Experimental Study on the Behaviour of Different Point Angled Drill Bits on Functionalized Nano Tubes Reinforced Carbon/epoxy Composites

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Abstract. This article studies drilling behaviour of polymer nanocomposites reinforced by functionalized amine carbon nanotubes/ Carbon fiber using a vacuum bagging technique fabrication. The main concept for assembling process without out which is impossible like machining process in which drilling the laminate has been treated the most vital role for which 85% of the assembly is depends on. The major parameters concentrated for drilling are drilling speed (S), feed-rate (F), drill point angle along with nanotube 0.5wt.% in designing the experimentation array for minimum delamination. The design of experiments is designed in Taguchi based on the cutting parameter, federate, and point angle as L27 orthogonal array. Delamination factor is investigated using images of digital microscope responses in which cutting speed 1000 rpm feed 20mm/s and 118deg point angles showed the best results and compared with Taguchi.

Keywords: Nano particles-functionalized amine · Drilling · Delamination

1 Introduction

Currently, nano particles along with Polymer matrix reinforcement finding its new path replacing most widely using metallic engineering functionalized materials based on unavoidable situation for next generation with sustainable development across the globe due to condensed mass and better-quality mechanical features. Observing last couple of decades, application of composites has been majorly used in industries like aero-industry, Defense, sports, marine, racing and motor car to perform substantial role [1]. Chemical treatment of carbon fiber with poly-ether-ether-ketone (PEEK) polished multi-walled carbon-nanotubes (HPEEK-g-MWCNT) fused by esterification process in turn observed to be high flexural strength and interlaminar shear strength (ILSS) [2]. CNTs/GFR Polymer composite investigate with variation of adding mwcnts %wt found to be better

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inter-laminar shear strength (ILSS) along with similar flexural strength,0.75% hundred-resin (phr), ILSS experienced improving 15.7% with flexural strength more 9.2% [3]. 0% & 1% weight-fraction nanomaterials Influence performing the best properties in overall mechanical aspects revealed in investigation of "residual stress," "weight loss under thermal fatigue" and "delamination damage in machining operations" of reinforced polymer composites. different composite specimens were fabricated with 0% and 1% weight fraction of multi-walled carbon nanotubes (MWCNTs) [4]. 4-Methylene-diphenyl-diisocyanate (MDI) sizing multiwall-carbon-nanotube (MWCNT) surfaces, resulted in good dispersity of nanoparticles in matrix which intern directly enhancing the interlaminar bonding in CFRP, thereby, mechanical, torsional fatigue life in material has improved and resulted 11% high in storage modulus [5]. The improvement of mechanical properties has been observed using epoxy resins by varying introduced mwcnts with (0.1%, 0.2%, 0.3% and 0.4%) weight which effected higher tensile and flexural strength compared to neat epoxy resin [6]. Here the work focused on push-out occurrence around exit of the hole while drilling concluded as highly influential damage in machining process investigation of damage evolution performed using X-ray computer tomography along with optical microscopy also to compare the results concluded to be bending deformation at bottom two laminas' initiations push out delamination [7]. Investigated delamination of composite laminate with various cutting parameters under varying percentage of MWCNTs designed for DOE L27 orthogonal array in ANNOVA extended the machining process further for hole quality inspection using thermography technique concluded with the delamination reduces with proper interlaminar bonding between the lamina to lamina (ply to ply) at the reinforcement process [8]. Proposed a novel drilling technique varying variable feed in machining operation to get delamination-free at very high machining rate. Orthogonal drilling operations were performed to measure torques, forces along with friction along the uncut chip. Summarized variable feed in drilling surprisingly controls delamination factor when compared to constant feed drilling even at the 100th drilling [9]. A532 nm nano-second laser with custom adjustable pulse interval used in scanning Z-direction Top-bottom incremental piercing and 2d plane direction cutting scanning mode for hole drilling, which in turn obtain high drilling concert. The results reflected narrow width of high friction affected zone. dropping the pulse intervals also helps to minimize the drilling taper (low taper range 0.046. instead, it effected the drilling performance to low- pulse energy with short- pulse duration [10]. Orbital and step drilling are analyzed in reducing delamination of polymer composites machining process compared for both numerical Vs geometrically. High cutting speed found for push-cut effect while exit in the machining/ drilling operation. The controlled parameters resulted in good machining with ODR tool which minimized thrust force, finally less processing delamination compares end mill [11]. Drilled hole quality evaluation based on 2-D digital image processing with segmentation extended feature recognition is measured to check hole entry damages in drilling. Robustness camera is used for evaluating results of 3D microscope. The evaluation process changed the duration of factor 60 with at least 67% of the accuracy of a 3D measuring [12, 13].A delamination detector has developed based on eddy current pointer (probe) works on the principle of numerical simulation of eddy current flow in the anisotropic at 4 m/s. Forces from the eddy currents is developed between pointer to direct perpendicular on fibers, enables probe sensitive to resolution in oblique conductivity caused by delamination [14].

2 Drilling of CFRP Laminate

2.1 Experimentation

The machining operation of drilling set-up for CFRP-Amine(0.5Wt%) laminate using Vertical machining Centre (VMC) is shown in Fig. 2. Drilling tests are conducted on a three-axis VMC with different cutting parameters designed based on the literature shown in Table 2. The workpiece dimensions are 285.5 mm (length) × 150 mm (width) × 3 mm (thickness), as shown in Fig. 3. As per the (DOE) design of experiments all 27 holes are performed along the fiber orientation. Solid carbide twist drills from Totem Forbes with different point angles are used, drills are shown in Table 1 where the geometrical configurations and specimens are drilled under dry condition (Table 2).

Table 1. Solid carbide twist drill specifications

S.No	Diameter	Point angle
1		85^0
2	06mm	118^0
3		135^0

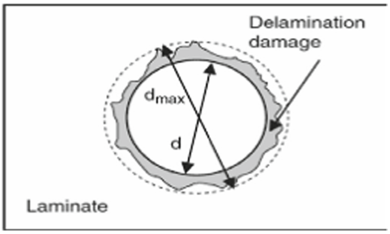

Fig. 1. Delamination factor

Table 2. Vertical machining Centre specifications

VMC specifications	BMV60 + TC24(mm)
Table longitudinal travel (X - Axis)	1050
Table cross travel (Y - Axis)	610
Headstock travel (Z - Axis)	610
Positioning	0.016
Repeatability	0.012

2.2 Delamination Assessment

Delamination during drilled holes usually occur while any machining operations performed over laminates and factor of delamination is purely dependent on the reinforcement of laminates (type of resin, hardener ratio, curing temperature and type of fabrication technique). In drilling of composite laminates drill bit at entrance and exit of laminate in the whole process is crucial due to which damage occurring at the interfaces of the composite layers. The drilled hole laminates are inspected using G2 mark "RE-50X" microscope analysis and Dewinter Biowizard 4.5 version software to analyses hole diameter with normal (base diameter) images (drilled holes). The delamination in this work denotes the ratio of the delaminated area to the drilled hole area. Required (Nominal diameter of the hole with maximum diameters occurred due to systematic errors in machining operation. Delamination factor (Fd) is calculated by using the formula under dry condition shown in Fig. 1. Fd = Dmax/D.

Fig. 2. Vertical Machining Centre (VMC)

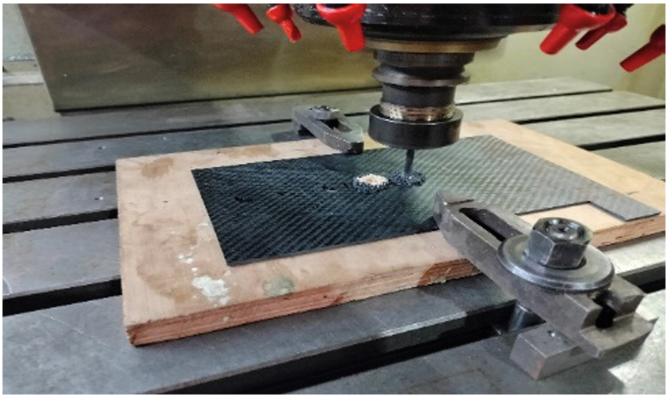

Fig. 3. Drilling operation

Table 3. Modes of S/N evaluation types

1	Nominal is the best: $\frac{S}{N} = 10\log\frac{\bar{y}^2}{{s_y}^2}$	2	Lower is the best: $\frac{S}{N} = -10\log\frac{1}{n}(\sum y^2)$
3	Higher is the best: $\frac{S}{N} = -10\log\frac{1}{n}(\sum\frac{1}{y^2})$		

Based on the DOE developed from the critical parameters l27 orthogonal array has finalized for machining and it has been investigated under the microscope for measuring the circle diameter from which error value has been determined to obtain delamination factor from which the least delamination factor has been proved among the parameters considered. The output of the experimented error values is integrated as an input to Taguchi analysis (signal-to-noise (S/N)) ratio. The S/N ratios are mainly of three types which are as follows in Table 3 highest is the best is appropriate technique to evaluate minimum delamination factor.

3 Results and Discussion

Drilling carbon laminate is performed using different critical parameters based on (DOE) Taguchi L_{27} further investigated shown in Figs. 4 and 5 respectively delamination factor on both peel off and push out techniques and the values are as follows in the below graphs.

From Fig. 6 output response of critical parameters vs delamination factor proved as 1000 rpm with 20mm/s federate and 118^0-point angle are showed better results compared for minimum delamination.

Figure 7 Taguchi analysis for delamination factor versus critical parameters has analyzed with lager is best by considering signal to noise ratio and the experimental results matched and proved the same (Table 4).

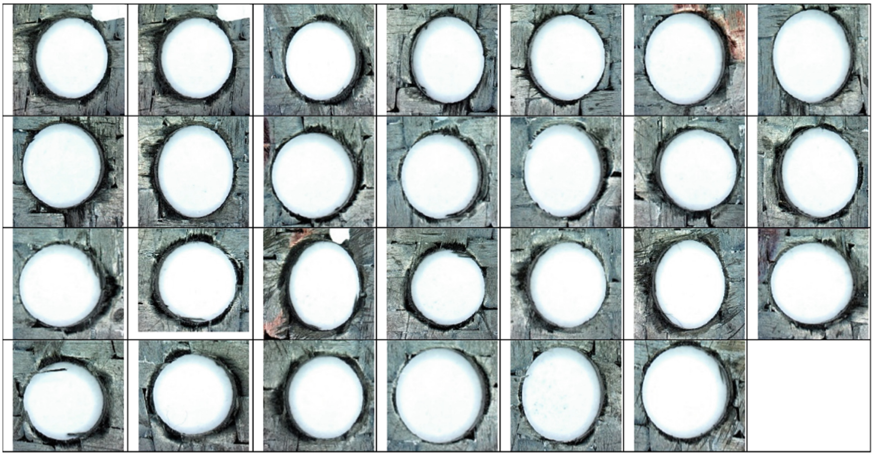

Fig. 4. Determination of de-lamination at peeling (entrance) Microscope image

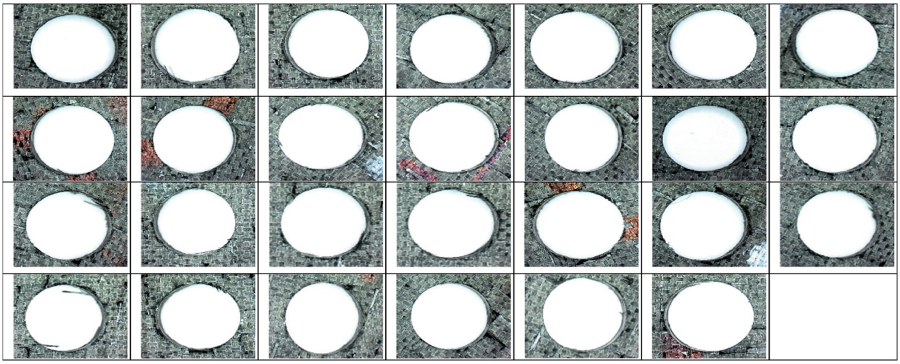

Fig. 5. Determination of de-lamination at push out(exit) Microscope image

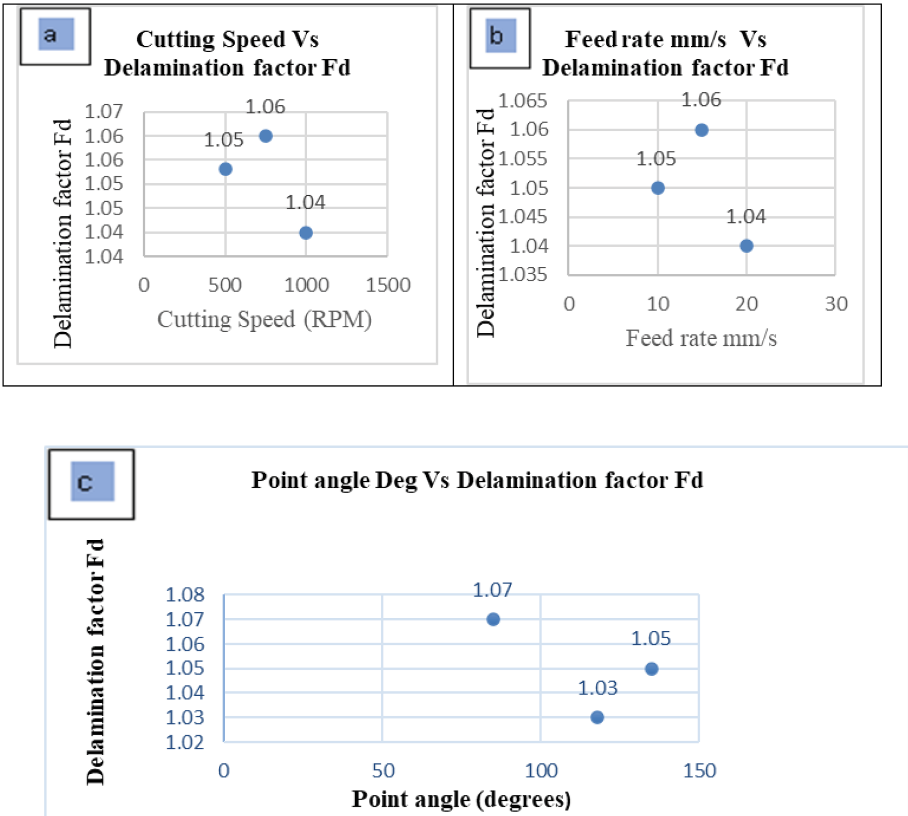

Fig. 6. Delamination factor vs Cutting Speed, Feed Rate & Point angle

Table 4. Taguchi Analysis: Delamination factor versus other Parameters

Response Table for Signal to Noise Ratios (Larger is better)				Response Table for Means			
Level	**Cutting Speed**	**Feed Rate**	**Point angle**	**Level**	**Cutting Speed**	**Feed Rate**	**Point angle**
1	0.4438	0.5221	0.6195	1	1.053	1.063	1.076
2	0.5589	0.4500	0.3062	2	1.069	1.054	1.037
3	0.3909	0.4215	0.4679	3	1.047	1.052	1.056
Delta	0.1680	0.1005	0.3133	Delta	0.021	0.012	0.038
Rank	2	3	1	Rank	2	3	1

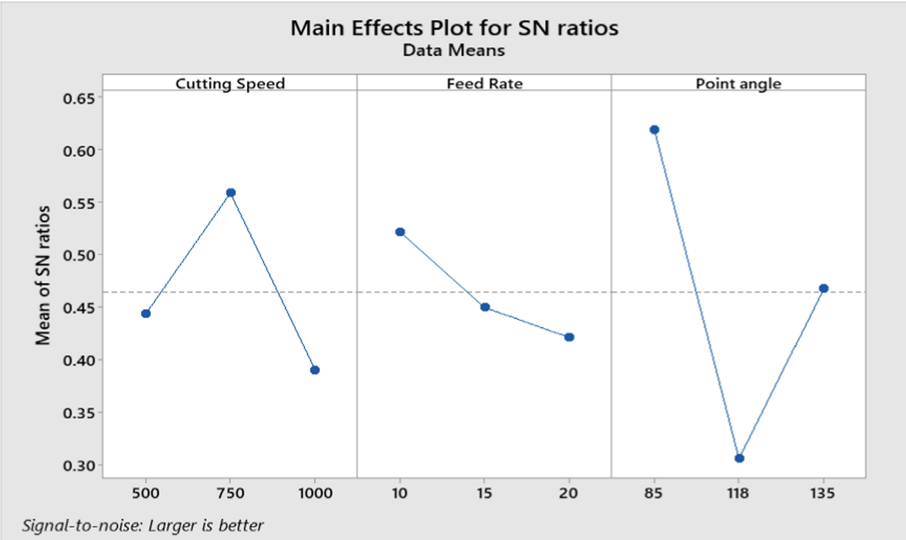

Fig. 7. Response S/N of delamination factor versus critical parameters

4 Conclusions

Delamination analysis of functionalized amine multiwall carbon nanotube reinforced laminate is performed based on the parameters and output- responses of the machining operation are as follows: -

1. The minimum delamination factor F_d is showed in cutting speed 1000 rpm feed 20mm/s and 118° point angle drill.
2. From the Signal to Noise ratios and means it is concluded that point angles have high impact on the delamination.
3. Hence, Experimental results computed with the Taguchi analysis with which it showed similar results without any deviations.

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