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

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ABSTRACT - Fiber reinforced composites are risen as a substantial piece of overall industry in the past, currentand furthermore a standout amongst the most well-known engineering materials. In this present work, hybridfiber reinforced composite is made-up by using basalt fiber and hemp fiber, polyester resin and add aluminumparticlesincomposites.Theselaminatesareproducedbyusinghandlay-upmethodwithonestackingsequenceofHHBBBBHHwithvaryingaluminumpercentage(0%,3%and6%).Drillingtestswerecompleted on the composite samples by changing of input factors (Particles percentage, helix angle, feed andspeed), 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 mostpromptingparameter andpercentageinfluenceof machiningparameter.
IndexTerms -Basalt,Hemp,Drilling,DesignofExperiments,ANOVA

I. INRODUCTION

During the previousmanyyears,expanding requestin anassortmentof industries(likeairplane,spaceapparatus, car, marine, and outdoor supplies) for elite execution, lightweight designs have invigorated areas ofstrengthforadevelopmentoffiberbuiltuppolymercomposites.Currently,naturalfibersreinforcedcomposites are developing in composite applications as they have advantages like low cost, low density andease of availability. Also, composites prepared from natural fibers have high-specific stiffness and lightweightcomparedtoprepared fromglass fibers [1]-[2].

Owing to the antagonistic effects of composite materials on the earth, their significant expense and otherominous properties, experts have begun to explore natural fiber-based hybrid composites. By changing type ofmatrix,typeoffibers,lengthoffiber,weightfractionofeachfiberandtheirarrangementinhybridcomposites, the properties of the hybrid composites can be varied [3]. Drilling is broadly employed as it is thegreatest efficient process than altered techniques and there are relatively rare different strategies that can markcircular hole. Drilling is over and over utilized for machining composites, in view of uninhibitedly existingmachinery. Composites are anisotropic materials, so piercing increments definite issues that will stimulus thestrength ofthepart[4].

The tool force generated during drilling is of attention to us as delamination promulgates by the TF. Theeminence of the drilled hole is influenced by TF; it goes about as a vital boundary to evaluate delamination.Different analysts concentratedon theimpactoffeed,speedanddrillgeometryonTF.

Numberofresearchershasstudiedondrillingofhybridcomposites.Chetia(2018)studiedondrillingoptimization for bamboo and basalt fiber. He used bamboo and basalt as fiber materials and epoxy as matrixmaterials to manufacture composite using hand layup method. He selected speed, feed rate as an inputparameter for drilling operation and drilling operation performed in CNC drilling machine and dynamometerwas used for measurement of TF. He choose three levels of cutting speed (450, 751, 1120 m/rev) and threeleveloffeedrate (0.08,0.125,0.20mm/rev).Heobservedahighcuttingspeedandlowestfeed ratehadfinest results.HenoticedthatfeedratewasmostpromptingparameterforTF[5].Sakthiveletetal.(2015)studiedon drilling analysis of polymer composite materials which, made from a basalt and sisal as fiber reinforcedmaterial and epoxy as a matrix materials. They took 20% of fiber fraction in composite materials for sisal andbasalt 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 wasmostprompting parameter for TF. They found3 mm diameter, 300 rpm speed and 0.1 mm/rev feed ratearethe optimal parameter from grey relational analysis [6]. Rajmohan et al. (2015) investigated on machining ofCFRPwithfly ashasparticles. They madecompositematerials form carbon asreinforcement,epoxy asmatrix material and fly ash used as filler materials. They took weight fraction fly ash (0.10 %), spindle speed(500,1250rpm)anddrilldiameter(6,10mm)asmachiningparameter.Theyusedcoatedhighspeedsteeldrill bits for drilling operation. They observed feed rate was leading prompting parameter for TF. They foundan optimal result as 1250 rpm spindle speed, 10% of fly ash weight fraction, 10 mm drill diameter with 0.04mm/rev feed rate [7]. Ramesh and Gopinath (2017) studied on drilling analysis on hybrid sisal and glasscomposite 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 amoderate drill diameter. TF was increasing with increment in feed rate with drilling diameter, whereas TFvalue drastically decreases as an increment in spindle speed. They concluded that, sisal and glass hybridcomposite prefer a low feed rate, high speed with moderate drilling diameter were more suitable for drillingoperation [8]. Patel et al. (2018) studied the impact of drill geometry, spindle rotation and feed on TF (TF) inhemp-glasshybridcomposites. Theyutilizedstackingarrangement,speed,feed,toolgeometry asinputparameters.Theysawthatdrillgeometrywas significantreasonforTF[9].

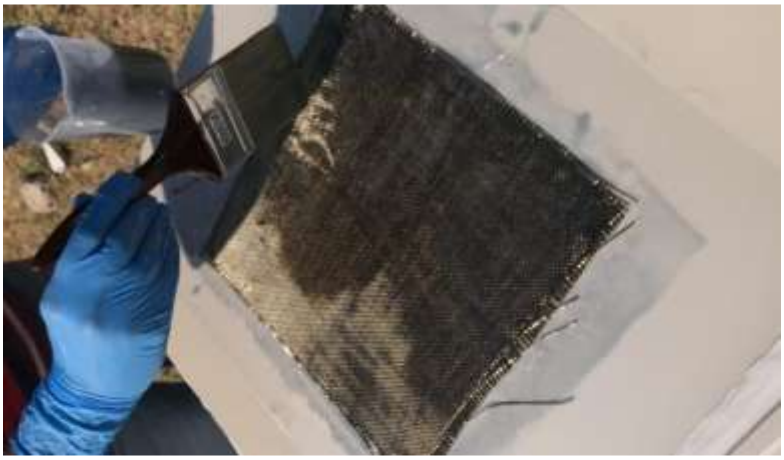
The main goal of this study was to fabricate woven basalt-hemp polyester hybrid composites with aluminumpowder as filler materialand to studythe effectonTFgeneratedduringdrillingoperation.

II. MATERIALS AND METHODS

I. FabricationofHybridCompositewithfillermaterial

The composite materials were fabricated using hand layup method. The woven hemp fiber, basalt fibers andaluminum powder as filler material with polyester resin was used for manufacturing composite materials(Fig.1).The detailsof preparedhybridcomposites areshown intable1.

FIGURE 1HANDLAYUPMETHOD



TABLEI
DETAILSOFPREPAREDHYBRIDCOMPOSITES

Sr.No	PlateNo.	Stackingsequence	Particle(%)	Weightfraction of fiber(%)
1.	P1	HHBBBBHH	0	53.39
2.	P2	HHBBBBHH	3	44.78
3.	P3	HHBBBBHH	6	41.85

II. MechanicalCharacterization
Thetestsfortensileandflexuralstrengthwerecarriedoutonuniversaltestingmachineasstatedby ASTMD638 and ASTM D790 respectively. The tensile and flexural strength are displayed in figure 2 andfigure3separately.

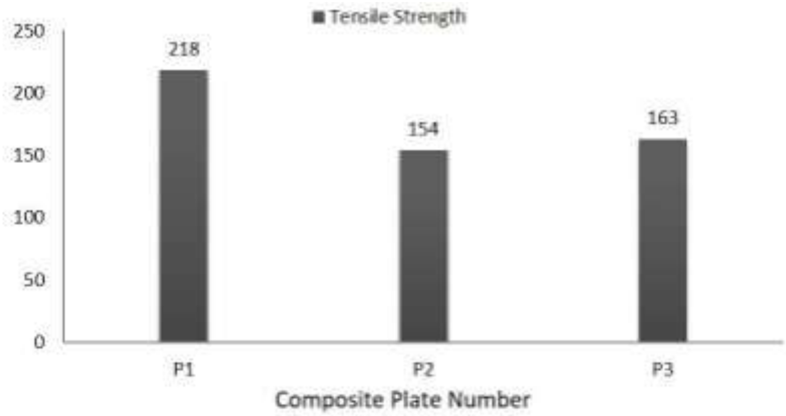


FIGURE 2TENSILESTRENGTH

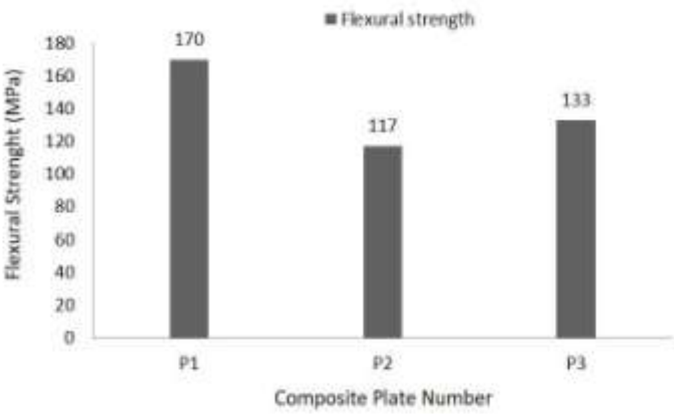


FIGURE 3FLEXURALSTRENGTH

III. Designof Experiments

Full factorial design gives an all problems combination of set factors. In this study the full factorial design wasusedforexperimentalruns. Table2 showsinputparametersthat are used in thisstudy.

TABLE IIINPUTPARAMETERS

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

IV. Experimentalsetup

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

FIGURE 4EXPERIMENTALSETUP

III. 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 till6%of aluminumparticle.

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

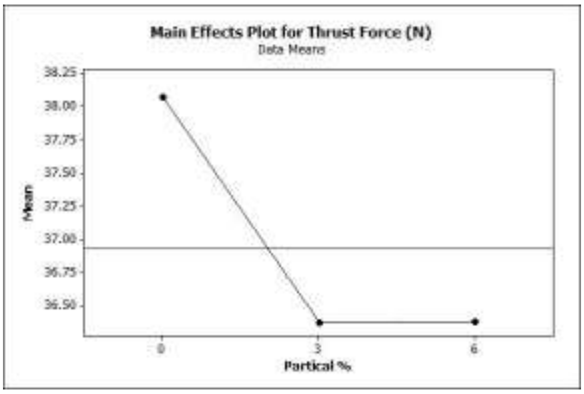


FIGURE5
IMPACTOFPARTICLES%ON TF(N)

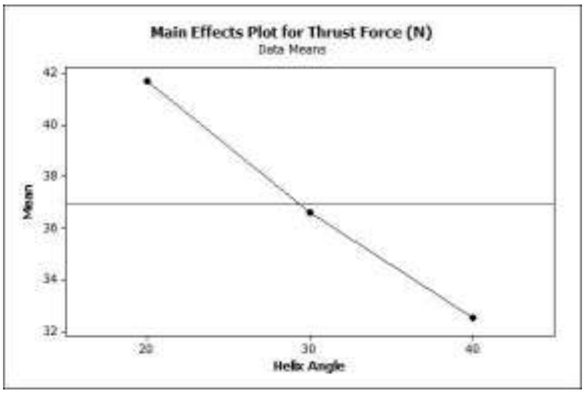


FIGURE6
IMPACTOF OFHELIXANGLEONTF(N)

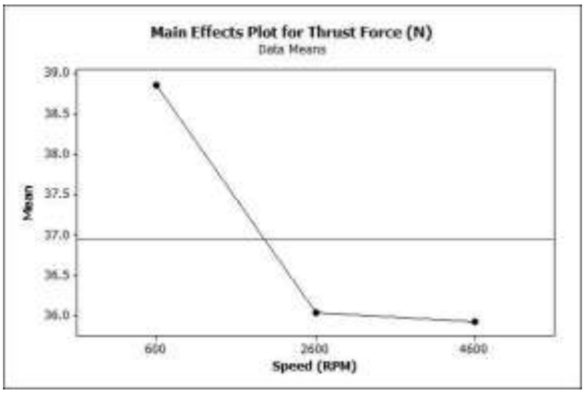


FIGURE7
IMPACTOF OFSPEEDONTF(N)

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

Figure 8 displays main effect plot of feed for TF. The diagram display increase in propensity as well as alsorushin feedincreasestheTFcorrespondingly.Itis notedthatmaximumTFat0.26 mm/revolution.

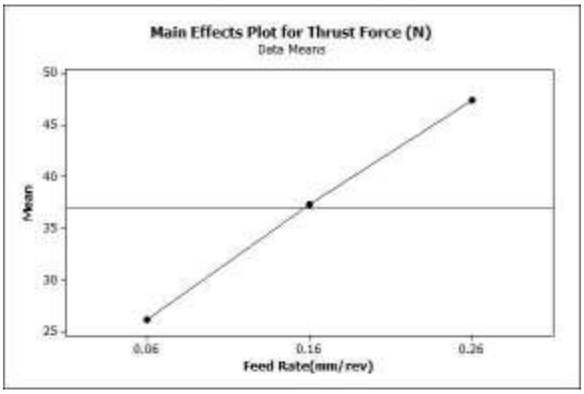


FIGURE8
IMPACTOF FEEDRATE ONTF(N)

TABLE IIIANOVATABLEFORTF

Source	DF	Seq SS	AdjSS	AdjMS	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= 4.09530R-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, FRmoreover the interaction parameter are HA and S, interaction HA and FD. From the table, it is evident that FRis most effective parameter for TF. However, HR and other interaction combination affect in complete onthrust 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 machiningoperation. However S*FR interaction has very less contribution (0.087%) to a TF. P*S, P*HA, P*FR andS*FRinteractionarehavinglowest amountof contribution fordrillingTF.

IV. CONCLUSIONS

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

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