ANALYSIS OF DELAMINATION AND SURFACE QUALITY IN DRILLING OF GFRP COMPOSITES

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Abstract: Glass Fiber Reinforced Plastic (GFRP) composites applications have been increased now-a-days due to its greater mechanical, structural and thermal properties. Drilling is the most extensively used manufacturing process in fabrication of composite components. It is commonly used in the final stage of manufacturing or assembling of components. In the process of drilling various undesirable effects occur such as matrix cracking, fiber damage, delamination, hole surface roughness, thermal damage etc., which reduces the quality of hole. Delamination is the major damage among all the undesirable effects. The appropriate cutting parameters and drill bit can minimize the delamination and improves the hole quality. In the present work, the influence of three different drill bits and cutting parameters (feed rate and spindle speed) on the hole quality parameters assessed which includes delamination and surface roughness. The delamination is measured by microscopy technique. Surface roughness value of the drilled hole is found by using Talysurf surface roughness tester. The obtained result concludes that for high spindle speeds include the slot drill gives less delamination and surface roughness.

Index Terms **- GFRP, Drilling, Delamination, Surface Roughness.**

I. INTRODUCTION

Glass fibre Reinforced Plastics (GFRP) finds its application in aerospace, automotive and machine tool industry due to its very good properties like durability, lightweight high specific strength and specific modulus, chemical and corrosion resistance. The GFRP composites are fabricated by various methods like filament winding, hand lay-up, resin transfer moulding, etc., [1]. Drilling is mainly performed for assembling the subcomponents. Due to the anisotropic nature and heterogeneity of composite materials, the drilling of these materials can lead to damages in the regions around the drilled holes [2]. Drilling within tolerances and good surface quality without affecting the strength are the requirements for defense and aerospace industry. Delamination is a critical problem in the process of drilling GFRP composites which reduces the structural integrity of the material, causes deficient assembly tolerances. There are two types of delamination mechanisms are present namely: peel-up and pullout. Peel-up delamination occurs at the entrance of the hole and push-out delamination occurs at the exit [3]. Jalumedi Babu et al [3].concluded in the review that refined delamination factor is the best method for the assessment of delamination & explained various methods for measuring delamination factor. Akhil.K.T et al.[4], in their work, The Taguchi Method and Grey Relational Analysis were implemented for optimizing input parameters like cutting speed, feed rate and drill diameter. He concluded that low feed rate and High speed are the optimum conditions for getting good quality hole.

Ramesh et al. [5] have developed a surface roughness model in terms of cutting parameters such as cutting speed, feed, and depth of cut and indicated that surface roughness increased with increasing feed rate but decreased with increasing cutting speed and depth of cut. T.J.Grilo et al.[6] assessed the influence of three different drill geometries, feed and speed on delamination with the help of two delamination factors. The drilled surfaces were analysed by processed images. The spur drill gave less delamination with a spindle speed of 6750rpm and a feed of2025mm/min. M. Mudhukrishan et al [7] investigated the influence of machining parameters and tool materials on the surface roughness and oversize of the drilled hole while drilling of GFR-PP composite material. The better results were observed from solid carbide drill with high spindle speed and minimum feed rate. Sina Alizadeh Ashrafi et al.[8] investigated the impact of varying drilling speed and feed on hole quality parameters such as surface roughness, hole roundness and fibre pull out geometries. Fibre pulls out geometries are analyzed by using scanning electron microscope (SEM) images. K.Phalani Kumar [9] conducted experiments on drilling of GFRP composites by considering three parameters speed, feed and drill diameter. ANOVA was implemented for analyzing the effect of process parameters.RSM is used to predict the surface roughness and delamination factor.

From the literature, it is observed that drilling of GFRP and its surface quality as well as delamination analysis is very important and it depends on drill types. Hence an effort has been taken with three kind of drilling tool namely twist, spur and slot. Also, the effect of process parameters on delamination and surface quality are analyzed.

II. MATERIALS AND METHODS

GFRP laminate is prepared by hand lay-up technique. Laminate is prepared using 16 layers of woven roven glass fiber of stacking order zero degrees. The fiber volume fraction of prepared laminate is 58.63%, Epoxy (LY566) resin and 5200 hardener is used in the preparation of laminate. Prepared laminate thickness is 5mm. The prepared GFRP laminate is drilled using vertical CNC milling machine. Figure 1 shows the machine setup. The drilling operation is performed on the laminate by using different speed, feed rate and drill bits (Twist, Slot & Spur). Drilling is performed by three different drills of 8 mm diameter namely twist, slot and spur dill bit of HSS material. These values are selected based on previous studies and

preliminary experiments. Table 1 shows the values of process parameters used in this work. Figure 2 shows the machined sample.

Fig. 1 Machine setup

Table 2.1: Process parameters and their levels

Parameters	**Levels**		
	Level 1	**Level 2**	**Level 3**
Drill types	Twist	Slot	Spur
Spindle speed (rpm)	1000	1500	2000
Feed rate (mm/rev)	0.10	0.15	0.20

Drilling induced delamination is measured by Microscope. The delamination factor is determined by the ratio of the maximum diameter of the delamination (D_{max}) and the diameter of the hole (D).

$$Delamination\ factor\ Fd = \frac{D_{max}}{D} \quad (1)$$

Where, F_d indicates the delamination factor, D_{max} and D are the maximum damaged zone diameter and hole diameter respectively. Surface roughness is measured using Talysurf surface roughness tester. Surface roughness (Ra) is measured at three places and the average value is considered for further investigation.

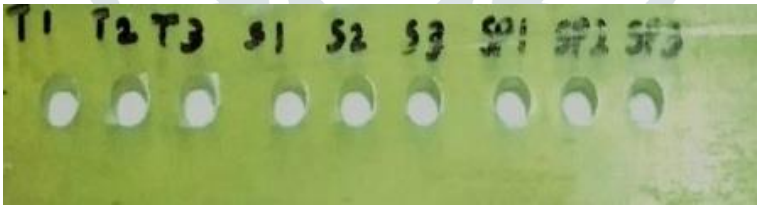


Figure 2 Machined sample

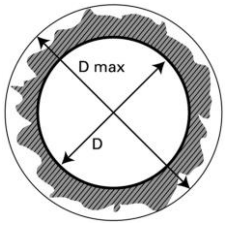


Figure 3 Pictorial view of delamination

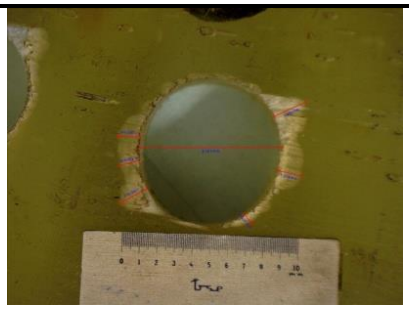


Figure 4 Microscopy image

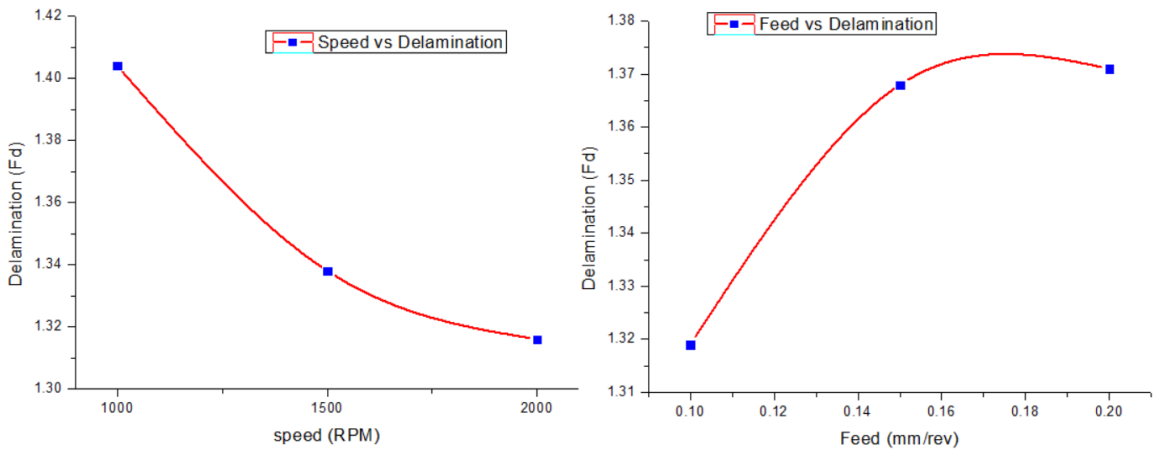
Table 2 Experimental results

Type of drill bit	Speed	Feed	Surface roughness	Delamination
	(RPM)	(mm/rev)	(microns)	Fd
Twist drill	1000	0.1	4.05	1.463
	1500	0.15	3.28	1.475
	2000	0.2	3.15	1.375
Slot drill	1000	0.15	1.56	1.275
	1500	0.2	1.56	1.265
	2000	0.1	1.35	1.219
Spur drill	1000	0.2	2.9	1.475
	1500	0.1	2.08	1.275
	2000	0.15	1.15	1.354

III. Results and Discussion

3.1 **Delamination analysis**:

Figure5 represents the influence of speed, feed rate & drill on delamination factor. It can be seen that delamination decreases as speed increases. With increasing of speed cutting temperature increases which soften the matrix & induces less delamination. The delamination factor increases as feed rate increases. This is due to the increase in thrust force which causes the damage in matrix of composite material. With conventional twist drill bit the delamination will be high. With special drill bits like slot dill, spur drill the delamination factor can be reduced. The slot drill bit is giving less delamination.



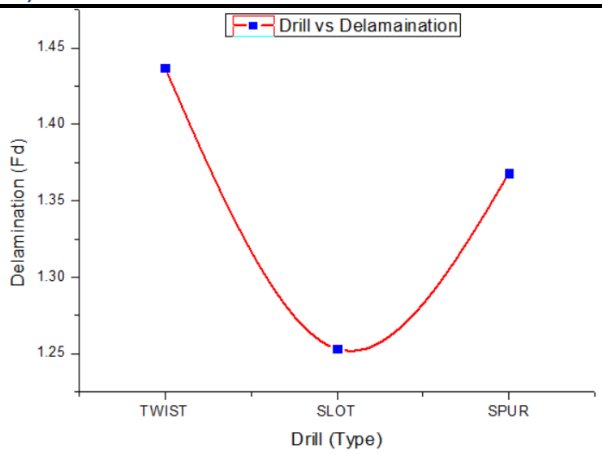


Figure 5: Delamination (Vs) speed, feed& drill bit

3.2 **surface roughness analysis**:

Surface roughness is mainly affected by drill geometry, machining parameters due to continuous vibration of the cutting tool. By increasing the spindle speed surface roughness of hole decreases. Surface roughness increases with increasing feed rate. As per theFig.6 the lower surface roughness is measured in case of slot drill .

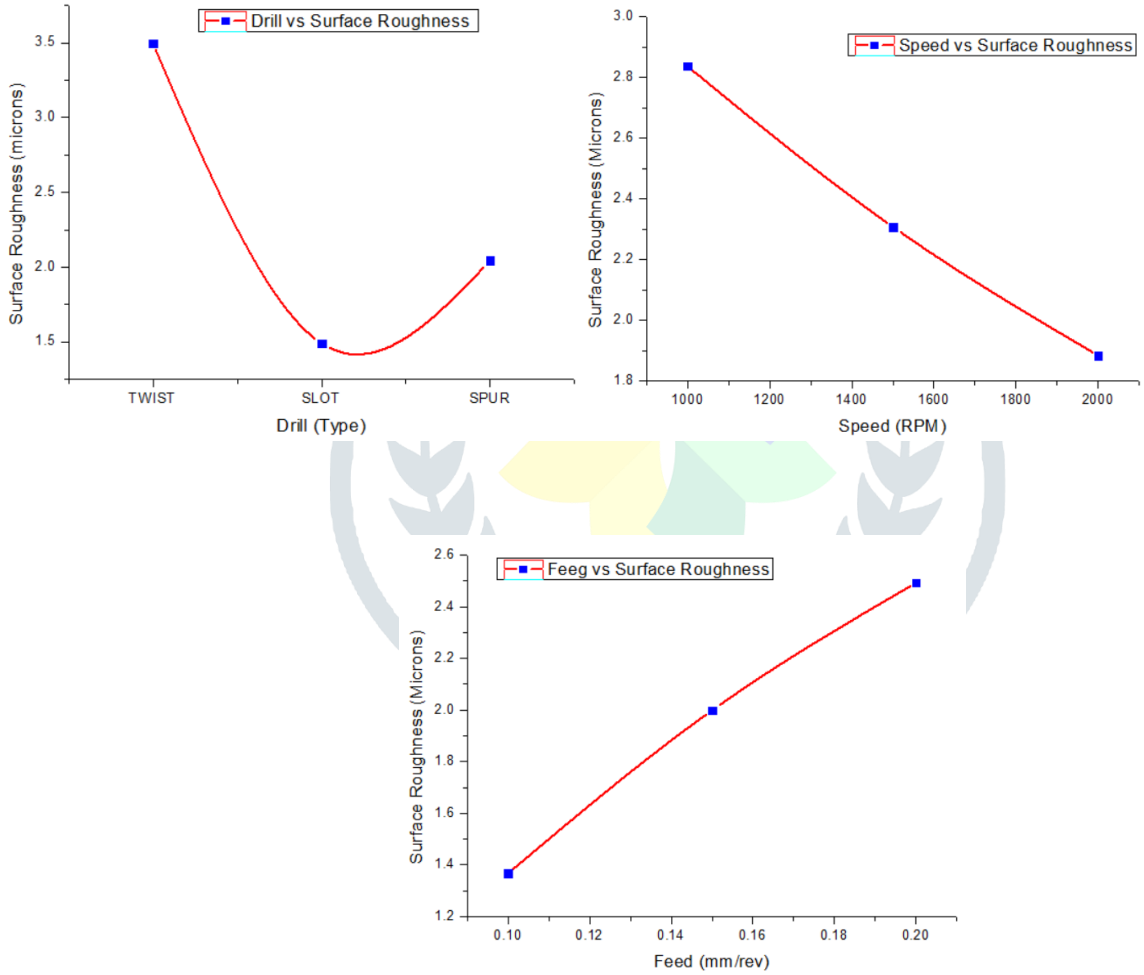


Figure 6: surface roughness Vs speed, feed& drill bit

IV.Conclusions:

In this work, drilling of GFRP composite with a different drill bit and process parameters for performing the experiments. Hole quality parameters such as delamination factor and surface roughness are analyzed. The following conclusions are derived from the work

- Hole quality parameters are influencing the assembly accuracy which is measured by microscope and surface roughness tester.
- Delamination is influenced by special drill bits, higher cutting speed and lower feed rate.
- Surface roughness is decreased by higher cutting speed and lower feed rate value.
- GFRP composite and drilling is used to analyze the hole quality with its process parameters. This work leads to analyze and predict the quality of drilled GFRP composites.

REFERENCES

1. Karimi, N.Z., Heidary, H., Minak, G. and Ahmadi, M., 2013. Effect of the drilling process on the compression behavior of glass /epoxy laminates, Composite *Structures*, *98*, pp.59-68.
2. Davim, J.P. and Reis, P., 2003. Drilling carbon fiber reinforced plastics manufactured by autoclave—experimental and statistical study, *Materials & design*, *24*(5), pp.315-324.
3. Babu, J., Sunny, T., Paul, N.A., Mohan, K.P., Philip, J. and Davim, J.P., 2016. Assessment of delamination in composite materials: a review. *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture*, *230*(11), pp.1990-2003.
4. Akhil, K.T.,Shunmugesh, K., Aravind, S. and Pramod kumar, M., 2017. Optimization of Drilling Characteristics using Grey Relational Analysis (GRA) in Glass Fiber Reinforced Polymer (GFRP). *Materials Today: Proceedings*, *4*(2), pp.1812-1819.
5. Ramesh, S., Karunamoorthy, L. and Palanikumar, K., 2008. Surface roughness analysis in machining of titanium alloy. *Materials and Manufacturing Processes*, *23*(2), pp.174-181.
6. Grilo, T.J., Paulo, R.M.F., Silva, C.R.M. and Davim, J.P., 2013. Experimental delamination analyses of CFRPs using different drill geometries. *Composites Part B: Engineering*, *45*(1), pp.1344-1350.
7. Mudhukrishnan, M., Hariharan, P., Palanikumar, K. and Latha, B., 2017. Tool materials influence on surface roughness and oversize in machining glass fiber reinforced polypropylene (GFR-PP) composites. *Materials and Manufacturing Processes*, *32*(9), pp.988-997.
8. Alizadeh Ashrafi, S.Miller, P.,Wandro, K. and Kim, D., 2016. Characterization and effects of fiber pull-outs in hole quality of carbon fiber reinforced plastics composite. *Materials*, *9*(10), p.828.
9. Palanikumar, K., 2010. Modeling and analysis of delamination factor and surface roughness in drilling GFRP composites. *Materials and Manufacturing Processes*, *25*(10), pp.1059-1067.