IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 3 Issue 6, June 2016
ISSN (Online) 2348 – 7968 | Impact Factor (2015) - 4.332
www.ijiset.com

Optimization of Drilling Parameters for Delamination Factor In Of Hybrid Fiber Reinforced Polymers

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Abstract

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 lamina and glass reinforced laminas making a laminate thickness of 4mm. Experiments were conducted HFRP composite for full factorial design to evaluate delamination factor at different drilling parameters, such as drill point angle, feed rate and cutting speed. Utilizing full factorial design and ANOVA approach the drilling parameters were optimized.

Keywords: *HFRP, Delamination Factor, ANOVA, Drilling parameter.*

1. Introduction

Hybrid fiber reinforced polymer (HFRP) composite is an advanced fiber reinforced polymer (FRP) composite that utilized two or more different fibers are used to make a laminate. Advantage of using this composite is that it is possible to improve the failure strain by incorporated high elongation fiber like glass fiber into low elongation fiber such as carbon fiber [1]. Drain grating covers and oil and gas platform are some of the applications HFRP. Holes are constantly required in these applications either for mechanical fastening reason notwithstanding, drilling holes on the fiber reinforced polymer (FRP) composite utilizing traditional drilling draw an incredible it will harm the material's structure because of the unacceptable drilling technique, for example, the choice of consideration as erroneous drill geometry and despicable determination of drilling parameters.

While drilling holes in fiber reinforced due to delamination phenomena structural integrity of the material is reduced resulting poor assembly tolerances which leads to shorter life for the assembly. The effect of delamination is measured by delamination factor. In this paper we optimized the drilling parameters for delamination factor.

2. LITERATURE SURVEY

Composite materials are widely used in many structural applications like an aerospace, land transportation and consumer goods. Fibre reinforced composites have been widely successful in hundreds of applications where there was a need for high strength materials. There are thousands of custom formulations which offer FRPs a wide variety of tensile and flexural strengths. When compared with traditional materials such as metals, the combination of high strength and lower weight has made FRP an extremely popular choice for improving a product's design and performance.

2.1 Literature Survey Related to Present Work

Polymer matrix composites are predominantly used for the aerospace industry, but the decreasing price of carbon Fibres is widening the applications of these composites to include the automobile, marine, sports, biomedical, construction, and other industries. **Desh Bandhu et.al[1]:**Investigates on Drilling of CFRP composite material finds widespread applications in many engineering fields during drilling fiber pull out, spalling, fuzzing fiber breakage, delamination are some if problems encountered to reduce this the different tool materials used in the present study along its point angles. The various drilling parameters and the response are explained. . **Biran Desai et.al[2]:**Investigates on in drilling the quality of hole is an important requirement for many applications. Thus the choice of optimized cutting parameters is very important for controlling the required hole quality. The focus on the present study optimize the parameters through work piece circularity and hole size. This paper represents a full factorial and ANOVA for formed on thin CFRP laminates using point angles 60 and helix angle 30. By varying the parameters spindle speeds and feed rate to determine the optimum of hole diameter and circularity. **Vijayan Krishna raj et.al[3]:**This paper represents an experimental investigation of full factorial deign on thin CFRP laminates using K20 carbide drill by varying drilling parameters spindle speed, feed rate. To determine the optimum conditions of hole diameter and delamination by using ANOVA and Genetic algorithm method is used in MAT lab. **Shunmughesh et.al[4]:**In this study composite undergo drilling and L27 orthogonal array is used to determine delamination and surface roughness by varying the parameters spindle speed feed rate point angles to determine the optimum conditions of hole diameter in the Grey relational analysis performed. **Mohd Azuwan Maoinser et.al[5]:**Investigates on drilling of Hybrid Fiber Reinforced Polymer(HFRP) and this paper presents

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optimisation of drilling parameters by varying parameters such as feed rate, spindle speed by using the full factorial design experiment and combination of ANOVA and signal to noise ratios. **M.Ramesh et.al[6]:**The aim of the experiment emphasize machining characterstics of HFRP by varying the parameters cuttings speed and feed rate, point angles and tool diameter. This paper presents the drilling induced damages is analysed with Scanning Electron Microscopy (SEM) analysis to reduce the delamination factor. **B.V.Kavad et.al[7]:**This paper presents the influence of machining parameters on the delamination damage of Glass Fiber Reinforced Polymer (GFRP) during drilling by varying the parameters spindle feed rate and also measure the minimum thrust force. **M.Saravanan et.al[8]:**This paper presents composite materials are used in air craft operations and highly sensitive operations, during drilling delamination, eccentricity of drilled hole which leads to loosening of rivets in joining various structures. For this by varying the parameters like cutting speed feed rate to determine the optimum hole eccentricity and M.R.R. by using Genetic Algorithm technique, numerical method and soft computing technique. **J.Babu et.al[9]:**Investigates the during drilling operations is hard to carry out the induced delamination. This paper presents the optimisation of delamination by conducting drilling experiments using Taguchi's L25 orthogonal array and ANOVA by varying the parameters cutting speed and feed rate. **Vinod Kumar.V et.al[10]:**This paper presents during drilling carry out induced delamination. To determine the optimization of delamination and hole quality by varying the parameters cutting speed point angle chisel edge width. In this work L9 orthogonal array used and ANOVA was conducted to determine significance and minimize the thrust force and torque. **Suresh.N et.al[11]:**Investigates the various drilling parameters like different twist drill bits of different point angles and deferent materials have been taken and the thrust force and torque measure for different machining conditions by using the DEFORM 3D Software in this simulate drilling process and measure the thrust force and torque by varying feed rate, spindle speed and point angles to determine the optimum values of thrust force and torque .

3. MATERIAL PREPARATION

Materials Used to Prepare A Composite Laminate:

1. Carbon Fiber.
2. Glass fiber
3. Epoxy Resin.
4. Hardener.

3.1. Carbon Fiber:

Carbon fiber is a material consisting of fibers about 5–10 μm in diameter and composed mostly of carbon atoms. To produce carbon fiber, the carbon atoms are bonded together in crystals that are more or less aligned parallel to the long axis of the fiber as the crystal alignment gives the fiber high strength-to-volume ratio (making it strong for its size). Several thousand carbon fibers are bundled together to form a tow, which may be used by itself or woven into a fabric.

The properties of carbon fibers, such as high stiffness, high tensile strength, low weight, high chemical resistance, high temperature tolerance and low thermal expansion, make them very popular in aerospace, civil engineering, military, and motorsports, along with other competition sports. However, they are relatively expensive when compared to similar fibers, such as glass fibers or plastic fibers.

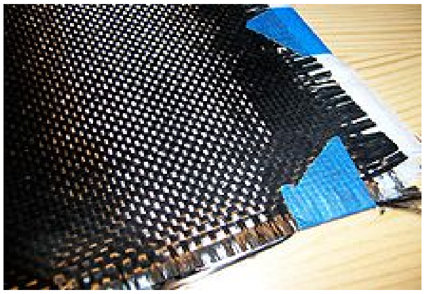


Fig 3.1 Woven Carbon Filaments

Fig3.2 Woven Glass filaments

Carbon fibers are usually combined with other materials to form a composite. When combined with a plastic resin and wound or molded it forms carbon fiber reinforced polymer (often referred to as carbon fiber) which has a very high strength-to-weight ratio, and is extremely rigid although somewhat brittle. However, carbon fibers are also composed with other materials, such as with graphite to form carbon-carbon composites, which have a very high heat tolerance. Each carbon filament tow is a bundle of many thousand carbon filaments parallel to each other. A single such filament is as thin as 5–8 micrometers and cross section may vary in different forms such as circular, elliptical and dog bone shape.

3.2. Glass Fiber

Over 95% of the fibers used in reinforced plastics are glass fibers, as they are inexpensive, easy to manufacture and possess high strength and stiffness with respect to the plastics with which they are reinforced. Their low density, resistance to chemicals, insulation capacity are other bonus characteristics, although the one major disadvantage in glass is that it is prone to break when subjected to high tensile stress for a long time.

3.3 Laminate Preparation

The HFRP composite specimen of 390mm×340mm×4mm is fabricated by the hand layup process technique at room temperature. The bi-directional plain weaves type glass fabric and carbon fabric with 460 GSM is used as reinforcement. The resin used for the preparation of matrix is Bisphenol A based epoxy resin L-12 and the hardener used is Amino K-6. The resin content of the composite laminate is maintained around 60 wt %. The resin mixture is applied onto each layer by using a brush and a roller. In this laminate 7 layers are used in this 4 layers are glass fabric and 3 layers are carbon fabric. these layers placed alternatively in the mould

Fig. 3.4 Hand layup process

Fig. 3.5 Mould

After 24 hours the mould could be open then the laminate of composites are removed and the laminates are shown below

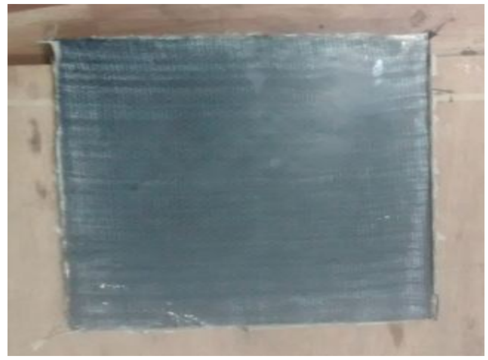


Fig. 3.6 HFRP laminate

4. EXPERIMENTAL INVESTIGATION

Work piece used for the experiment is HFRP (Hybrid Fiber Reinforced Polymer) with epoxy resin composite. The size of the specimen used was 390 x340 x4 mm. The drilling process was carried out using radial drilling Machine and KISTLER dynamometer.

Drilling is the cutting process of using a drill bit in a drill to cut or enlarge holes in solid materials, such as wood or metal. Different tools and methods are used for drilling depending on the type of material, the size of the hole, the number of holes, and the time to complete the operation. Drilling is a cutting process in which a hole is originated or enlarged by means of a multipoint, fluted, end cutting tool. As the drill is rotated and advanced into the work piece, material is removed in the form of chips that move along the fluted shank of the drill. A composite material is a heterogeneous material created by the synthetic assembly of two or more components, one a selected filler of reinforcing material and the other a compatible matrix binder, in order to obtain specific characteristics and performance. The binder and the filler have two very different properties but when combined together form a material with properties that are not found in either of the individual materials. Machining of composites involves the removal of any extra or unwanted material. Some of the most common machining processes are drilling, turning, and milling. Earlier composites machined like metals. But poor surface finish and faster tool wear led to the further study of composite machining. Unlike metals, composites need separate tools and working conditions. Although tools used for machining of metals can still be used for composites, care must be taken to maintain optimum levels of, feed rate, thrust force, and other factors. Metal tools tend to wear out faster when used for machining of non-metals. One of the main advantages of composites has been the fact that an entire part can be manufactured. This minimizes the machining of composites. However with “part integration,” sometimes composites need to be joined to form a larger part, which means that a certain amount of machining needs to be done for composites too. "A typical aircraft wing might have as many as 5,000 holes" Hence, machining is a cost factor in the production of composites. A composite might have to go through all or some of the machining processes like milling, drilling and cutting.

4.1 DELAMINATION

Delamination is defined as "the separation of the layers of material in a laminate." Delamination can occur at any time in the life of a laminate for various reasons and has various effects. The two different mechanisms of delamination are peel-up and pullout. Peel-up delamination mechanism is due to upper layers tend to be pushed through cutting faces instead of being cut and push down delamination occurs due to indentation effect due to quasi stationary drill Chesil edge, acting over uncut layers of laminate. The delamination takes place when the thrust force exerted by the drill is more than the inter laminar fracture toughness of the layers.

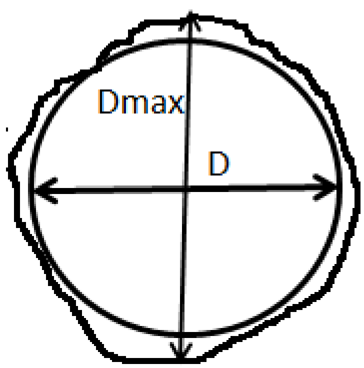
Delamination factor is defined by ratio of maximum diameter (of damaged zone around hole) to actual diameter.

Delamination factor = D max/D actual

Where

D max is damaged diameter around the hole

D actual real diameter to be drilled



4.2 Input Parameters

The cutting tool used for the machining was HSS twist drill bit. The parameters and their levels selected for the experimental design are listed below in

4.3 Design of experiment:

The objective of this research work is to study the effect of different parameter such as point angle feed rate and speed for this design model has been prepared by choosing three levels :Three levels of point angle have been used

- Three levels of feed rate have been used
- Three levels of speed have been used

The two most important out puts are thrust force and torque for this research work has been analyzed the effect of variation in input process parameters will be studied on this two response parameters and the experimental data will be analyzed as per full factorial method to find out the optimum machining condition .

4.3.1 Selection of orthogonal array and parameter assignment:

In this experiment there are three parameters at three levels each in this full factorial design for experimentation by applying (3*3) 27 by taking three levels for each factor.

4.3.2 Full factorial standard design:

Full factorial design is used for simultaneous study of several factor effects on the process. By varying levels of factors simultaneously we can find optimal solution. Responses are measured at all combinations of the experimental factor levels.

The combination of the factor levels represent the conditions at which responses will be measured. Each experiment condition is a run of an experiment. The response measurement is an observation. The entire set run is a design. It is used to find out the variables which are the most influence on the response and their interactions between two or more factors on responses.

4.3.3 Measurement of Dmax:

Measuring the Dmax by using tool makers microscope .However the drill hole work piece is placed on microscope and the high resolution lens are attached to the microscope by using this measure the Dmax.

5. RESULTS AND DISCUSSION

A drilling test was conducted to evaluate the effect of cutting parameters on the damage around the work was measured by using tool makers microscope after measuring the maximum diameter Dmax in the damage around the each hole the delamination factor is determined by utilising the equation in above

The results of Delamination factor of each sample are shown in table5.1. The experimental results were transformed into Minitab16, software.

Table5.1inputparameters

Control factor	Unit	Level-1	Level-2	Level-3
Point angle	Degree	100	118	135
Feed rate	mm/min	18	20	26
Speed	rpm	485	795	1250

Table 5.1 Experimental results

Experiment no	Point angles(degree)	Feed rate (mm/min)	Spindle speed (rpm)	Delamination Factor
1	100	18	485	1.3
2	100	18	795	1.2
3	100	18	1250	1.18
4	100	20	485	1.28
5	100	20	795	1.15
6	100	20	1250	1.12
7	100	26	485	1.25
8	100	26	795	1.2
9	100	26	1250	1.16
10	118	18	485	1.12
11	118	18	795	1.17
12	118	18	1250	1.22
13	118	20	485	1.23
14	118	20	795	1.11
15	118	20	1250	1.1
16	118	26	485	1.19
17	118	26	795	1.13
18	118	26	1250	1.14
19	135	18	485	1.24
20	135	18	795	1.13
21	135	18	1250	1.16
22	135	20	485	1.16
23	135	20	795	1.11
24	135	20	1250	1.1
25	135	26	485	1.12
26	135	26	795	1.09
27	135	26	1250	1.17

Table 5.2 Analysis of Variance for Delamination Factor

Source	D.F	Seq ss	Adj ss	Adj ms	F	P
Point angle	2	0.0213	0.0213	0.0106	4.65	0.046
Feed rate	2	0.0090	0.0090	0.0045	1.98	0.200
Spindle speed	2	0.0237	0.0237	0.0118	5.18	0.036
Point angle*feed rate	4	0.0015	0.0015	0.0003	0.17	0.948
Point angle*spindle speed	4	0.0102	0.0102	0.0025	1.12	0.412
Feed rate*spindle speed	4	0.0082	0.0082	0.0020	0.90	0.507
Error	8	0.0183	0.0183	0.0022		
Total	26	0.0926				

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5.1 Analysis of Variance for Delamination Factor:

Table 5.2 presents the results of ANOVA for Delamination Factor. It is observed from the table the spindle speed is significant parameter for the Delamination Factor. However F-test decides whether the parameters significantly different. A larger value F shows the greater impact on the machining performance characteristics

5.3 Main effect plots analysis for Delamination Factor:

The analysis is made with the help of a software package MINITAB 16. The main effect plots are shown in fig.4. shows the variation of response with the three parameters i.e. point angle, Spindle speed and feed separately. In the plots, x axis indicate the value of each parameter at three level and y- axis the response value. Horizontal line indicates the mean value of the response. The main effects plots are used to determine the optimal design conditions to obtain the optimum Delamination Factor.

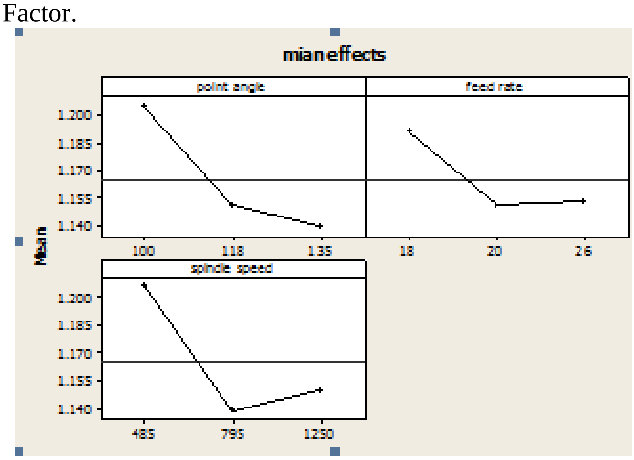

Fig 5.1 Main effects plots for Delamination Factor

The interaction plot for Delamination Factor is shown in figure 5.2

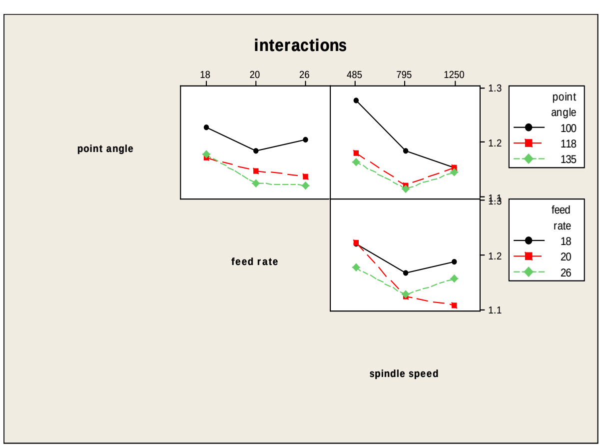

Fig 5.2 Interaction plots for Delamination Factor

CONCLUSION

This paper presents the optimization of cutting process parameters namely, point angle, feed rate and spindle speed in drilling of hybrid fiber reinforced polymer (HFRP) composites using the full factorial and ANOVA analysis. The conclusions drawn from this work are as follows:

The optimum process parameters in the drilling of hybrid fiber reinforced polymer (HFRP) composites are:

- Point angle 135°, feed rate at 20 mm/min and spindle speed at 795 rpm Delamination Factor is found to be optimum
- The ANOVA results reveal that spindle speed is most significant influencing on the Delamination Factor

REFERENCES

1. Desh Bandhu, Sandeepsingh Sangwan and Mukeshverma “optimization of drilling parameter and surface roughness using different tool material by drilling of CFRP composite material” international journal of current engineering and technology (2014)
2. Biran Desai, Jaipalsinh Rama and Hiren Gajera “study of hole quality parameters in drilling CFRP using design of experiments” journal of information knowledge and research in mechanical engineering
3.Vijayan Krishnaraj, A.Prabhukarthi and Arun Ramanadhan “optimization of machining parameters at high speed drilling of CFRP laminates” journal of home page :www.elsevier.com/locate/compositesb
4. Shunmughesh, Paneerselvam and Jospaul Thomas “ optimization of drilling parameters of GFRP by using Grey Relational Analysis” international journal of research in engineering and technology
5.Mohd Azuwan Moinser, Fiaz ahmed and Safian sharif “minimizing thrust force for HFRP composite by optimize process parameters using the combination of ANOVA approach and signal to noise ratio”owned by authors, published by EDP sciences (2014)
6. M.Ramesh, K.Palanikumar and K.Hemachandrareddy “experimental investigation and analysis of machining characterstics in drilling hybrid –glass –sisal-jute fibre reinforced polymer compiosites” 5th international and 26th all india manufacturing technology design and research conference (2014)
7. B,V.Kavad, A,B.Pandey,M.V.Tadvi and H.C.Jakharia “a review paper effect of drilling on GFRP” 2nd international conference on innovations in automation and mechatronics engineering (2014)
8. M.Saravanan, D.Ramalingham and G.Mani kandan “multi objective optimization of drilling parameters”

9. J.Babu and Tom sunny “optimization of process parameters in drilling of GFRP composites by an End mill” international journal of recent development in engineering and technology (2013)

10. Vinod kumar.V and Venkateswarlu Ganta “optimization of process parameters in drilling of GFRP composite by Taguchi method” journal of material research and technology (2014)

11. Suresh.N, Rajesh Kumar.S, Prakash.K and Venkatesan.T “study and optimization of drilling parameters in GFRP”international journal of innovative research in technology (2015)

12. Mechanics of Composite Materials-AK KAW

13. Mechanics of Composite Materials-Robert M Jones

14. www.compositeworld.com

15. www.wikiepedia.com