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EFFECT OF STRAIN RATE AND THICKNESS ON MECHANICAL PROPERTIES OF JUTE/GLASS HYBRID FIBER COMPOSITES

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Abstract - Composite *material in the past was considerably used to save secondary structures of automobile and aircraft. Present work involves a detailed testing of strain rate and thickness dependency on mechanical properties such as tensile modulus, yield strength, ultimate strength and tensile toughness, of jute/glass hybrid fiber composite. With 40% of hybrid fiber content (20% of jute and 20% of glass) and 60% of Matrix (Epoxy) is used for the preparation of laminates of different thickness of jute/glass hybrid fiber composites. Specimen thickness used in this project are 3.25mm, 4.8mm and 6.5mm and different strain rate used are 0.0165/s, 0.024/s and 0.034/s. Universal Testing Machine(UTM) used for testing. In tensile test, maximum stiffness obtained is 3084 N/mm, Yield strength of 111N/*mm^2*, tensile modulus of 6678N/mm2 and Ultimate strength is of 113 N/*mm^2*. Results indicate that Strain rate and thickness of specimen affects the properties of jute/glass hybrid fiber composite material*

Key Words: **Strain rate, thickness, hybrid composites, jute/glass hybrid composites, mechanical properties, fracture properties, Natural composites.**

1. INTRODUCTION

Composites are used as chemical equipment, sporting and civil goods, automobiles, helicopters, aircraft, space craft, satellites, ships and submarines, and there is the chance for regular use in medical prosthesis and microelectronic devices. Composites materials have developed as significant materials because of their properties such as high specific strength, stiffness and excellent fatigue resistance, light-weight, and excellent corrosion resistance than to most metals and metallic alloys such as steel and aluminium. Composite materials are accepting in several areas of applications due to characteristics and properties of composites which they possessing. Generally tensile, fractures, shear properties, compressive etc. The capacity of a material to resist breakage against tensile stress is one of the mainly important and extensively measuring properties of materials used in applications of structure.

2. LITERATURE SURVEY

Ajith Gopinath.et.al., [1] In this work, comparison and characterization of two different PMCs having different matrix materials and same reinforcement material is studied. Fiber used is 5-6mm lengthened jute fiber and matrix materials used are epoxy and polyester resin. Composites were prepared with fiber-resin ratio of 18:82 by weight percentage and mechanical properties characterized are impact strength, hardness and tensile strength. Conclusion drawn from this study is mechanical properties were better exhibited by the epoxy based composite material than with polyester resin based.

Mahmood M Shokrieh.et.al., [2]. This paper clarifies the properties of glass fiber reinforced PMCs by increasing compressive strain rates. Present work clarifies the description of unidirectional glass-fiber reinforced PMCs. Properties are checked by servo-hydraulic testing device at different strain rates running from 0.001 to100 s^{-1}. The consequences of the dynamic tests are contrasted and the aftereffects of the static tests completed on examples with indistinguishable geometry. Observational functions are created in terms of strain rates for the composite materials. The aftereffects of the study demonstrate that, strain rate has a critical effect on the material reaction. It was given that when strain rate changes then compressive strength and modulus both changes.

M Kabir.et.al., [3] In this paper, the tensile properties of hemp fiber was measured by considering the variety in fiber diameter. Alkali, acetyl and silane treatment of fibers were done to acquire a superior surface finish. The impacts of fiber medications on tensile mechanical properties were explained about and given relationship between treatment of fiber and varieties in fiber diameter. Results are demonstrated that, the strength of chemically treated fibers diminished contrasted with untreated fibers. Strength examinations between three types of treatments are tested.

M. Sakthivei.et.al., [4] In this paper, work is related to some of natural fibers like banana, coir and sisal. In this paper mechanical test conducted to quantify the hardness, water absorption capacity, density and impact strength. Specimen preparation procedure is understood by this journal. Hybrid fiber morphology was not discussed. Constant strain rate was used during tensile test and effect of varying strain rates and specimen of different thickness is not considered.

H. Hamada.et.al.,[5] In this paper, main examination on the impact properties and jute fiber PMC morphologies with different moisture contents were conducted and also hybridization effects with glass fiber investigated. Jute/glass composite were tested for impact by Izod impact test along with influence of moisture content. Results shows that moisture content has linear relationship with mechanical properties. In case of hybrid composite materials, structure has a great effect on properties of mechanical. The Jute/Jute/Glass hybrid composite has more impact energy than Jute/Glass/Jute hybrid composites. This paper is limited to only impact energy, paper lacks to give information of tensile and fracture properties

Sanjay M R.et.al.,[6] In this work they fabricated specimens by hand layup process which was very simple, fabrication technique is taken from this paper. Different weight fractions of jute and glass hybrid fiber composites are prepared such as 30/70, 40/60 and 50/50.This paper quantifies the values for jute/glass hybrid composites mechanical properties such as tensile, impact, flexural strength etc. The results are compared for different fiber weight fractions of jute and glass, the composite which has 50/50 glass and jute shown better tensile and impact strengths.
Limitation: This paper is restricted for few mechanical properties and fracture toughness is not determined and also fiber orientation is unidirectional.

M.Sakthivei.et.al., [7] In this work, an person behind provide information related to banana, sisal and coir natural fibers. Few mechanical properties also determined by experiments such as by density test, hardness test, impact test. This paper also gives information of specimen preparation and experimentation.
Limitation: Experiments are limited for few mechanical properties and few natural fibers. Fiber orientation is not mentioned, bending test is not discussed.

Patil Deogonda.et.al.,[8] This work describes the glass fiber reinforced PMCs development and mechanical characterization. Filler materials used in this work are TiO_2 and ZnS. Characterization of newly developed composite

3. PREPARATION OF SPECIMENS AND EXPERIMENTATION

Test standard includes the calculation of the tensile properties of glass/jute hybrid fiber composite materials. Tensile test specimen dimensional view and standard dimensions are shown in Figure 1.The standard dimensions along with different thickness used is given in Table 1. In tensile test, three different thicknesses specimens are used and there are nine specimen of same thickness are used hence twenty seven prepared for three different thickness. Tensile specimens are subjected to 3 different strain rates i.e. high, medium and low strain rates. Hence 9 samples of specimen were experimented. According to ASTM D3039 standard tensile test specimens are prepared.

3.1 Tensile test

Table 1 Standard dimensions of tensile specimen

Thickness	3.25mm,4.8mm,6.5mm
Width	20mm
Guage length	120mm
Total length of specimen	Gauge length+ gripper 120+(20+20) mm
Strain rates	3 rates (high, medium and low)

Fig 2. Standard tensile test specimen dimensions

Fig 2. Tensile test specimens before test

Fig 3. Tensile test specimens after test

Universal Testing Machine (UTM) is utilized for Tensile test. This tensile test method determines the in-plane properties of PMC materials reinforced by elevated-modulus fibers. A thin flat strip of a constant rectangular cross section material is fixed in the grip holders of a UTM and loaded in unidirectional tension while recording load. The ultimate strength of the composite material can be calculated from the maximum load sustained before breaking of specimen. According to ASTM D3039 standard tensile test specimens are prepared. T0est standard includes the calculation of the tensile properties of glass/jute hybrid fiber composite materials. Tensile test specimen dimensional view and standard dimensions are shown in Figure 1. The standard dimensions along with different thickness used is given in Table 1. In tensile test, three different thicknesses specimens are used and there are nine specimen of same thickness are used hence twenty seven prepared for three different thickness. Tensile specimens are subjected to 3 different strain rates i.e. high, medium and low strain rates. Hence 9 samples of specimen were experimented.

4. RESULTS AND DISCUSSION

This section covers the outcomes acquired for tensile test for different thickness and in addition differing strain rates.

4.1 Load-displacement behavior

The specimens are prepared according to ASTM D 3039 and subjected to tensile test. Since in the tensile test, three types of specimens(3.25mm,4.8mm and 6.5mm) are used and each specimen are subjected to three variation of strain rates i.e. 0.165 s-1,0.024s^{-1} and 0.034$s^{-1.}$

According to ASTM D 3039, the specimens are readied and specimens are tested in UTM to measure tensile properties. Since in the tensile test, three different thickness specimens (3.25mm,4.8mm and 6.5mm) are utilized and every specimen are tested to three variety of strain rates i.e. 0.0165 s^{-1},0.025s^{-1} and 0.034s^{-1}.

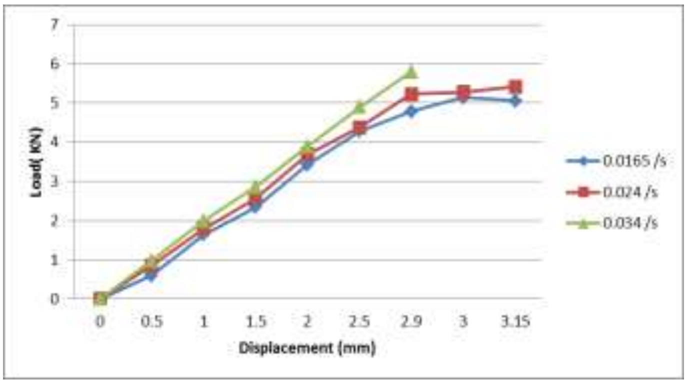

Chart-1 Load-Displacement for 3.25mm tensile specimens

Chart 1 demonstrates the load-Displacement curves of specimen thickness 3.25mm tested to 3 distinctive strain rates. At strain rate 0.0165s^{-1} due to low cross head speed of 1mm/min, 3.25mm thickness specimens have huge extension of 3.20 mm which applies progressively load will be increasing, so material shows the huge deformation and peak load is 5.15KN. Further specimen of same thickness which is subjected to medium strain rate 0.025s^{-1}, then load carrying limit is of 5.42KN and extension is 3.15mm At high strain rate 0.034s^{-1},time taken to break is decreased, load carrying limit is 5.72KN and displacement is only 2.90mm. The maximum time taken for break is also decreased as strain rate increases. The outcome demonstrates that, as strain rate builds load carrying limit likewise increments yet displacement decreases.

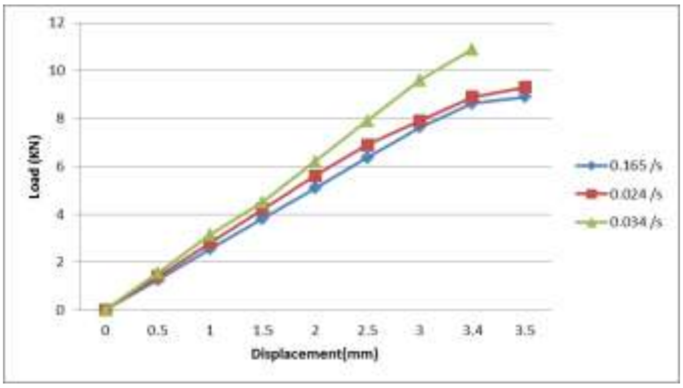

Chart-2 Load-Displacement for 4.8mm tensile specimen

Chart-2 demonstrates the heap the load -displacement for the 4.8mm thickness of specimen. For strain rate 0.0165s^{-1}, 9.82 KN and 3.85mm is the maximum load sustaining capacity and displacement of jute/glass hybrid fiber composite. For strain rate 0.025^{-1}, almost displacement remains same but load carrying capacity of is increased as 10.2 KN. At strain rate of 0.034s^{-1}, greatest load is 10.9KN is achieved and displacement is of 3.40mm. As thickness of specimen increases, then increase in load carrying capacity is observed but for same thickness specimens which are subjected to different strain rates, increase in load carrying capacity observed but decrease in displacement is observed. When strain rate increases then stiffness of material

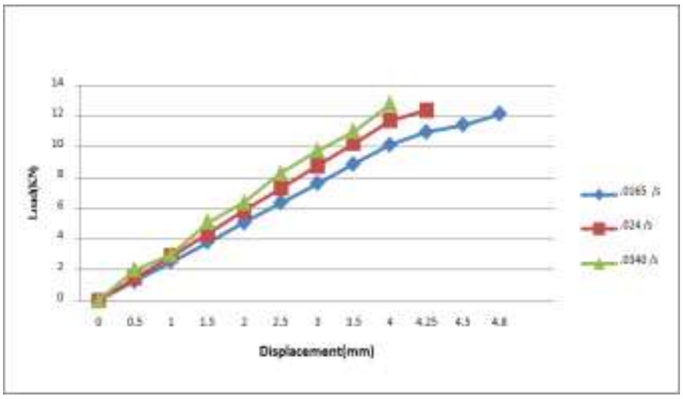

Chart-3 Load-Displacement for 6.5mm tensile specimens

Load-displacement curves of specimen 6.5mm thick are shown in figure 3. At strain rate 0.0165s^{-1}, the maximum load and displacement are 12.16KN and 4.81mm respectively. For strain rate 0.024s^{-1}, specimen of same dimensions breaks at a peak load of 12.40KN and possess elongation of 4.75mm. At high strain rate i.e. 0.034s^{-1}, specimens are withstands of load 12.80KN and displacement of 4.45mm. Stiffness obtained for the strain rates of 0.0165s^{-1}, 0.024s^{-1} and 0.034s^{-1} are 2533N/mm, 2917N/mm and 3084N/mm respectively which are increases with increase in strain rates.

Results obtained from load-displacement of different specimens which are subjected to varying strain rates shows that, as thickness increases the load carrying capacity increases. This is because of area of specimen increases due to increase in the thickness which often increases the fiber content in the specimen. Specimens are rate dependent, as strain rate increases load carrying capacity of hemp fiber composites are increased but displacement decreased, stiffness of material is increases with increase in strain rate as well as increases with increase in thickness of same material, which intern gives the information for the design of proper strain rate of composites will gives the better life to the products.

4.2 Stress-strain curves

The stress-strain curves for jute/glass hybrid fiber composites for different specimens with varying strain rates from stress-strain curve, mechanical properties of material such as tensile modulus, tensile strength, ultimate strength and toughness are obtained

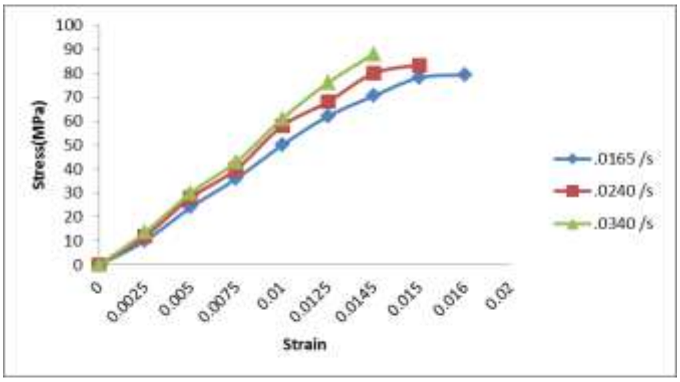

Chart-4 Stress-strain curves for 3.25 mm specimen

Chart 4 indicates the stress-strain curves for the jute/glass fiber composite having specimen of thickness3.25mm.From graph, it is easy to understand, stress has linear and directly proportional relation with strain. At strain rate 0 .065 /s, material fails at 79.23 MPa, similarly for medium strain rate (0.024 /s) breaking occurred at 83.38 MPa and high stress obtained also at high strain rate 88 MPa. As strain rate of material increased then load bearing capacity and also stress increases.

Chart 5 indicates the stress-strain for 4.80mm thickness specimens which are tested to different and varying stain rates. It is same as that, load capacities of jute/glass hybrid fiber composite specimens are increased with raise in strain rate. At low strain rate, maximum stress is 102.29 M Pa. Maximum stress obtained for medium strain rate is 106 M Pa. Maximum stress obtained is from all strain rates and thickness in this project is 113.54 M Pa which is for medium thickness specimen and highest strain rate. Stress is also varying and it is increasing with increasing in load rate

Chart-6 confirms that stress-strain curve for different strain rate value for specimens of thickness of 6.5mm thickness. Stresses obtained for different strain rate are 92.4 MPa, 95.3 MPa and 98.4 MPa for low, medium and high strain rate respectively

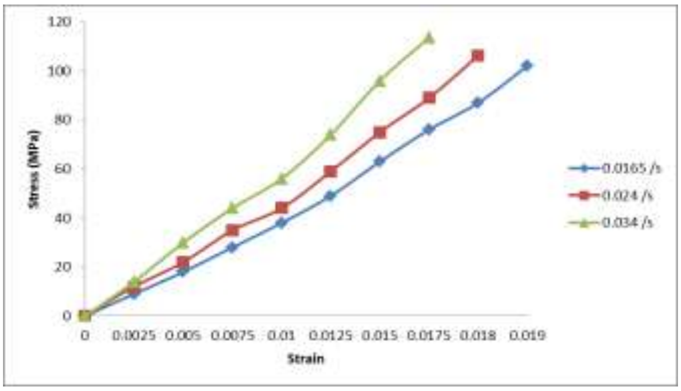

Chart-5 Stress-strain for 4.80mm thickness specimens

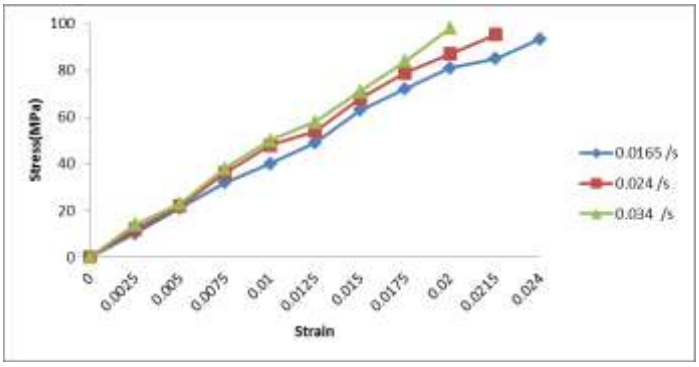

Chart-6 Stress-strain for 6.5mm thickness specimens

It is prove that, during tensile test, strain rate affects seriously affect the mechanical properties of jute/glass hybrid fiber composite materials

4.3 Stiffness

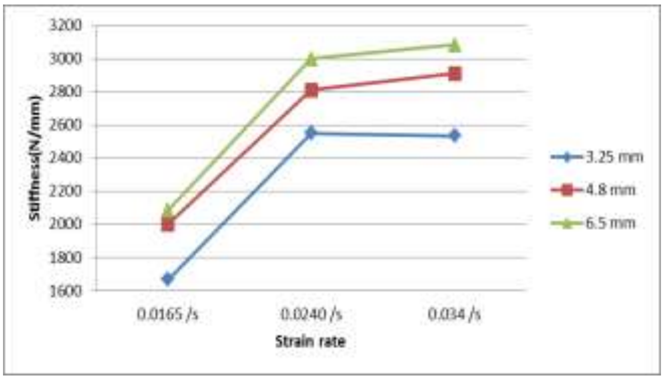

Chart-7 Effect of strain rate on stiffness of jute/glass hybrid composite material.

Stiffness is capacity of material to resist elastic deformation that was determined with help of load-displacement graphs of different thickness of jute/glass hybrid fiber composite materials. Linear curve helps us to get stiffness of material

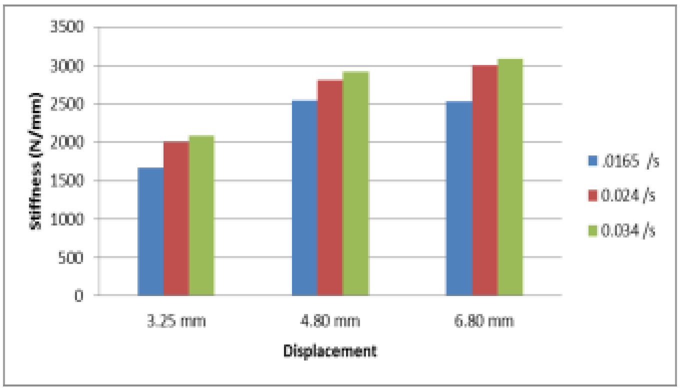

Chart-8 Effect of thickness on stiffness of jute/glass hybrid composite material.

Chart 8 indicates the stiffness of material for different thickness specimens. Specimen of thickness 6.8 mm has greater stiffness compared to other thickness specimens. Maximum stiffness obtained is 3084N/mm for specimen 6.8mm at high strain rate.

4.4 Tensile modulus

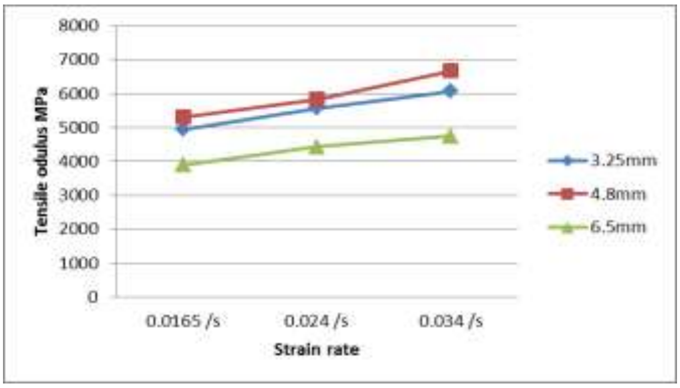

Chart-9 Effect of strain rate on tensile modulus of jute/glass hybrid composite material

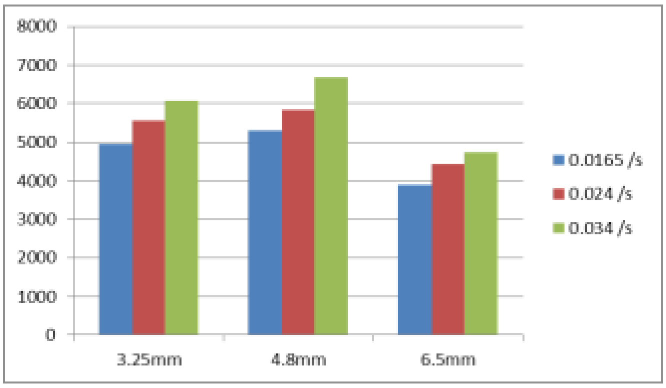

Chart-10 Effect of thickness on tensile modulus of jute/glass hybrid composite material

Tensile modulus is basic property of material which defined as capacity of material to resist tensile deformation. For 3.25mm thickness specimen, tensile modulus increased when strain rate increased that is 4951N/mm^2; 5572N/mm^2 and 6068N/mm^2.Similarly for medium thickness specimen values obtained for tensile modulus are 5314 N/mm^2, 5840 N/mm^2 and 6678 N/mm^2 for low, medium and high strain rate respectively. Tensile modulus is more for the medium thickness specimen and proportional to strain rate. Tensile modulus obtained from the 6.8mm specimen is 3897 N/mm^2, 4436 N/mm^2 and 4745 N/mm^2 for strain rate low, medium and high respectively. Medium thickness specimen (4.80mm) has more tensile modulus when compared with low and high thickness specimens. Tensile modulus is function of stress which intern function of area or thickness of a material.

4.5 Yield strength

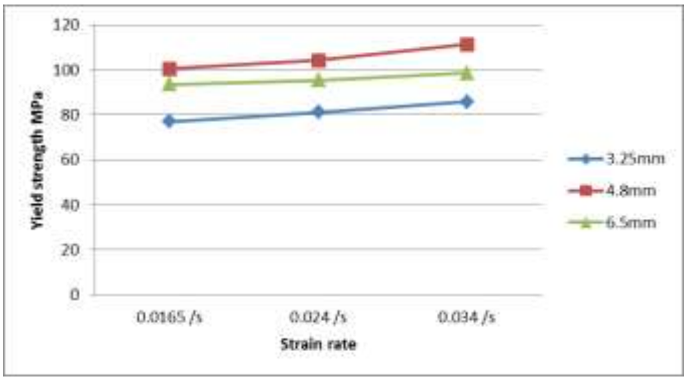

Chart-11 Effect of strain rate on yield strength of jute/glass hybrid composite material

Yield strength is a property of material to resist loads without failure due to excessive stress under pulling forces. It is cleared from that stress-strain curve of different thickness material that depends on area of jute/glass hybrid composite material. For specimen thickness 3.25mm, the yield strength obtained is the yield strength for low, medium and high strain rates are 77MPa, 81MPa and 85MPa respectively.

For medium thickness of specimen yield strength obtained is 100.5 M Pa, 101.2MPa and 104.4MPa for three different strains that is low to high. As same as other two thickness specimen, yield strength also obtained for 3 different strain rates with increase order 91.3MPa, 92.8MPa and 96.6MPa respectively. Medium thickness specimen gives the yield strength better than other thickness specimens and high strain provides better yield strength low and medium strain rate.

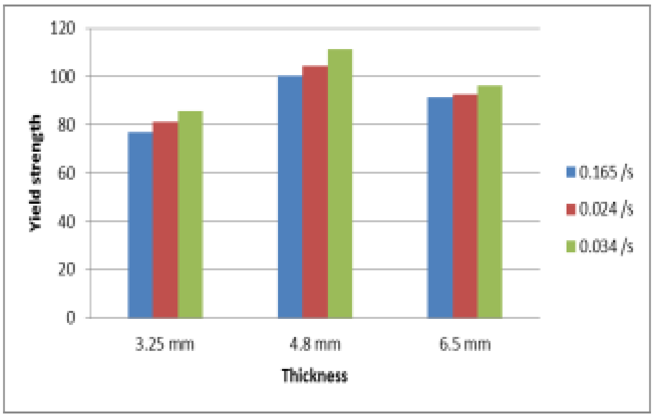

Chart-12 Effect of thickness on yield strength of jute/glass hybrid composite material.

4.6 Ultimate strength

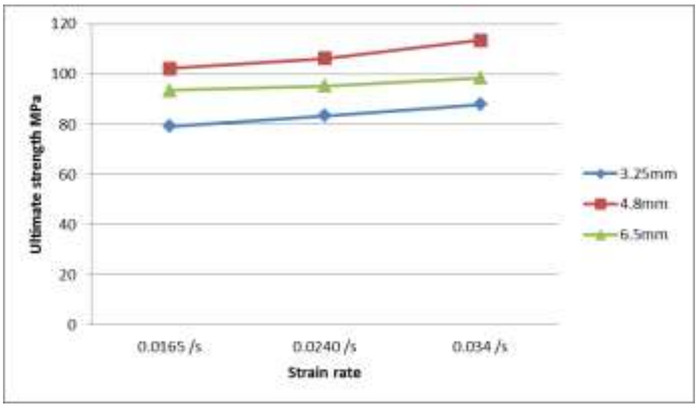

Chart-13 Effect of strain rate on ultimate strength of jute/glass hybrid composite material.

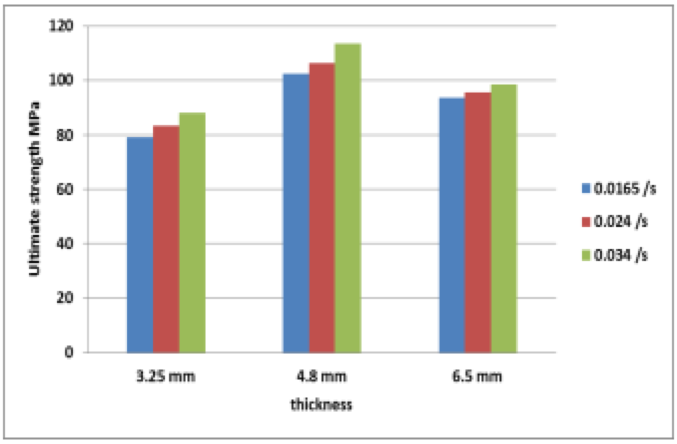

Chart-14 Effect of thickness on ultimate strength of jute/glass hybrid composite material.

Ultimate stress is greatest stress induced in the specimen. Ultimate stress is determined for all type of strain rate and also for different thickness specimen where maximum ultimate stress is obtained from 4.8mm specimen at high strain rate. Strain rate and thickness of specimen also affects the ultimate stress of the specimen. Load carrying capacity of jute/glass hybrid fiber increases with increase in thickness of specimen but rate of loading also participate a significant role in the material properties.

5. Conclusions

In this present work jute/glass hybrid fiber composite materials are made use for experimental investigation for different thickness of specimens as well as different strain rates. The experiments are done to determine the mechanical properties like yield strength, ultimate strength tensile modulus, stiffness, and toughness of jute/glass hybrid fiber composite material were determined to judge their suitability in composite materials also to evaluate fracture toughness of the composite material with different thickness of specimen.

The different strain rates used are varied from 0.0165/s to 0.034/s. The following observations and conclusions drawn rooted in the test outcome of experiments It is observed that, strain rate has a considerable influence on both stress-strain and load-displacement relationship of the bidirectional jute/glass hybrid fiber composite materials. Capacity of load carrying improved from low strain rate to high strain rate. When strain rate increases then stiffness of material increases. Stiffness observed is 3084 N/mm at high strain rate i.e., 0.034/s. Tensile modulus of jute/glass hybrid fiber composite material depends on strain rate. Tensile modulus of 4.8mm thickness specimen in tensile test is more at high strain rate and shown as 6678MPa. Observed yield stress at high strain rate is 111.4MPa which is highest in the all experimental results. Ultimate stress of a material is influenced by strain rate, since at high strain rate loading highest stress achieved is 113.5MPa. It also showed that, thickness of specimen bidirectional jute/glass hybrid fiber composite specimen has considerable effects on mechanical properties.

All mechanical properties are very good from the specimen of having thickness 4.8mm which mechanical properties are yield strength, ultimate strength stiffness, and tensile modulus. It is observed that both small and high thickness specimen of jute/glass hybrid fiber materials not convictional for measuring mechanical properties. Intermediate thickness specimen confirms better properties when they are subjected to any type of loading or strain rate.

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