An Experimental Analysis to Determine Ultimate Tensile Strength of Jute Reinforced Glass Fibre Composite by Acousto-Ultrasonic Technique

Shilesh Dwivedi[1] Rajesh Kumar Satankar[2]
[1]M.E. Student [2]Assistant Professor
[1,2]Govt Engineering College Jabalpur (M.P)

Abstract— From past few decades, there is been substantial growth and development in field of Composites. Advanced materials and Composites are being used in almost every industry in some form or the other. Composites have found wider applicability and liking in designing industries. This has triggered researchers towards this emerging technology. Jute reinforced composites may be used in combination with biodegradable polymer or to replace conventional glass fibre reinforced composites. In this case, the main concern is their impact resistance. The production of hybrid laminates by coupling layers of glass fibre reinforced with jute reinforced laminates, proved also effective to improve the mechanical characteristics. In recent years, a number of studies have been carried out, aimed to compare properties of jute fibre reinforced laminates. This project studies Mechanical properties of Jute Reinforced Glass Fibre Composite by Acousto-Ultrasonic Technique. The specimens were tested for UTS on UTM and the correlation factors were determined by comparing SWF (Stress Wave Factors) and UTS. The comparative analyses are presented in results.

Key words: Composite materials, acousto-ultrasonic technique, SWF, UTS

I. INTRODUCTION

From the very beginning, man has always been keen towards exploring newer and better ways to do the work. He invented machines, discovered new materials and is been continuously learning through experiences and failures to improve the technology. Man's evolution has been tied to his progress in materials. Yesterday it was the Stone, Bronze and Iron Ages. Today it is the Age of Composites. However, even in these earlier ages man experimented with and learned to use composite materials. Many of such evidences can be found like Israelites' use of chopped straw in their brick, Egyptian used cloth tape soaked in resin for Mummy Embalming, Japanese Samurai swords formed by the repeated folding of a steel bar back on itself etc.

The use of natural fibres (e.g., straw, flax, hemp, banana and jute) as material reinforcement was investigated with considerable interest in last decades. The most common concerns about the use of these fibres regard their coupling with a polymeric matrix, which needs to be compatible with the cellulose contained in the fibres. Another issue widely investigated is the weathering behaviour of natural fibre reinforced composites, including the study of the influence of water sorption on the mechanical properties of the laminate.

Jute is among the best natural fibres in terms of tensile strength and flexural properties, due to its longer continuous length. In addition, jute fibres are versatile, since they can be combined with different polymeric resins (e.g., phenolic, polyester and epoxy). Jute reinforced laminates are currently used e.g., to produce wood replacement panels, insulators and automotive components.

However, jute fibre reinforced composites are not always very stiff. A number of studies are already available on impact and mechanical properties of these laminates. Most commonly reported problems include the large scattering in mechanical properties, due to the highly non-uniform cross-section of jute fibres, and the reduction of performance observed after water absorption, that is believed to affect the dimensional stability of fibres. Moreover, the limitations imposed on the mechanical performance of the composite, due to internal porosity, are not well known.

Acousto-Ultrasonic is an approach to characterizing the properties and defect conditions of fibre reinforced composites. The approach was introduced in order to deal primarily with highly attenuating, heterogeneous and orthographic composites and composite like structures. The term Acousto-Ultrasonic (AU) denotes a combination of some aspects of Acoustic Emissions with Ultrasonic Technique. Unlike the usual NDT approaches, AU is less concerned with overt flaw detection than with evaluation of the integrated effect of diffuse population of defects. Instead of attempting to have well defined wave propagation, as in flaw detection, the AU approach requires that the received signal be the result of multiple interactions with material.

II. FLOW CHART

The project is carried out according to the following Flow Chart, which is shown in Fig (1).

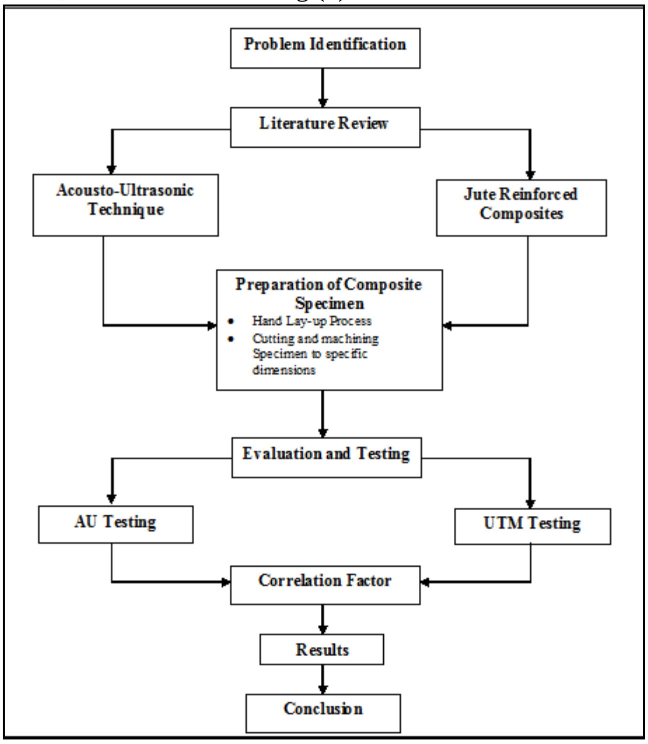

Fig. 1: Flow Chart

III. EXPERIMENTAL TESTING

A. Preparation of specimen

Preparation of Specimen is one of the key factors and there are many critical factors involved with Specimen preparation such as concentration of resin and hardener, setting time, orientation of fibre etc. All of these parameters are discussed in following section.

For the current project, Glass Fibre composites are considered. There two main types of glass fibres, E-class and S-class, which come in many forms such as Yarn, Woven Fabric Yarn, Continuous-Strand Roving, Woven Roving etc. Along with Glass Fibres, other important constituent is Epoxy which forms the matrix of Composite.

Epoxy is a copolymer; that is, it is formed from two different chemicals. These are referred to as the "resin" or "compound" and the "hardener" or "activator". The resin consists of monomers or short chain polymers with an Epoxide group at either end. The hardener consists of polyamine monomers. When these compounds are mixed together, the amine groups react with the Epoxide groups to form a covalent bond. Each NH group in amines can react with an Epoxide group, so that the resulting polymer is heavily cross linked, and is thus rigid and strong.

To prepare composites in this project work, E class Glass Fibre and Jute fibre woven sheets are used along with Araldite Epoxy and Triethylenetetramine (TETA). The Hardener content should be around 5% to 10% by volume that of Epoxy.

The process of polymerization is called "Curing", and can be controlled through temperature, choice of resin and hardener compounds, and the ratio of said compounds; the process can take minutes to hours. Some formulations benefit from heating during the cure period, whereas others simply require time and ambient temperatures. The Hardener content should be varied anticipating the ambient temperature.

The Specimens were prepared by Hand Lay Up method. In this method, the Glass Fibres are oriented in required direction. The test specimen dimensions. Number of layers of Jute and Glass depends upon the thickness requirement of the specimen and thickness. These layers are stacked upon each other and mixture of Epoxy & Hardener is applied by hand in between the two Fibre layers, leaving composite to set for 2 days approximately.

The Composite specimens prepared are shown in Fig. (2)

Fig. 2: Specimen

B. Methodology:

1) Acousto-Ultrasonic Techniques

a) General Concepts

Acousto-ultrasonic (AU) is defined as a nondestructive method that uses stress waves to detect and evaluate diffuse defects, damage, and variations in mechanical properties of materials. Whereas conventional ultrasonic methods can be used to assess large voids or other discontinuities, AU techniques can be used to assess subtle flaws and associated strength variations in wood and wood-based composite materials, particularly at adhesive joints. The AU method combines aspects of acoustic emission (AE) signal analysis with ultrasonic characterization methods. A pair of ultrasonic piezoelectric probes in a send/receive configuration are used to send a stress wave through a specimen. The receiving signals result from multiple reflections and interactions with the material microstructure in a volume of material between the sending and receiving probes. The output signal from the receiving transducer is processed in the same way as an AE signal. Different places in the specimen can be scanned as the pair of send/receive transducers is moved.

Breaking the lead of a mechanical pencil at the surface of a wood specimen has been used in place of an AU transducer to generate an ultrasonic pulse. The AU wave generated by the breaking lead is referred to as artificial AE.

The basic approach in the AU technique is to rate the material using a stress wave factor (SWF). The SWF is the relative energy loss (attenuation) or propagation efficiency of the stress wave travelling through a specimen. The simplest definition is based on AE peak voltage or the ringdown count method.

Ringdown SWF is defined as

SWF = RTC

Where R is the repetition rate of input waveforms, T is the predetermined time interval, and C is the number of oscillations in the received waveforms that exceed a preselected voltage threshold (ringdown count).

Peak voltage SWF is defined as

SWF = peak voltage = V_{max}

Where V_{max} is the maximum

(peak to peak) voltage oscillation.

RMS voltage SWF is defined as

$$SWF = (V_{rms})^2 = \int_{t1}^{t2} V^2 dt$$

Where SWF is based on root mean square (RMS) voltage, T is a time interval (t_1 to t_2), t is time, and V is time-varying voltage.

The hypothesis is that more efficient strain energy transfer and strain redistribution during loading corresponds to in-creased strength and fracture resistance in composites. The energy dissipation of the stress wave is caused by discontinuities in damaged areas. Higher attenuation will usually indicate lower strength and impact resistance for composites. The AU technique is used to examine the presence or change of micro flaws in composite materials, whereas the measurement of ultrasonic velocity is conventionally used to estimate the elastic constants.

Methodology

To assure reproducibility of AU measurements, it is necessary to choose appropriate transducers and ensure proper coupling between the surface of the material and the transducer (ASTM E1495–97). Special attention is required when placing transducers to distinguish AU results from other factors such as coupling pressure, surface roughness, and mixed background noise.

As with AE signals, AU signals are affected by the coupling conditions between the substrate and probes, such as couplant selection, amount of couplant, and probe alignment and pressure (ASTM E1495). When the couplant is applied, the technician needs to avoid trapping air bubbles between the sample and transducer. Trapped air as well as surface roughness will decrease the amplitude of AU signals.

Properties of transducers also affect AU results. It is important to select a sending transducer that has a wide frequency range (broadband transducer). If a resonant transducer is used, it is difficult to separate the resonant property of the sending transducer from the AU signals travelling through the materials. The AU signal, like the AE signal, depends on the character of the transducers. For many fiber-reinforced composites, broadband transducer pairs with center frequencies ranging from 0.5 to 5 MHz are appropriate (ASTM E1495). However, materials having high attenuation require more sensitive receiving transducers. Ultrasonic attenuation can be large in wood, particularly in the tangential and radial directions. Accordingly, the resonant frequency of the receiving transducer for wood is usually lower than the frequency employed for other materials (100 to 500 kHz range).

IV. Results

A. Testing

The composite specimens were studied by AU technique to determine the SWF. The following tables show the results of the analysis.

Parameter.	**Composition 1(4G3J)**			**Composition 2 (4G4J)**			**Composition 3 (4G6J)**		
	Sp. 1	**Sp. 2**	**Sp. 3**	**Sp. 4**	**Sp. 2**	**Sp. 1**	**Sp. 4**	**Sp. 3**	**Sp.2**
Thickness(mm)	5.69	5.87	5.48	6.02	5.97	5.983	7.59	7.60	7.66
Width (mm)	27.03	27.13	27.26	27.31	27.26	27.2	27.12	27.12	27.16
Glass Vol. Fraction	29 %			26%			21%		
Jute Vol. Fraction	30%			40%			49 %		
Matrix	41%			34%			30%		
Length	140 mm			140 mm			140 mm		

Table 1: Specimen Specifications

Specimen were Tested by AU technique and the results were obtained in table 2

Parameter	**Composition 1 (4G3J)**			**Composition 2 (4G4J)**			**Composition 3 (4G6J)**		
	Sp. 1	**Sp. 2**	**Sp. 3**	**Sp. 4**	**Sp. 2**	**Sp. 1**	**Sp. 4**	**Sp. 3**	**Sp.2**
SWF (mV)	773.8	900.8	800.8	1187.3	1280.9	1020.7	1385.8	1314.7	1239.8

Table 2: AU Test Results

The specimens were then tested on digital UTM to determine the UTS of the composite. So, the testing was carried on UTM and the results are summarized in Table (3).

Parameter	**Composition 1(4G6J)**			**Composition 2 (4G4J)**			**Composition 3 (4G3J)**		
	Sp. 1	**Sp. 2**	**Sp. 3**	**Sp. 4**	**Sp. 2**	**Sp. 1**	**Sp. 4**	**Sp. 3**	**Sp.2**
Breaking Load (KN)	6.135	3.86	12.7	10.74	13.685	12.945	16.625	17.6	17.2
Max Disp. (mm)	12.6	12.15	11.59	10.79	11.86	10.75	11.63	14.04	10.22
Elongation	9%	8.679%	8.279%	7.707%	8.47%	7.69%	8.307	10.029	7.3%
UTS (MPa)	95	87	85	90	84	84	81	86	82

Table 3: UTM Test Results

B. Correlation prediction

The results obtained from AU and UTM were compared and thus plotted to determine the Correlation Factor. The following figures show the Pots of SWF and UTS for various Specimens.

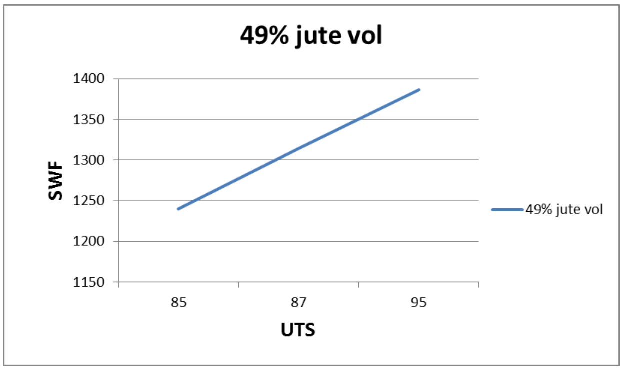

Fig. 3:

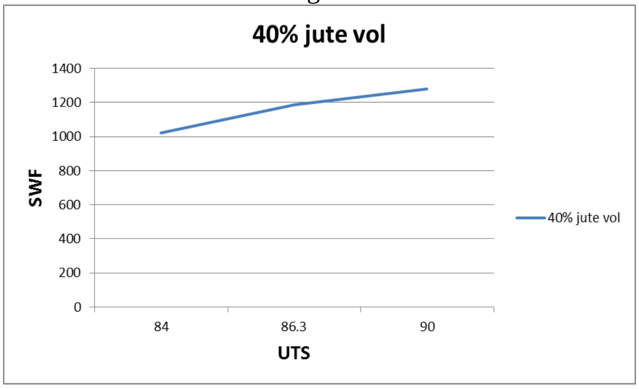

Fig. 4:

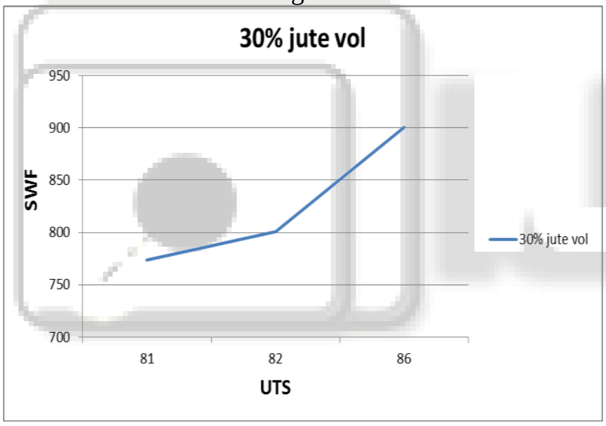

Fig. 5:

Thus, the correlation Factors were determined from these plots which are tabulated in Table (4)

Sr. No.	Composition	Correlation Factor
1	Composition 1 4G3J (30%)	9.93
2	Composition 2 4G4J (40%)	13.52
3	Composition 3 4G6J (49%)	14.75

Table 4: Correlation Factors

V. CONCLUSION

Glass Fibre reinforced Jute Composite were studied and tested for variable compositions. Variations were observed in the comparison of results which are more ambiguous than expected therefore the validation is being carried out and it is expected to be rectified soon. Also, the specimens were prepared by Hand Lay-up method. So, it is difficult to achieve same degree of accuracy in coating. Non-uniformity is observed in these properties of composite. This is because of highly non-uniform cross-section of jute fibres, and so, there is huge scope for studying effects of all these parameters on mechanical behaviours of Jute based Composites.

Jute can play key role in evolution of new age composite technology through the production of fibre-based composite materials. We need to put our collective minds and resources into revitalizing and diversifying jute into a bright new future in composites.

REFERENCES

[1] Carlo Santulli Mechanical And Impact Properties Of Untreated Jute Fabric Reinforced Polyester Laminates Compared With Different E-Glass Fibre Reinforced Laminates
[2] Srivastav A. K., Behera M. K. and Ray B. C. Loading Rate Sensitivity of Jute/Glass Hybrid Reinforced Epoxy Composites: Effect of Surface Modifications
[3] Roger M. Rowell Potentials For Jute Based Composites
[4] Roe P J Ansell M P, Jute Reinforced Polyester Composites
[5] Summerscales John, Non-Destructive Testing of Fibre Reinforced Plastic Composites, vol 2, Elsevier Applied Science Pub.
[6] Smith F. William, Hashemi Javed and Prakash Ravi, Material Science and Engineering, TMH Publications.