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Investigations on Drilling of Basalt-Hemp Hybrid Composites with Aluminum as Filler Material

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Abstract - Fiber reinforced composites are risen as a substantial piece of overall industry in the past, current and furthermore a standout amongst the most well-known engineering materials. In this present work, hybrid fiber reinforced composite is made-up by using basalt fiber and hemp fiber, polyester resin and add aluminum particles in composites. These laminates are produced by using hand lay-up method with one stacking sequence of HHBBBBHH with varying aluminum percentage (0%, 3% and 6%). Drilling tests were completed on the composite samples by changing of input factors (Particles percentage, helix angle, feed and speed), and the response was thrust force (TF). Three diverse helix angle (20º, 30º, 40º), speed (600, 2600, 4600 rpm) and feed rate (0.06, 0.16, 0.26 mm/rev) used in this study. ANOVA was used to study the most prompting parameter and percentage influence of machining parameter.

Index Terms - Basalt, Hemp, Drilling, Design of Experiments, ANOVA

INRODUCTION

During the previous many years, expanding request in an assortment of industries (like airplane, space apparatus, car, marine, and outdoor supplies) for elite execution, lightweight designs have invigorated areas of strength for a development of fiber built up polymer composites. Currently, natural fibers reinforced composites are developing in composite applications as they have advantages like low cost, low density and ease of availability. Also, composites prepared from natural fibers have high-specific stiffness and lightweight compared to prepared from glass fibers [1]-[2].

Owing to the antagonistic effects of composite materials on the earth, their significant expense and other ominous properties, experts have begun to explore natural fiber-based hybrid composites. By changing type of matrix, type of fibers, length of fiber, weight fraction of each fiber and their arrangement in hybrid composites, the properties of the hybrid composites can be varied [3]. Drilling is broadly employed as it is the greatest efficient process than altered techniques and there are relatively rare different strategies that can mark circular hole. Drilling is over and over utilized for machining composites, in view of uninhibitedly existing machinery. Composites are anisotropic materials, so piercing increments definite issues that will stimulus the strength of the part [4].

The tool force generated during drilling is of attention to us as delamination promulgates by the TF. The eminence of the drilled hole is influenced by TF; it goes about as a vital boundary to evaluate delamination. Different analysts concentrated on the impact of feed, speed and drill geometry on TF.

Number of researchers has studied on drilling of hybrid composites. Chetia (2018) studied on drilling optimization for bamboo and basalt fiber. He used bamboo and basalt as fiber materials and epoxy as matrix materials to manufacture composite using hand layup method. He selected speed, feed rate as an input parameter for drilling operation and drilling operation performed in CNC drilling machine and dynamometer was used for measurement of TF. He choose three levels of cutting speed (450, 751, 1120 m/rev) and three level of feed rate (0.08, 0.125, 0.20 mm/rev). He observed a high cutting speed and lowest feed rate had finest results. He noticed that feed rate was most prompting parameter for TF [5]. Sakthivelet et al. (2015) studied on drilling analysis of polymer composite materials which, made from a basalt and sisal as fiber reinforced material and epoxy as a matrix materials. They took 20% of fiber fraction in composite materials for sisal and basalt fiber. They selected tool diameter (3, 4, 5 mm), spindle speed (300, 600, 900 rpm) and feed rate (0.1, 0.2, 0.3 mm/rev) as an input parameter. From the ANOVA analysis, they found that a drilling diameter was most prompting parameter for TF. They found 3 mm diameter, 300 rpm speed and 0.1 mm/rev feed rate are the optimal parameter from grey relational analysis [6]. Rajmohan et al. (2015) investigated on machining of CFRP with fly ash as particles. They made composite materials form carbon as reinforcement, epoxy as matrix material and fly ash used as filler materials. They took weight fraction fly ash (0.10 %), spindle speed (500, 1250 rpm) and drill diameter (6, 10 mm) as machining parameter. They used coated high speed steel drill bits for drilling operation. They observed feed rate was leading prompting parameter for TF. They found an optimal result as 1250 rpm spindle speed, 10% of fly ash weight fraction, 10 mm drill diameter with 0.04 mm/rev feed rate [7]. Ramesh and Gopinath (2017) studied on drilling analysis on hybrid sisal and glass composite materials. They took spindle speed (1000, 2000, 3000 rpm) and feed rate (0.04, 0.06, 0.08 mm/rev) with drilling diameter (6, 9, 12 mm) as input parameter for drilling operation. They noticed maximum TF at a moderate drill diameter. TF was increasing with increment in feed rate with drilling diameter, whereas TF value drastically decreases as an increment in spindle speed. They concluded that, sisal and glass hybrid composite prefer a low feed rate, high speed with moderate drilling diameter were more suitable for drilling operation [8]. Patel et al. (2018) studied the impact of drill geometry, spindle rotation and feed on TF (TF) in hemp-glass hybrid composites. They utilized stacking arrangement, speed, feed, tool geometry as input parameters. They saw that drill geometry was significant reason for TF [9].

The main goal of this study was to fabricate woven basalt-hemp polyester hybrid composites with aluminum powder as filler material and to study the effect on TF generated during drilling operation.

MATERIALS AND METHODS

I. Fabrication of Hybrid Composite with filler material

The composite materials were fabricated using hand layup method. The woven hemp fiber, basalt fibers and aluminum powder as filler material with polyester resin was used for manufacturing composite materials (Fig.1). The details of prepared hybrid composites are shown in table 1.

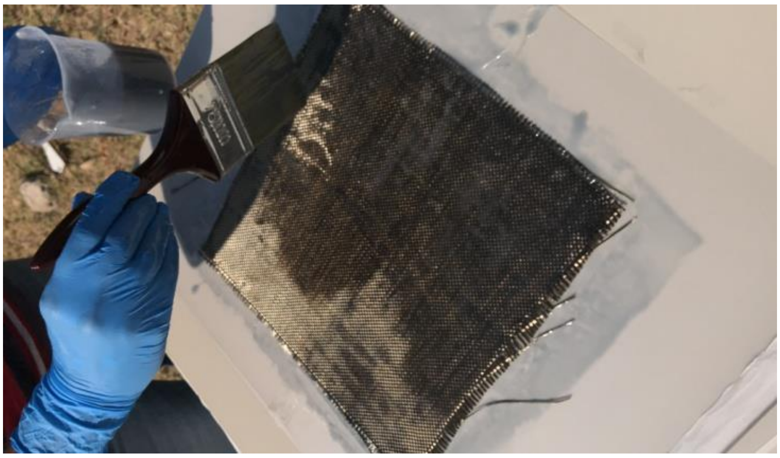

FIGURE 1

HAND LAYUP METHOD

TABLE I

DETAILS OF PREPARED HYBRID COMPOSITES

Sr. No	Plate No.	Stacking sequence	Particle (%)	Weight fraction of fiber (%)
1.	P1	HHBBBBHH	0	53.39
2.	P2	HHBBBBHH	3	44.78
3.	P3	HHBBBBHH	6	41.85

II. Mechanical Characterization

The tests for tensile and flexural strength were carried out on universal testing machine as stated by ASTMD638 and ASTM D790 respectively. The tensile and flexural strength are displayed in figure 2 and figure 3 separately.

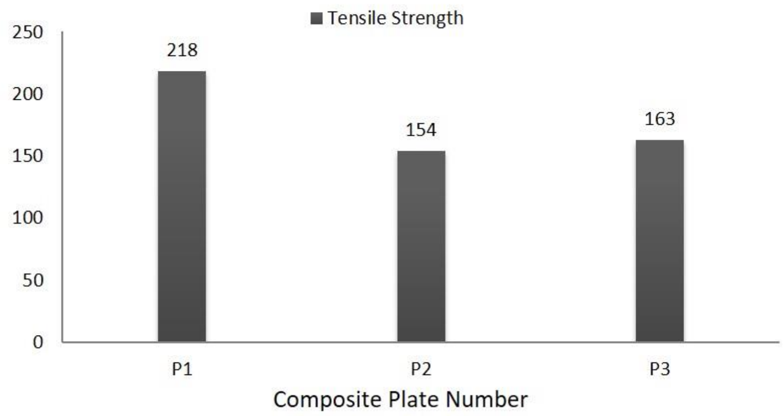

FIGURE 2

TENSILE STRENGTH

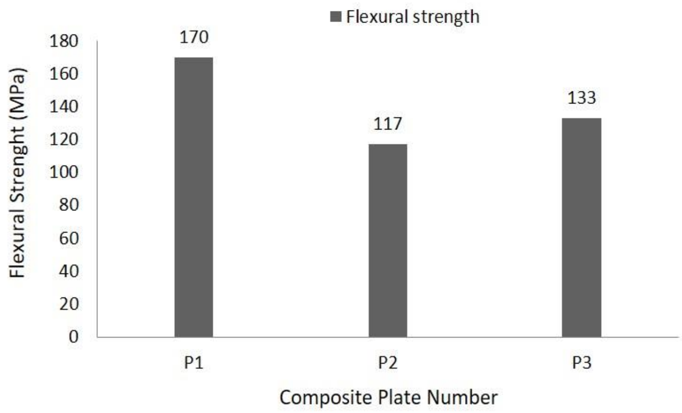

FIGURE 3

FLEXURAL STRENGTH

III. Design of Experiments

Full factorial design gives an all problems combination of set factors. In this study the full factorial design was used for experimental runs. Table 2 shows input parameters that are used in this study.

TABLE II

INPUT PARAMETERS

Factors	Units	Level		
		1	2	3
Particles (%)		0	3	6
Helix angle	degree	20°	30°	40°
Feed Rate	mm/rev	0.06	0.16	0.26
Spindle Speed	rev/min	600	2600	4600

IV. Experimental set up

Fiber reinforcement specimen cut in dimension of 30 x 300 centimeter. Drilling tests were completed on vertical milling machine (VMC). TF was measure by Kistler Dynamometer. The test set up is displayed in figure 4.

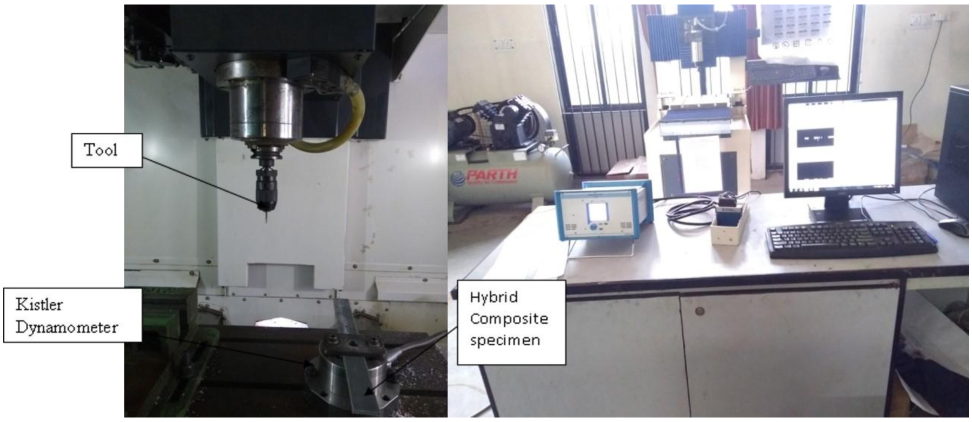

FIGURE 4

EXPERIMENTAL SET UP

RESULTS AND DISCUSSION

Figure 5 shows the main effects plot of particles percentage for TF. In comparison with other parameters, Particles percentage display vital effects on TF. Here, 0% of aluminum particle has maximum amount of TF, which is around 38.00 N. where it drastically declines at the 3% of aluminum particle and slightly increase till 6% of aluminum particle.

Figure 6 shows the main effects plot of helix angle for TF. Helix angle display leading effects on TF. It shows that increasing helix angle then squinty decreasing TF. Here, 20° helix angle has maximum amount of thrust for, which is around 42.00 N. It is obviously noted that 40° helix angle has small amount of TF value. It denoted that TF value saucily decreasing with increasing of helix angle.

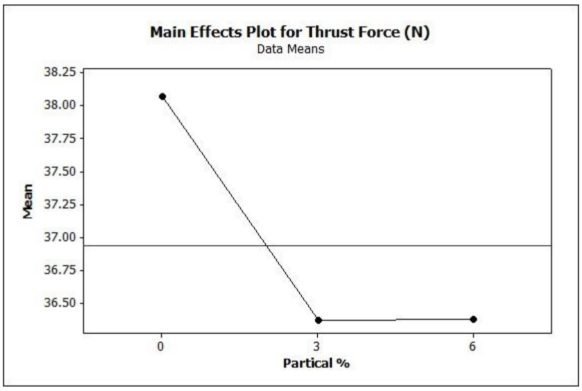

FIGURE 5

IMPACT OF PARTICLES % ON TF (N)

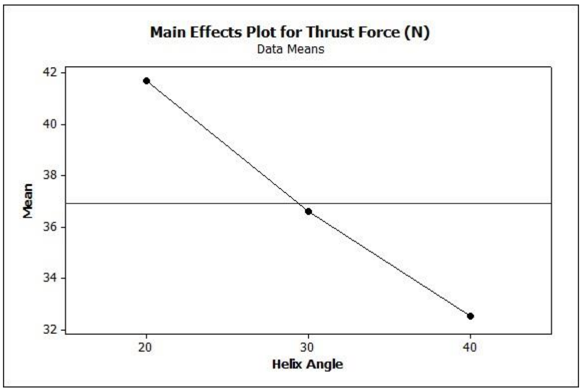

FIGURE 6

IMPACT OF OF HELIX ANGLE ON TF (N)

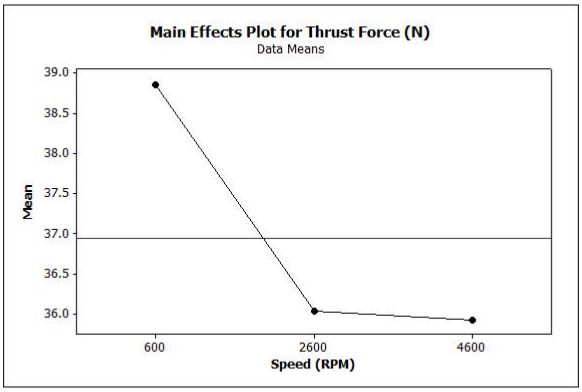

FIGURE 7

IMPACT OF OF SPEED ON TF (N)

Figure 7 demonstrate foremost outcome plan of speed for TF. The chart depict downward trend in speed display engorgement in TF. 600 RPM has highest TF, at 2600 RPM TF has huge downward and at 4600 RPM slightly decrement in TF.

Figure 8 displays main effect plot of feed for TF. The diagram display increase in propensity as well as also rush in feed increases the TF correspondingly. It is noted that maximum TF at 0.26 mm/revolution.

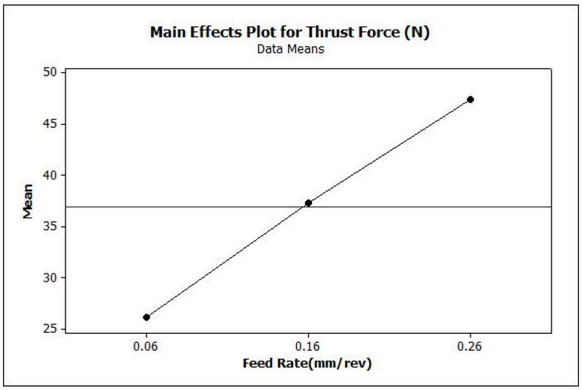

FIGURE 8

IMPACT OF FEED RATE ON TF (N)

TABLE III

ANOVA TABLE FOR TF

Source	DF	Seq SS	Adj SS	Adj MS	F	P	% Contribution
P%	2	51.70	51.70	25.85	1.54	0.22	0.6621
HA	2	1136.1	1136.1	568.06	33.87	0.00	14.549
S (RPM)	2	149.64	149.64	74.82	4.46	0.01	1.9163
FR	2	6166.1	6166.1	3083.0	183.83	0.00	78.968
P%*HA	4	37.23	37.23	9.31	0.55	0.69	0.1192
P%*S	4	22.08	22.08	5.52	0.33	0.85	0.1413
P%*FR	4	49.76	49.76	12.44	0.74	0.56	0.3186
HA*S	4	160.70	160.7	40.18	2.40	0.06	1.0288
HA*FR	4	271.33	271.3	67.83	4.04	0.00	1.7373
S*FR	4	1.39	1.39	0.35	0.02	0.99	0.0089
Error	48	805.03	805.0	16.77			0.4295
Total	80	8851.1		3904.2			
S = 4.09530 R-Sq = 90.90% R-Sq(adj) = 84.84%							

P-value from the ANOVA table (table 3) indicate that affected parameter for TF such as a P, HA, S, FR moreover the interaction parameter are HA and S, interaction HA and FD. From the table, it is evident that FR is most effective parameter for TF. However, HR and other interaction combination affect in complete on thrust for force. The contribution of FR on TF is highest 78.96% then, HA, S and contribute 14.54%, 1.91% and 0.66% respectively. It can be conclude that feed rate most effect on TF while carried out machining operation. However S*FR interaction has very less contribution (0.087%) to a TF. P*S, P*HA, P*FR and S*FR interaction are having lowest amount of contribution for drilling TF.

CONCLUSIONS

In study of drilling analysis, all three sample to be used for drilling operation in set of 27 drills per plate with repeated operation by using DOE. ANOVA analysis was used for understanding of which drilling input parameter influencing with contribution rate for TF. The hybrid composites with 0% of particles showed highest tensile and flexural properties compared to 3% and 6% aluminum particles. Tool Spindle speed, Helix angle and feed rate were chiefly influencing the TF. Interaction among feed rate with helix angle and spindle speed, the higher speed and lower feed by using 40°helix angle with P1 (0% aluminum particles) composites specimens less TF.

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