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EXPERIMENTAL INVESTIGATION ON COMBINE BASALT & JUTE REINFORCED NATURAL FIBERS

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Abstract - *Of late, the usage of composite materials has increased due to easy availability at low cost and ease in the fabrication processes. In the present work, a novel material is fabricated and tested according to ASTM standards for different mechanical properties. Analysis is performed by using design of experiment to find the optimum design from Taguchi L9 orthogonal array. The optimal condition composition is; Basalt with 4 layers, jute with 10 layers and an orientation of 45°. It is found that the tensile strength and flexural strength of the optimum material condition are good enough for the targeted material.*

Key Words: **Design of experimentation ANOVA, SEM, Hand layup, Vacuum bagging**....

1. INTRODUCTION

The fabric which acquired with the aid of two or extra unique substances with often one-of-a-kind physical and chemical properties which lead to individual component. The individual aspects will be continue to be separate and actually inside the completed structure.

The many factor substances and specific procedures that can be used make composites extraordinarily versatile and efficient. They normally end result in lighter, stronger, greater long lasting options in contrast to ordinary materials.

Now a days for constructing bridges, boat hulls, water pool panels, auto bodies, bath tubs, imitation items like granite structures, marble sinks etc.., are the usage of these composite materials. These kind of composite substances desire the fiber reinforced polymer which is easier to manufacture by the way of hand layup technique.

1.1 BASALT

Past in 1923 American scientists founded. Basalt cloth onces suggested in army wear during the world war2 between the Europe and US. After the many research's the polymer industries uses basalt for their best mechanical properties in wide range. These fibers are now used in many industries and in civil applications. Various natural and inorganic fibers are available in the market but having less structural strength but highly-priced for use in moderate loadings. Basalt fiber is the fabric need in modern times and is an inorganic fiber with extraordinarily precise modulus, more strength, extended pressure to failure, excessive temperature resistance, fantastic stability, chemical resistance, and it is handy to process, on-toxic, natural, eco-friendly and inexpensive. Basalt fiber is an extrusion from basalt-based molten igneous volcanic rock, which is observed in flowing lava.

Figure-1.1: basalt fiber materials

Table-1.1: properties of basalt fiber

Thickness (mm)	0.42
Weight (gsm)	241
Diameter (mm)	1-1.3
Density (g/cm3)	2.69
Moisture Content (Wt%)	0.5
Monofilament Dia	10-13

1.2 JUTE FIBER

Jute is a long and soft fiber that can be converted to coarse, sturdy threads. It comes particularly from a flora in the genus Corchorus, which was once categorised with the family Tiliaceae. The predominant supply of the fiber is Corchorus olitorius, however it is viewed inferior to Corchorus capsularis.

Jute fibers are less expensive than natural fibers, and 2nd solely to cotton in the quantity produced and range of uses. Jute fibers are composed notably of the plant substances cellulose and lignin. It falls into the bast fiber class alongside with kenaf, industrial hemp, flax, ramie, etc. The industrial time period for jute fiber is uncooked jute. The fibers are white to brown, and 1–4 metres long. Jute is additionally known as the golden fiber for its coloration and excessive value.

Figure-1.2: pictorial representation of jute fiber.

Table-1.2: properties of jute fiber.

Property	Test value
Moisture content (%)	9.59
Diameter of fiber (mm)	0.4498
Mean breaking strength(G)	1570.74
Cv of strength(%)	26.90
Mean elongation(%)	1.50
Cv of elongation(%)	16.90
Density at room temperature(g/cm^3)	1.350

2. LITERATURE SURVEY

Jee-Seok WANG et. Al. (2009), The study was done to find out the limit of bending moment of steel and basalt composite pipe, its endurance was calculated and the limit curvature of the pipe in the safe range is presented. It is also examined the temperature of steel & basalt pipe due to different coefficients among basalt, mortar and mild steel .In steel and basalt are used to make the composite pipe which steel has toughness and strength but it does not have the abrasion and corrosion so the basalt is used to support weaker points in steel[1].

Bin Wei et. Al. (2011), concluded that when the pure epoxy and sio_2 nanoparticle are coated on the basalt fiber that which increase the strength of the basalt fiber than with only epoxy coating. It also helps in increasing the mechanical properties of basalt fibers. Solution and gel method and coupling agent macromolecules were attached on the sio_2 particles. The tensile strength of the basalt fiber increased up to 30% and fiber composite enhanced by 15% [2].

Aleksandar Todic et. Al. (2011), in this study was done on the basalt-polymer composite. The basalt is inexpensive material and it has the remarkable physical and mechanical characteristics. The 18 samples with different basalt percentage are made and tested for the results. Hence finally expressed that the basalt is the best material that can be used for the further applications in the future[3].

Pilar de la Rosa Garcia et. Al. (2013) This study is based on the reinforced pine timber beams with composite materials. In this study both basalt and carbon fibers are used for the reinforcement. The behaviour of beams was analysed with respective with unidirectional and bidirectional fabrics. finally it concluded that in the unidirectional structuring of the basalt fiber given high than the carbon fiber. Also mentioned that use of bidirectional fabrics are better than the unidirectional fabrics and also when the bidirectional fabrics are used in less grams. The stiffness of the beam increases when the percentage of fabrics increases. But in terms of stresses the carbon fiber use is better for optimization[4].

Nihat Morova et. Al. (2013) The study conducted on the basalt fibers to test the stresses occurring at the surface layer and specimens were tested on marshall stability test. The three specimens were prepared with 5% of bitumen and different compositions of basalt fiber. The best optimum value is chosen. Later on in order to obtain the better stability basalt fiber ratio of (0.50%) and with different bitumen content, extra specimens are prepared and tested compared close to the optimum value. The samples were compressed with same number of strokes. Finally concluded that 5% of bitumen and 0.50% of basalt fiber given the best optium result compared with all the samples tested[5].

S.Ezhil Vannan et. Al. (2014) The study is based on the thermal expansion of basalt short fiber composites using the thermal mechanical analyser technique. Expressed that the dimension change of the basalt fiber occurred when the rapid increase in temperature of around (280-300^{0}c).it concluded that is due to increase in the lattice but when increasing the basalt percentage the thermal strain also increased, Both non reinforced composite matrix alloy and composite appeared increased with increasing the temperature[6].

T. Bhat et. Al. (2015) The study was explained in detail about fire structural resistance of the basalt fiber in experimental and analytical way. Concluded that basalt fibers are replacing with e-glass fibers of polymer matrix composites in some applications. When heated up under same heat flux the basalt fiber got heated up more faster than e-glass fiber due to its higher thermal emissivity. That helped the basalt fiber to comeup with the softening and decomposition of polymer matrix and weakening of fibers at the faster rate[7].

Suleyman Basturk et. Al. (2016) study was based on the investigation of the nonlinear dynamic response of basalt/nickel functionally graded materials under the blast load. Two different approximations were chosen such as homogeneous laminated model and power law model,the boundary conditions are kept all simply supported and the effects are investigated and results discussed well[8].

B. Soares et. Al. (2016) The study concluded that basalt fiber are having best mechanical properties than comparative to

e-glass fibers and carbon fibers. The mechanical properties of a basalt fiber with an unsaturated polyester matrix produced by the resin transfer molding,the subjected to composites tensile, compression, shear and flextural tests. the compare of the values and analysis made with rein transfer molding and discussed the benefits of basalt fibers[9].

T. Scalicia et. Al. (2016) This study was on experimental characterisation of composite made out of quasi unidirectional basalt fabric. To examine the ability of commercial basalt fabrics and their composites to get extent potentials of basalt fibers. Two different making techniques used to make the composites: vacuum assisted resin infusion and hand pressed vacuum bagging.Two panels one another more samples are made to test the composite pieces for stiffness, tensile, flexural shear, beam shear, cantilever beam and flexural tests. after evaluating all the results vacuum hand bagging gives best results compared to the vacuum assisted resin infusion[10].

3. FABRICATION AND METHODOLOGY

Consistent advancements in the assembling procedures and execution of fiber fortified fiber have prompted huge development in its market acknowledgment. The manufacture of composites is an unpredictable procedure and it requires the concurrent thought of different boundaries, for example, factor math, layering succession, creation volume, support and framework types, tooling necessities, strategy financial matters. Format and assembling be coordinated during in the improvement way itself. For composites to get serious with metals, value markdown is a need, anticipate sturdiness, viability and dependability.

The huge number of errands worried in the assembling of composite overlays can be partitioned into two phases: (1) Fabrication/producing strategies and (2) Processing values. The fiber and grid may furthermore be in a pre-impregnated structure, or the fiber and lattice texture can likewise be mixed unexpectedly, at some stage in this progression of developing the basic structure. Creation techniques for composites are currently not organized on the sort of network material. Truth be told, some steel shaping techniques have been adjusted to composites manufacture, though, the preparing requirements are totally settled on the sort of lattice material utilized. For example, thermosets require protracted handling times, while thermoplastics require profoundly unnecessary weights and temperatures. In the current trial study, a brisk prologue to the assembling of composites by method of the use of the hand lay-up measure, and the issues related to assembling are presented and referenced in detail.

In all assembling strategies, the utilization of gear like the bite the dust, buildup and mandrel is normal, and they outfit the auxiliary structure to the composite material. These hardware are commonly a converse, of the ideal basic shape, and the arrangement of the gadget is an essential and exceptionally valued cycle. The estimation of the gadget every now and again far surpasses the texture and work costs to create a composite structure. Additionally regular to all assembling strategies, is the need to follow temperature and stress to the basic part, after the fiber and network are added all things considered to the supported basic structure. The strain takes two structures: genuine weight, in a perfect world hydrostatic, to merge the tows and layers; a vacuum to remove the air ensnared between the layers, and to limit the amount of unwanted gases emitted by utilizing the tar as it fixes. The product of stress can be in the structure of shutting each parts of the apparatus, or similarly as with a level basic issue earnest the overlay in a warm press. At last, the vacuum prerequisite is met by method of encasing the basic angle in a vacuum-tight pack and drawing a vacuum.

3.1 TYPES OF FABRICATION METHODS

- Hand layup
- Open molding
- Resin infusion methods

1. HAND LAYUP

The hand lay-up is the most principal strategy of creation utilized on thermoset composites. The methodology involves laying prepreg employs onto an apparatus by utilizing hand to make a cover stack.

When the lay-up is finished, you need to follow the tar to the layer of handles. In a particular variation of the hand lay-up perceived as the soggy lay-up, you need to cover each employ with tar sooner than layering them together.

2. OPEN MOLDING

Contact embellishment or Open Molding is an economical way utilized in the presentation of fiberglass composite materials. The form is first taken care of with a dispatch specialist and gel sooner than the creation starts.

Spot the embellishment substances on apex of the form through procedure or the hand lay-up measure. In the splash up measure, you need to shower the tar and slashed strands on to the embellishment floor at the same time.

At that point minimized the overlay the utilization of hand the use of rollers, and add any center texture now. A last shower up layer assists with setting the center substances between the cover. A while later, you can empower the trim to fix.

You can sometimes utilize the hand lay-up method close by the shower lay-up in an offer to limit the work.

3. RESIN INFUSION METHODS

Because of the unreasonable interest for composite materials, there is a reach out in the need for a speedier assembling rate. Numerous individuals are switching the lay-up strategy with decision procedures that motivate the computerization of creation.

These creation systems include:

The Resign Transfer molding

Here, you need to place dry support into the shape and later siphon a mix of the gum and impetus underneath low weight.

The gum utilized is of low thickness with the goal that it can pervade the preform sooner than it fixes. The way delivers striking parts other than the need for an autoclave.

Reaction injection molding

It bears an exceptional qualification to the tar switch forming. Rather than infusing the gum and impetus as a blend, you embed them in two separate streams.

The synthetic response that occurs over the span of the consolidate then takes region in the form rather of the apportioning head.

Vacuum assisted resin transfer molding

Vacuum assisted resin transfer molding(VRTM) stands apart from the distinctive sap switch shaping methodologies in see that it does at this point don't need the utilization of warmness or weight. Instead of siphoning the tar the utilization of weight, the VARTM pulls in it into the preform the utilization of a vacuum.

Consequently, VARTM utilizes more affordable instruments, making it easy to create a decent estimated amount of more affordable and confounded parts.

Tube rolling

Tube rolling is a manufacture procedure that you can use in the creation of poles and cylinders. Its significant items are tightened or barrel shaped cylinders with a little breadth.

In this cycle, you need to first pre-cut the texture into designs that will help with the fiber engineering. They are then spread out on a surface where a mandrel turn over them to minimized and debulk the materials.

You need to reposition the example pieces at conventional spans so you can gracefully the cylinder bowing quality.

Compression molding

This method is advantageous in the handling of high-volume thermosets. It is the pleasant decision to utilize when you need to deliver extra than 10,000 sections.

Composite sheet substances are made the utilization of a sheet making compound. You need to first region a pitch glue down and pour hacked fiberglass on top. At that point you can cover the fiberglass the utilization of a leftover layer of tar glue.

The auto venture is investigating the utilization of sheet shaping mixes that have a carbon fortification. It is in an offered to take advantage of the quality and solidness to weight proportion of carbon.

Infusion molding

It is a rapidly and low-pressure strategy regular in the manufacture of stuffed thermoplastics. The procedure is brisk, with infusion speeds between one to 5 seconds. One hour is satisfactory to deliver upwards of 2000 little parts.

Robotized infusion embellishment of BMC is ascending in the positions and assuming control over a portion of the business sectors held by utilizing steel castings and thermoplastic producers.

3.3 PROCEDURE USED TO MAKE OUR COMPOSITE

RAW MATERIAL SELECTION

Basalt and jute are used in our project as mentioned above.

Epoxy resign CY230-gel time of 2hr used

Hardner NY951 used to harden the composite

Resin to hardner ratio used was 100:1

Basalt and jute fabrics are cutted to required sizes 200*100 . Later on as mentioned above the resin and hardner are kept a side with respective to the quantity needed to our composites.By placing basalt and jute fibers one on another with adding resin, hardner and polyurethane in between. Total 9 pieces are prepared with different arrangement of layers and count of layers with respective of different orientation. Orientation and layers are mentioned in the below table.

After completion of arrangements the vacuum bagging process is used to remove uneven air bubbles and to get better surface finish. This pieces are kept dried upto 24hr and later on pieces are cutted into pieces as per ASTM standards. In each 200*100 test pieces two different pieces are cutted into size of 150*30.

Table-3.3: layers and orientation orders in detail

Jute (layers)	Basalt (layers)	Orientation(deg)
6	2	0^0
6	3	45
6	4	60
8	2	45
8	3	60
8	4	0
10	2	60
10	3	0^0
10	4	45^0

4. RESULTS AND DISCUSSION

Response factors such as Tensile and Hardness were determined from the results observed after the experimental process. The statistical analysis was then conducted by using Minitab software and the values of the signal-to-noise ratio are tabulated.

Experimental tests were conducted out by using Design of Experiments to evaluate the effect of parameters including Jute, Basalt and Orientation of various compositions on Tension and Flexural of the target material.

Taguchi Method

The Taguchi approach is very simple, structured and effective to optimise the design of experiments. It's a safer methodology than conventional experimental design, which decreases the number of tests, time and cost. The Taguchi orthogonal array technique gives a series of balanced tests. The L9 orthogonal array was picked in the current study, consisting of 9 rows and 3 columns. The degree and operating parameters are seen in the table below. The experiments are composed of 9 orthogonal array (OA) experiments. In OA, the first column is dedicated to Jute, the second column is dedicated to Basalt, and the third column is dedicated to Jute.

Selection of Orthogonal array

The set of OA depends on the number of variables and levels of which each one of the variables relates. The degree of freedom is 2 for each element and thus the total DOF obtained is 6 (i.e. 3x2=6). The preferred OA degree of freedom must be greater than the total DOF of all the variables. The DOF for OA is 8 , which is the number of experiments. For the study, L9 is also considered. The OA that was chosen can be seen in the following table.

Table 4: Taguchi orthogonally array with results and Signal to Noise ratio

Jute layers	basalt layers	orientation	Tensile strength	Flexural strength	SNRA 1	SNRA 2
6	2	0^0	89.26	148.03	39.01	43.40
6	3	45^0	107.08	176.53	40.59	44.93
6	4	60^0	96.85	172.51	39.72	44.73
8	2	45^0	101.09	164.82	40.09	44.34
8	3	60^0	92.97	166.45	39.36	44.42
8	4	0^0	95.69	158.48	39.61	43.99
10	2	60	93.98	156.65	39.46	43.89
10	3	0^0	93.54	154.09	39.41	43.75
10	4	45^0	116.41	189.12	41.31	45.53

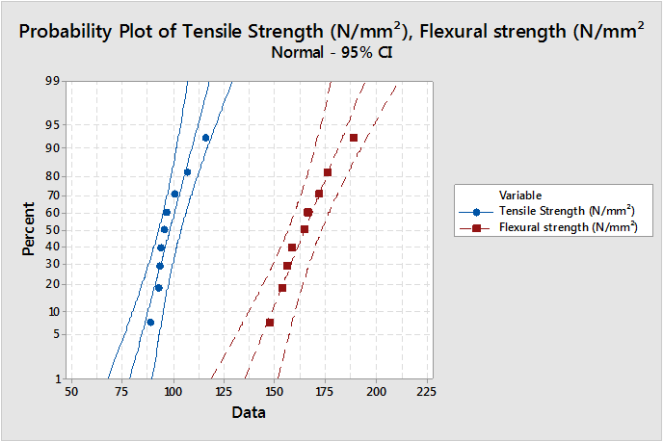

FIGURE-4.1: Probablity plot of responses

Signal- to-Noise Ratio

The "signal" of the intended effect is a component applied in reaction to experimental design while testing components to adjust the product's consistency characteristics. However, experiments that affect reaction (output) have not been taken into consideration by several external influences when experiments were performed. These external variables are mentioned as noise factor, and their impact on the performance of the experiment conducted is mentioned as "noise." The signal-to-noise ratio is a log function of acceptable output response, which performs as the objective function of optimization. It helps to understand the details and to estimate optimal outcomes. In Figs for S / N ratios of composite materials, all interaction plots are shown. The S / N ratio is established from the equation given.

$$S/N = -10\log\left[\frac{1}{n}\sum_{i=1}^{n}(y_i 2)\right]$$

Where n = No. of Measurements (in the trial)

y_i = The measured value (also in the trial)

The S/N ratio can be the efficient representation in order to locate the important parameters by measuring the minimal

variance. For the SR values for each L9 OA experiment, the S/N ratio values for machining efficiency can be determined by applying abovementioned equation.

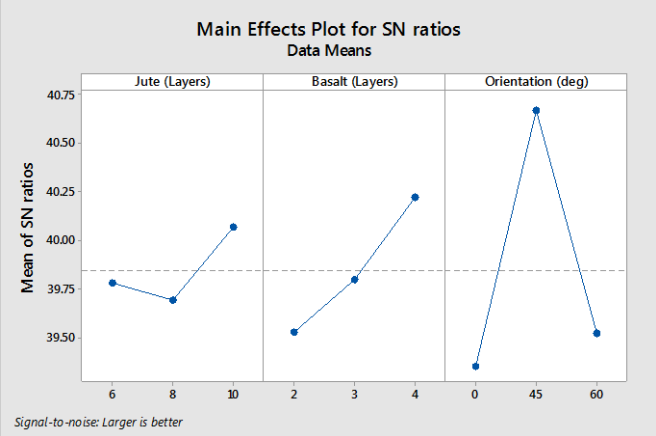

Figure-4.2: Main effects plot for Tensile strength

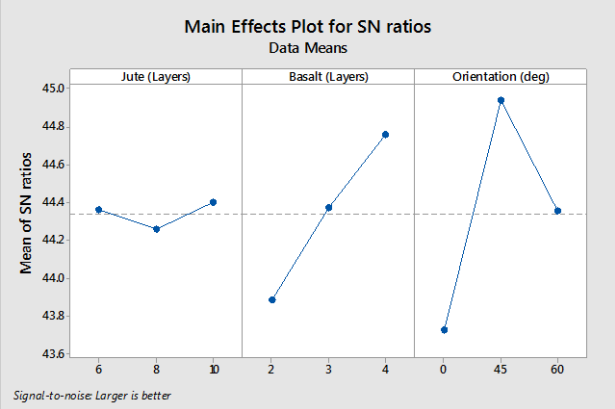

Figure-4.3: Main effects plot for Flexural strength

Analysis of variance

The Analysis of variance (ANOVA) is used to describe findings as the starting method. It is used to assess the dependent importance of the various response behavior parameters. ANOVA was used in the current study to examine the influence of the load, sliding velocity & sliding distance test parameters on the wear efficiency of composite materials. Study was conducted with a good 95 % confidence significance level. The percentage attribution of the impact factor on the square sum was determined. The higher value of the square sum implies a greater effect on the output parameters.

SEM Analysis

For the ideal composition of tensile and flexural strength after test conditions, images are captured using scanning electron microscopy. Seen below in fig. Images clearly demonstrate that manufacturing is carried out up to the mark where there is intactness between fibres without any interference that contributes to strength enhancement.

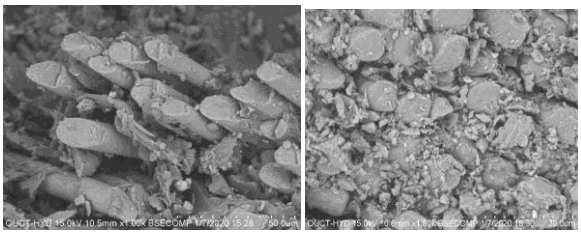

Figure-4.4: SEM images of Tensile tested sample

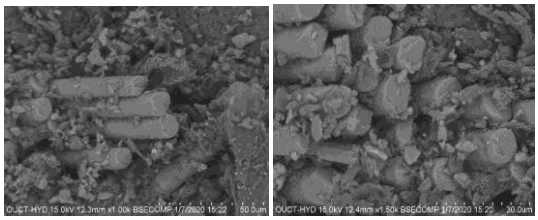

Figure-4.5: SEM images Flexural tested sample

5. CONCULSIONS

In this current project, a composite material is developed and different mechanical tests were performed.

The analysis is performed based on minitab to evaluate R^2 of the model with which best fit is known for 95% confidence interval. From the table 4.1 s/n ratio for the responses are tabulated and from fig 4.1 it is evident that experimented results are with in the range of normality.

The highest strength is observed when the jute fiber is making an angle of 45^0 and each basalt layer is adding a strength of 12-15N/mm^2. It is clear from the table 4.2 that the standard deviation is within the limit i.e 2.14 for tensile strength and 4.02 for flexural strength.

Based on the design of experiments analysis (Taguchi L9 orthogonal array), the optimal condition composition is; Basalt with 4layers, jute with 10layers and an orientation of 45º. The tensile strength for the optimum composition is superior and in the tune of 116.41N/mm^2 and the flexural strength

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