

Effects of Drilling Parameters on Delamination of Coconut Meat Husk Reinforced Polyester Composites

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ABSTRACT

Drilling is the most frequently employed operation of secondary machining for composite materials owing to the need for structure joining. However, drilling composite materials present number of problems such as delamination. Delamination has been a major form of failure in drilled composite materials due to the composites lack of strength in the drilling direction, which results in poor surface finish, reduction in bearing strength, reduction in structural integrity and ultimately poor performance of the composite. This present paper investigated the effects of drilling parameter by drilling the holes on the coconut meat husks reinforced polyester composites and evaluate its hole quality by measuring delamination. Drilling process is carried out for three spindle speed (1500 rpm, 2000 rpm and 2500 rpm) and three feed rate (0.1 mm/rev, 0.2 mm/rev and 0.3 mm/rev) by using a carbide twist drill. The results indicate that by using lower feed rate, it can obtain minimum delamination while effect of increasing spindle speed showed less influenced.

Key words: Delamination, Coconut Meat Husk Reinforced Polyester Composites, Drilling.

Introduction

Nowadays, natural fibers have the potential to be used as a replacement for glass or other traditional reinforcement materials in composites [1-5]. One of them is coconut meat husk fiber which abundantly available in Malaysia. This fibre can be obtained easily from the wet markets which are rendered as a waste and can be explored as a potential reinforcement. The advantages of using natural fibre composites include low density, high toughness, comparable specific strength properties, reduction in tool wear, ease of separation, decreased energy of fabrication [6].

However, due to the inhomogeneous and anisotropic nature of composite materials, their machining behavior differs in many respects from metal machining [7]. As the developments of natural fiber reinforced composites are growing now, machining of composite materials requires the need for better understanding of cutting processes regarding accuracy and efficiency. Though near-net shape processes have gained a lot of attention, more intricate products need secondary machining for the required accuracy. Drilling is the most frequently employed operation of secondary machining for fiber-reinforced materials [8].

Drilling is one of the common machining processes used in composite materials for making holes for screws, rivets, and bolts. The machined

holes are used for joining different components of the composites structures. Since composite materials are neither homogeneous nor isotropic, the drilling of these materials can lead to damages in the regions around the drilled holes. The most frequent defects caused by drilling composite materials are delamination, fiber pull-out, interlaminar cracks, or thermal degradation.

Delamination is a major problem associated with drilling fiber reinforced composite material because it reducing the structural integrity of the material[9], also result in poor assembly tolerance and has the potential for long-term performance deterioration. Delamination is mainly caused by the thrust force action on the chisel edge. Its develops along the fiber direction and caused by two phases, the chisel edge action phase and the cutting-edge action phase. The first phase begins when the thrust force of the chisel edge onto the exit surface reaches a critical value and ends when the chisel edge penetrates the plate [10]. The chisel edge has a strong effect on the formation of the delamination.

Most of the major research reported delamination address specific of machining fiber glass, graphite fibre or carbon fiber reinforced polymer composites. It is not yet clear how different drilling parameters affect the machinability of natural fiber reinforced polymer composite materials and

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quality of drilled holes. Therefore, in this study, drilling of coconut meat husk reinforced polyester composites by using carbide twist drill was investigated by evaluating delamination at various spindle speed and feed rate.

Experimental Methods:

The untreated coconut meat husk reinforced polyester composites was manufactured by hand lay-up method, the commonly used method for small-scale composite manufacturing. Coconut meat husk as shown in Fig. 1 was used as a reinforcement and Polyester resin is used as a matrix with 1 percent of hardener (butanox M60).



Fig. 1: Coconut meat husk fiber

All composite panels were prepared with ten percent fibre by weight and fabricated using hand lay up technique with size mould of 200 mm (*L*) × 150 mm (*W*) × 3 mm (*T*). The curing time was about 24 hours applied near room temperature. Finally, composites plates were cut to 135 mm x 35 mm.

Drilling experiments were performed on an HAAS CNC milling machine and twist drill with 118° point angle used was made of K20 carbide and have a diameter of 6 mm as shown in Fig. 2.



Fig. 2: Twist drill with 118° point angle

Besides that three spindle speeds were used are 1500 rpm, 2000 rpm and 2500 rpm. In addition, the feed rate used are 0.1 mm/rev, 0.2 mm/rev and 0.3 mm/rev. Six holes were drilled for each plate, and drilling is done without using a sacrificial plate. Push down delamination as shown in Fig. 3, is measured using a tool maker microscope (Fig.4)

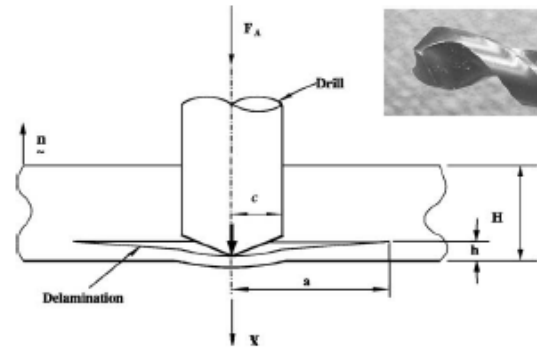


Fig. 3: Push down delamination (twist drill)



Fig.4: Tool maker microscope

Evaluation of delamination damages as shown in Fig. 5 was referred to delamination factor proposed by Chen [11]. Delamination factor (*F_d*) is defined as the ratio between the maximum delaminated diameter *D_{max}* and the nominal hole diameter *D*, according to Eq. 1:

$$F_d = \frac{D_{max}}{D}$$

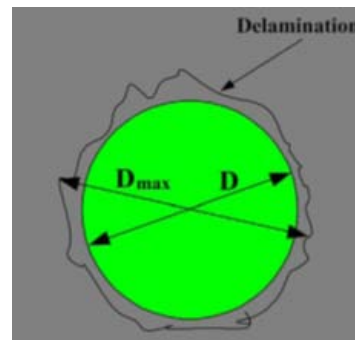


Fig. 5: Delamination factor measurement

Result and Discussion

Delamination extension was measured according to the procedure already described. Fig. 6 shows the influence of feed rate by using spindle speed of 1500 rpm. The increased in feed rate of 0.1 mm/rev to 0.3 mm/rev show an increasing trend in delamination.

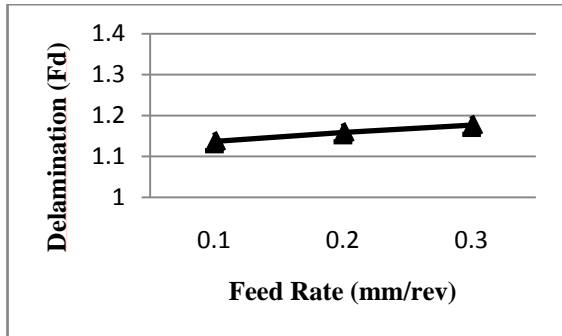


Fig. 6: Influence of using spindle speed 1500 rpm on delamination (F_d)

Fig. 7 shows the increased of spindle speed of 1500 rpm to 2000 rpm. The delamination still at the same range from 1.1 up to 1.2. By increasing the spindle speed the effect on delamination rate did not show any sudden increased.

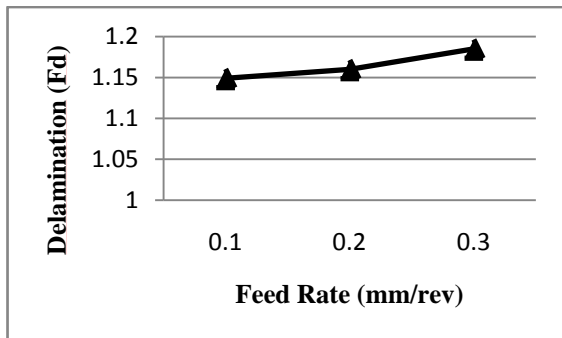


Fig. 7: Influence of using spindle speed 2000 rpm on delamination (F_d)

Fig. 8 shows the increasing spindle speed from 2000 rpm to 2500 rpm. Again, effect of increased spindle speed still showed the same delamination trend.

The result confirmed with the studied done by Davim and Reis [12] where the author concluded that feed rate has a greater influence on delamination when higher damage by increasing the feed rate. This supported by Hocheng and Tsoa [13] where in their work, authors concluded that thrust force varies with drill geometry and with feed rate. More recently Tsoa and Hocheng [14] find that the influence of spindle speed was relatively insignificant. Delamination results in drilling coconut meat husk reinforced polyester composite follow the same trend as

previous researches where increasing the feed rate causes an increase in delamination factor. This outcome stresses the general idea that low feed rates should be used when drilling composites.

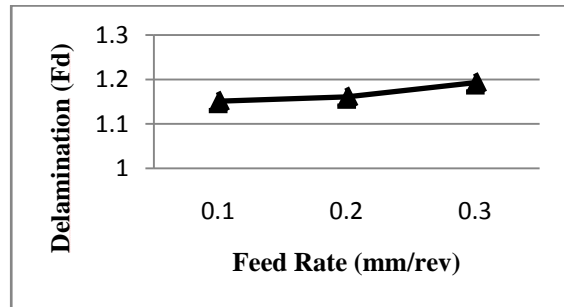


Fig. 8: Influence of using spindle speed 2500 rpm on delamination (F_d)

Conclusion:

An experimental analysis for drilling coconut meat husk reinforced polyester composites induced delamination associated with various drilling parameters (spindle speed and feed rate) is presented in this study. The following conclusions can be drawn from the above investigation:

- From the graph, feed rate was seen to make the largest contribution to the delamination factor. By increasing the feed rate the size of delamination also increased.
- Higher spindle speed did not show any sudden increased in delamination factor.
- The delamination factor of drilled coconut meat husk fiber reinforced polyester composites was in some cases better than those of glass fibre reinforced plastic [15]. This suggests that this coconut husk fibre composites have a potential to be used in many applications where machining is needed.
- Therefore, for the future research it is recommended to use different tool type and geometry so that we can determine whether effect of different tool geometry will give higher or lower delamination value.
- Besides that the use of ANOVA to establish a correlation between spindle speed, feed rate and type of drills with the delamination is highly encouraged.

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