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Determination of Delamination of Milled Natural Fiber Rainforced Composits

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ABSTRACT

Milling composite materials is a very common and an important process used in industry to perform the assembly of composite structures. However, milling composite materials present number of problems such as delamination roughness associated with the characteristics of the material and with the used cutting parameters. In order to reduce these problems a study is present with the objective of evaluating the cutting parameters (cutting velocity and feed rate) and the influence of the fibers (hemp, jute, banana, and glass) under delamination factor (f_d) and surface roughness(R_a). The approach is based on a combination of Design of Experiment (DoM) techniques and on the analysis of variance (ANOVA). A plan of experiment, based on the techniques of factorial design, was performed milling with cutting parameters in various hand lay-up FRP's (Hemp Fiber Reinforced Plastics, Jute Fiber Reinforced Plastics, Banana Fiber Reinforced Plastics and Glass Fiber Reinforced Plastics) using cented carbide(K10) end drill. The objective was to establish a correlation between cutting velocity and feed rate with the delamination and roughnees in hemp , jute, banana and glass fiber reinforced laminates. The correlation was obtained by multiple linear regression. Finally, confirmation tests were performed to make a comparison between the results form the mentioned correlation.

NTRODUCTION

The word "composite" means two or more distinct parts physically bounded together". Thus, a material having two more distinct constituent materials or phases may be considered a composite material. Fiber-reinforced composite materials consist of fiber of high strength and modulus embedded in or bonded to a matrix with distinct interfaces (boundary) between them. In this form, both fiber and matrix retain their physical and chemical identities, yet they produce a combination of properties that cannot be achieved with either of the constituents acting alone. In general, fiber are the principal load-carrying members, while the surrounding matrix keeps them in the desired location and orientation, acts as a load transfer medium between them, and protects them from environmental damages due to elevated temperatures and humidity etc.

The properties that can be improved by forming a composite material include strength, stiffness, corrosion resistance, wear resistance, attractiveness, weight, fatigue life, temperature-dependent behavior, thermal insulation, thermal conductivity, acoustical insulation and electrical insulation. Naturally, neither all of the properties are improved at the same time nor is there usually any requirement to do so.

Composite materials have a long history of usage. Their beginnings are unknown, but all recorded history contains references to some form of composite material. For example, straw was used by the Israelites to strengthen mud bricks. Plywood was used by the ancient Egyptians when they realized that wood could be rearranged to achieve superior strength and resistance to thermal expansion as well as to swelling owing to the presence of moisture.. More recently, fiber reinforced resin composites that have high strength-to-weight and stiffness-to- weight ratios have become important in weight-sensitive applications such as aircraft and space vehicles.

FABRICATION OF COMPOSITE SPECIMEN

Composite specimens are prepared using variour natural fiber (hemp, jute, and banana) and glass fiber reinforcements.

The mould is prepared on smooth ceramic tile with rubber shoe sole to the required dimension. Initially the ceramic tile is cleaned with shellac (NC thinner) a spirituous product to ensure clean surface on the tile. Then mould is prepared keeping the rubber sole on the tile. The gap between the rubber and the tile is filled with mansion hygienic wax. A thin coating of PVA (polyvinyl alcohol) is applied on the contact surface of specimen, using a brush. The resulting mould is cured for 24 hours.

Hand lay up method is adopted to fill the prepared mould with general-purpose polyester resin. ECMALON 4411 is an unsaturated polyester resin of ortho-phthalic acid grade with clear colourless or pale yellow colour. Its viscosity is 500-600 CPS (Brookfield Viscometer) and specific gravity is 1.13 grams/c.c. at 25^0 C. Acid Number (mg KOH/g) is 22 and monomer content is 35%. Cobalt accelerator and MEKP catalyst are added for curing the resin at room conditions. The quantity of each of these materials, added is 1.5% of the volume of resin. The gel time is found to be about 20 min. The accelerator is mixed thoroughly with the resin and the catalyst is added later to avoid explosion. A thin coating of the resin is applied to the mould surface and known weight of the fiber is placed along the longitudinal direction of the specimen so that the fibers are oriented 0^0 90^0 along the axial direction of the specimen. Then the rest of the mould is filled with the resin making sure that there are no air gaps in the mould. Then, a thin Polyethylene paper of 0.2mm thick is placed on the rubber mould. A flat mild steel plate is placed on the mould and a pressure of $0.05MN/m^{-2}$ is applied and left for 24 hours to cure. Later the specimen is removed and filed to obtain the final dimensions. The specimen is cleaned with NC thinner and wiped off to remove dirt particles.

INDUSTRIAL APPLICATIONS OF COMPOSITE MATERIALS:

It is impossible to list all the commercial and industrial applications of fiber-reinforced composites. The major structural application areas are aircraft, space, automotive, sporting goods, and marine engineering. The major structural applications for fiber-reinforced composites are in the field of military and commercial aircraft. Ever since the production application of boron fiber-reinforced epoxy skins for F-14 horizontal stabilizers in 1969, the use of fiber-reinforced polymers has experienced a steady growth in the aircraft industry

Applications of fiber-reinforced composites in the automotive industry can be classified into three groups: body components, chassis components, and engine components. The hood, door panels etc. are some of the exterior body components, which are made up of composite materials. The radiator supports, bumper reinforcement beams, and doorframes are some of the interior components made up of composite materials.

Over the last few years, fiber-reinforced polymeric composites have experienced a substantial usage in the sporting goods industry. The sport goods like, Tennis rockets, Racket ball rackets, Gold club shafts, Fishing rods, Bicycle frames, Snow and water skis, Ski poles, pole vault poles, Hockey sticks, Sail boats and kayaks, Oars, paddles, Canoe hulls, Surfboards, Arrows, Archery bows, Javelins, Helmets etc. are made of fiber-reinforced polymeric composites.

Reinforced composites have been found very good in Chemical industry because of their corrosive-resistance, low maintenance cost, chemical-resistance and cheaper than conventional non-corrosive metals like stainless steel.

Composite materials occupied considerable area in the building industry for making parts like corrugated sheets, windows, swimming pool, cladding the columns and exterior walls, etc. High performance fiber composites will go a long way in the equipment industry. Fiber reinforced plastics have proved effective in bulkheads, blower housings, base pans and enclosure of air cooler, computer, duplicating machines, etc. The primary components of water turbine and windmills are now a day made of composites.

Design of experiment and experimental

A scientific approach to planning of experiments must be incorporated in order to perform the experiment most effectively. Design of experiment is a statistical technique which allows to run the minimum number of experiments to optimize the product or process.

The input parameters are presented in table 1.Influence of each factor on delamination and roughness is found out by analyzing the results using software Design Expert. Model equations have been developed between F_d V_S machining parameters and R_a V_S machining parameters using Minitab software.

Table 1. Levels of the variables used in the experiment.

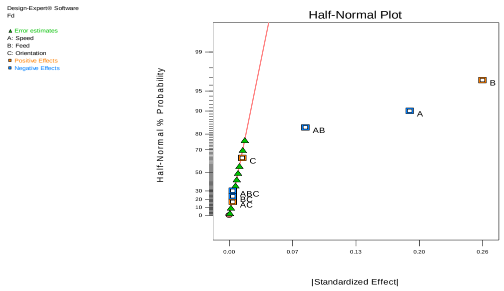
Name	*Type*	*Low*	*High*
Speed rpm(A)	*Factor*	*1000*	*2000*
Feed Mm/min(B)	*Factor*	*100*	*300*
Orientation Degrees(C)	*Factor*	*0^0*	*90^0*

Experimental results and discussion

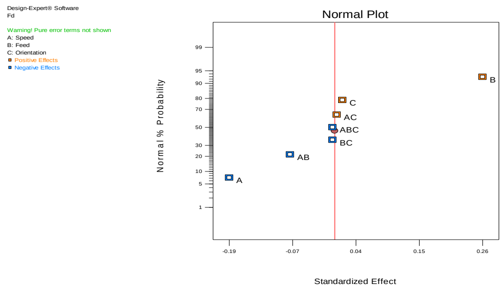
Table 2 and 3 shows the experimental results and the analysis of the delamination and roughness of milled composites.

The half normal probability and normal probability chart for delamination and roughness are shown in the figure (1-2-3-4).

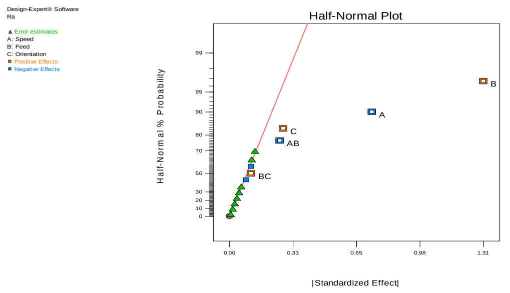
From the analysis it can be noticed that the delamination and roughness factors increases as the feed is elevated but decreases as the spindle sppe is increased. In addition to that, under the highest spindle speed (2000 rpm) the delamination and roughness factors seems to be less sensitive the feed .This behaviour may be explained by the cutting temperatures, i.e., at lower temperatures are observed and delamination takes place as a result of the stresses imposed by shearing, however, at a spindle speed of 2000 rpm. Comparing the effects of the hemp, jute, banana, glass fibers tested, one can conclude that the four fibers provides higher delamination and roughness factors values at low cutting speed and high feed rate.



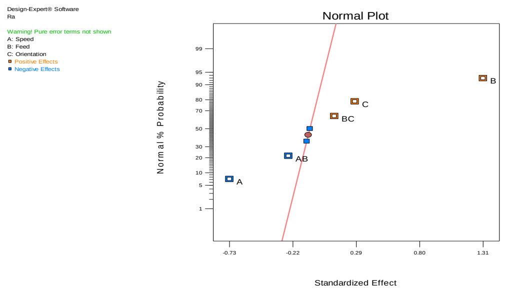
Figerr 1. half normal probability chart for delamination for jute



Figerr 2.Normal probability chart for delamination for jute



Figerr 3. half normal probability chart for roughness for jute



Figerr 4. Normal probability chart for roughness factor for jute

Table 2.Plan of experiment and obtained delamination factors and roughness factors

Std	Run	Factor 1 A:Speed rpm	Factor 2 B:Feed mm/min	Factor 3 C:Orientation degree	Response 1 Fd	Response 2 Ra
2	1	1000.00	100.00	0.00	1.29	2.28
12	2	2000.00	100.00	90.00	1.32	1.62
9	3	1000.00	100.00	90.00	1.2	2.74
7	4	2000.00	300.00	0.00	1.42	3.65
14	5	1000.00	300.00	90.00	1.72	5.02
4	6	2000.00	100.00	0.00	1.21	1.48
13	7	1000.00	300.00	90.00	1.68	4.62
5	8	1000.00	300.00	0.00	1.56	4.77
15	9	2000.00	300.00	90.00	1.42	3.78
3	10	2000.00	100.00	0.00	1.19	1.4
10	11	1000.00	100.00	90.00	1.3	2.42
8	12	2000.00	300.00	0.00	1.36	3.74
16	13	2000.00	300.00	90.00	1.49	3.97
11	14	2000.00	100.00	90.00	1.25	1.5
1	15	1000.00	100.00	0.00	1.34	2.01
6	16	1000.00	300.00	0.00	1.62	4.49

Response 1 Fd (delamination)

ANOVA for selected factorial modelAnalysis of variance table [Partial sum of squares]

Source	Sum of Squares	df	Mean Square	F Value	p-value Prob > F
Model	0.000	0			
Residual	0.44	15	0.029		

Lack of Fit	*0.42*	*7*	*0.061*	*30.79*	*< 0.0001*	*significant*
Pure Error	*0.016*	*8*	*1.969E-003*			
Cor Total	0.44	15				

Response 2 Ra (roughness)

ANOVA for selected factorial modelAnalysis of variance table [Partial sum of squares]

Source	Sum of Squares	df	Mean Square	F Value	p-value Prob > F	
Model	25.13	7	3.59	119.97	< 0.0001	significant
A-Speed	*3.25*	*1*	*3.25*	*108.59*	*< 0.0001*	
B-Feed	*21.60*	*1*	*21.60*	*721.93*	*< 0.0001*	
C-Orientation	*0.21*	*1*	*0.21*	*7.15*	*0.0282*	
AB	*6.006E-003*	*1*	*6.006E-003*	*0.20*	*0.6660*	
AC	*0.026*	*1*	*0.026*	*0.88*	*0.3750*	
BC	*8.556E-003*	*1*	*8.556E-003*	*0.29*	*0.6073*	
ABC	*0.023*	*1*	*0.023*	*0.78*	*0.4037*	
Pure Error	0.24	8	0.030			
Cor Total	25.37	15				

CONCLUSIONS

An experimental analysis for milling induced delamination and roughness associated with various machining parameters (speed and feed rate) and natural fibers(hemp fiber, jute fiber, banana fiber, and glass fiber) is presented in this study. The following conclusions can be drawn from the above investigation:

[1] As seen in this study, the Design of experiment method provides a systematic and efficient methodology for the design optimization of the process parameters resulting in the minimum delamination and roughness with far less effect than would be required for most optimization techniques.

[2] Based on the results, the optimal parameters for the minimum delamination are the feed rate at 100 mm/min ,the cutting speed at 2000 rpm and fiber orientation at 0^0

[3] Similarly. the optimum parameters for the minimum roughness are the feed rate at 100mm/min. the cutting speed at 2000rpm at fiber orientation at 0^0

[4] The feed rate and cutting speed are seen to make the largest contribution to the delamination and roughness effects. Generally, the use of high cutting speed and low feed favor the minimum delamination and roughness of the chosen fiber reinforced composites.

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