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Experimental Investigation of Leaf Spring Using Fibre Material

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ABSTRACT

High-performance composite materials are now being researched extensively for use in aerospace and industrial applications. The standards for composite materials have increased as a result of increasing energy & environmental considerations, in addition increased in electronics and other on-board vehicle structures. As the car industry becomes more competitive and innovative, traditional vehicles are being modified with modern and improved material products. Vehicle suspension systems are another field where these advancements are made on a regular basis. Leaf springs are also one of the first suspension systems being used in vehicles today. Because of it highest stability, high tensile strength, low weight, high chemical resistance, high temperature tolerance, and low thermal expansion, the vehicle industry is increasingly interested in replacing steel leaf springs through fibre composite leaf springs consisting of carbon fibre. The aim of this research is to find out whether carbon fibre combined with jute fibre is suitable for use in vehicle leaf springs. Mechanical experiments were used to examine the composite leaf spring in the study.

Keywords: Carbon fibre, jute fibre, leaf spring, Fiber reinforced composites (FRC)

INTRODUCTION

In vehicles, the suspension system plays a critical role in determining automotive comfort and safety. The suspension mechanism is in a state of dynamic equilibrium as the tyre rotates, constantly compensating with and adapting to changing driving conditions. Suspension modules perform simple functions including retaining the proper vehicle ride height, reducing the impact of shock forces, protecting the vehicle weight, and bearing the driving torque, among others.

The spring is mounted between the shaft housing and, as a result, the vehicle's chassis, and it can be thought of as a purely balanced beam with a centred load in the middle. The bending moment is greatest in the middle of the spring and decreases at the ends, so the spring selection ranges from greatest in the middle to least in the ends. In a standard multi-leaf steel spring, this can be achieved by gathering a number of leaves of different lengths in such a way that the thickness is greater in the centre and reduces toward the ends.

Clamps and a central bolt hold the leaves together as they are stacked one on top of the other. The master leaf is the one that lasts the whole length of the season. The master leaf's ends are shaped into loops, which are referred to as eyes. The spring bolt that holds the leaves together passes through a hole in the centre of each metallic leaf. The outer ends of the shorter leaves are connected to the master leaf with spring clips.

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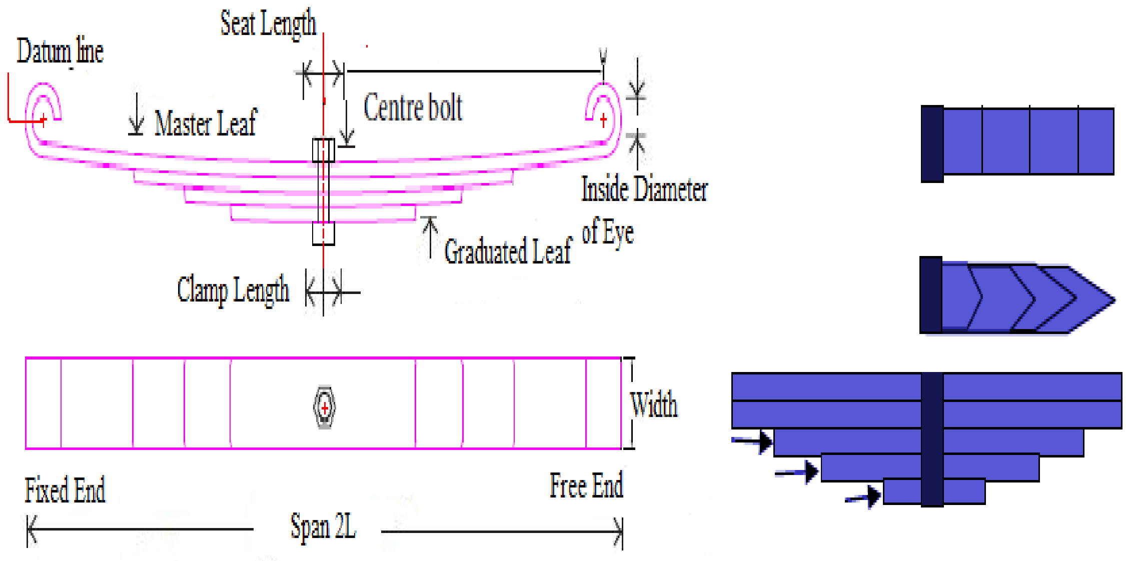


Fig. 1 Leaf spring

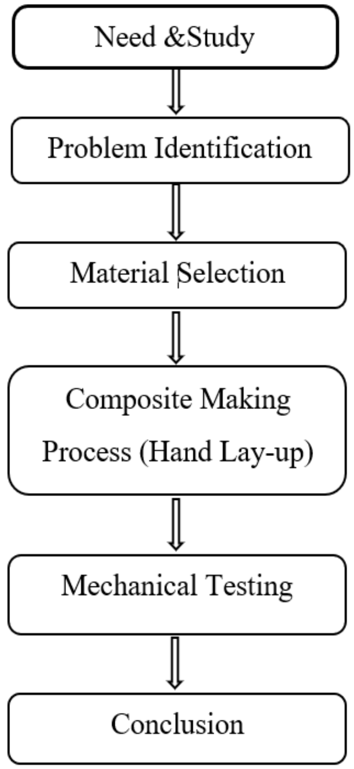
Principles Of Suspension System

The suspension system aids areas of the vehicle such as the body, frame, and transmission, which are referred to as sprung mass. The body, chassis, internal components, passengers, and cargo are all considered sprung weight. Unsprung weight, on the other hand, refers to components that match the contours of the road, such as wheels, tyres, braking systems, and any portion of the steering and suspension that is not supported by the spring. The suspension mechanism protects the body from road vibrations and motions that would otherwise be conveyed to the passengers and mounted on them. It's also responsible for keeping the tyres on the track. There is a reaction force when a tyre collides with an obstruction. The size of this reaction force varies based on the unsprung mass at each wheel alignment.

LITERATURE REVIEW

G. Prasad and K. S. Sridhar Raja (2019) GFRP & SiC composite has the most promising properties to serve as a substitute for GFRP material when considering deformation, shear stress caused, and resulting frequency. It's powerful enough to be used in car leaf springs. The lands of Md. Milon Hossain and M. A. Khan the tensile and bending properties of different matrix materials were significantly improved. The CK/epoxy composite showed the highest tensile and bending properties, with the exception of bending modulus, as opposed to other matrix materials. The bending modulus of CK/PE composite materials was observed to be higher in comparison to its counter composite specimens, CK/PP has low mechanical properties. Compression moulding was used to fabricate Aloe Vera, Jute, and Glass Fiber Reinforced Epoxy composite by Ashwin Sailesh and P. Vignesh Pothiraj (2018). The Aloe Vera-Jute-Glass fibre reinforced epoxy composites have tensile strength, flexural strength, and then impact strength of 60.017 MPa, 107.896 MPa, and 0.026 J/mm2 respectively. According to Amir Pradhan and Yogendra Rathore (2016)**,** Steel and plastic leaf spring deflection and stresses differ greatly when the static load is the same. In the same loading state, the deflection of a composite leaf springs are smaller amount than a steel leaf spring. The weight of a traditional steel leaf spring are discovered to be 23 kilogrammes, while E-Glass/Epoxy mono leaf springs weighed just 12 kilogrammes. indicating a weight loss of 80% while maintaining the same degree of efficiency. The composite leaf spring, conferring to Rajagopal D, Varun (2014), is light and more cost-effective than a traditional steel spring with comparable design requirements. E-Glass/Epoxy composite leaf springs are 85 percent lighter than traditional leaf springs.

Working Methodology



Problem Statement

Researchers have recently based their attention on the failure of the Leaf spring suspension mechanism. The Leaf spring fails after just 6 years of use, despite the manufacturer's recommendation of a 10-year lifespan. In the case of such an early breakdown, the Leaf spring must be replaced as soon as possible to ensure uninterrupted drive from the consumer. Replacement of leaf springs on a regular basis results in a less comfortable ride, shortened suspension span, and more repair work. The aim of this research is to see if it is possible to build a Leaf that is both solid and light.

Objective

- The aim of the project is to substitute steel leaf springs by composite materials in leaf spring applications.
- The engineered composite leaf spring is when opposed to standard leaf spring material, which is concrete.
- Various mechanical testing for composite and steel components will be carried out as part of this initiative.
- The experimentation's final outputs for both materials are to be compared.
- According to this comparison, composite leaf spring materials have less stress caused deformation and weight than steel leaf spring materials.

MAKING PROCEDURE

Hand Lay-Up Technique

The fibres, which are normally sheets, are cut and inserted into a mould. Rollers are used to apply the resin. Vacuum bagging is a method of curing that involves using a vacuum bag. Excess air is absorbed by applying vacuum, and ambient pressure is used to compress the composite. The hull of a boat is a popular Thermosets commodity. The benefits include the process's high versatility and efficiency, as well as the low cost of tooling. Long processing times, a labour-intensive nature, and limited automation options are all called drawbacks.

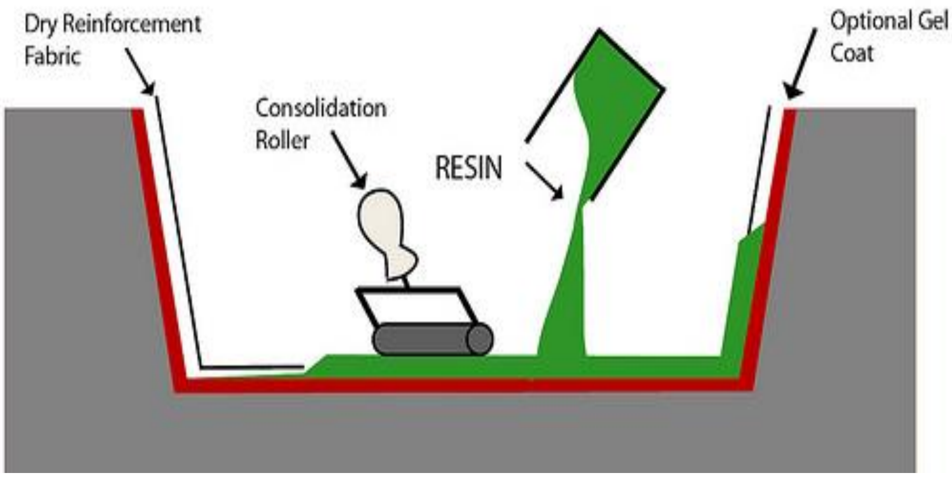


Fig. 2 Hand Lay-up Technique

MATERIAL SELECTION

Plain Carbon Steel (Existing Material)

Carbon steel in its purest form is a metal alloy. It's made up of two different elements: iron and carbon. Other elements are found in trace amounts and have little effect on its properties. Leaf springs are normally made of pure carbon steel with a carbon content of 0.90 to 1.0 percent. Following the shaping process, the plates are heat treated. Heat treatment of spring steel gives it more strength, which translates to more load power, a wider range of deflection, and improved fatigue properties.

Carbon Fibre (Proposed Material)

Carbon fibres are made of mostly by carbon atoms and have a diameter of 5–10 micro-metres. Carbon fibres have numerous compensations, with high density, high tensile strength, low weight, high chemical tolerance, high temperature resilience, and low thermal expansion. Because of its special qualities, carbon fibre is extensively used in aircraft, civil engineering, defence, and motorsports, as well as other sporting activities.

Jute Fibre

Jute is a bast fibre that can be woven into coarse, solid threads and is long, smooth, and shiny. It is mainly made from plants in the genus Corchorus, which was formerly known as part of the Tiliaceae family. Corchorus olitorius is the main source of fibre, although it is inferior to Corchorus capsularis. Jute is one of utmost cost-effective natural fibres, and only to cotton in terms of production & number of applications. The plant products cellulose and lignin make up the majority of jute fibres. It, as well as kenaf, industrial hemp, flax (linen), ramie, and other bast fibres (fibre obtained from the plant's phloem, often referred to as "skin"), falls under the bast fibre group.

EXPERIMENTAL TESTING

An experimental study was performed on a leaf spring to analyse it under various loading conditions and determine the stresses and deformations that resulted. Understanding how the design responds to various loading conditions and using carbon and jute fibre instead of traditional steel leaf spring material. Leaf springs were subjected to a variety of mechanical tests, including tensile, compression, impact, and bending tests, in order to validate their strength. Designers will be able to make modifications before physical prototyping.

Tensile Test

Placing the test specimen in the measuring machine and slowly spreading it until it cracks is how the test is done. During this procedure, the gauge section's elongation is measured against the applied force. The data were distorted to make it unrelated to the research sample's geometry. The engineering strain is calculated using the elongation measurement.

Fig. 3 Tensile Test

Impact Test

The impact test is a technique for determining engineering materials' hardness and notch sensitivity. It's most commonly used to assess the hardness of plastics, but it's still used to assess the toughness of polymers, ceramics, and composites. The effect of a large pendulum or hammer, dropping at a set rate over a specified gap, breaks the notched test specimen. The energy consumed by the broken specimen is measured in this examination.

Fig. 4 Experimental set up for Impact strength test

Izod Impact Test

A V-notch test fragment is shattered by a single blow from a freely swinging pendulum in the Izod impact test, which is a complex process (Fig.4). The blow is delivered on the same side of the notch as the notch, and at the same height above it. The amount of electricity used is kept track of. The amount of energy consumed is a measure of the material's effect power.

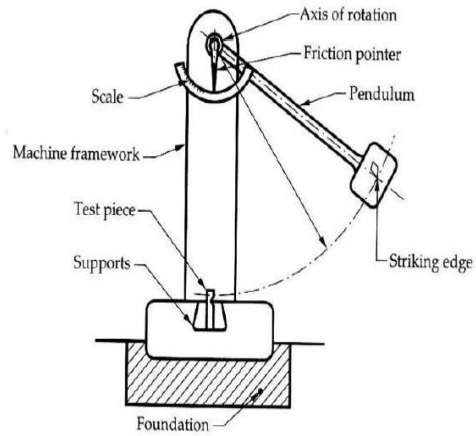


Fig. 5 Izod Test equipment

Compression Test

Any measurement in which a sample is compressed, "squashed," crushed, or flattened as a result of opposing forces pressing downward on the specimen from opposite sides is called a compression test. The test specimen is typically made up of plates that uniformly distribute the applied force to two sides of the test specimen, and the plates are pressed together through a universal machine to flatten the sample. A compact sample is typically compressed in the route of the applying forces then reversed. Compression testing is the polar opposite to traditional stress testing.

Fig. 6 Compression Testing

Bend Test

The bend test is a low-cost qualitative test for determining the ductility and strength of a substance. Since the test piece and equipment are both basic, it's a standard quality control measure for leaf spring stability. There is no need for costly laboratory instruments, test specimens are simple to plan, and, if appropriate, the test should be conducted on the shop floor as a quality control test to ensure output consistency. Bending a coupon in three points to a certain angle is part of the bent evaluation. The bend's exterior is highly deformed, exposing defects or embrittlement in the material due to the coupon's early loss. There are two types of bend tests: direct and unguided. In the guided bend test, the coupon is wrapped around a former with a specific set.

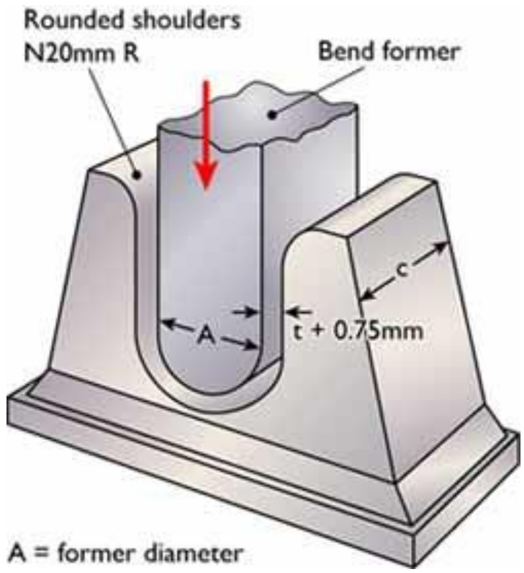


Fig. 7 shows a driven bend test jig with a male and female former, which is the most common type of equipment

RESULT AND DISCUSSION

Polymer matrix composite is made from two different components, each with a different proportion of fibres. We'll be analysing three specimens of different composition ratios, including carbon (100%), carbon + jute, and jute (100 percent).

Table. 1 Material Composition

S. NO	MATERIAL	SAMPLE ID
1	Carbon (100%)	A5
2	Jute (100%)	A6
3	Carbon + Jute	A7

Fig. 8 A5-Carbon Fiber

Fig. 9 A6 – Jute Fibre

Fig. 10 A7 – Carbon Fibre + Jute Fibre

Tensile Test

The samples were sliced to a scale of 165 mm x 25 mm x 3 mm in accordance with ASTM standards. Normal "dumbbell" or "dog bone" specimens are used in this research process. Using a universal measuring unit, the tensile strength was determined. Continuous tensile loading was applied to the samples until they failed. After that, the load at which the failure occurred was registered. The test results show that specimen A5 has the least elongation (2.390) and specimen A6 has the highest tensile strength (69.455 N/mm2).

Table 7.2 Tensile Test Result

Sample ID	C.S Area (mm^2)	Peak Load (N)	% Elongation	Ultimate Tensile Stress (N/mm^2)
A5	45.00	867.685	2.390	19.286
A6	45.00	3125.603	6.590	69.455
A7	45.00	2492.603	3.010	55.387

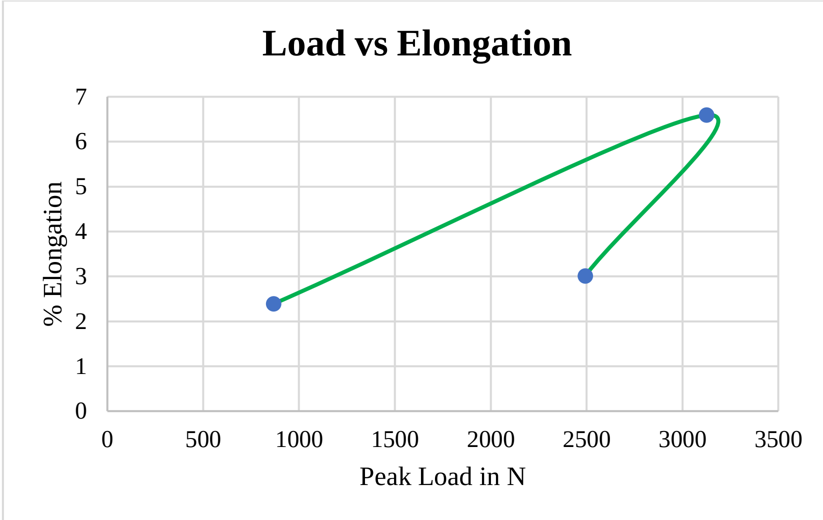


Fig. 11 Load vs Elongation

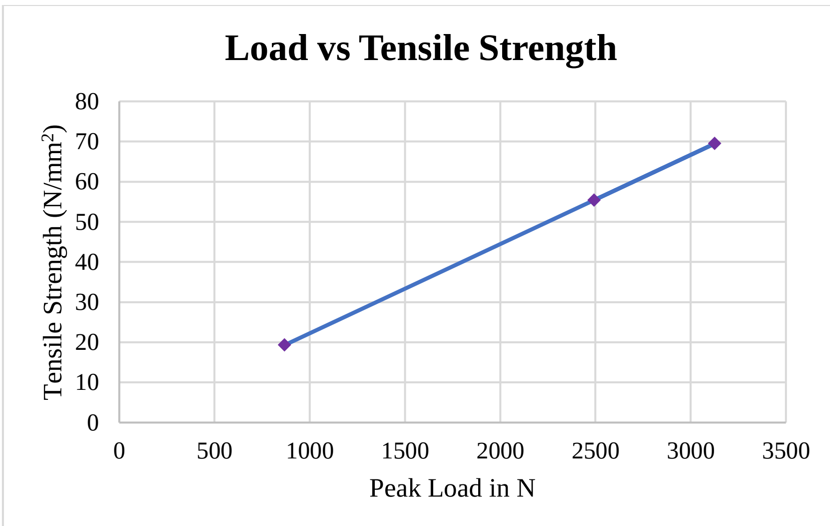


Fig. 12 Load vs Tensile Strength

Flexural Test

Composites are flexural strength tested according to ASTM standards in a range of 125mm X 13mm X 3mm. This research is carried out on a universal measuring unit. Figures 7.5 and 7.6 show the flexural test findings graphically. Specimen A5 has the highest flexural pressure, 78.756 MPa, and specimen A6 has the highest flexural modulus.

Table 7.3 Flexural test results of specimens

Sample ID	C.S Area (mm^2)	Peak Load (N)	Flexural Strength (MPa)	Flexural Modulus (GPa)
A5	39.00	122.860	78.756	2519.676
A6	39.00	102.220	65.526	7036.325
A7	39.00	30.764	19.721	671.474

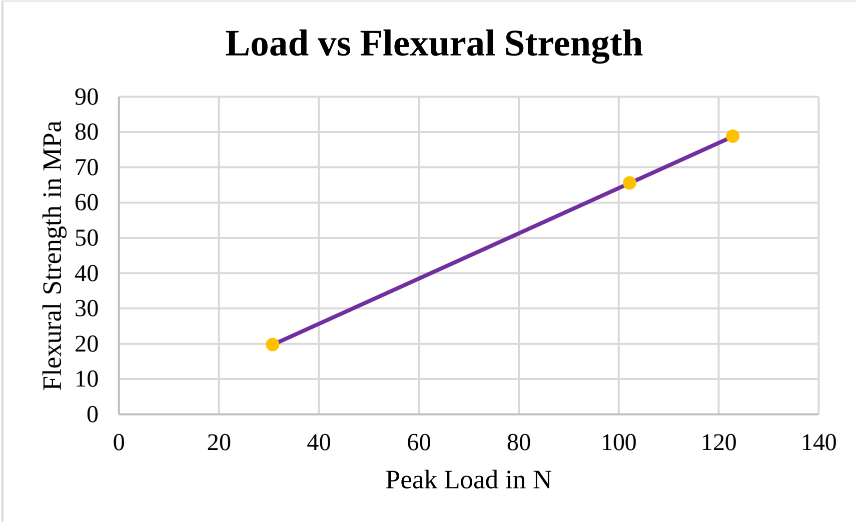


Fig. 13 Load vs Flexural Strength

Compression Test

Composites are compressed according to ASTM standards in a format of 150mm X 25mm X 3mm.

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This research is carried out on a universal measuring unit. The overall flexural strength of specimen A7, as determined by the compression test, is 15.343 N/mm2

Table 7.4 Results of compression test

Sample ID	C.S Area (mm^2)	Peak Load (N)	Compressive Strength (N/mm^2)
A5	75.00	322.641	4.307
A6	75.00	254.962	3.394
A7	75.00	1150.919	15.343

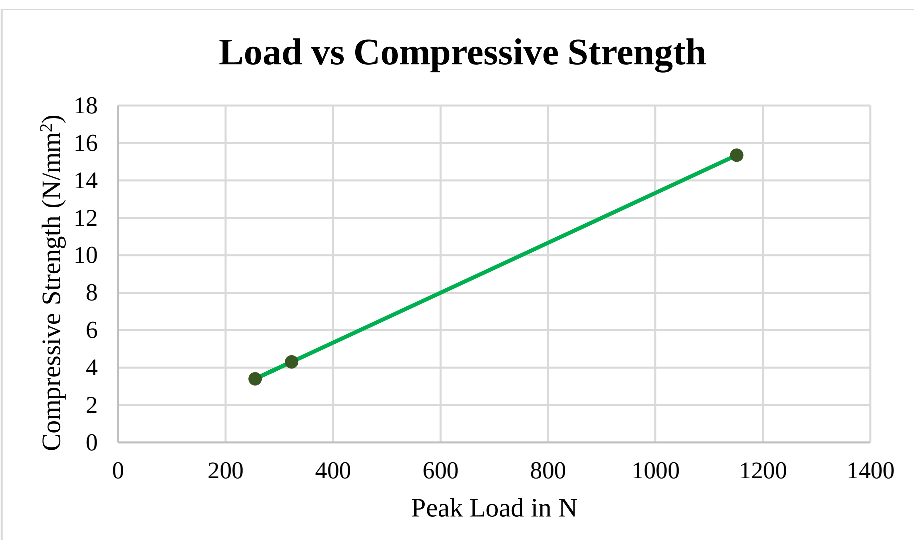

Fig. 14 Load vs Compressive Strength

Impact Test

Both samples were cut and packed to ASTM specifications, measuring 65mm X 13mm X 3mm. An Izod measuring system was used to determine the impact power. The whole collection of samples used for the Impact evaluation. Impact was applied to the samples, which were suddenly loaded before failure occurred. When a malfunction occurs while under load, the results are registered. A9 has the highest impact rating of the impact test specimens.

Table 7.5 Impact Test results

Sample ID	IZOD Impact Value (Joules) for thickness of 3mm
A5	1.00
A6	0.40
A7	0.30

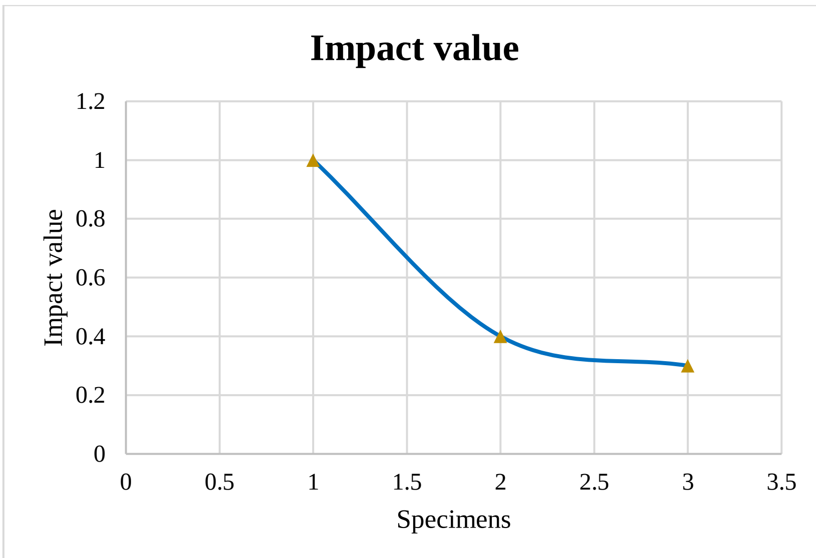

Fig. 15 Impact test results

CONCLUSION

Experimentally, the use of carbon and jute to create polymer reinforced fibre composites is studied. The effects of different fibre ratios on mechanical properties have also been investigated. The composites are made by hand lay-up process with carbon, jute, and epoxy resin in three distinct ratios. Specimen A5 has a flexural power of 78.756 MPa since it contains 100 percent biomass. The maximum tensile strength and flexural modulus of specimen A6 with 100% jute content are 69.455 N/mm2 and 7036.325 GPa, respectively. Specimen A7 has a compressive power of 15.343 N/mm2, which is outstanding. These materials are used to minimise part weight and increase durability.

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