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OPTIMIZATION OF DRILLING PARAMETERS FOR DELAMINATION FACTOR IN OF HYBRID FIBER REINFORCED POLYMERS

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Abstract: The natural fibres and fillers from renewable natural resources offer the potential to act as a reinforcing material for polymer composite material alternative to the use of natural fibres and other man-made fibres. Among various natural fibres and fillers like aramid, wheat straw, sisal fiberwood powder, jute, hemp etc. are the most widely used natural fibres and fillers due to its advantages like easy availability, low density, low production cost and reasonable physical and mechanical properties. This research work presents the effects of natural fillers, hybrid composite structure is formed. Hybrid fiber reinforced polymer (HFRP) composite is a novel methodology in fiber reinforced polymer (FRP). A Laminate is prepared by stacking of alternative layers of carbon fiber reinforced jute and sisal reinforced composite making a laminate thickness of 10mm. Experiments were conducted HFRP composite for full factorial design to evaluate delamination factor at different drilling parameters, such as drill bit diameter, feed rate and cutting speed. Utilizing full factorial design and ANOVA approach the drilling parameters will optimize.

Index Terms **- Optimization, Drilling, Hybrid FRP, Delamination, Polymer.**

I. Introduction

The growing demand in the world for more adaptable materials suitable for various applications led to the development of polymeric composites with natural fibre as reinforcing agents. Synthetic fibers are not environment friendly because its create environmental pollution so this has shifted the focus on utilizing natural fibers, capitalizing on their advantages of being environment friendly, economical, lower densities, higher filling levels, environment friendly and renewable nature, recyclability. Natural fibers can be used as alternatives of synthetic fibers, e.g. aramid, glass, carbon, etc. Natural fibers such as sisal fiber, jute, hemp, aramid, corncob, luff etc. have satisfactory mechanical properties make them an attractive ecological alternative to synthetic fibers used for the manufacturing of composites.

The matrix also serves to protect the fibers from environmental damage before, during and after composite processing. When designed properly, the new combined material exhibits better strength than would each individual material. Composites are used not only for their structural properties, but also for electrical, thermal, tribological, and environmental applications. Natural fibers have superior mechanical properties such as flexibility, stiffness and modulus compared to glass fibers. The natural fibers such and sisal fiber are replacing the glass and other synthetic environment friendly and user-friendly materials and have very good elastic properties. Sisal fiber and jute fiber is the best reinforcement because of low cost, low density, high specific strength, no health hazards and finding applications in making of ropes, mats, carpets, fancy articles etc. In addition to this, adding sisal fiber etc., mechanical properties and water resistance of the hybrid composites. Sisal fiber contains 85-90 % organic matter such as cellulose, lignin etc. and rest mineral components such as silica, alkalis and trace elements.

Sisal fibers unusually high in ash compared to other biomass fuels in the range 10-20%. The ash is 87-97% silica, highly porous and light- weight, with a very high external surface area. Presence of high amount of silica makes it a valuable material for use in industrial application. Other constituents of Sisal fiber(RHA), such as $K2O$, $Al2O3$, CaO, MgO, $Na2O$, $Fe2O3$ are available in less than 1 %.aramid fiber having bulk density of 96-160kg/m3, oxygen 31-37%, nitrogen 0.23-0.32%, sulphur 0.04-0.08%.It is noted that cellulose is the main constituent of plant fibers followed by hemicelluloses and lignin interchangeably and pectin respectively. Cellulose is also the reinforcement for lignin, hemi cellulose and Pectin. Jutefiber and sisal fiberhave 60-70% and cellulose, hemi cellulose 6-19%, lignin 5-10%, pectin 3-5%, ash 1-3 %.

II. Experimental Materials and Methods

Raw materials used in this experimental work are natural fiber, jute, sisal, epoxy resin and hardener. The epoxy resin employed in the present study is LY556 and the hardener is HY951 was purchased from M/s Javanthee Enterprises, Chennai. Epoxy LY556 / Hardener HY951 (Room Temperature cure type): LY556 resin is a bi-functional epoxy resin ie., Diglycidyl Ether of Bisphenol-A (DGEBA) and HY951 is an aliphatic primary amine, viz., TriethyleneTetramine – TETA. Mixing ratio is 10:1 w/w. In the present work Hardener (araldite) HY 951 is used. This has a viscosity of 10-20 poise at 250C.

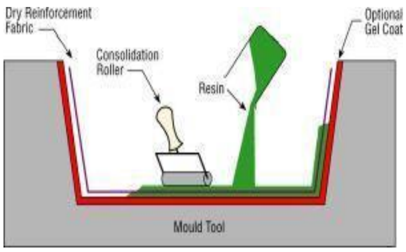

Fig. 2.1 Hand Lay-up technique

Table 2.1 Properties of Sisal Fiber

Sl No	Properties	Sisal Fiber
1	Density (kg/m^3)	1200
2	Flexural modulus (GPa)	2-5
3	Tensile strength (MPa)	23
4	Young's modulus (GPa)	3.4878

Table 2.2 Comparison of Material properties

Properties	Sun hemp	Epoxy resin	flax	sisal
Density (Kg/m^3)	1500	1250	1300	1200
Youngs modulus (GPa)	42	38	38	41
Poisson ratio	0.3	0.28	0.29	0.32
Tensile strength (MPa)	86	54	110	96

The composites sheets were fabricated from jute fiber, with (jute) and resin matrix. The resin used was epoxy resin. The weight fraction of composites was maintained at 25% fiber and 75% resin. Number of plies for each fiber taken was two i.e. total number of plies used in natural fibre composite are four. One natural natural fibre composites are made. After the natural fibre composites fabrication cutting of the specimen is done in the desired shape to test the mechanical properties of the natural natural fibre composite fiber. The tensile testing of the samples were done by UTM (universal testing machine). This apart, hardness, impact and density are done by sohr D, Charpy machine.

Designation of compositions in the composites is Jute fiber (10%) + sisal fiber(15%)+ Epoxy resin(75%). Experiment designed by use of design of experiment is design experiment in such way, so that number of experiment required for prediction of response is reduced without compromise quality of experiment.

Table 2.3 Control Factors and Their Range of Setting for the Experiment

Control Variable	SPEED	FEED RATE	DEPTH OF CUT	TOOL
Level-I	400	0.4	2	1
Level-II	652	0.6	4	2
Level-III	1060	1	6	3

III. Results and discussion

In this work L9 orthogonal design is followed. The possible controllable parameters of drilling machine are speed, depth of cut, feed rate, drill diameter, tool material composition of work piece. From the above a full factorial experimental set consisting of speed, depth of cut, feed rate as process parameters considering each at 3- levels with all possible combinations leading to a total of 9 experiments is chosen. The process parameters range is specified in Table 4.4. Selection of the particular orthogonal array from the standard OA depends on the number of factors, levels of each factor. Based on the above values and the required minimum number of experiments to be conducted (9), the nearest OA fulfilling this condition is L9 (313). It can accommodate a maximum three number of control factors, each at three levels with 9 experiments. All 9 experiments are conducted at j20 spindle head. The specimen is weighed before and after the experimentation. The ratio of the volume difference to total cutting time gives the volumetric material removal rate.

Table 3.1 Experiment design with expected range

SL. NO	Speed (RPM)	Feed rate (mm)	Depth of cut (mm)	TOOL dia
1	400	0.4	2	1
2	400	0.6	4	2
3	400	1	6	3
4	652	0.4	4	3
5	652	0.6	6	1
6	652	1	2	2
7	1060	0.4	6	2
8	1060	0.6	2	3
9	1060	1	4	1

The equipment used for machining the samples is DWJ drilling machine equipped with KMT model of surface roughness with the designed speed of 400-1060 rpm andfeed rated 0.4-1mm/rev and depth of cut from 2-3mm. All the cutting experiments were performed on C45 material and are single pass experiments conducted by choosing Speed 652 and the impact angle of 90.The surface roughness was measured with the profile projector of magnification x10 and a least count of 0.02 mm. surface roughness of each cut was measured at three different places for accurate evaluation and the specimen is weighed before and after the experimentation.

Table 3.2 Results for SR and MRR

S.No	MRR(mm^3/min)	SR(µm)	S/N ratio of SR	S/N ratio of MRR
1	2224	0.60	-66.9427	-4.43697
2	2526	0.78	-68.0487	-2.15811
3	2940	0.79	-69.3669	-2.04746
4	2400	0.62	-67.6042	-4.15217
5	2700	0.78	-68.6273	-2.15811
6	2100	0.69	-66.4444	-3.22302
7	2654	1.02	-68.478	0.172003
8	2015	0.83	-66.0855	-1.61844
9	2327	0.92	-67.3359	-0.72424

The values of MRR observed are transformed into S/N ratio values to find out the optimum combination of parameters for response variable. For any given material during machining process, the removal rate has the objective of "higher is better" characteristic. To maximize the quality characteristic of MRR, the value of S/N ratio is analyzed based on Equation using Minitab 18 statistical software. The MRR is shown in Table 6.4. MRR versus cutting speed, feed rate, depth of cut and insert are plotted. These plots are generated to form the value of S/N ratio of MRR as per Table 6.4 in Minitabe-18 statistical software andit is graphically represented.

Figure 5.2 implies that the optimum combination of each process parameter for MRR rate is met at high Drilling speed (A3), high feed rate (B2), high depth of cut (C3) and tool (D2). The S/N ratio of the MRR for every level of each machining parameter can be computed in Minitab 18. Results reveal the effectiveness of each parameter on the response. Further, the mean MRR is analysed with the same software and shown in Table 5.4.

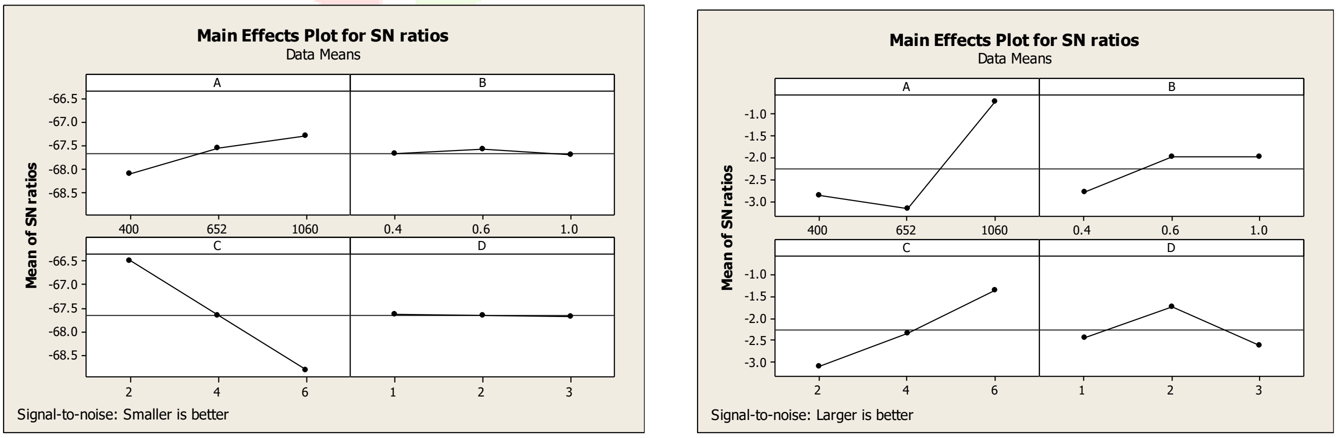

Figure 3.1 Mean effect plot of MRR Vs cutting speed, feed, doc and insert and Mean effect plot of surface roughness Vs cutting speed, feed, doc and insert

IV. Conclusion

From the test results it is concluded that the present work consists of two main phases. The first phase has aimed to develop high quality hybrid polymer composite (jute-sisal). This is done by using hand layup method. The study focuses on the effect of drilling parameter with main consideration being the tool life for drilling process of the polymer composite. Optimizing the process parameter of drilling with single performance responses like surface roughness and material removal is done. The optimal parameters for the drilling of hybrid fiber laminated composites has been studied. The most significant parameter for lower surface roughness value is velocity and tool type. Speed, feed and depth of cut also have significant importance. Optimum surface roughness is obtained for the following parametric combinations: Speed (A) at level 3 (300 m/min), feed (B) at level 3 (1 mm/rev), Depth of cut (C) at level 3 (6 mm) and Insert (D) at level 3 (sample c). Material Removal Rate (MRR) higher material removal rate value is affected the most by cutting speed followed by feed, depth of cut and tool type. Optimum material removal rate is obtained for the following parametric combinations: Speed (A) at level 3 (1060 m/min), feed (B) at level 3 (1 mm/rev), depth of cut (C) at level 3 (6 mm) and tool (D) at level 2 (tool 2).

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