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FABRICATION AND CHARACTERIZATION OF LAMINATED COMPOSITE WITH WOVEN E GLASS AND JUTE FIBERS IN EPOXY

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ABSTRACT

Design/methodology/approach :*Composites are good alternatives to mertals. The low-densities of the composites are beneficial for many industries. Moreover, composites are cheaper than metals. In this study, the hand layup method has been adapted to fabricate laminated composites in epoxy matrix with the help of e-glass and jute fibers. The different type of materials required to perform the testing for the Mode I and Mode II inter laminar fracture toughness and the change in energy release rate in a composite of glass fiber and jute fiber, when the specimen is fabricated under the temperature varying from* $40℃\ to\ 60℃$ *in two different cases.*

Purpose *: The purpose of this study is to investigate the Mode II interlaminar fracture of a laminated composite formulated in epoxy matrix with woven e-glass and jute fibers when the temperature range remains between 40℃ to 60℃.*

Findings :*At first the layers of woven jute are in tension and woven glass is in compression, then the woven jute layers are in compression with woven glass fibers layer in tension. In second case random type of jute layers were kept in compression with random type of glass fiber in tension and then the random type of jute layers in tension with random type of glass fiber in compression. For the detailed study of the specimen the change in the energy release rate is noted at an interval of* $5℃$ *with the specimen temperature rising gradually from* $40℃\ to\ 60℃$. *The standard deviation is also calculated to show the variation in the values of change in energy release rate of the specimen under different temperatures.*

Originality/value: *The research show the comparative study of MODE I and MODE II at varying temprature. This research report the value of energy release rate is less in jute layers in tension in comparison with jute layers in compression. From our experiment composite having piles of woven glass fiber and jute turned out to be better to sustain delamination.*

Keywords: *Polymer matrix composite, Tensile test, Jute composite tension and compression.*

I.INTRODUCTION

It is assumed that composite materials have a significant part all through mankind's set of experiences, from lodging early developments to empowering future advancements. Composites have saturated our regular daily existences, for example, items that are utilized in developments, clinical applications, oil and gas, transportation, sports, aviation, and much more[Yousef Saadati et.al 2020].

At least two constituents are required to formulate a composite material. These two constituting materils must have distinct physical properties. After the formation of the composite material, the individual physiocal properties of the constitutens take a composte form developing completely new physical properties in the composite material.

The singular parts stay discrete and particular inside the completed design. The new material might be liked for some reasons: normal contrasted with conventional materials. Composites have been observed to be the most encouraging and knowing material accessible in this century[Leif A. Carlsson et.al 1989]. Fibre-supported polymerized composites have diverse advanatges. Apart from high solidarity to weight proportions, these composites offers better toughness, damping protection, and fire protection. The features of composite materials mostly dcepends on the featurtes of constituting materials. It also depends on the temperatures and assembling strategies in the production environmnets. The specific properties of the fiber materials including their orders and

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assembling processes followed to formulate tjhe composite materials are to be considered for planning their ideal applications. [Wen-Xue Wang a et. Al. 2009]. Composite materials are framed by at least two parts with the goal that the properties of the last material are superior to the properties of the parts independently.

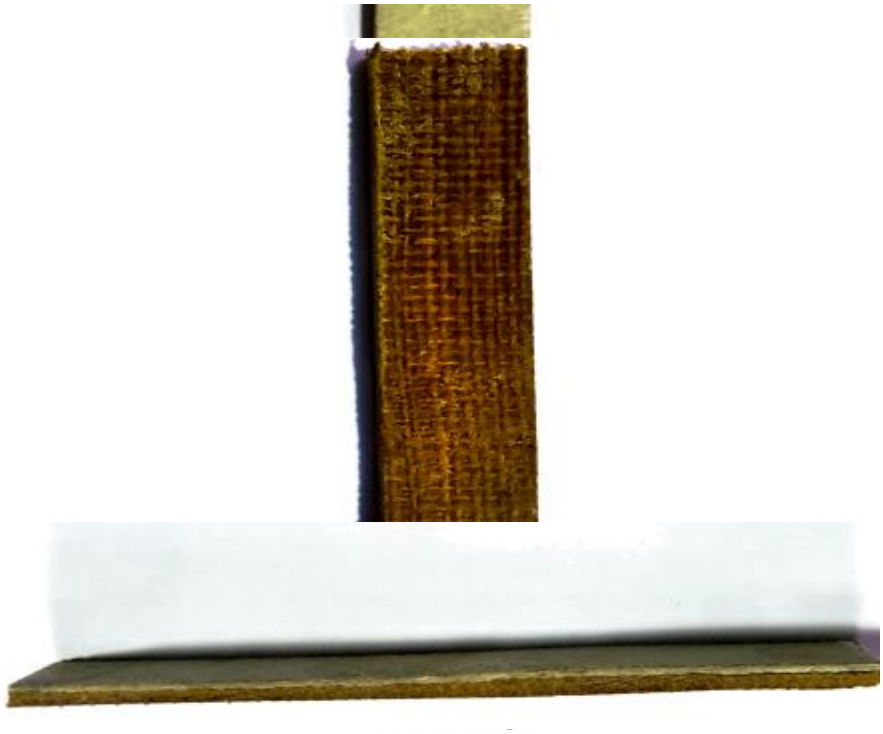

Figure 1. Specimen of glass and jute fiber prepared for analysis.

In aviation, there is the necessity of lightweight and strength, and if the wings of the plane are made with the assistance of two unique materials, they give lightweight and strength.In particular, glass fiber have the accompanying attributes like top caliber and low weight, while at the same time it doesn't burn-through viably and has electrical and warm assurance properties [H. Saidpour et.al. 2003].

The improvement of tractable properties of the glass fiber strengthened blend composites with the development of fiber glass content. It is found that fiber builtup compounds with excellent laminar shear and higher transitional toughness have better applications than GFRP (Glass Fiber Reinforced Plastic) products[T. Kevin O'Brien et. al. 2010]. Graphene is good choice for energy-related constructions because of its double part molecule structure, high electrical or warm conductivity, visual clearness, fantastic mechanical quality, general adaptability, and an enormous earth surface [Walter L. Bradley et.al. 1989].

Regular composites are effectively best from an ecological angle.Beside the environmental advantages, regular composites offer a couple of different advantages, as well. These incorporate the sturdiness and life span of items, because of their inexhaustibility. There are financial advantages as a result of a similar sustainability, as well. The strain energy release pace of fiber fortified polymer composite bars lessens with an addition of the modulus of flexibility of the supporting fibers [Alessandro Cannas et.al. 2007, Aaron Michael Cook et al. 2001].

This report will introduce crack mechanics and exploratory mechanics approach used to describe mode-II interlaminar break of composites. This report is coordinated into four significant segments: Foundation, Scientific, Mathematical, and Exploratory Outcomes. Consistence, strain energy discharge rates, delamination offset from the mid-plane, and frictional impacts are researched. Results are contrasted with scientific arrangements [Santhanam V1 et.al. 2014, Vishnu Prasad et.al. 2019]. Mode I and Mode II interlaminar break durability is assessed utilizing DCB and ENF test examples. The outcomes show that nanoparticle expansion works on the interlaminar break sturdiness esteems [H. F. M. de Queiroz et. al. 2021, Vishwesh Dikshit et. al. 2017]. This analysis concentrates on the mode II break conduct of an adhesively fortified joint made out of GFRP overlays. In this model, the deformity of 4-ENF examples brought about by the overall redirection point between the upper and lower layers and by the bowing twisting of the upper and lower layers, individually, is presented; the impact of the glue layer deformity is introduced. The high precision of present logical arrangements is checked by limited component examination through fortified GFRP 4-ENF examples and contrasted with the inflexible joint model and the CBT model[Mohammad Reza Hosseini et. al. 2020, Xiao Zhang et. al. 2020].

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Enjoying ecological and monetary benefits, flax fibers have been perceived as a possible swap for glass fibers as support in epoxy composites for different applications. Its broadening applications require utilizing disappointment standards and investigation strategies for designed plan, examination, and streamlining of this material. Nonetheless, the delamination attributes of unidirectional flax/epoxy composites in unadulterated Mode I have seldom been tended to, while Mode II and Mixed-mode I/II have never been tended to. The interlaminar break sturdiness of the not really set in stone and approved dependent on the particular qualities of regular fibers [S. Jose, R et.al. 2000, M.S.Sham Prasad et.al. 2011]. Break strength is a basic measure as to exhaustion, while tasteful approaches.An ASTM (American Society for Testing and Materials) standard for FRP (Fiber-Propped Polymer) Grid Composites exists for reference. The feelings are diverse when investigations are made on FRP network composites.[Pablo Garcia Perez et.al. 2019, Frantisek Sedlacek et.al. 2019].

A comprehesive investigative model based on point-grinding supposition and traditional shaft hypothesis is designed to apply 4ENF and ONF tests to investigate the impact of friction between break faces related to Mode II interlaminar crack capacity. It is evident from the results of expereimnts that ENF test provides a trustworthy inception worth of crack strength with a little disperse. At the same time, the measurement of 4ENF test for break sturdiness was found to be 2% more than break sturdiness measurement on ENF test. On comapring the tests results, it is found that the grinding impact in the 4ENF test is lower than the grinding impact in the ONF test. In the later test, as the breal develops, the impact of rubbing increases singnificantly. Thus, 4ENF test is the right strategy for the assessment of Mode II engendering interlaminar crack strength of the composites[Dipen Kumar Rajak et.al. 2019, Thomas Jollivet et.al 2013].

IM7/8552 material was tested following the latest ASTM convention draft. The outcomes for material delivered by the two providers were comparative for all material property estimated. The understanding acquired is important for current and future material property guidelines advancement [JP. Marrouzé et.al. 2013, M. J. Suriani et.al. 2021]. G_{IIc} esteems were determined as all out break sturdiness energy at the most extreme burden supported by the materials as the delamination expanded. The outcomes showed that high-temperature forming frameworks have the most noteworthy G_{IIc} esteems well over 1000 J/m^2. For medium temperature frameworks, G_{IIc} has likewise expanded essentially after post-fix. It is especially recognizable for restoring at 135°C and 80°C of medium and low temperature shaping frameworks [V. Rizov et.al.2015].

The relationship of pitch break strength to delamination crack durability is considered in this report. In situ perceptions of break in the SEM show that expanding the pliability and diminishing the yield strength of the matrix sap increment the delamination crack sturdiness by expanding the plastic zone size in front of the break tip parting with more prominent burden reallocation from the break tip and more break tip dulling. The shockingly high mode-II delamination strength seen in composites made with weak saps is because of the idea of the break interaction; specifically, the development of sigmoidal formed miniature breaks over an extensive distance in front of the break tip giving huge burden rearrangement [Gupta, N.K et.al. 2020]. A review has been led to assess the advantages of utilizing novel molded fiber support to further develop the mode-II strain energy discharge pace of fiber built up polymer composites. Unidirectional and cross-employ overlays were made utilizing molded and round glass fiber support and tried utilizing the end indented flexure and end stacked split calculations. Due to the contrasts in gum and fiber volume parts and fiber calculations, a rectification factor was applied to the CBT articulation to permit a more attractive examination [Yan, J. et.al. (2020)]. Deeply shell organized latex particles to work on the water-and warmth opposition of PVAc-based cements was explored. The capacity of the uniting layer was investigated by tuning the A stacking levels and center to-shell proportions. The wood glue execution of PVAc-based latex glues, especially for warmth and water-safe holding, were assessed by shear strength at both dry and wet conditions, just as the bubbling water disappointment time, showing a critical upgrade of bubbling water resistance.

Composite materials are supplanting standard designing metals and compounds for some applications. Their intrinsic capacity to be specially customized for any application has made fiber built up composites an entirely feasible material choice. The essential restriction of fiber built up composites is break durability, explicitly delamination. Delamination disappointments are normal because of the idea of composite construction.An assortment of assembling procedures are accessible to make composites. For the most part, this load of strategies utilize a layered stacking of fibers in an essential plane. The interface between these layers is commonly not supported with fibers and is the wellspring of delamination or interlaminar crack. The material property that best addresses protection from delamination is the strain energy discharge rate. The essential focal point of this review was the improvement of an interaction that would portray and address interlaminar break in composites. The essential plan was a screening system that utilized relative testing to down select composite structures dependent on plan drivers and applications. Each contextual analysis was a different undertaking that researched a one of a kind theme identifying with interlaminar break of composites [Somani, N et.al.2021]. Composite materials, particularly fiber built up plastics are generally utilized in mechanical, auto and family applications. Ecological effect of engineered fibers constrains us to examine substitute means as normal fibers. Among different normal fibers, banana fiber is specifically noteworthy in that, as it has high rigidity, high pliable modulus, and low extension for break close to its minimal price and facilitates of accessibility. Tests were led to compute break durability of these composites. The trials were completed to research the impact of fiber length on the break sturdiness of the composite . Exploratory investigations are done to decide the interlaminar break sturdiness of unidirectional overlays made of M55J/M18 carbon/epoxy material under various blended mode proportions. A blended mode delamination break measure utilizing blended mode twisting examples is created . An end indented flexure test was utilized to concentrate on the impact of development dependability on Mode II interlaminar break durability of a carbon/PEEK composite. The consistence procedure enjoys the benefit of being basic and it has as of now been affirmed for standard tests. Its outcomes might be eeoneous for unsteady break developmet engendering. The two strategies are corresponding and this review arrived at the resolution that G_{IIc} is touchy to break development speed. Break durability showed a low incentive for break development start and unsound proliferation, and a high incentive for stable break development [Aouad, R et.al 2018]. This paper likewise manages a mathematical recreation of the

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interlaminar break sturdiness of woven carbon fiber supported polymer.It gives an approach for deceding the main boundaries for Mode II interlaminar break sturdiness utilizingmathematical reenactment. End Notch Flexure examples were made for fitting break sturdiness boundaries of the cover as per ASTM(American Society for Testing and Materials) principles. The outcomes from the mathematical reproduction compare to those from the test with a precision of 4% [Dipen Kumar Rajak et.al 2019].

This report presents the investigation of test strategies for the estimation of delamination opposition of woven composite materials. The assessment of mode I and mode II interlaminar crack durability of woven texture glass/epoxy overlays in the Double Cantilever Beam and End-Notched Flexure tests were researched. The impacts of example stacking groupings with starter delamination in 0/0, and 0/,90 interfaces on interlaminar break strength of past research were examined. To gauge legitimate interlaminar basic strain energy discharge rates G_{Ic} and G_{IIc}, of inception from the film and from a pre-break were examined [Vishnu Prasad et.al 2019]. On other hand we take aftereffects of crack sturdiness of woven E-glass/epoxy and we see that end-indented flexure examples were utilized to inspect the effect of the mat layer between woven layers on the Mode II interlaminar break durability of glass/epoxy composites. ENF examples are created utilizing the hand lay-up strategy helped by the vacuum stowing method . Polymer composites are a run of the mill material comprising of a matrix built up with fiber/filler and the overall idea of development of the actual material gives countless locales to the inception of a deformity or for the development of delamination. Break testing of fiber-built up polymer-matrix composites is a functioning space of exploration. The new perspectives in the exploratory investigations of interlaminar and intralaminar crack strength of polymer matrix composites were underscored in this audit paper [Pablo Garcia Perez et.al 2019].

The utilization of supportable composites is relied upon to ceaselessly increment around here as the expense and weight of vehicles could be to some degree decreased by supplanting glass fiber composites and aluminum with normal fiber composites. Cement holding is the favored joining technique for composites and is progressively utilized in the auto business. The fundamental target of this review was to research tentatively adhesively fortified joints made of regular, manufactured, and interlaminar half breed fiber-supported polymer composites [Vishwesh Dikshit et.al 2017]. Composte materials are prone to delamination as the materails are more exposed at the width heading. This research paper shows the progresses accomplished until now in the local area and the possibility of further development in Mode I and II related to interlaminar break strength by all the possible procedures including the impact of multiscale support. The utilization of various techniques and approaches alongside their presentation in improving the crack strength of the composites is summed up .

There are various strategies to produce composite, for example, Hand-Layup, Pressure forming, Vacuum shaping, and so forth. The quantity of imperfections in composite influences straightforwardly the mechanical and actual properties of material during its application. Composite materials are utilized broadly in aviation as well as in auto applications.To have the option to plan composite parts, understanding the miniature instruments of harm is fundamental. The article presents the primary weakness harm systems on thermoset and thermoplastic composites. A condition of craftsmanship is done on various deals with composite weakness and fractographic examinations [Gelaw, M. Et.al 2018]. The utilization of composites in airplane structures requires a precise appraisal of the impacts as referred to as assembling imperfections such as holes, fiber waviness, and disbands. Holes in hardened boards were found to have negligible impact on steadiness and strength. Other than hole abandons, composite level boards with delamination in type of disbonds were displayed and examined to assess their consequences for security reaction. Primary investigation and trial of the level boards showed that underlying delamination can antagonistically influence the security of composite boards once the disbonds arrived at a basic size. The surface morphologies related with imperfections like neighborhood or circulated material deformities, a primary or mathematical component or harm, and the related underlying elements and harm are examined. Right off the bat, deserts related with the constituents and afterward the 'third' constituent, the fiber/matrix interface, are thought of. At last, the morphologies related with in-administration harm, for example, that initiated by sway, are introduced. Deformities can accidentally be created in composite materials either during the assembling system . The main deformities in solid designs are porosity, brought about by mistaken assembling, and effect harm during in-administration use. For sandwich structures with honeycomb centers, the presence of bond disappointment or center pulverizing is similarly huge [LijinKottayil Raghavan et.al 2015]. This review researches the impact of texture control on the exhibition of unidirectional non-crease fiber supported polymer composites. Tests were made by stacking four layers of texture one over one another with an unequivocal shift point and afterward followed by pitch imbuement and afterward cut the coupons for testing. The greatest strength level focus followed up on the mark of grasp on the texture test. The outcome from the trial tests backing and assist with clarifying the effect of moving on the unidirectional fiber built up polymer composites and is utilized to build up the assembling absconds in the unidirectional texture from the moving system [M. J. Suriani et.al 2021]. Lately, most boat creation organizations utilize 100% manufactured fiber-supported composite materials, because of their superior mechanical properties. In the recent times the manufacture of boat structure utilizes normal fiber cross breed with Kevlar/fiber glass supported composite, the aftereffect of pliable, bowing, and effect strength showed that glass fiber built up polyester composite invigorated high with expanding glass fiber substance. Sooner or later, understanding the expense of manufactured fiber is getting higher, analysts today have begun to utilize regular fibers that are viewed as a more savvy choice. Lately, hybridization is suggested by most specialists as an answer for regular fiber's shortcomings and to diminish the utilization of manufactured fibers that are harmless to the ecosystem.

Apart from that, an hybrid composite has some exclusive advantages. The fiber hybrid-composites having synthetic nature are used in different applications in diverse manufacturing sectors [M. J. Suriani et.al. 2021].The natural fibers have some advanrtages over sysnthetic fibers. The natural fibers are biodegradable, non-toxic, light weight, sustainable, and recyclable. Reseracher and industries show interest in natural fibres due to these advantages. This research papaer focuses on the mechanical properties natural fiber reinforced composites and key factors that have impacts on various mechanical features of these fiber-reinforced composites.

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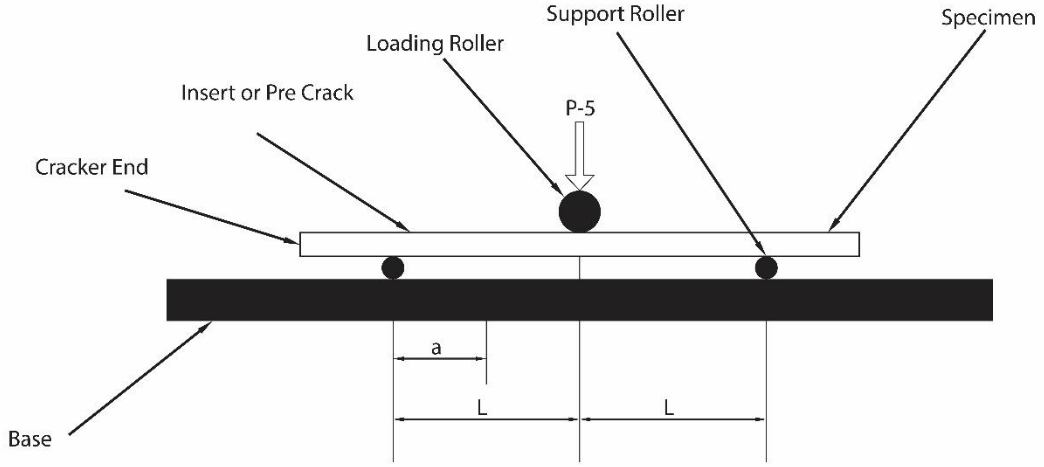

Figure.2 Setup for 3-point bending test.

II.METHODOLOGY

High performance composites should possess high in-plane strength and stiffness. The Inter laminar performance of composite material is characterized by its weakness under both tensile and shear stresses. Inman laminates, the strength reduction has been noticed due to delamination between the plies. Fiber cracking and matrix breakage also have an effect on the strength. Inter laminar shear, tension and the matrix breakage largely is root of internal delamination which in turn gives rise to residual stresses that further reduces the strength.

Interlaminar fracture toughness for Mode II is determined by employing an end notched flexure specimen. The edge crack is on the mid plane where the shear stress is the highest. The initial crack length is approximately equal to 0.5L but it should not exceed0.69L.

$G_{IIc} = \frac{(9P^2Ca^2)}{(2B(2L^3+3a^3)}$..... (1)

$C = \frac{(2L^3+3a^3)}{8EBh^3}$……………………..…….... (2)

C is determined directly from the *P-u* record (Figure 2). [10]

Where :

- P=load applied (Pascal),
- C= compliance (m/N),
- a= crack length (m),
- B= specimen width (m),
- L= half length of the specimen (m)
- h= specimen thickness (m)

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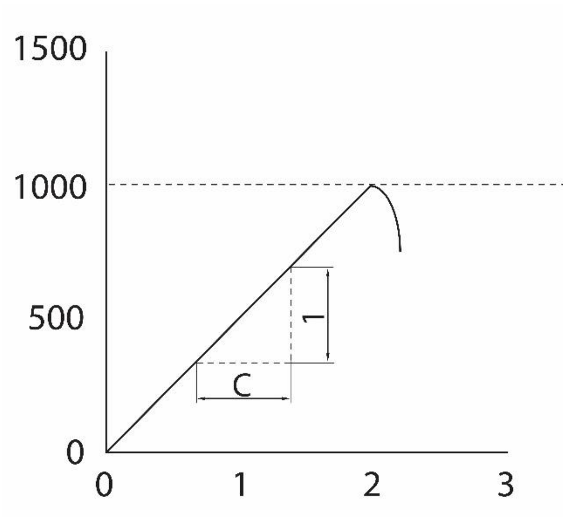

Figure.3 Sample plot to determine the compliance [10].

The End Notch Flexure (ENF) test method is good at accompanying Mode II testing. In this test procedure, identical coupons are used to the “Double Cantilever Beam” (DCB) test (in absence of the tabs) and develops delamination underneath 3-point bending. Figure 2 shows the complete setup in this test process. Here, the sample undergoes a compressive load that staysas long as the crack spreads. This is traceable with the help of a “drop” in the load-displacement tracing process. Mode II Fracture Toughness (G_{IIc})can be calculated with the help of the equation I provided before.

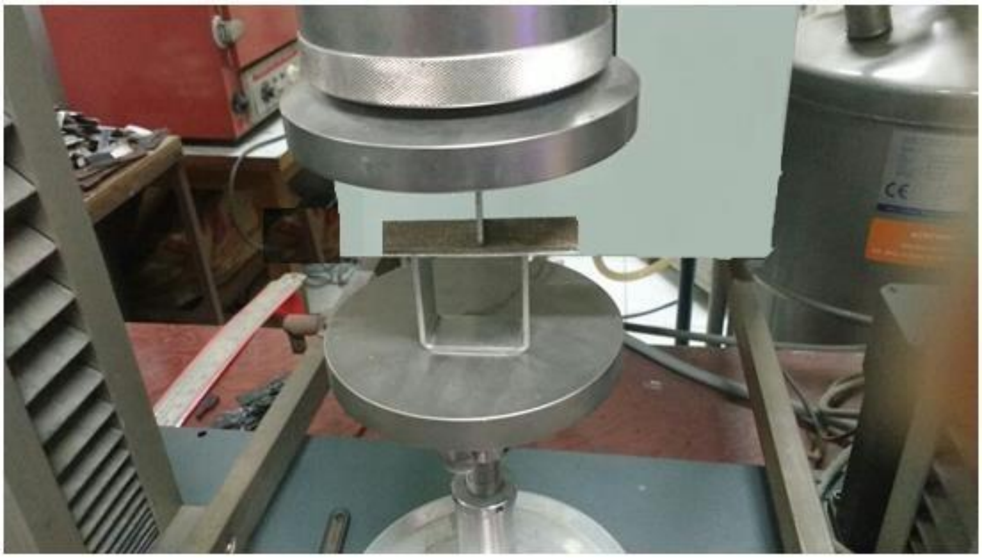

Figure.4 3-Point bend testing setup.

As the specimens are prepared at higher temperatures it has been studied that the value of G_{IIc}. increases which leads to the increased creep performance of composite fiber. At room temperature and at elevated temperature the composite fiber experience larger creep deformation, especially for initial crack between the layers. However, for smaller crack opening the effect of temperature variations is negligible but as the temperature increases the matrix plastic deformation rate also increases which results in increasing value of G_{IIc}.. With increase in temperature, the viscosity of matrix decreases giving more time for jute and fiber-glass to settle down on a complete matrix thereby increasing its G_{IIc}. value as a result extensive micro-cracking and void formation decreases.

The setup for performing the experiment is shown in Fig.4. In the experiment we used 8 sheets of glass fiber along with 8 sheets of jute along with resin (AY 105) & hardener (HY 951) in the ratio of 10:1. In this experiment we have employed woven type and random type glass fibers. The woven type is used with a regular pattern while the random type is used in the chopped type pattern. We cut 8 pieces of glass fiber and 8 pieces of jute of same dimensions. After that, we apply the mixture of resin and hardener on its layers one by one alternatively. After completing this, we spread grease on the Teflon sheet to prepare the hand outline. The heat resistance of jute is low. So, we maintained the temperature within 400C to 600C. We restricted the maximum temperature up to 600C because firstly Jute catches fire at the temperature of 800C. Above 600C, the basic characteristics of jute starts to degrade. The outermost part of the hand layout is jute, so there remains a high chance of fire at higher temperature. That’s why we could not raise the temperature above 600C. Several specimen were designed at different temperatures and then compared with G_{IIc}.

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TABLE 1: Specification of different material used.

Composites	**Weight per unit area (Kg/m^2)**	**Thickness (mm)**
Jute	0.255	0.52
Woven Glass Fiber	0.283	0.31
Random Glass Fiber	0.362	0.26

The above table present specification of jute, woven glass fiber and random glass fiber. The variation in graph is due to some of the specific characteristics of glass fiber. Jute and the random glass fiber used in the making of this specimen glass fiber consist of a very high tensile strength and it is very lightweight as compared to other conventional material like aluminium or some other composites which we have chosen these materials for making of our Specimen because of its good thermal resistance property, its ease of availability and dimensional stability. Jute is also a very good and suitable material for several reasons such as its high sound insulation, high heat insulation, and low thermal conductivity. For these resons, jute is wildly used in industries like aviation industries, aerodynamic industries, and composite reinforcement.

All the test in this experiment above, areperformed under displacements control and rate of loading 5 mm per minute.

The sets of experiments on composite fabricated for a temperature range of 40℃ to 60℃ with a difference of 5℃ in each set was conducted. The main objective was to focus on the various variations that occurred in our specimen result when it was fabricated at different temperatures. Now, inter-laminar fracture toughness in Mode II (variation shown in graph).

TABLE 2: Glass woven tension and jute woven in compression.

Temperature, ℃	**40**	**45**	**50**	**55**	**60**
G_{IIC}, J/m^2	1256	1309	1619	1879	2027
	1370	1390	1632	1899	2156
	1229	1480	1538	1719	1901
	1300	1497	1578	1801	2205
	1334	1451	1599	1993	2109
Average	1297.8	1425.4	1593.2	1858.2	2079.6
Standard Deviation	57.03	76.75	37.02	103.58	119.47

When woven jute is in compression,the percentage increase in energy release rate is 76.5% when temperature is varying from 40℃ to 60℃ during fabrication of laminate and when in tension,percentage increase in energy release rate is 16.8% in the same temperature rangeduring fabrication of laminate. When the temperature increases from 40ºC to 45ºC there is an increase of 4.2%, when increased from 45ºC to 50ºC there is a variation of 4.0%, but when there is an increase of 5ºC from 55ºC to 60ºC, there is a sudden change of 28%, it shows that specimen manufactured at higher temperatures has more interlaminar fracture toughness as compared to the specimen which is prepared at lower temperatures, this may be due to high absorption of epoxy to the fibers at higher temperatures so a better laminate is fabricated at higher temperatures corresponding to Fracture toughness.

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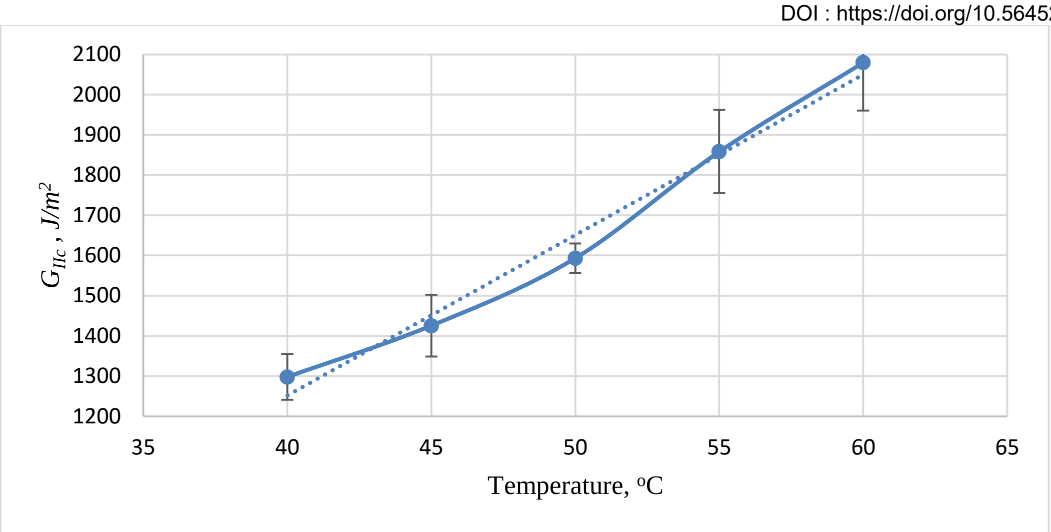

Figure 5: Glass woven in tension and jute woven in compression.

Fig.5 Shows the relationship between energy release rate (G_{IIC}) and temperature (°C) with random type glass fiber when woven jute is in compression and woven glass fiber is in tension, here G_{IIC} is the energy release rate and is measured in J/m^2.

The result from the above testing shows that when the specimen is fabricated at 40 degrees Celsius it has energy release rate of about 1297.8 J/m2. The increase in the energy release rate was noted from 1297.8 J/m2 to approximately 2079.6 J/m2, when the fabrication temperature was increased from 40 °C to 60 °C. To observe the different results the material is put under various conditions. Now, interlaminar fracture in Mode II (variation in graph) when jute layers are in tension and the glass fiber layers are in compression.

The graph in Fig.5 represents the standard deviation in the energy release rate G_{IIc}, when the specimen is fabricated at different temperature ranging from 40℃ *to* 60℃ at an interval of 5℃ during each test. It clearly shows how the standard deviation increases when the temperature is increased gradually at an interval of 5℃ throughout the entire test.

Fig.6 represents the condition of the specimen when the jute layers are in tension and the layers of glass fiber are in compression. As the specimen was treated at fabricating temperature of 40°C, the rate of G_{IIc} release was about 690.8 J/m^2 and when we use the specimens fabricated at temperatures from 40 °Cto 60 °C then it is observed that there is an increase in rate of energy release of approximately 814.6 J/m^2.

Table 3: Glass woven in compression and jute woven in tension.

Temperature (°C)	40	45	50	55	60
G_{IIC} , J/m^2	650	701	751	781	801
	671	723	749	750	798
	709	698	729	812	820
	723	696	718	823	834
	701	701	730	768	820
Average	690.8	703.8	735.4	786.8	814.6
Standard Deviation	29.70	10.94	14.15	30.36	14.96

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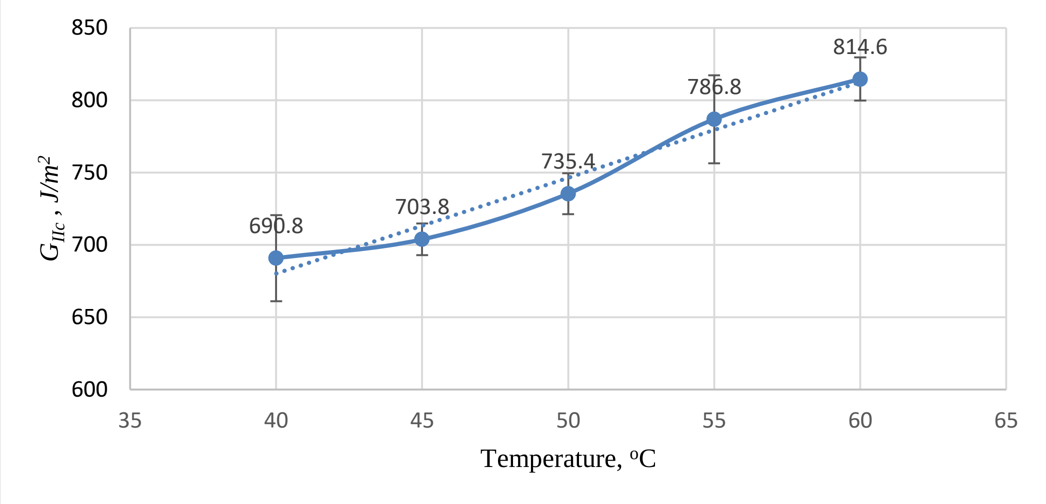

Figure 6: Glass woven in compression and jute woven in tension.

The reason behind taking mat glassfiber into compression is its high thermal resistance property,due to which, it can be exposed to high temperature and pressure. As the specimen is introduced to a higher temperature, the epoxy melts completely and hence, it increases the strength of composite. So, as a result of this, there is a very small change in the energy release rate G_{IIc}. The energy release rate increase from 690.8 J/m^2 to 814.6 J/m^2. It is noted that this composite is far better than the previous one. Now, Inter-laminar fracture toughness in Mode II (Variations shown in graph) when jute layers (woven type) were in Compression.

The graph in the fig.6 shows the standard deviation when the specimens were fabricated under different temperature. The woven glass fiber passed through compression while woven jute layer passed through high tension. We can see the change in values of standard deviation with change in temperature and energy release rate during the fabrication of composite.

Table 4: Random glass fiber in tension and woven jute in compression.

Temperature (°C)	**40**	**45**	**50**	**55**	**60**
G_{IIC} , J/m^2	699	879	980	1130	1230
	712	860	970	1151	1290
	740	812	1021	1111	1281
	745	833	1016	1097	1300
	732	871	977	1158	1260
Average	725.6	851	992.8	1129.4	1272.2
Standard Deviation	19.48	27.88	23.81	25.85	27.82

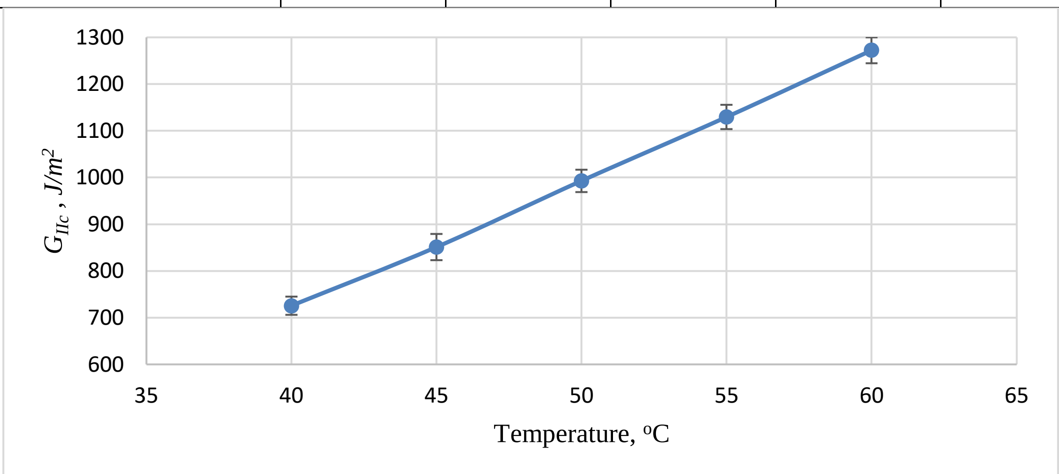

Figure 7: Random glass in tension and woven jute in compression

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Fig.7 Shows the situation when woven type glass fiber is used and jute is kept under compression with glass fiber being in tension. We can illustrate from the above figure that the rate of energy release gradually increases from 725.6 J/m^2 to nearly 1272.2 J/m^2 when the specimen is treated at diverse temperatures within the range of 40°C to 60°C. Now, the interlaminar toughness in the Mode II. (Variation shown in graph) when the jute layers (woven type) were in compression and the glass fiber were in tension.

It can be seen through the graph in fig.7 that when the specimen is fabricated under the temperature varying between 40℃ to 60℃ at an interval of 5℃ during the testing, there is an increase in the energy release rateG_{IIc}, which also results in the change of value of standard deviation.

Table 5: Random glass in compression and woven jute in tension.

Temperature (℃)	**40**	**45**	**50**	**55**	**60**
G_{IIc} , J/m^2	420	430	509	515	620
	469	500	496	545	680
	500	510	487	503	700
	512	470	523	560	710
	480	487	534	545	680
Average	476.2	479.4	509.8	533.6	678
Standard Deviation	35.61	31.41	19.18	23.66	34.93

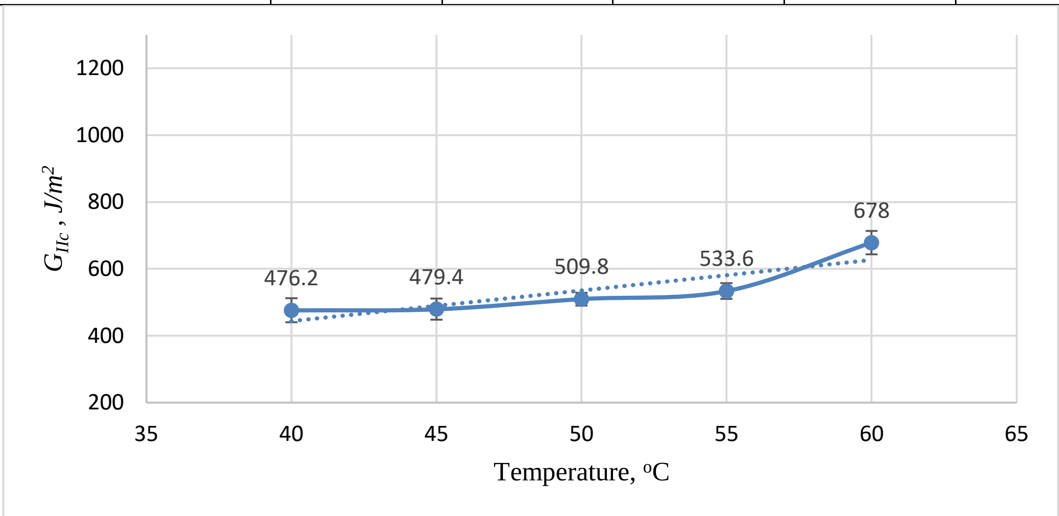

Figure 8: Random glass in compression and woven jute in tension

Fig. 8 that when the sample is treated at diverse temperature within the above -mentioned temperature range (40°C to 60°C) some changes are detected in the rate of energy release but that changes were not significant. As we conducted the experiment on our specimen which consist of glass fiber and jute composite, the G_{IIc} release rate was about 476.2J/m^2 at 40°C and it was around 678 J/m^2 at 60°C.

The above graph in fig.8 shows the standard deviation when the specimen is fabricated at temperature 40°C to 60°C.

III.RESULTS AND DISCUSSION

The comparison of difference in reading of specimen prepared at varying temperature from 40°C to 60°C, in both the cases of glass fibers.

When the random glass fiber is used in the first case where the random glass fiber is used the layers of jute is kept in compression after performing the experiment it is seen that when the temperature is 40 ℃the rate of release is about 725 J/m^2. As the sets of experiment on composite fabricated for a temperature range of 40 ℃to 60 ℃with a difference of 5 ℃was conducted, the rate of energy release also kept constantly increasing from 725 J/m^2 to approximately 1272 J/m^2. Hence, in this case we have restriction that we can't use the specimen treated above 60 ℃as we see there is a stagnant increase in the rate of energy release.

Now, when the jute layers are in tension and random glass fiber are in compression, here as the temperature is increased gradually it is found that the bond between composite material also increases. Thus, there is a noticeable change in the energy release rate, which has been increased from 476J/m^2 to 678J/m^2. As shownin the outcome of this, it can be seen that this composite is far better than the previous one and it can also be treated at high temperature without any failure or deterioration.

When woven glass fiber is used where the jute layers are in compression and glass fiberis in tension, as it depicts from the chart there is a gradual increase in energy release rate that is from 1297J/m^{2}to 2079J/m^2 when the specimen is fabricated at different temperature varying from 40℃ up to 60℃. As the result of this we can see that the strength of this composite increases when the specimen is fabricated from lower temperature to a higher temperature

For the case of Jute layers in tension, as we did experiment on woven glass fiber and Jute composite, the G_{IIc} release rate was about 815 J/m^2 at 40°C and it was around 679 J/m^2 at 60°C. Comparison of energy releasee increase and decrease rate with respect to temperature varying from 40°C to 60°C is shown and table 6.

TABLE 6: Comparison of % increase and decrease.

	Increase when Glass Fiber-Random type (%)	Decrease When Glass Fiber-Woven Type (%)
Compression	76.5	8.3
Tension	16.8	16.6

IV.CONCLUSIONS

It is concluded from the above experiment that generally the change in energy release rate is affected by the positioning of glass fiber and jute. By studying the behaviour of change and energy release rate from 40°C to 60°C, we have obtained the different values of energy release rate at different temperatures respectively. In case of random type glass fiber, the energy release rate increase with increase in temperature. The increase energy release rate is higher in jute when Jute layers are in compression . On the other hand in case of Jute layers in tension, energy release rate increases with slow rate. Whereas, in case of woven glass fiber energy release rate decreases with increase in temperature.The value of energy release rate is less in jute layers in tension in comparison with jute layers in compression. From our experiment composite having piles of woven glass fiber and jute turned out to be better to sustain delamination.

Conflict of interest **-** Authors do not have any conflict of interest with this work.

REFERENCES

[1]. Yousef Saadati, Jean-Francois Chatelain, Gilbert Lebrun, Yves Beauchamp Philippe Bocher and Nicolas Vanderesse, 2020, "A study of the Interlaminar Fracture Toughness of unidirectional Flax/Epoxy Composites", Journals of Composites Science, Vol. 4, 1-23.

[2]. Leif A. Carlsson, John W. Gillespie Jr, 1989, "Mode-II interlaminar fracture of composites, Composites Materials Series", Elsevier, Vol. 6, 113-157.

[3]. Wen-Xue Wang a, Miko Nakata b, Yoshihiro Takao a, Terutake Matsubara a, 2009, "Experimental investigation on test methods for mode II interlaminar fracture testing of carbon fiber reinforced composites", Composites Part A: Applied Science and Manufacturing, Elsevier, Vol. 40, 1447-1455.

[4]. H. Saidpour, M. Barikani, M. Sezen, 2003, "Mode-II interlaminar fracture toughness of carbon/epoxy laminates", sid.ir, 389-400.

[5]. T. Kevin O'Brien, William M. Johnston, Gregory J. Toland, 2010, "Mode II interlaminar fracture toughness and fatigue characterization of a graphite epoxy composite material", core.ac.uk, 28 pages.

[6]. Walter L. Bradley, Ph. D, 1989, "Relationship of matrix toughness to interlaminar fracture toughness, Composite Materials Series", Elsevier, Vol. 6, 159-187.

[7]. Mr. Alessandro Cannas, Dr. Ian Bond, Dr. Amir Rezai, Mr. Matteo Lusi, 2007, " Mode-II interlaminar fracture investigation of novel shaped glass fiber composites", iccm-central.org, 1-10.

[8]. Aaron Michael Cook, 2001, "Characterization of interlaminar fracture in composites materials: a case study approach", scholarworks.montana.edu, 1-270.

[9]. Santhanam V1, Chandrasekaran M2, 2014, "Studies on fracture toughness of Banana-Glass fibre hybrid composite", Indian Journal of Engineering, discoveryjournals.org, 21-29.

[10]. Vishnu Prasad, K. Sekar, Soney Varghese, M.A. Joseph, 2019, "Enhancing Mode I and Mode II interlaminar fracture toughness of flax fiber reinforced epoxy composites with nano TiO2", Composites Part A: Applied Science and Manufacturing, Elsevier, 1-11.

[11]. H. F. M. de Queiroz, M. D. Banea and D. K. K. Cavalcanti, 2021, "Adhesively bonded joints of jute, glass and hybrid jute/glass fbre-reinforced polymer composites for automotive industry", Applied Adhesion Science, Springer, 1-14.

[12]. Vishwesh Dikshit, Somen K. Bhudolia and Sunil C. Joshi, 2017, "Multiscale polymer composites: a review of the interlaminar fracture toughness improvement", mdpi.com, 1-27.

[13]. Mohammad Reza Hosseini, Fathollah Taheri-Behrooz, Mazaher Salamat-talab, 2020, "Mode II interlaminar fracture toughness of woven E-glass/epoxy composites in the presence of mat interleaves", International Journal of Adhesion and Adhesives, Elsevier, Vol No. 98, 102523.

[14]. Xiao Zhang, B.A.I. Long, Jiaxing Sun, Zhiguo Li, Zhao Jia, Jiyou Gu, 2020, "Design and fabrication of PVAc-based inverted core/shell (ICS) structured adhesives for improved water-resistant wood bonding performance: I. Influence of chemical grafting", International Journal of Adhesion and Adhesives, Elsevier, Vol. No. 98, 102522.

[15]. S. Jose, R. Ramesh Kumar, G.Venkateswara Rao and P.Sriram, 2000, "Studies on mixed mode interlaminar fracture toughness of M55J/M18 Carbon/Epoxy laminates", journals.sagepub.com, 1-6.

[16]. M.S. Sham Prasad, C.S. Venkatesha, T. Jayaraju, 2011, "Experimental methods of determining fracture toughness of fiber reinforced polymer composites under various loading conditions", scirp.org, Vol. No. 10, 1263-1275.

[17]. Pablo Garcia Perez, Christophe Bouvet, Ameur Chettah, Frédéric Dau, Ludovic Ballère, Patrick Peres, 2019, "Effect of unstable crack growth on mode II interlaminar fracture toughness of a thermoplastic PEEK composite", Engineering Fracture Mechanics, Elsevier, 486-497.

[18]. Frantisek Sedlacek, Tomas Kalina and Karel Raz, 2019, "Determination of mode II interlaminar fracture toughness of CFRP Composites using numerical simulations", Trans Tech Publications, 71-76.

[19]. Dipen Kumar Rajak, Durgesh D. Pagar, Pradeep L. Menezes and Emanoil Linul, 2019, "Fiber-reinforced polymer composites: Manufacturing, properties, and applications", mdpi.com, 1-37.

[20]. Thomas Jollivet, Catherine Peyrac, Fabien Lefebvre, 2013, "Damage of composite materials", Elsevier, 746-748.

[21]. JP. Marrouzé, J. Housner and F. Abdi, 2013, "Effect of manufacturing defects and their uncertainties on strength and stability of stiffened panels", iccm-central.org, 7596-7605.

[22]. M. J. Suriani, Hannah Zalifah Rapi, R. A. Ilyas, Michal Petru and S. M. Sapuan, 2021, "Delamination and manufacturing defects in natural fiber-reinforced hybrid composite: a review", mdpi.com, 1-24.

[23]. V. Rizov, 2015, "Impact Fracture Study of Laminated Composite Using Single Edge Notched Bend Specimens", Polymers and polymer composites, Vol. No. 23., 21-28.

[24]. Somani, N., Singh, N. and Gupta, N.K. (2021), "Joining and characterization of SS-430 using microwave hybrid heating technique", Journal of Engineering, Design and Technology, Vol. aheadof-print No. ahead-of-print. https://doi.org/10.1108/JEDT-08-2020-0322.

[25]. Gupta, N.K., Thakre, G.D. and Kumar, M. (2020), "Dry sliding wear performance on self-healing Al6061 composites", Journal of Engineering, Design and Technology, Vol. 18 No. 5, pp. 1357- 1370. https://doi.org/10.1108/JEDT-03-2020-0078.

[26]. Yan, J. (2020), "3D printing optimization algorithm based on back-propagation neural network", Journal of Engineering, Design and Technology, Vol. 18 No. 5, pp. 1223-1230. https://doi.org/10.1108/JEDT-12-2019-0342.

[27]. Aouad, R. and Amara, I. (2018), "Influence of the cutting condition on the wear and the surface roughness in the steel AISI 4140 with mixed ceramic and diamond tool", Journal of Engineering, Design and Technology, Vol. 16 No. 6, pp. 828-836. https://doi.org/10.1108/JEDT-05-2018-0086.

[28]. Gelaw, M., Ramulu, P.J., Hailu, D. and Desta, T. (2018), "Manufacturing and mechanical characterization of square bar made of aluminium scraps through friction stir back extrusion process", Journal of Engineering, Design and Technology, Vol. 16 No. 4, pp. 596-615. https://doi.org/10.1108/JEDT-02-2018-0030.

[29]. LijinKottayil Raghavan, 2015, "Industrial looks at ways of manufacturing defects of fiber reinforced polymer composites", lib.dr.iastate.edu, 1-63.

[30]. M. J. Suriani, Hannah Zalifah Rapi, R. A. Ilyas, Michal Petru and S. M. Sapuan, 2021, "Delamination and manufacturing defects in natural fiber-reinforced hybrid composite: a review", mdpi.com, 1-24.