International Journal of Engineering & Technology, 7 (3.6) (2018) 382-385

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Evaluation of Mechanical Properties of Kevlar Fibre Reinforced Aluminium 6061 Sandwich Composites

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Abstract

In the present scenario composite materials has got a good value in making a high strength component. Kevlar fibre reinforced composite have a good property of making materials with high strength and low weight. With proper fabrication these Kevlar fibres will produce good property in making components that will be used for specific applications. Our project is dealt with the preparation of a laminate using Kevlar fibre reinforced composite in 0o-90o orientation by using epoxy resin as adhesive and to analyze the mechanical properties of that particular laminate and study that it has high mechanical properties or not. Main objective of this project is to make a composite laminate with high strength, high stiffness, and low weight for various applications.

Keywords: *Kevlar fibre, Aluminium composites, mechanical properties, fibre orientation.*

1. Introduction

Composite materials also called composition materials or composites) are materials made from two or more constituent materials with significantly different physical or chemical properties, that when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct with in the finished structure .The new material may be preferred for many reasons and common examples include materials which are stronger, lighter or less expensive when compared to traditional materials. Composites are made up of individual materials referred to as constituent materials. There are two main categories of constituent materials, Matrix and reinforcement. Atleast one portion of each type is required.

2. Materials and Methods

We laminated the kevlar fibre with epoxy resin with 0˚- 90˚ orientation in the form of fabric. Aluminium 6061 metal plate is used and in that plate one layers of kevlar fibre mate is coated with the help of epoxy resin on both the sides of the plate.
SIZE = 200x100mm
LAYER OF MATRIX = 2 layer of kevlar fibre RESIN:
HARDENER RATIO = 10:1

Aluminium 6061

SIZE 200x100mm NO. OF PLATES: 1



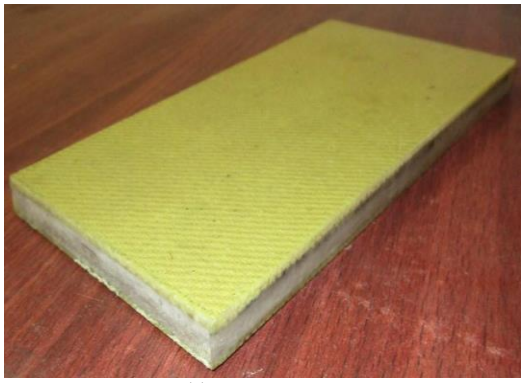
+ (a) kevlar mat



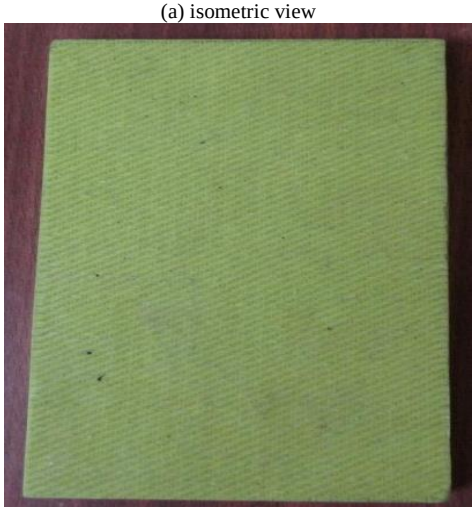
(b) Aluminium plate

Fig. 1

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(a) isometric view



(b) Top view and



(c) Side view

Fig. 2: Fabricated sample

3. Experimental

Tensile Test

Machine Name: Universal Testing Machine
Testing load range: Max 5 Ton
Make: Associated Scientific Engg. Works
Digital Encoder make: Auto Instruments – Kolhapur
Software details: FIE make India

The testing machine used in tensile testing is the universal testing machine. This type of machine has two cross heads; one is adjusted for the length of the specimen and the other is driven to apply tension to the test specimen. There are two types, hydraulic powered and electromagnetically powered machines. The machine must have the proper capabilities for the test specimen being tested. There are three main parameters: force capacity, speed, and precision and accuracy.

Force capacity refers to the fact that the machine must be able to generate enough force to fracture the specimen. The machine must be able to apply the force quickly or slowly enough to properly mimic the actual application. Finally, the machine must be able to accurately and precisely measure the gauge length and forces applied; for instance, a large machine that is designed to measure long elongations may not work with a brittle material that experiences short elongations prior to fracturing.

Alignment of the test specimen in the testing machine is critical, because if the specimen is misaligned, either at an angle or offset to one side, the machine will exert a bending force on the specimen. This is especially bad for brittle materials, because it will dramatically skew the results. This situation can be minimized by using spherical seats or U joints between the grips and the test machine. A misalignment is indicated when running the test if the initial portion of the stress-strain curve is curved and not linear

The strain measurements are most commonly measured with an extensometer, but strain gauges are also frequently used on small test specimen or when Poisson's is being measured. Newer test machines have digital time, force, and elongation measurement systems consisting of electronic sensors connected to a data collection device (often a computer) and software to manipulate and output the data. Here the test is conducted by the ASTM D 638 standard in UTM Lloyd LR 100K machine. The following image shows the broken pieces of tested component we have prepared. The tested results are pasted in the upcoming chapters.



Fig. 3: Tensile test specimen (a) before test and (b) after test

Impact Test

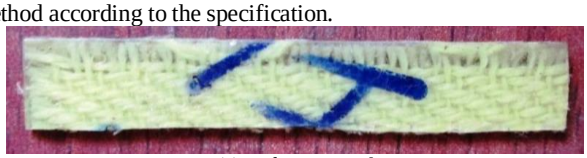
The izod impact test is has become the standard testing procedure for comparing the impact resistances of plastics. While being the standard for plastics it is also used on other materials. The izod test is most commonly used to evaluate the relative toughness or impact toughness of materials and as such is often used in quality control applications where it is a fast and economical test. It is used more as a comparative test rather than a definitive test.

This is also in part due to the fact that the values do not relate accurately to the impact strength of moulded parts or actual components under actual operational conditions. Izod test specimens vary depending on what material is being tested. Metallic samples tend to be square in cross section, while polymeric test specimens are often rectangular, being struck parallel to the long axis of the rectangle. Izod test sample usually have a V-notch cut into them, although specimens with no notch as also used on occasion.

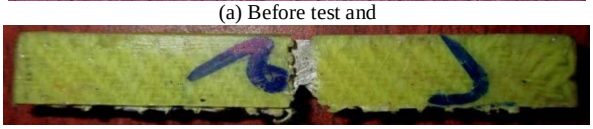
Machine Name: Impact testing machine
Testing load range: Max 6 Ton
Make: Associated Scientific Engg. Works
Digital Encoder make: Auto Instruments – Kolhapur
Software details: FIE make India

The test method generally utilized in North America is ASTM D256. The result of the Izod test is reported in energy lost per unit of specimen thickness at the notch . Additionally, the results may be reported as energy lost per unit cross-sectional area at the notch (J/m^2 or $ft\text{-}lb/in^2$). In Europe, ISO 180 methods are used and results reported based only on the cross-sectional area at the notch (J/m^2). Polymeric materials that are sensitive to the stress concentrations at the notch ('notch-sensitive') will perform poorly in the notched izod test. Engineers use this knowledge to avoid using such polymers in designs with high stress concentrations such as sharp corners or cut-outs. Unnotched specimens are also frequently tested via the izod impact method to give a more complete understanding of impact resistance. Izod impact tests are commonly run at low temperatures – down to -40°F (-40°C) or occasionally lower – to help gauge the impact resistance of plastics used in cold environments. The impact resistance of a specific commercial grade of polymer is a function of the base resin plus the presence of any impact modifiers (such as elastomers) and reinforcing agents that may be added by the

manufacturer/compounder. Here izod test is done in impact test method according to the specification.



(a) Before test and



(b) After test

Fig. 4: Impact test specimen

Flexural Test

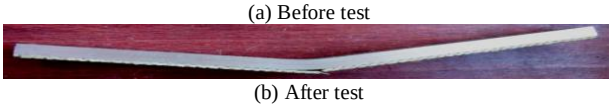
The flexural test method measures behavior of materials subjected to simple beam loading. It is also called a transverse beam test with some materials. Maximum fibre stress and maximum strain are calculated for increments of load. Results are plotted in a stress-strain diagram. Flexural strength is defined as the maximum stress in the outermost fibre. This is calculated at the surface of the specimen on the convex or tension side. Flexural modulus is calculated from the slope of the stress vs. deflection curve. If the curve has no linear region, a secant line is fitted to the curve to determine slope. The Flexural test ASTM D6272 measures the force required to bend a plastic beam under a four point loading system. The test method is used for reinforced or unreinforced materials including high modulus composites and for materials that do not fail within the limits of ASTM D790 (a three point loading test). The major difference between the three point and four point flexural tests is the location of the bending moment. The four point bending method allows for uniform distribution between the two loading noses, whilst the three point bending method's stress is located under the loading nose. Since the flexural properties of many materials can vary depending on temperature, rate of strain and specimen thickness, it may be appropriate to test materials at varied parameters.

Flexural strength and stiffness are not basic material properties. They are the combined effects of a material's basic tensile, compressive and shear properties. That is, when a flexural loading is applied to a specimen, all three of the material's basic stress states are induced. Material failure, then, is dictated by which of the three basic stresses is the first to reach its limiting value-that is, its strength. Despite the obvious complexities implied by the above, flexural testing is common, the test specimen is easy to prepare, the fixture can be simple and the test itself is easy to perform. To simplify the stress state in the specimen, it is customary to minimize the shear stress component. This is done by making the specimen support span (ℓ) long relative to the specimen thickness (t), because shear stress is independent of specimen length while the bending moment (and thus the tensile and compressive stress) is directly proportional to specimen length. Here flexural test is done in impact test method according to the specification.

Machine Name: Flexural testing machine
Testing load range: Max 5 Ton
Make: Associated Scientific Engg. Works
Digital Encoder make: Auto Instruments – Kolhapur
Gear rotation speed (For gradual loading) : 1.25, 1.5 and 2.5 mm/min
Software details: FIE make India



(a) Before test



(b) After test

Fig. 5: Flexural test specimen

4. Results and Discussion

Tensile Test Report

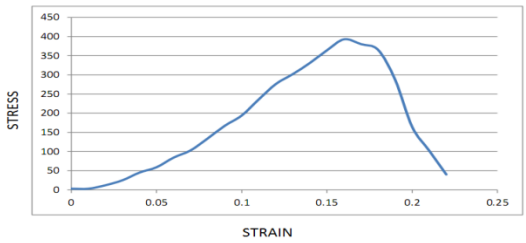


Fig. 6: Tensile test report

For the tensile report T1 shows the above mentioned stress strain graph. From this the graph shows the ultimate stress obtained is 392.65MPa.

Flexural Test Report

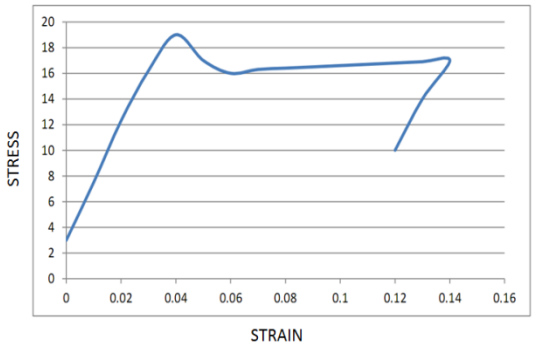


Fig. 7: Test report for flexural load

For the flexural test shows the above mentioned stress strain graph. From this the graph shows the maximum flexural load is 5.4 KN.

Impact Test

Impact value = 27 Joules

Here we give the overall view of our project and its result discussion. We made our kevlar fibre reinforced plastic aluminium sandwich of specification 300 x 150 mm by hand lay-up method with epoxy resin (LY556) and hardener (HY951) in the ratioof 10:1. We made laminates with 0°-90° orientation. The laminate (0-90°) has single layer by kevlar fibre above and below the aluminium plate. These laminates then cut according to the standard specimen size followed in the "OMEGA" testing center. They follow the standard of ASTMD 638 for the mentioned specification. These specimen were cut using band saw machine at "OMEGA TESTING CENTER" industry located in guindy industrial estate. After the cutting process, the test has been performed for tensile, flexural and impact as per the standard they follow in testing center. Test output were given by graphs obtained through FIE software. From this output, we got the following values.

Table 1: Test Result

Sample	Tensile strength (MPa)	Flexural strength (KN)	Impact strength (Joules)
1	392.65	5.4	27

5. Conclusion

As mentioned before kevlar fibre will give a high flexural and impact property in light weight and it us useful in many aircraft body make industries. Here we prepared the laminated composite and found the mechanical properties. After the entire test was

done we obtained the test report. We got the ultimate tensile strength as 392.65 MPa, Flexural load as 5.4 KN and impact result as 27 Joules. We finally conclude that the property of kevlar laminated aluminium composite will be suitable to replace the conventionally used aluminium.

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