeezed out using a roller. The glass fiber and polyester resin were then left for 3 min to allow air bubbles to escape from the surface of the resin. The mould was closed and the composite panel was left to cure in a hydraulic press at a room temperature and at a compaction pressure of 5 bars for 5hrs. After 5hrs the specimen is removed from the mold.[6] The prepared specimens are shown in thefigure2.

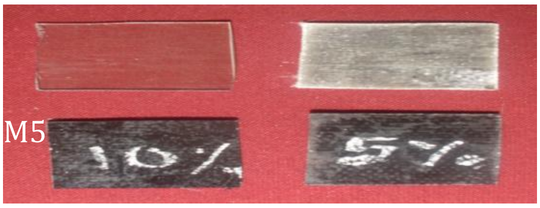

Figure (2a): Specimen for Compression Test

Figure (2b): Specimen for Tensile Test

R1- 100 % Resin,
R1M- Resin with Woven fiber
R1M5-Resin, Woven fiber & 5% Carbon
R1M10-Resin, Woven fiber &10% Carbon

8. MECHANICAL TESTING COMPRESSION TEST:

Tests are carried out on polyester resin and composite specimens to determine compressive strength, the specimens are prepared as per the ASTM D3039-76 specification .The formula used for find out compression strength as given below. Compression strength = P/A

Table 1 Compression Results for Pure Polyester Resin

S. No.	Results	Value	Units
1	Area	3.60	cm^2
2	Yield Force	159.03	Kg

3	Maximum Force	182.6	Kg
4	Total Deflection	2.14	mm
5	Compressive Yield strength	44.17	Kg/cm^2
6	Compressive strength	50.73	Kg/cm^2
7	Deflection	3.57	%

Table 2 Compression Results for Resin and Woven laminated specimen

S. No.	Results	Value	Units
1	Area	4.20	cm^2
2	Yield Force	189.64	Kg
3	Maximum Force	236.7	Kg
4	Total Deflection	2.02	mm
5	Compressive Yield strength	45.15	Kg/cm^2
6	Compressive strength	56.37	Kg/cm^2
7	Deflection	3.37	%

Table 3 Compression Results for Resin and Woven laminate with 5%Carbon

S. No.	Results	Value	Units
1	Area	3.60	cm^2
2	Yield Force	776.11	Kg
3	Maximum Force	872.8	Kg
4	Total Deflection	2.17	mm
5	Compressive Yield strength	215.59	Kg/cm^2
6	Compressive strength	242.45	Kg/cm^2
7	Deflection	3.62	%

Table 4 Compression Results for Resin and Woven laminate with 10%Carbon

S. No.	Results	Value	Units
1	Area	3.60	cm^2
2	Yield Force	955.80	Kg
3	Maximum Force	1057.8	Kg
4	Total Deflection	1.95	mm
5	Compressive Yield strength	265.50	Kg/cm^2
6	Compressive strength	293.83	Kg/cm^2
7	Deflection	3.25	%

9. COMPARISON OF COMPRESSION TEST RESULTS:

From the test result, the comparison was made between the resin, resin and woven, resin and woven with 5% carbon, resin and woven with 10% carbon fiber laminate and shown in fig 13. From the Fig 3, it is observed that the fiber and woven with 10% laminate has higher strength than other laminates.

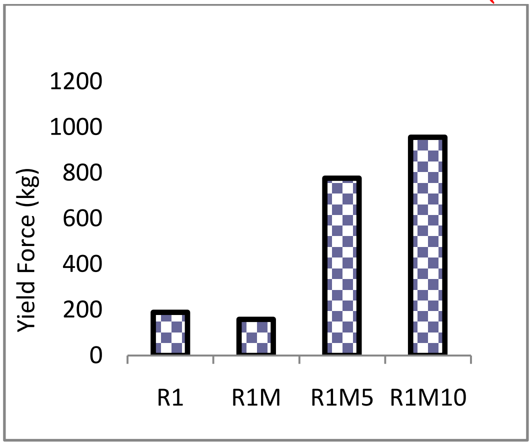

Figure (3a): Yield force comparison of specimen under compression test

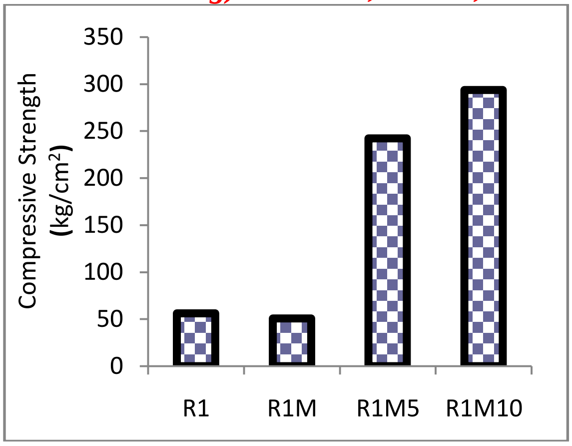

Figure (3b): Comparison of compressive strength of specimens

R1-Pure Polyester Resin
R1M-Resin and Woven laminated specimen
RIM5-Resin and Woven laminate with 5% Carbon
R1M10-Resin and Woven laminate with 10% Carbon

10. TENSILE TEST:

Tests are carried out on polyester resin and composite specimens to determine tensile strength, the specimens are prepared as per the ASTM D638 specification .The formula used for find out tensile strength as given below.

Tensile strength = P/A

Table 5 Tensile Results for Pure Polyester Resin

S. No.	Results	Value	Units
1	Area	0.60	cm^2
2	Yield Force	105.85	Kg
3	Yield Elongation	1.80	mm
4	Break Force	176.4	Kg
5	Break Elongation	1.85	mm
6	Tensile Strength at Yield	176.41	Kg/cm^2
7	Tensile Strength at Break	294.02	Kg/cm^2
8	Elongation	2.31	%

Table 6 Tensile Results for Resin and woven laminated specimen.

S. No.	Results	Value	Units
1	Area	0.60	cm^2
2	Yield Force	410.15	Kg
3	Yield Elongation	4.32	mm
4	Break Force	683.6	Kg
5	Break Elongation	0.00	mm
6	Tensile Strength at Yield	683.59	Kg/cm^2
7	Tensile Strength at Break	1139.31	Kg/cm^2

8	Elongation	4.12	%

Table 7 Tensile Results for Resin and woven laminate with 5%carbon.

S. No.	Results	Value	Units
1	Area	0.67	cm^2
2	Yield Force	581.06	Kg
3	Yield Elongation	4.05	mm
4	Break Force	873.8	Kg
5	Break Elongation	4.00	mm
6	Tensile Strength at Yield	873.78	Kg/cm^2
7	Tensile Strength at Break	1313.96	Kg/cm^2
8	Elongation	5.00	%

Table 8 Tensile Results for Resin and woven laminate with 10%carbon.

S. No.	Results	Value	Units
1	Area	0.57	cm^2
2	Yield Force	643.20	Kg
3	Yield Elongation	4.33	mm
4	Break Force	1128.4	Kg
5	Break Elongation	4.38	mm
6	Tensile Strength at Yield	1128.42	Kg/cm^2
7	Tensile Strength at Break	1979.68	Kg/cm^2
8	Elongation	5.47	%

11. COMPARISON OF TENSILE TEST RESULTS:

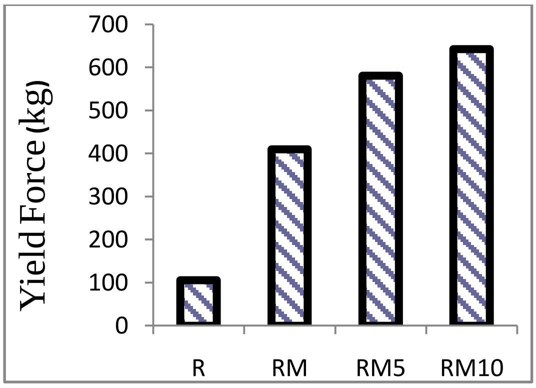

Figure (4a): Yield force comparison of specimen under tensile test

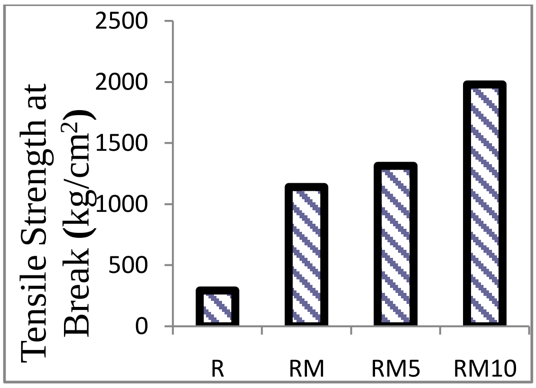

Figure (4b): Comparison of tensile strength of specimens

R1-Pure Polyester Resin
R1M-Resin and Woven laminated specimen
RIM5-Resin and Woven laminate with 5% Carbon
R1M10-Resin and Woven laminate with 10% Carbon

12. IMPACT TEST:

Impact strength is defined as the ability of a material to resist the fracture under stress applied at high speed. The impact properties of composite materials are directly related to its overall toughness [3]. The following formula is used to calculate the impact strength,

Table 9 Impact Test Results

Impact strength=Impact Energy/ Area

C1-pure resin with glass fiber

C2-5% carbon powder with glass fiberC3-10% carbon powder with glass fiber

Specimen	Initial scale reading in J	Final scale reading in J	Energy absorbed In J	Impact Energy in J/mm^2
C1	90	164	74	1.85
C2	86	164	78	1.95
C3	78	164	86	2.15

13. HARDNESS TEST:

In all hardness tests, a define force is mechanically applied on the test piece for about 15 seconds. The indenter, which transmit the load to the test piece, varies in size and shape for different tests. In Brinell hardness testing, steel balls are used as indenter. Diameter of the indenter (D) and the applied force depend upon the thickness of the test specimen, because for accurate results. The indentation is measured and hardness calculated as BHN = $\frac{2P}{\pi D\,(D-\sqrt{D^2-d^2})}$

Table 10 Hardness Test Results

Specimen	Diameter of indentor (D) in mm	Diameter of indentation (d) in mm	Brinell Hardness Number
C1	6.35	0.30	849.19
C2	6.35	0.25	1222.8
C3	6.35	0.20	1910.4

Load =60kg.

14. CONCLUSION:

The materials such as (glass fiber, carbon powder, polyester resin, catalyst and accelerator) that are required for the project are collected effectively. The hand lay-up technique is chosen for specimen preparations in addition to that the literature related to the project are also collected. Combination of samples has been prepared now, The characterizations carried out with the help of characterizing tool SEM. Mechanical behavior tests (tensile, compressive, hardness, impact) has been carried out From our experimental test results, the following observations were made. The woven fiber resin laminate has higher ultimate tensile and compressive strength than random fiber mat laminate. By adding 5 % of carbon powder along with normal glass fiber\ resin laminate, the increase of tensile strength is 13.2 % is achieved [2]. Further, the addition of 10% of carbon powder with normal glass fiber\ resin laminate, the increase of tensile strength is 42.2 % is achieved.

Similarly, by adding 5 % of carbon powder with normal glass fiber\ resin laminate, the increase of compressive strength is 79 % is achieved. Addition of 10% of carbon powder with normal glass fiber\ resin laminate, the increase of compressive strength is

80.8 % is achieved [2]. Also hardness and impact strength has been improved. It is also observed that, adding of filler material beyond 10 % produces premature failure of laminate. This is due to the un-even dissolve of carbon powder with in resin and insufficient of resin materials. Finally we concluded that at 10% of carbon powder reinforcement with fiber matrix gives better mechanical properties.

15. REFERENCES:

[1] Lars Boger, Jan Sumfleth, Hannes Hedemann, Karl Schulte (2010) "Improvement of fatigue life by incorporation of microparticles in glass fiber reinforced epoxy", Indian Journal of Science and Technology, Volume 12, Issue 2, Page Number 77-81, 2010.

[2] Marino Quaresimin, Russell J. Varley (2008), "Understanding the effect of micro-modifier addition upon the properties of fiber reinforced laminates", Ain Shams Engineering Journal, Volume 4, Issue 1, Page Number 55-62, 2011

[3] Ajit D. Kelkar, Ram Mohan, Ronnie Bolick, Sachin Shendokar (2010) "Effect of microparticles and microfibers on Mode I fracture toughness of fiber glass reinforced polymeric matrix composites", Journal of Mechanical Science and Technology, Volume 10, Issue 2, Page Number 99-108, 2007.

[4] Boeing, "Fibers composites for 7E7 Aircraft model: composite for extreme environment", Journal of Colloid and Interface Science, Volume 2, Issue 2, Page Number 55-62, 2007