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Drilling on Glass Fiber Reinforced Composite Material for Enhancement of Drilling Quality: A Review

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Abstract:

A composite material can be distinct as a mixture of a matrix and a reinforcement, which when combined gives properties higher to the properties of the individual components. In the case of a composite, the reinforcement is the fibres and is used to fortify the matrix in terms of strength and stiffness. The reinforcement fibres can be cut aligned placed in different ways to affect the properties of the resulting composite. The matrix, normally a form of resin, keeps the reinforcement in the desired orientation. It protects the reinforcement from chemical and environmental attack, and it bonds the reinforcement so that applied loads can be effectively transferred.

Keywords: Reinforcement, Environmental attack, stiffness-to-weight

I. Introduction

Engineering materials are changing faster and the choice is wider than ever before. This is mainly because of the expansion in materials, processes, and computational abilities. Advanced high – tech industries adopted new materials and processes; replacement of mild steel with high strength steel, lighter non – ferrous alloys, such as aluminium and magnesium alloys, plastics, and composites. Many industries developing high strength, low weight materials for wide applications such as composite materials. The machining of composite materials is a growing problem in various fields such as aeronautical, automotive, wind turbine industries. In particular, the drilling of these materials, required to assemble different parts, is difficult to control and often leads to delaminating at the exit of the laminates. This can affect the strength of the structure. This project involves experimental and analytical investigation of drilling on Glass fibre reinforced plastic material [2].

GFRC mostly used in the industries due to their high mechanical properties such as high strength-to-weight and stiffness-to-weight ratios. Our objective is to reduce delimitation of GFRC work piece by selecting process parameters and tool parameters. By selecting suitable ranges of the parameters as per the convenience and by selecting the drilling machine as per availability we made the drilled holes. Inspecting the drilled holes on tool makers' microscope, analysis of delimitation factor for each drilled hole was done. By comparing the delimitation factor of various drill holes we found the suitable range of parameter in which the delimitation was least. By improving the quality of drill we can improve the life of the work piece. Classification of composite according to matrix the composite may classify as follows:

1. Metal Matrix Composites (MMCs)

2. Polymer Matrix Composites (PMCs)

3. Ceramic Matrix Composites (CMCs)

4. Intermetallic Matrix Composites (IMCs)

5. Carbon Carbon Composites (CCCs)

The technological and commercial interest in composite material lies in their superior properties of strength-to-weight, stiffness-to-weight, fatigue and thermal expansion compared to metals. Extensive use of composite in application such as rockets, satellites, missiles, light combat aircraft, advanced light helicopter and trainer air craft has shown that India is on par with the advanced countries in the development and use of composites in this area.
The machining of composite materials is a growing problem in various fields such as aeronautical, automotive, wind turbine industries [3].

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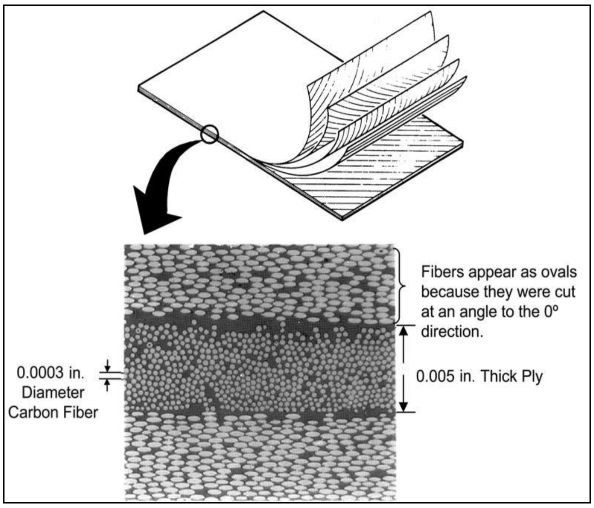

Fig1: Composite material

DELAMINATION:

Delamination is a critical failure mechanism in laminated fiber-reinforced polymer matrix composites, and is one of the key factors differentiating their behavior from that of metallic structures. It is caused by high inter laminar stresses in conjunction with the typically very low through-thickness strength. The phenomenon arises because fibers lying in the plane of a laminate do not provide reinforcement through the thickness, and so the composite relies on the relatively weak matrix to carry loads in that direction. This is compounded by the fact that matrix resins are typically quite brittle. Delamination failure may be detected in the material by its sound as shown in fig.2.

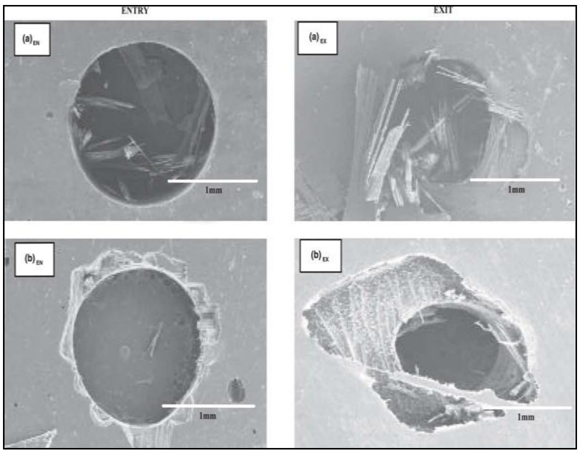

Fig2. Delamination

- It reduces the compressive strength of composite material
- It reduce considerable amount of toughness.
- It can be formed due to tensile stresses at the notches
- Failure of material due to delamination can cause human harm.

II. Literature Review

P. Rahme et.al [1] had been studied analytical model was developed to determine the critical thrust force at delamination at the hole exit. This model gives the drilling thrust force as a function of the cutting conditions. Finally, the two considered models are used to determine the optimal cutting conditions for delamination-free drilling. The results are validated numerically and experimentally. A drilling thrust force model is developed in order to calculate the drilling forces of each zone in function of the feed rate per tooth. The results of the two proposed models are used to calculate the critical feed rate per tooth, at delamination, in the case of a large-diameter twist drill, without thinning its chisel edge. These feed rates are determined for the two zones of the drill. They are calculated according to the number of the non-drilled plies remaining under the drill. The most critical feed rate per tooth corresponds to the lowest value.

Tom Sunny et.al [2] had been studied the effect of speed and feed on delamination behavior of composite materials by conducting drilling experiments using Taguchi's L25, 5-level orthogonal array and Analysis of variance by using three different tools namely Twist drill, End mill and Kevlar drill. ANOVA was used to analyse the data obtained from the experiments and finally determine the optimal drilling parameters in drilling Glass fibre reinforced composite (GFRP) materials. Results of these experiments revealed that increasing the spindle speed and reducing feed rate can reduce the delamination within limits of specified speed and feed rates. Too low feed rate and too high spindle speed can also increase the delamination. Results also revealed that feed rate is the more influential factor on delamination than spindle speed.

Patil A.A [3] had done review on drilling on composite material, It has been predicted that most of the problem associated with hole making operation, such as drilling, can be attributed to the force generated during cutting operation. Many developments and experiments are going on drilling of Sandwich composite for damage free drilling along with the quality of the hole and the effect of tool geometry and tool material. This paper aims at the comprehensive analytical and experimental investigation work done on the composites material.

R.A. Kishore et al.[4] Studied the effect of the cutting speed, the feed rate, and the drill point geometry on the residual tensile strength of the drilled unidirectional glass fiber reinforced epoxy composite using the Taguchi method and suggests the optimal conditions for maximum residual tensile strength. Three important parameters, that is the drill point geometry, the cutting speed and the feed rate have been studied. The optimum levels of the drill point geometry, the cutting speed and the feed rate have been established for getting maximum residual tensile strength in drilled UD-GFRP laminates. The maximum residual strength is found with 8-facet drill at cutting speed of 750 rpm and feed rate of 15 mm/min. It is observed that the drilling-induced damage at higher cutting speeds severely affects the residual tensile strength of drilled laminates. The optimum selection of the drill point geometry is also important to ascertain the minimum drilling induced damage and subsequently the maximum residual tensile strength.

C. C. Tsao [5] Analyzed the Taguchi method for drilling quality associates with core drill. The thrust force and surface roughness of core drill with drill parameters (grit size of diamond, thickness, feed rate and spindle speed) in drilling Carbon Fiber Reinforcement Plastic (CFRP) laminates was experimentally investigated. Composite material for drilling was fabricated using autoclave molding. A L27 orthogonal array and signal-to-noise (S/N) were employed to analyze the effect of drill parameters. Using Taguchi method for design of a robust experiment the interaction among factors is also investigated. For thrust force, thickness and feed rate are the most significant factors and for surface roughness, the feed rate and spindle speed are the most significant factors in drilling GFRP laminates as experimentally and analytically obtained. In general high speed and low drilling feed rate are recommended for the production of delamination free and good surface finish holes in epoxy composites.

E. Kilickap [6] Investigate the influence of the cutting parameters, such as cutting speed and feed rate, and point angle on delamination produced when drilling a GFRP composite. The damage generated associated with drilling GFRP composites were observed, both at the entrance and the exit during the drilling. Moreover, this paper presents the application of Taguchi method and analysis of variance (ANOVA) for minimization of delamination influenced by drilling parameters and drill point angle. The optimum drilling parameter combination was obtained by using the analysis of signal-to-noise ratio. The conclusion revealed that feed rate and cutting speed were the most influential factor on the delamination, respectively. The best results of the delamination were obtained at lower Student cutting speeds and feed rates.

S. Arul et al. [7] Drilling trials have been carried out on glass Fibre reinforced plastics (GFRP) with plain high speed steel (HSS), TiN coated HSS and tipped tungsten carbide drills. Most of the defects in drilling of composites are due to thrust force experienced by the work piece. The parametric influence on cutting force was experimentally evaluated. The experimental results show that the defects toleranced drilling can be attained by proper selection of cutting parameters and tool material. This is substantiated by monitoring flank wear, hole shrinkage and acoustic emission during drilling.

Birhan Isık [8] had given new comprehensive approach to select cutting parameters for damage factor in drilling of glass fiber-reinforced polymer (GFRP) composite material. The influence of drilling on surface quality of woven GFRP plastic composite material was investigated experimentally. Drilling tests were carried out using carbide drills of 8 mm in diameter at 50, 70, and 90 m/min cutting speeds and at 0.06, 0.12, and 0.18 mm/rev feed rates. Damage factor was investigated based on hole entrance and exit. Analysis of variance (ANOVA) test was applied to the experimental results. The compared values were employed by Duncan test to identify which groups were significantly different from other groups.

J. Campos Rubio et al.[9] done work on employs HSM to realize high performance drilling of glass fibre reinforced plastics (GFRP) with reduced damage. In order to establish the damage level, digital analysis is used to assess delamination. A comparison between the conventional (Fd) and adjusted (Fda) delamination factor is presented. The experimental results indicate that the use of HSM is suitable for drilling GFRP ensuring low damage levels.

B.V.Kavad et.al. [10] had done review on influence of machining parameter on the delamination damage of GFRP during drilling. In conventional machining feed rate, tool material and cutting speed are the most influential factor on the delamination hence machining at higher speed, harder tool material and lower feed rate have lesser delamination of the GFRP. Vibration assisted drilling and Ultrasonic assisted drilling have lesser thrust and hence lesser delamination compared to conventional drilling, which indicates that both vibration assisted drilling and Ultrasonic assisted drilling are more appropriate for drilling of GFRP.

III. Problem Identification

The machining of composite materials is a growing problem in various fields such as aeronautical, automotive, wind turbine industries. The drilling of these materials, required to assemble different parts, is difficult to control and often leads to delamination at the exit of the laminates. This can affect the strength of the structure. Analysis and study of this machining process can be helpful for reducing induction of stresses and preventing change in dimension of component. Drilling is important and mostly used machining process. Analysis and study of Drilling process can be helpful for reducing induction of stresses.

Process Parameters:

1. Cutting speed
2. Feed rate
3. Depth of cut

Performance Measures:

1. Delamination factor
2. Material removal rate
3. Surface roughness

IV. Objectives

1. To improve the quality of drill with minimum delamination.

2. To study delamination factor using various parameters

3. To study the effect of cutting speed, feed rate & depth of cut on surface roughness, material removal rate (MRR) and delamination factor of the composite material.

4. To study the effect of variation of machining parameter on response factor.

5. To study the contribution of parameters on response factor.

IV. Methodology

The methodology of presents investigation include following steps:

Step1: Selection of raw material and preparation of GFRC plate of required dimension.

Step2: Selection of machine.

Step3: Selection of drill.

Step4: Selection of drilling parameter.

Step5: Selection of levels and parameter values.

Step6: Selection of Taguchi method to optimise parameters.

Step7: Conduction of experiment.

Step8: Recommending optimum level of machining parameters while concluding work.

Step9: Analysis of results.

Step10: Result and discussion with conclusion.

Conclusion

I have concluded in this Paper work is to evaluate and optimize the effect of process parameters viz. speed, feed rate, and depth of cut for response of surface roughness and material removal rate and delamination factor**.** The effect of machining parameters will be identified for optimum outcome. Taguchi analysis method will be selected for design of experiment.

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