Experimental Investigation of Mechanical Properties on Kevlar and Flax Fiber Reinforced Hybrid Composite Material with Filler Material

M. Jaya Prakash, Dr.B.V.Ramana Murty

Abstract— The recent modern technologies need materials with combined properties like high strength to weight ratio, high stiffness, high corrosion resistance, high fatigue strength, high dimensional stability, etc., these can't be met by the traditional metal alloys. Composites made by Polymeric materials are reinforced with natural and synthetic fibers have high stiffness and strength to weight ratio as compared to traditional materials. The current work primarily describes the improvement of mechanical properties of hybrid composite consists of woven kevlar29 laminate and woven flax laminate reinforced with epoxy with and without filler material. The effect of filler material has been studied for different percentages of aluminium 2.7%, 5.4%, and 8% by weight. Specimens are made as per ASTM standards by using hand lay-up technique. Experiments are conducted to investigate mechanical properties such as tensile, compression, flexural, toughness, and hardness. Results obtained from the above tests are very encouraging due to the addition of filler material in natural and synthetic fiber reinforced hybrid composites. It has been observed that the mechanical proprieties are increasing with increase of composition of filler material.

Index Terms— Hybrid Composites, Flax Fiber, Filler Material, Kevlar.

I. Introduction

The research mainly focused on flax fiber composites due to their superior mechanical properties and chemical modifications. The synthetic fiber Kevlar fabricated for reaching the demand for industrial and improved-technology applications. However, the cost of Kevlar fiber is high when compared to natural fiber flax. Shahirul et al. [1] conducted Indentation and impact tests on woven E-glass with flax and jute which are formed with sandwich-like and intercalation. Maheswaran et al. [2] studied the fracture behavior of the Kevlar/Glass-Epoxy Hybrid Composite using finite element analysis and experimental method. Ou et al. [3] used Kevlar fibers grafted by functional silane and allyl and used as reinforcements in Wood-Flour/High-Density-Polyethylene composites to improve the mechanical properties. Foruzanmehr et al. [4] used modified TiO_2 grafted flax fibers to reinforce polylactic acid (PLA) composites. Murali et al [5] used natural fibers Sisal, banana and jute reinforced with epoxy for manufacturing helmet. Mursalin et al. [6] studied the flexural properties of the composites fabricated by reinforcing bagasse, coir and banana fiber with epoxy resin matrix.

Manuscript revised June 7, 2019 and published on July 10, 2019
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II. EXPERIMENTAL INVESTIGATION

2.1 Materials

The Two Reinforcement materials used are Synthetic Material as woven Kevlar 29 fiber and Natural Plant Fiber as woven Flax fiber and Matrix used in this hybrid composite is Epoxy LY556 (Araldite) with combination of Hardener HY951 (Aradur) in 10:1 (E:H) ratio along with addition of aluminium filler material with different proportions i.e. 5, 10, and 15 grams.

Table 1: No of layers and weight of each fiber.

Fibers	No of layers of fibers	Weight of the fibers in grams	Weight of the resin in grams	Desired thicknes s mm
Hybrid (flax+kevlar)	3+3	53	121	3
Hybrid (flax+Kevlar+ Al5 grams)	3+3	53	126	3
Hybrid (flax+Kevlar+ Al10 grams)	3+3	53	131	3
Hybrid (flax+Kevlar+ Al15 grams)	3+3	53	136	3

2.2 Relative Weights of fiber and resin

Resin weight is taken by considering fiber manufacturing properties. For woven flax fiber, the weight ratio of fiber and

doi: 10.32622/ijrat.76201928

resin is 1:3.5 and woven kevlar29 fiber, the weight ratio of fiber and resin is 1:1.

2.3 Composition of hybrid composite materials

Table 2: Weight percentage of fiber and matrix in the composite.

S.No	Specimen name	Composition of composite by (wt %)
1	Hybrid(flax+kevlar)	Flax (15.5%) + Kevlar (14.9%) + Epoxy (69.5%)
2	Hybrid with Al 5 grams	Flax (15%) + Kevlar (14.5%) + Epoxy (67.5%) + Al (2.7%)
3	Hybrid with Al 10 grams	Flax (14.6%) + Kevlar (14.1%) + Epoxy (65.7%) + Al (5.4%)
4	Hybrid with Al 15 grams	Flax (14.2%) + Kevlar (13.7%) + Epoxy (64%) + Al (8%)

Fig 1: Fabricated hybrid composite materials with varying different proportions of filler material (Al).

III. MECHANICAL TESTING

The following tests are to be performed on fabricated hybrid composite material.

1. Tensile test
2. Compression test
3. Flexural test
4. Charpy impact test
5. Brinell's hardness test

Fig 2: Specimens before testing.

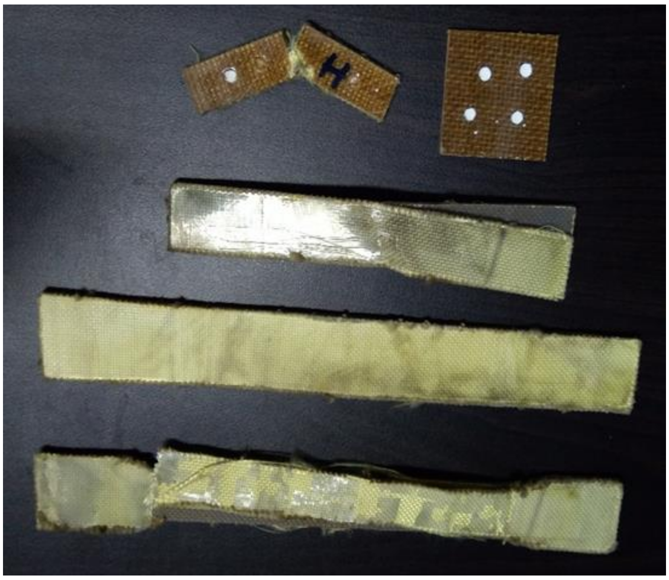

Fig 3: Specimens after testing.

3.1 Tensile test

The dog-bone-shaped tensile specimens with a size of 250×25×3 mm according to ASTM D3039 standard is tested using an INSTRON 8801 testing machine at strain rate of 3mm/min. The results are presented in the table 3.

Table 3: Tensile Test results.

S. NO	Specimen label	Maximum load (KN)	Load at break (KN)	Modulus (E-modulus) (MPa)	Ultimate tensile strength (MPa)
1	Hybrid	5.06	3.11	4272.16	112.35
2	Hybrid with Al 5 gms	4.12	3.66	4555.52	91.58

doi: 10.32622/ijrat.76201928

3	Hybrid with Al 10 gms	5.02	3.12	4749.50	111.45
4	Hybrid with Al 15 gms	6.38	4.74	4732.09	141.71

3.2 Compression test

Rectangular shaped compression a specimen with a size of 140×25×3 mm according to ASTM D3410 is tested using an INSTRON 8801 testing machine. The results are presented in the table 4.

Table 4: Compression Test results.

S.NO	**Specimen label**	**Maximum load(N)**	**Modulus (MPa)**	**compressive strength (MPa)**
1	Hybrid	568.63	5518.84	7.58
2	Hybrid with Al 5 gms	619.69	5548.60	8.26
3	Hybrid with Al 10 gms	735.93	5719.98	9.81
4	Hybrid with Al 15 gms	935.53	7076.02	12.47

3.3 Flexural test

Flexural test has been performed to determine the modulus of rupture. Specimens with dimensions 125×20×3 mm according to the standard ASTM D709 is tested with 3-point bending test machine using the same mechanical testing machine.

Table 5: Results from flexural test.

S.NO	**Specimen label**	**Maximum load (N)**	**Flexural stress at maximum flexural load (MPa)**	**Modulus (MPa)**
1	Hybrid	219.97	154.36	6465.14
2	Hybrid with Al 5 gms	200.51	140.71	7412.22
3	Hybrid with Al 10 gms	274.07	192.33	7754.62
4	Hybrid with Al 15 gms	275.41	193.27	7730.81

3.4 Brinell's hardness test

Hardness of the specimens was measured with Brinell's hardness testing machine by applying 500 kgf load and using indenter of 5mm diameter.

Table 6: Results from hardness test.

S.NO	**Specimen label**	**Load applied (N)**	**Diameter of indenter D=5mm**	**Average diameter of indentation d (mm)**	**Brinell's Hardness Number (BHN) Kg/mm^2**
1	Hybrid	4905	5	3.73	38.13
2	Hybrid with Al 5 gms	4905	5	4	31.84
3	Hybrid with Al 10 gms	4905	5	3.93	33.36
4	Hybrid with Al 15 gms	4905	5	3.7	38.90

3.5 Charpy impact test

Impact strength was calculated for specimens measuring 63.5×12.7×3 mm using a notched impact testing instrument as per ASTM D256 standard.

Table 7: Results from impact test.

S.NO	**Specimen label**	**Cross sectional area below the notch (mm^2)**	**Initial energy (J)**	**Reading after impact (J)**	**Error in reading (J)**	**Actual energy (J)**	**Toughness J/mm^2**
1	Hybrid	18	300	-12	-6	282	15.66
2	Hybrid with Al 5 gms	18	300	-11	-6	283	15.72
3	Hybrid with Al 10 gms	24	300	-13	-6	281	11.70
4	Hybrid with Al 15 gms	21	300	-10	-6	284	11.83

IV. RESULTS

The results obtained by various tests are presented in the form of Bar charts from fig 4 to fig 10.

doi: 10.32622/ijrat.76201928

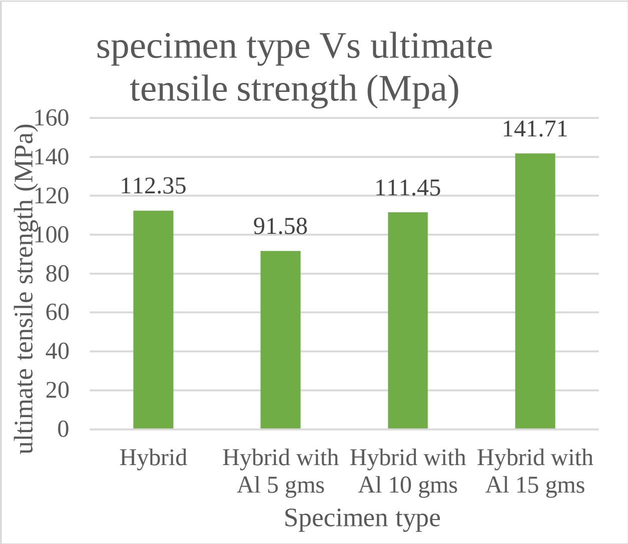

Fig 4: Plot between specimen type and Tensile strength.

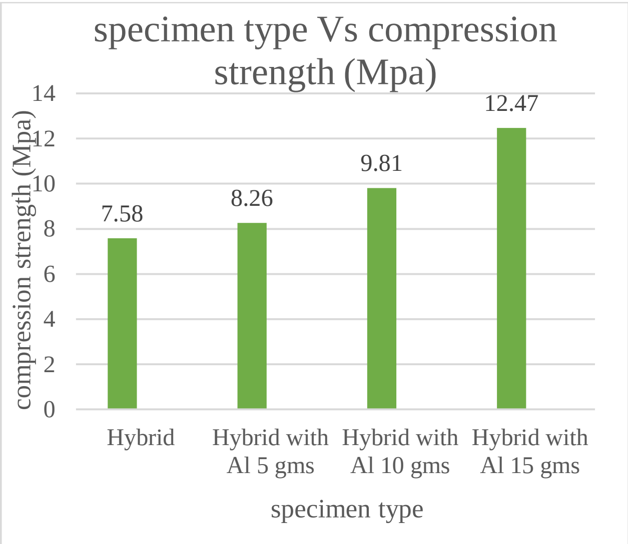

Fig 5: Plot between specimen type and compressive strength.

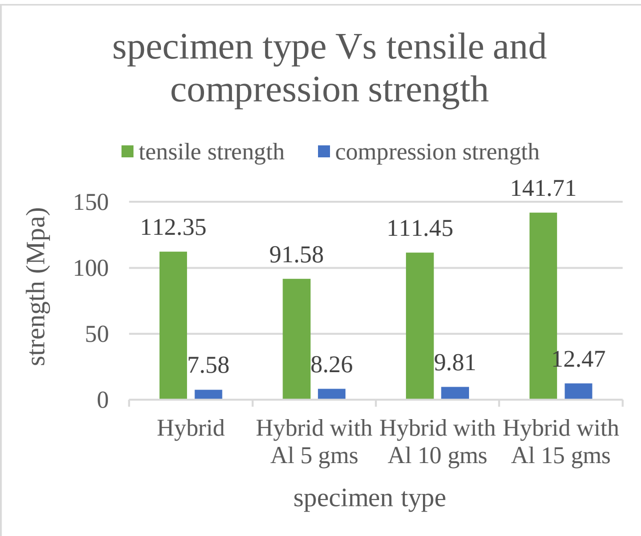

Fig 6: Plot between specimen type and relative tensile and compression strengths.

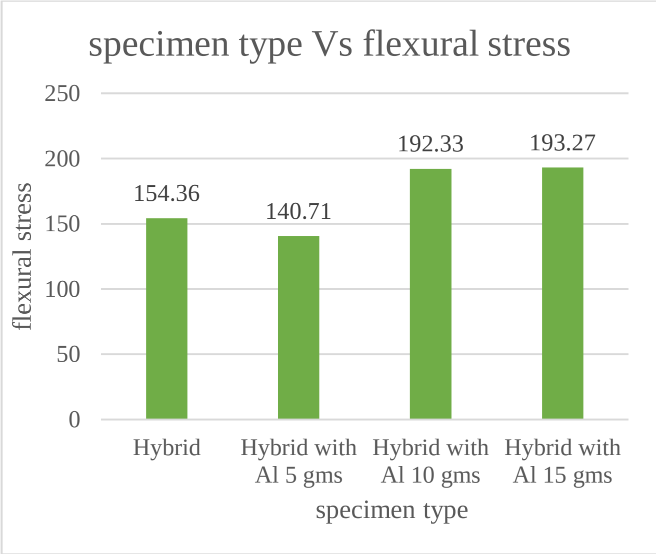

Fig 7: Plot between specimen type and flexural stress.

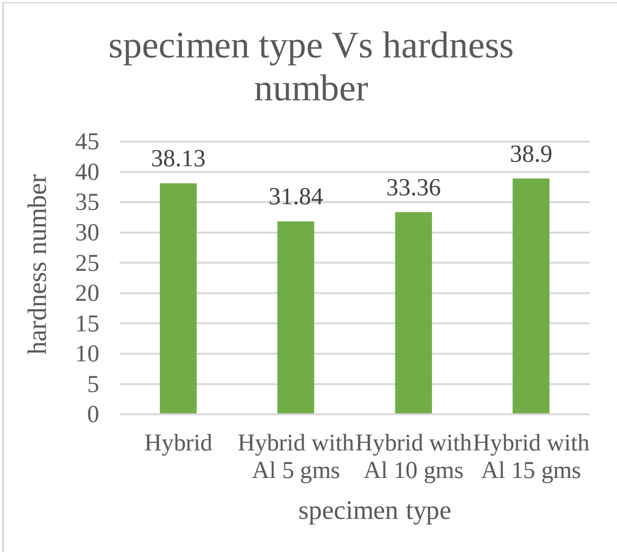

Fig 8: Plot between specimen type and hardness number.

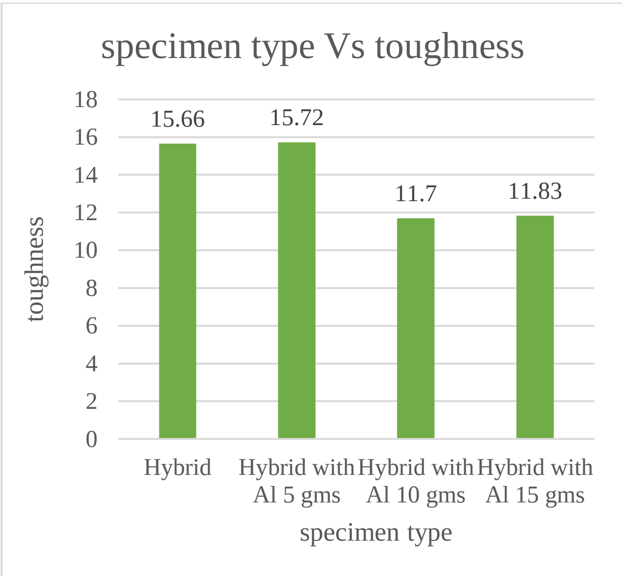

Fig 9: Plot between specimen type and toughness.

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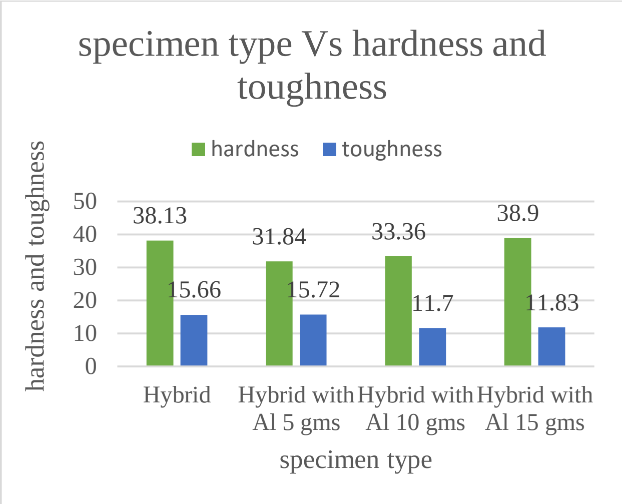

Fig 10: Plot between specimen type and relative hardness and toughness.

V. DISCUSSIONS

- From the figure 4 it has been observed that as the percentage of filler material increases the tensile strength is increasing in hybrid composite.
- From the figure 5 the compression strength of hybrid composite increases with the increase of the percentage of filler material.
- From the figure 7 it is evident that the flexural stress decreases for hybrid composite containing 5grams of filler material and by increasing the filler material more than 5 grams the flexural stress increases.
- From the figure 8 Kevlar has high brinell's hardness number compared to other composite materials.
- From the figure 9 it clearly shows that by addition of filler material into hybrid composite the toughness decreases.

VI. CONCLUSIONS

- From this work it is evident that, hybrid composite materials have higher strength as compared to the natural composite materials.
- Hybrid composite materials are more economical as compared to the synthetic fiber reinforced composite materials.
- The properties of the natural fibers can be improved by combining with synthetic fibers. It also reduces the cost.
- The properties of these hybrid composite materials are further improved by addition of optimal proportion of filler material.

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doi: 10.32622/ijrat.76201928