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Optimization of Drilling Parameters on Delamination Based on Taguchi Method in Drilling of Natural Fiber Reinforced (Agave) Composite

K. S. K. Sasikumar

Abstract- Agave is the one of the abundantly available plant in India. The wide application of agave reinforced composite plate necessitate the joining of two plates together. For making such joint drilling of those plates is required. Drilling of natural fiber composites is different from the other metals because of its mechanical properties. The major problem faced in drilling of theses natural fiber composites was delamination of the fiber. This paper studies the effect of the input parameters such as cutting speed and feed and Drill diameter on the delamination induced during drilling. Taghuchi method is used for minimizing delamination induced due to input parameters .This study revealed that the input parameters such as cutting speed and feed rate both are influential in on the delamination. ANOVA is carried out to find the influencing parameters.

Keyword: rilling,Taghuchi,Agave,NFRP,Composite

I. INTRODUCTION

Natural fibers are attractive over man made fibers due to their advantages such as low cost, biodegradability, light weight, renewability, high specific mechanical properties and low density[1, 2]. The natural fiber reinforced composites are environment friendly, and utilized in automobiles, packaging, and consumer products, etc. Applying bark fibers and seed fibers as an alternative for fiber-reinforced composite was explored in the study made by Ashori and Bahreini[3]. The tensile, compressive, flexural, impact strength and water absorption of the alkali treated continuous Agave fibre reinforced epoxy composite (TCEC) and untreated continuous Agave fibre reinforced epoxy composite (UTCEC) were analyzed [4]. In both analyses the TCEC has shown good performance than UTCEC. The fine structure of *Agave americana* L. fiber was examined using scanning electron microscopy (SEM) analysis[5]. It was suggested that the delamination growth during drilling can be linked directly to the modification in the thrust force during exit of the drill bit. Koplev et al. [6] analyzed the principal cutting mechanisms with reference to arrangement of fiber and geometry of tool. Takeyama and Lijima [4] analyzed the surface roughness while machining of GFRP composites. The found that higher cutting speed yields more damages on the machined surface. Hocheng and Tsao elucidated the mechanisms of formation of push down delamination and justified the dependence of extent of delamination on the feed rate[7].

Major drilling characteristics of Aramid fiber-reinforced plastics are experimentally predicted[8]. It was found that the chip looks highly deformed and tends to smear on the tool. Forces and, mainly, torque are more altered by the tool diameter than by the feed rate and cutting speed. This paper studies the delamination characteristics of agave fiber reinforced composite plate made using hand layup technique.

II. MATERIALS AND METHODS

2.1 Materials

In this experimental study, Agave fiber extracted using water retting process was used as reinforcement and polyester resin was used as matrix. The composite plate of 300x300x5 mm was made using hand layup method. The drilling tests were carried out on a LMILL vertical machining center. The agave plant is shows in figure.1.The extracted fiber is shown in figure.2. The properties of the extracted agave fiber is list in the Table.1.Table 2 give the properties of the polyester resin.

Figure. 1 Agave plant

Figure. 2 Extracted Agave fiber

Table 1 Properties of agave fiber

Parameters	Values
Load	6.92 N

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* Correspondence Author
K. S. K. Sasikumar, Assistant Professor, Department of Mechanical Engineering, Kongu Engineering College, Perundruai, Erode-638052, Tamil Nadu, India.

Stress	384.66 MPa
Strain (%)	49.64
Initial Modulus	61.01 CN/tex

Table 2 Properties of polyester

Parameters	Values
Density	1.2-1.6 g/cc
Poisson ratio	0.2-0.33
Tensile strength	60-135 MPa
Compressive strength	18000-40000 psi
Izod impact	0.3-10
Specific gravity	1.3-1.5

2.2 Delamination factor

The hole quality has to be retained in proper manner in drilling of composite materials, which is the main significance in production. The hole quality is measured by surface finish, roundness error, hole diameter with tolerance, etc. Delamination is a damage phenomenon, which happen due to the anisotropy and brittleness of the composite materials. The damage around the holes (delamination) is measured and analyzed in this study by using digital scanner. The delamination factor (Fd) is quantified by the following relation.

$$A_d = \frac{\text{Maximum dimension of the delamination zone}}{\text{Hole diameter}}$$

$$A_d = \frac{D_{max}}{D}$$

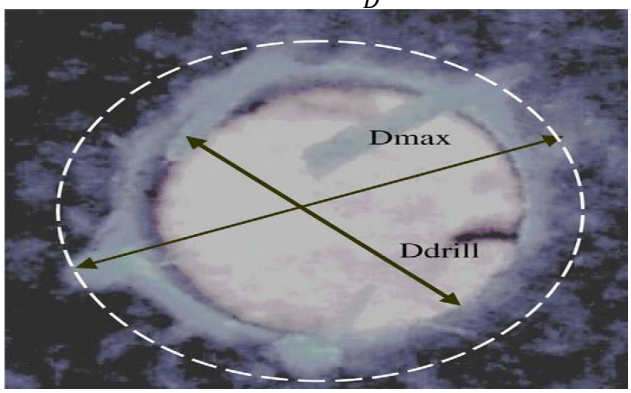

Figure 2. Scheme of delamination factor[9]

2.3 Taghuchi optimization method

The factors considered in this study were cutting speed, feed rate and drill diameter. The parameters and the levels are shown in the table.3.The response variable taken for this study is delamination factor. Taguchi's L9 orthogonal array was utilized in this study which consists of three column and nine rows. Table 4 shows the orthogonal array. For the optimization smaller the better characteristics are considered.

Table 3 Parameters level

Levels of Drilling parameters	Cutting speed (m/min)	Feed rate (mm/rev)	Drill diameter (mm)
1	5	1	6
2	10	2	8
3	15	3	10

Table 4 orthogonal array

Run Order	CS	FR	DD
1	5	1	6
2	5	2	8
3	5	3	10
4	10	1	8
5	10	2	10
6	10	3	6
7	15	1	10
8	15	2	6
9	15	3	8

III. RESULTS AND DISCUSSION

Drilling test was performed with parameters from the orthogonal array. The drilled hole was imaged using digital scanner. The delamination zone was covered with circle. The ratio of the actual hole and delamination zone hole was found and tabled. The sample drilled hole is shown in figure 3.

Figure 3. Agave fiber reinforced composite drilled hole

The effect of process parameters on the delamination factor values was shown in Figure 4. The delamination factor increases with increase in cutting speed and feed rate. The drill diameter plays less significant role in affecting delamination factor. So to get the lesser delamination Cutting speed and feed rate should be kept at low level. ANOVA is a statistics based decision-making tool for predicting any differences in the average performance of groups of items tested. ANOVA assists in formally testing the significance of all main factors and their interactions by relating the mean square against an estimate of the experimental errors at specific confidence levels.

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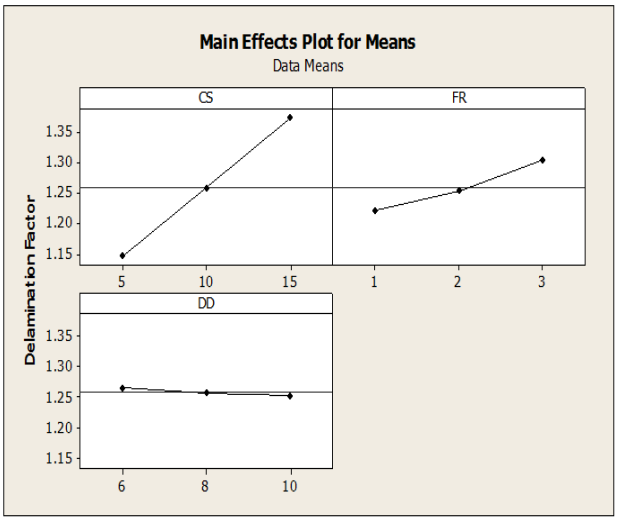

Figure 4. Mean effect plot for delamination

The importance of the drilling parameters relative to the delamination factor was explored to find the optimum combinations of the cutting parameters by using ANOVA. The analysis of variance (ANOVA) was used to study the effect of drilling parameters on the delamination factor. Tables 5 provide ANOVA results for delamination factor in drilling Natural finer reinforced composites. With respect to the p value the order of influencing parameters are determined. The factors which as p value less that 0.005 are considered as significant factors. From the ANOVA table it can be seen that the most influenced parameter is the cutting speed followed by feed rate and drill tool diameter.

Table 5 ANOVA for Delamination factor

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Cutting speed (CS)	2	0.077089	0.077089	0.038544	495.57	0.002
Fedd rate (FR)	2	0.010556	0.010556	0.005278	67.86	0.015
Drill diameter (DD)	2	0.000289	0.000289	0.000144	1.86	0.35
Error	2	0.000156	0.000156	0.000078		
Total	8	0.088089				

IV. CONCLUSION

This study analyzed the effect of drilling parameters such as cutting speed, feed rate and point angle on the delamination factor which needs to be reduced in hole making operation. ANOVA study revealed the order of influence of the parameters as Cutting speed and feed rate. Cutting speed has the F value a 495.57. Feed rate has the F value as 67.86. According to this study the delamination is low at the low level factor setting for cutting speed and feed rate. The drill diameter has least effect on the delamination.

REFERENCES

1. Nirmal, U., et al., *Effect of betelnut fibres treatment and contact conditions on adhesive wear and frictional performance of polyester composites.* Wear, 2010. **268**(11): p. 1354-1370.
2. Gellert, E. and D. Turley, *Seawater immersion ageing of glass-fibre reinforced polymer laminates for marine applications.* Composites Part A: Applied Science and Manufacturing, 1999. **30**(11): p. 1259-1265.
3. Ashori, A. and Z. Bahreini, *Evaluation of calotropis gigantea as a promising raw material for fiber-reinforced composite.* Journal of Composite Materials, 2009. **43**(11): p. 1297-1304.
4. Mylsamy, K. and I. Rajendran, *The mechanical properties, deformation and thermomechanical properties of alkali treated and untreated Agave continuous fibre reinforced epoxy composites.* Materials & Design, 2011. **32**(5): p. 3076-3084.
5. [Chaabouni, Y., et al., *Morphological Characterization of Individual Fiber of Agave americana L.* Textile research journal, 2006. **76**(5): p. 367-374.
6. Koplev, A., A. Lystrup, and T. Vorm, *The cutting process, chips, and cutting forces in machining CFRP.* Composites, 1983. **14**(4): p. 371-376.
7. Ho-Cheng, H. and C. Tsao, *Analysis of delamination in drilling composite materials using core drill.* Australian Journal of Mechanical Engineering, 2003. **1**(1): p. 49.
8. Veniali, F., A. Di Ilio, and V. Tagliaferri, *An Experimental Study of the Drilling of Aramid Composites.* Journal of Energy Resources Technology, 1995. **117**(4): p. 271-278.
9. Kilickap, E., *Optimization of cutting parameters on delamination based on Taguchi method during drilling of GFRP composite.* Expert Systems with Applications, 2010. **37**(8): p. 6116-6122.

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