SYNTHESIS & CHARACTERISATION OF EPOXY MATRIX COMPOSITES FILLED WITH ALUMINIUM POWDER

Samjid Bava T[1], P. Lingeswaran[2]

[1]*ME Student, Dept. of Mechanical Engineering, Shree Venkateshwara Hi-Tech Engineering College, Tamil Nadu,*

[2]*Assistant Professor, Dept. of Mechanical Engineering, Shree Venkateshwara Hi-Tech Engineering College, Tamil Nadu, India.*

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Abstract - *Composites Materials are combinations of two phases in which one of the phases, called the reinforcing phase, which is in the form of fiber sheets or particles and are embedded in the other phase called the matrix phase. Composite materials have successfully substituted the conventional materials in several applications like light weight and high strength. The reasons why composites are selected for such applications are mainly due to their high strength-to-weight ratio, high tensile strength at elevated temperatures, high creep resistance and high toughness. The composites are manufactured using the hand lay technique. Manufactured composite material with two percentage aluminium and making clutch friction liner with attached to clutch plate. The Universal Testing Machine is used to characterize the composite materials. From the computerized result the tensile strength of the tensile test can be directly known & the result of the test can be easily calculated using the values from the computer. The two results are analyzed & compared.*

Key Words: **Reinforcement, Matrix, Hand lay-up. Glass Fibre, Epoxy.**

1. INTRODUCTION

Composite materials are finding increased applications in many engineering fields. In the aerospace industry, the use of composite materials in commercial and military aircrafts has increased greatly over the last 20 years. For example, the usage of composites has evolved from less than 5 percent of the structural weight in the Boeing 737 and 747 to about 50 percent in the Boeing 787 Dream liner. By contrast, Aluminium will comprise only 12 percent of the Boeing 787 aircraft.

According to Chambers, while the use of composites is less than 10% of the structural weight in the F14 fighter it has increased to about 40% of the structural weight in the F22 fighter. In the ship building industry, thick-section glass and carbon fiber composites and sandwich composites are more widely incorporated into ship structures than before to fulfill special demands, such as light-weight, good insulation, low maintenance cost, and resistance to corrosion (Daniel and Ishai 2006). In civil structures, such as bridges, the use of carbon fiber-reinforced plastics (CFRP) has extended from only internal reinforcement in structures to both internal and external reinforcement. In addition to structures, wide application of composite materials can be found in automobile parts and frames, trucks, sports equipments, etc. Among these composite materials, the laminated fiber-reinforced composite material is becoming common place in primary load bearing members of structures an machines as a high performance material. Compared to metallic materials, laminated fiber-reinforced materials can provide not only the primary advantage of high strength to weight ration, but also offer extra benefits of low coefficient of thermal expansion, good resistance to corrosion, low maintenance cost, and low pollution.

1.1 Composite Materials

The primary functions of the matrix are to transfer stresses between the reinforcing fibers or particles and to protect them from mechanical and environmental damage whereas the presence of fibers or particles in a composite improves its mechanical properties such as strength, stiffness etc. A composite is therefore a synergistic combination of two or more micro-constituents which differ in physical form and chemical composition and which are insoluble in each other.

Basically, composites can be categorized into three groups on the basis of matrix material. They are Metal Matrix Composites (MMC), Ceramic Matrix Composites (CMC), Polymer Matrix Composites (PMC).

1.2 Classification Of Polymer Composites

(I) Fiber Reinforced Polymer

The fiber reinforced composites are composed of fibers and a matrix. Fibers are the reinforcing elements and the main source of strength while matrix glues all the fibers together in shape and transfers stresses between the reinforcing fibers. The fibers carry the loads along their longitudinal directions. Sometimes, filler is added to smoothen the manufacturing process and to impact special properties to the composites. These also reduce the production cost. Most commonly used agents include asbestos, carbon/graphite fibers, beryllium, beryllium carbide, beryllium oxide, molybdenum, aluminum oxide, glass fibers, polyamide, natural fibers etc. Similarly common matrix materials include epoxy, phenolic resin, polyester, polyurethane, vinyl ester etc. Among these materials, resin and polyester are most widely used. Epoxy, which has higher adhesion and less shrinkage than polyesters, comes in second for its high cost.

(II) Particle Reinforced Polymer

Particles which are used for reinforcing include ceramics and glasses such as small mineral particles, metal particles such as aluminum and amorphous materials, including polymers and carbon black. Particles are used to enhance the modulus and to decrease the ductility of the matrix. Some of the useful properties of ceramics and glasses include high melting temp., low density, high strength, stiffness; wear resistance, and corrosion resistance etc. Many ceramics are good electrical and thermal insulators. Some ceramics have special properties; some have magnetic properties; some are piezoelectric materials; and a few special ceramics are even superconductors at very low temperatures. One major drawback of ceramics and glass is their brittleness. An example of particle –reinforced composites is an automobile tyre, which has carbon black particles in a matrix of poly-isobutylene elastomeric polymer.

(III) Structural Polymer Composites

These are laminar composites which are composed of layers of materials held together by matrix. This category also includes sandwich structures. Over the past few decades, we find that polymers have replaced many of the conventional materials in various applications. The most important advantages of using polymers are the ease of processing, productivity and cost reduction. The properties of polymers are modified using fillers and fibers to suit the high strength and high modulus requirements. Fiber reinforced polymers offer advantages over other conventional materials when specific properties are compared. That's the reason for these composites finding applications in diverse fields from appliances to spacecraft.

2. HAND LAY-UP PROCESS

Hand Lay-up process was the method employed for the hybrid composite formation. It is the simplest method for the preparation of composites. The infrastructural requirement is also minimal for this method. The processing steps are quite simple and are follows.

- Initially, put thin plastic sheets as the base to get good surface finish of the product.
- Reinforcement in the woven mats or chopped strand mats form are cut as per the required size of 20 x 20 mm.
- Prepare the matrix by mixing resin and hardener in a proper ratio and spread it over plastic sheets provided as base by means of a brush.
- Now place the reinforcement above resin applied at the plastic sheet. The resin should spread properly by means of rollers to get a good base and also excess resin can be removed by the usage of rollers.
- Apply resin over the base layer and place layers in alternate order by placing resin in between them and roll it effectively.
- The top portion of the stacked composite is covered by means of a plastic sheet and finish it using rollers.
- The prepared specimen is kept at room temperature and proper loading is provided for one day.
- After a day, the loads are removed and the developed composite part is taken out.
- The curing time mainly depends upon the type of polymer used for composite formation.
- The prepared stacked composite specimen is cut into ASTM standard specimens by means of a cutter.

Since the focus of the paper was to minimise the cost as well as to obtain better property than laminate composites, two percentage of aluminium powder was used in the specimen along with glass fibre.

Table -1: Comparison Of New composite With Conventional Material

Properties	Conventional	New composite
Poisson's ration	0.3	0.35 – 0.4
Weight	More	Less
Electrical Resistance	Decrease	Increase
Thermal conductivity	Increase	Decrease
Yield Point	78 X 103 MPa	90 X 103 MPa
Breaking Point	81 X 103 MPa	94 X 103 MPa
Tensile Strength	1.8 X 103 MPa	2.1 X 103 MPa
Impact Load - Izode	132 J	152 J
Impact Load Charpy	235 J	282 J
% of elongation	3.5 %	4.2 %
Brinell Hardness No:	298	386

3. EXPERIMENTAL TESTS CONDUCTED

3.1 TENSILE TESTING

Tensile testing utilizes the classical coupon test geometry as shown below and consists of two regions: a central region called the gauge length, within which failure is expected to occur, and the two end regions which are clamped into a grip mechanism connected to a test machine. These ends are usually tabbed with aluminum, to protect the specimen from being crushed by the grips. This test specimen can be used for longitudinal, transverse, cross-ply & angle-ply testing. It is good idea to polish the specimen sides to remove surface flaws, especially for transverse tests. The specimen geometry is based on the ASTM standard 3039. The composite is cut into the desired geometry after manufacturing. Two specimens are required for the tensile testing, one with 0.2% Al & the other specimen without Aluminum.

Fig -1 : UTM

3.2 MODE I INTERLAMINAR FRACTURE TOUGHNESS TESTING

Mode I interlaminar fracture toughness (IFT) tests were conducted under quasi-static loading conditions with the Double Cantilever Beam (DCB) specimen. In this chapter, DCB test configurations and methods used in this investigation are introduced. The Mode I interlaminar fracture toughness at crack onset and fracture resistance with crack extension was characterized with DCB quasi-static specimen.

3.3 BRINELL HARDNESS TEST

- Take the Specimen for hardness testing.
- Place work piece on the work table.
- Pull down the liver of the Brinell Hardness machine.
- Regain Liver to Original Position.
- Take Specimen for Observation by using Microscope and detecting dimension of indentation.

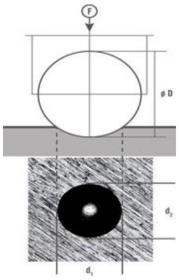

Fig -2: Brinell Hardness Indentation

$$B.H.N = \frac{P}{\pi\ D/2\left(D - \sqrt{D^2 - d^2}\right)}$$

P = 3000 kg
D = 10 mm
d1 = d2 = 3.1 mm
B.H.N = 386

Test Method Illustration

D = Ball diameter
d1 = d2 = impression diameter
F = load
HB = Brinell result

3.4 IZODE & CHARPY IMPACT TEST

- Make specimen 48 X 24 mm and making grew on the specimen at centre.
- Fix specimen on the test rig.
- Release Izode hammer and allow to hit the specimen.
- Note the readings.

Fig -3 : Izode Machine

IZODE = 152J

CHARPY TEST

- Make specimen 24 X 24 mm and making grew on the specimen at centre.
- Fix specimen on the test rig.
- Release Izode hammer and allow to hit the specimen.
- Note the readings.

CHARPY = 282 J

3.5 UTM (Universal Testing Machine)

- Make Specimen 10 X 3 mm.
- Mark the gauge length of specimen.
- Fix the specimen on UTM
- Open the left valve gradually.
- Note the Yield Point from dial gauge.
- Open the valve slightly and break the specimen and note the reading.

Gauge Length = 5.65 X √A0
= 30.94 mm
Percentage of elongation.

$$\delta = \frac{l - l_0}{l_0} \text{ X } 100$$

= 4.2 %
Yield Point = 90 X 103 MPa
Breaking Point = 94 X 103 MPa
Tensile Strength = 2.1 X 103 MPa

4. TEST RESULTS

4.1 TENSILE TEST

Length Vs. Load

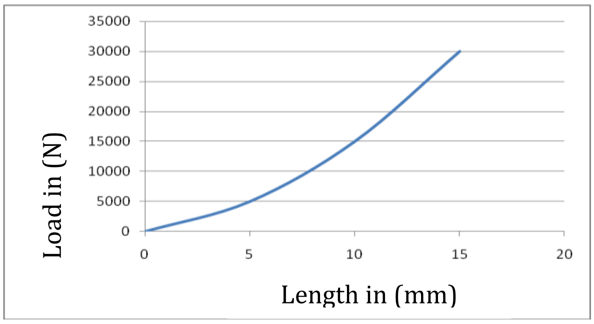

Chart -1: Tensile specimen without Al

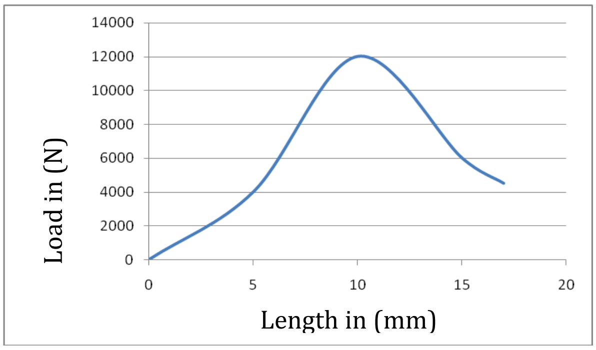

Chart -2: Tensile specimen with Al

4.2 MODE I ILFT TEST

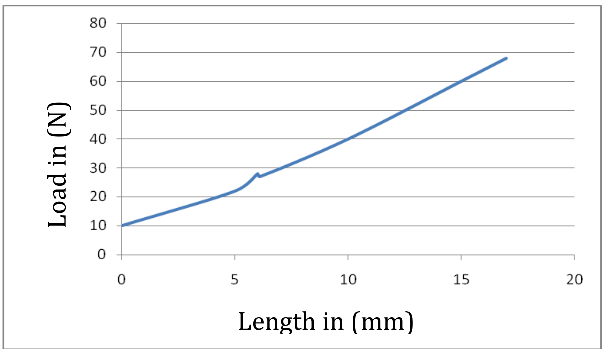

Chart -3: DCB Tensile specimen without Al

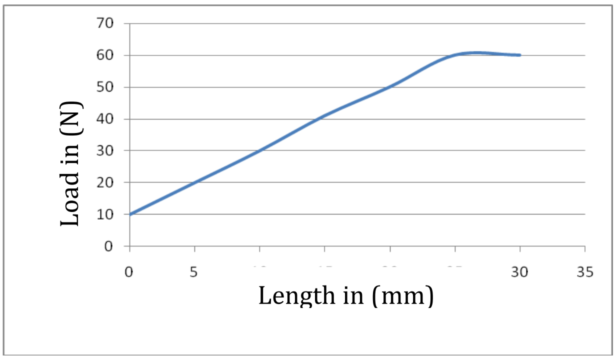

Chart -4: DCB Tensile specimen with Al

4.3 Results and Discussion

- From the Tensile load test results, it was found that maximum peak load was obtained for glass fibre composite.
- UTM was also found maximum for glass fibre composite compared to asbestos.
- Yield load was higher for glass fibre alone composite, but glass fibre with aluminium almost came close to that value.
- Strain was found higher for glass fibre composite.

5. CONCLUSIONS

This experimental investigation on Aluminium filled epoxy composites have led to the following specific conclusions. Successful design of epoxy based composites filled with micro-sized Al by hand-lay-up technique is possible. Determined the making and testing of fiber glass composite with aluminium powder. Fiber glass composite with Aluminium powder like sandwich composites which has less weight and good strength. These new class of Al filled epoxy composites can be used for applications such as electronic packages, encapsulations, die (chip) attach, thermal grease, thermal interface material and electrical cable insulation. New created Clutch liner with epoxy composite material is compared with asbestos, as the result Mechanical Properties and Thermal Properties are better than conventionally used material.

REFERENCES

[1] H. Tavman (1997), Thermal and mechanical properties of copper powder filled poly (ethylene) composites, J. Powder Tech., 91 63–7.

[2] K. Jung-il, P.H. Kang and Y.C. Nho(2004), Positive temperature coefficient behavior of polymer composites having a high melting temperature, J. Appl. Poly Sci., 394–401.

[3] K. Zhu and S. Schmauder,28 (2003) Prediction of the failure properties of short fiber reinforced composites with metal and polymer matrix, J. Compute. Mater.Sci., 743–8.

[4] M. Rusu, N. Sofian and D. Rusu,20 (2001) Mechanical and thermal properties of zinc powder filled high density polyethylene composites, J. Polymer Testing, 409–17.

[5] RajlakshmiNayak, Dr. Aloksatapathy(2010).A study on thermal conductivity of particulate reinforced epoxy composites.

[6] R.N. Rothon64 (1997), Mineral fillers in thermoplastics: filler manufacture, J. Adhesion, 87–109.

[7] S. Nikkeshi, M. Kudo and T. Masuko69 (1998), Dynamic viscoelastic properties and thermal properties of powder-epoxy resin composites, J. Appl. Poly. Sci., 2593-8.

[8] S.W. Gregory, K.D. Freudenberg, P. Bhimaraj and L. S Schadler254 (2003), A study on the friction and wear behavior of PTFE filled with alumina nanoparticles, J. Wear, 573–580.

[9] Y. Agari and T. Uno32(7) (1986), Estimation on Thermal Conductivities of Filled Polymers, J. of App. Poly. Sci., 5705–5712.