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A Review of Influential Parameters in Drilling Delamination on Fiber Reinforced Polymer Composites

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Abstract : In global developments, the composite materials are plays a vital role in science and technology. In the field of composites materials, fiber reinforced composites are occupy a major portion on development of materials and its products. For the real time applications, the developed composites converted to suitable components with high accuracy by means of machining. In that machining, the drilling is one of the operations are commonly used in many industries due to their applications. On behalf these, the present work are aimed to get a clear idea about fiber reinforced composites on machining study. The study is mainly covers on drilling delamination factor on fiber reinforced polymer composites. Its deals with influential of process parameters, material parameters, types of fabrication and optimization techniques are discussed. From this study, the feed rate is one of the most influential controllable factors among all the process parameters such as applied load, sliding distance, drill bit diameter, point angle, and chisel edge.

Introduction

In recently, the most of research work carried in the field of bio composites. Since, the researchers are concentrated to utilize natural materials to meet the global requirements. Because of its, peculiar properties and availability, recycling, lightweight, inexpensive etc. [1-3] The developed fiber composites are used in many engineering applications such as aircraft industry, space research, automobile fields, naval, sports goods, structural applications, household application etc. [4-5] To covert a real time application of developed fiber composites, machining process such as drilling, grinding, edge shaping, facing are used. In machining process, drilling is one of most frequently used and secondary operation for near net shaped components and assemble section in many industries.In the aircraft industry, the final assembly section a 60 % of components are to be rejected due to delamination effect on drilled hole [6] and a small aircraft engine have 100,000 holes for his assembly [7].

From the literature review, the most of researcher have reported that to obtain a quality hole during drilling is mainly depends on the cutting parameters, cutting tool geometry and materials, specification of machine, work materials & its fabrication method etc [8-11]. The proper selection of above parameters produce a high of hole and falls to above selection lead to so many defects are occurring on developed fiber reinforced composites such as fiber pullout drilling operation, thermal gradient due to uneven bonding, stress concentration on drilled hole, fiber – matrix bonding, fiber cracking, pealing and delamination [12-15]. From

the above defects, the delamination is one of the most occurring defects at entry (peel up) and exit (push out) of drill tool on drilling operation. [16-18]

For minimizing delamiation effect on composites, the researchers may followed many techniques in fabrication process itself. On the way, the selected materials formed as a laminate via adding number of layers one over another and finally these laminate were combined together by means of either hand layup method or compression molding techniques. A chopped fiber or short & long fibers are used to make a lamina. By increasing impact strength of fabricated composite a woven type fiber are used on outer surface of composites. [19]

On drilling of fiber composites, the top & bottom of layers are de-aliened from the composites because of fiber matrix bonding damaged. In practically it is not possible to avoid entirely, but these defects are minimized by improving (adhesive) interfacial strength between the fiber and matrix.The nanoclaymaterials are used to improving adhesive strength between the materials on fiber composites. Hence, the clay content having nucleating effect due to this, crystallization characteristic improved. In addition of above it is used to reduced melt flow rate of polymer, because delamination induced on fiber pullout during drilling operation. On decreasing melt, flow of polymer improves the bonding strength. A correct propagation of clay content needed to achieve good adhesive strength. It may vary means polymer-degassing defects induced due to increasing viscosity. The 7.5 % of nanoclay content improves good strength of composites. Poor bonding and stress concentration produced due to excessive clay content on composites. [20-23]

Significance of parameters and Techniques

A quality-drilled hole are produced at minimum level of feed rate on GRFPC and at the same time high feed rate are produce fiber fracture on composites, because of increasing thrust force. The same nature happened on one more process parameters and namely diameter of drill (size of drill). The contact surface between the tool and work is to be increasing load on drill bit and hence, temperature deviation takes place. This leads to quality of hole and fiber – matrix bonding damaged [24].

The tool materials [18] and variation of tool geometries are used to minimize the delamination effect on fiber-reinforced composites. [25-28]Solid and hollow in shape tool geometry is used for drilling sisal fiber-reinforced polypropylene composite and a considerable amount of delamination factor decreased [29] and the effect of hollow drill bit on drilling is less than the solid [30] and also, the effect of HSS twist drill [31], special drill bits [32] are reported. The delamination effect is reduced on FRPC due to used of a specially made drill bits [33]. The performances of produced hole on composites are much higher by using trepanning tool [34] and carbide tool [35].The effect of tool material on drilling of sisal – Glass fiber reinforced polymer composites. There are three type of tool material (SC, CSC, HSS) used to drill the developed composites and it's found that tool material is important parameter than the feed rate. [36]

Drilling analysis is carried out on chopped fiber composites with three speeds, five feeds, and five fiber volume fractures. The results revolved that fiber volume is directly affect the thrust force and torque during drilling operation. The speed level is not much effect produced on delamination and feed rate is a significant factor [37]. Thrust force, torque, surface roughness and delamination factor (both at entry and exit) are evaluated on CFRP composites. The drill speed, feed and drill diameter are taken in account as a process parameters with TiAlN coated solid carbide drill bit are used for drilling of CFRPC. A Multi Performance Characteristic Index (MPCI) are carried by Fuzzy Inference System (FIS) and also a harmony search (HS) are employed to searching optimal parameter. The result shows that HS tool are effectively used than the other techniques. [38]The optimization of thrust force and torque on drilling CFRP composites are carried by Genetic Algorithm (GA) and Particle Swarm Optimization–Gravitational Search Algorithm (PSO–GSA) techniques with cutting speed, feed rate and drill tool materials. The L 27 designs are employed to evaluate the response value. Feed rate is most significant factor for both response followed by cutting speed. There no much more effect on drill tool materials. [39]

The effect of machining parameters such as feed, speed and drill diameter on woven type GFR/epoxy composites were investigated. The Delamination size, surface roughness, and bearing strength are measured and results shows that the delaminations free drilling on composites are not obtained on the selected parameters [40]. The researcher is trying to minimizing effect of delamination in drilling on fabricated composites by

means of process parameters, materials parameters and fabrication. Hence, need to give special attention on selecting parameters and its level. Because it is very sensitive and its impact are directly related to quality of drilled components.

Epoxy resin and E glass fiber are used as a matrix and reinforcement materials on fiber reinforced polymer composites, because of their thermal and mechanical properties. [24]Due to high damping, corrosion resistance,thermal expansion on Carbon fiber reinforced plastic composites are used in functional and structural applications [18]The minimum damage is produced on GFRC are drilled by high speed machining [41]

Taguchi orthogonal array L 9 is used find optimal level of parameter among the other selected parameter through minimum number of experiments on glass fiber reinforced polymer composites. The obtained results are reveled by S/N ratio, in that "lower-is-better" is most suitable for the response. Because, it is need to minimizing effect on composites.(11)The E glass with Epoxy resin composites are undergone a Taguchi L 27 (313) orthogonal array techniques employed for optimize the process parameters effectively. This study also viewed interaction properties between the parameters. The predicted and experimental values are very close to each other because of developed multi regression model are used efficiently. [24]

Taguchi and ANNOVA techniques are employed to determine optimum level of process parameters on GFRP composite materials. The minimum delamination occurred on low level (5 mm) drill size, low level feed rate (0.02mm/rev.) and mean level of spindle speed (1440 rpm) [42].Taguchi orthogonal L18 design is developed for optimizing drilling process parameter on glass fiber reinforced plastic composites. The controlled factor namely drill diameter, feed rate and spindle spped. In addition of above, parameters the surface condition of composites also taken an account. The S/N ratio are obtained from the delamination results. The result shows that the feed rate is most significant factor followed by drill diameter, spindle speed and surface condition. [43]

The Response surface methodology techniques are employed to optimize effect of drilling delamination on carbon fiber reinforced plastic composites. The results are also analyzed through ANOVA techniques and 95% confidence level adequacy obtained [18]. In RSM, the Box–Behnken design are used to design the number of experiments and developing empirical model, which is used to predict the interaction results without conducing experiment test on glass fiber reinforced plastic composites. in this test were carried by carbide grade K20 helical drill bit of 5 mm diameter [44-48]. Taguchi with multi objective optimization techniques are plays a vital role on fiber reinforced polymer composites to determining significant factor for minimizing delamination effect [49] The RSM techniques are used to optimizing machining parameter on ytterbium fiber laser. During machining, the parameters namely laser power, modulation frequency, gas pressure, wait time, pulse width are considered with different level. The aim of this paper is to maximizing metal removal rate (MMR) and minimizing tapering. In RSM – CCD method used to design 31 numbers of experiments and mathematical model were developed for predicting response results. From the ANOVA analyzing the wait time and modulation frequency are most influential factor for response. The interaction effects between the selected parameters explained with the help of 3-D surface plots. []50

Central composite rotatable design is used to setting up experimental design with 30 number of experiments and considering four factor namely spindle speed, tool feed rate, drill diameter and fiber orientation angle with five levels on GFRPC. From this analysis fiber orientation is not that much effect produced on delamination and found that the tool feed rate is most influential factor. [51]Integration of Taguchi and Response surface methodology are used to study the effect of process parameters on GFRP composites [52].The tensile strength were measured after drilling flax natural fiber composites. The two level three factors (spindle speed, feed rate and drill point geometry). Taguchi L 8 designs are employed to identify significant factor. From the S/N ratio, the feed rate is one of influential factor followed by spindle speed and drill point geometry. In total parameter contribution, the feed rate is occupying 74% effect on response obtained from ANOVA techniques. [53]Optimization of wet milling process parameters on nano particle are carried by integration of taguchi, RSM method. In addition to that a Genetic algorithm are employed and it is found most optimal parameter. [54]

The parameters effect of delamination on medium density fiber board are analyzed by taguchi techniques and the 37 % & 39.2% contribution effect produce on feed rate and cutting sped respectively. The reaming contribution carried by interaction effect on cutting parameters [55].The delamination factor at exit is more than the entry panel of drill tool. The main reason of this variation is due to the adjusted layer is product

the delamination effect at the entry level(top layer of composites) on drilling and at the same time the bottom layer is pulled out from the adjutant layer due to the direction cutting force. In other words the top layer is compressed to nearby layer and bottom layer is pulled from the composites [48].

Conclusion

This review work on fiber reinforced polymer composites under the influential factor is effectively studied. From the above work it is concluded as follows,

- The delamination factor on exit is more than the entry panel of drill bit. Because the compression action takes place between the fiber at entry level and bush out of fibers happened at exit level of drill bit. This deviation happed because of direction of cutting tool to work.
- The feed rate is one of the most significant factor over the eother process parameters.
- The delamination effect on FRP composites can be reduced by proper selection of parameters and its level.
- To minimizing thermal deviation on drilling, the small size hole is preferred as compare to large size of hole, because of reducing contact between tool and work.
- For effective utilization of experiments (ie) to predict experimental value of output response by empirical model, suitable optimization techniques are to be followed.

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