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Investigation On the Effect of Variation of Drilling Parameters On the Delamination Factor in Waste Tire Rubber Polyester Composite Laminates

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Abstract

The waste tire rubber particles are as a filler for a laminated polyester composite with glass fiber, resulting in improved mechanical and physical properties. This innovative material has a wide range of uses, including automotive pumpers and the aerospace sector. The influence of drilling factors such as different twist drill sizes and varying feed rates on the delamination factor is studied in this paper. Comparison between different twist drill sizes shows that the minimum size leads to minimum delamination factor, and the lowest feed rate leads to minimum delamination factor by using optimum speed in all cases.

Keywords: Polyester, Waste tire rubber, Fiber-Reinforcement Composite, Mechanical and physical qualities, Twist drill sizes, Feed Rate.

1. Introduction

The unsaturated polyester resin (UPR) is exploited in many common industries due to its low cost and good strength to weight ratio, even though it's a thermoset material it used in aircraft structures and parts of car bodies and yachts [1]. As a result of the using UPR in many applications the interests increase to improve the filler of polyester composites laminates. Fillers should improve the mechanical, physical, and structural properties of composites. [2].

Waste tires are a disturbing problem nowadays all over the world, more than a billion waste tires are resulted approximately each year [3], and this numbers may increase due to the over use of vehicles transportation worldwide, leading to health and environmental problem as the main component of tires is rubber that does not degrade [4].

Composite materials are widely used nowadays in structural applications which require drilling process to be able to join parts together. Conventional drilling remains the most common, fast and economically way of drilling [5]. Many types of hole damage could be associated with drilling of composite laminates. Cracks and bonding breakdown can be observed in micro scale while hole delamination can be seen in macro scale [5].

Khashaba et al. [6] reported the hole damage in glass fiber reinforced polyester during drilling. Peel up and push out methods are the two types of hole delamination processes. When the twist drill makes contact with the work piece at the commencement of drilling, peel up occurs on the front side of the work piece. The cutting force generated at the drilled hole's periphery is the driving force for this kind. The twist drill's slope created an axial force known as the peeling force, which separated the layers on the work piece's front side surface, resulting in a front delamination zone When the twist drill finishes drilling and starts to get out of the work piece, it causes delamination on the rear side of the work piece, which is known as push out. The rest of the chip is smaller here, therefore drilling resistance is reduced. The axial force may be greater than the bond strength between laminates, resulting in the formation of a second delamination zone on the reverse side of the workpiece. Cutting and thrust forces are affected by tool geometry, applied pressure, cutting conditions, and friction created between the workpiece and the twist drill. [6]. Bassant Hany Mousa et al [7] found that the optimum drilling speed for optimization of delamination factor of polyester / fiber glass with 10% vol rubber particles is 1150 rpm.

This research is concerned with the use of waste tire rubber particles. as a filler to polyester / fiber glass composites besides investigating the delamination resulted of Joining composite plates. One of the main steps of joining the plates by pins or bolts is drilling such plates. The drilling of the novel composite is examined. Twist drill sizes 4, 5 and 6 mm and feed rates 0.01, 0.1 and 0.5 mm/rev are used to study the damage and delamination in the composite with a selected cutting speed 1150 rpm [7].

2. Materials and Methods

2.1. The composite preparation

The composite is prepared as follows;

1. Polyester resin is weighted to the appropriate volume fraction and degassed in a vacuum chamber for 5 minutes.
2. The hardener is added according to the supplier's instructions, and the mixture is degassed for 3 minutes in the vacuum chamber.
3. The liquid is then poured into a silicon rubber mold and let to solidify.
4. Step 2 is repeated once more. The rubber particles are then added, followed by stages 2 and 3.
5. Repeat the previous procedures with the specimen-sized fiberglass material.
6. The specimen dimensions' fiberglass material is placed, and the preceding processes are repeated as shown in Fig. (1).

Fig. (1) composite preparation

2.2. Delamination Factor

Drilling process done using a conventional drilling machine. The drilling tools utilized in the experiments were CARMON® s.r.lCL .'s 415. It featured a strengthened shank and was composed of strong metal with cobalt and tungsten carbide. It was a two flutes tool with a diameter of 4,5 and 6 mm. The point angle of the tools was 140°c, the helix angle was 30° and the tools geometry followed the DIN 6537 k standard.

The drilling experiments were carried out in accordance with Table 1 experimental strategy.

Three different values of the feed rate were chosen: one in the range of the conventional feed rate and the other two in the range of high feed rates. In parallel with the change in feed rate the size of twist drill was changed. This choice was made in order to investigate what happened when high values of feed rate and different twist drill sizes were adopted.

2.3. Delamination Factor

Both peel-up and push-out delamination were evaluated through image analysis according to the procedure reported in [8].

As illustrated in Figure 2, there are two types of hole delamination mechanisms: peel up and push out mechanisms. Peel up is a delamination that happens on the front side of the workpiece when the twist drill meets it at the start of drilling. The cutting force generated at the hole's periphery is the driving force for this kind. The twist drill's slope produces an axial force, which is a peeling force that separates the laminates on the workpiece's front surface, forming a front delamination zone. When the twist drill finishes drilling and starts to get out of the workpiece, it causes delamination on the rear side of the workpiece, which is known as push out. Because the residual chip is smaller at this point, drilling resistance is reduced. The axial force may be greater than the bond strength between laminates, resulting in the formation of a second delamination zone on the reverse side of the workpiece.

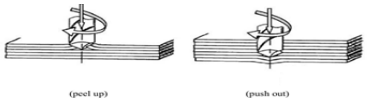

Fig. (2) Delamination mechanism

The delamination factor Fd can be calculated as proposed by Davim [**8**] as shown in fig. (3)

$$Fd = \frac{D\ max}{D\ nom}$$

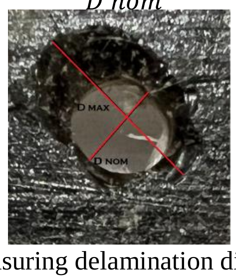

Fig. (3) Measuring delamination diameter

3. Results and discussions

3.1. Delamination factor

Fig. (4) shows the effect of twist drill with feed rate on the peel up and the push out, and the fig. (5) shows the effect of twist drill with feed rate on the push out and fig. (6) for the effect of different feed rates on delamination factor.

Fig. (4) peel up delamination factor

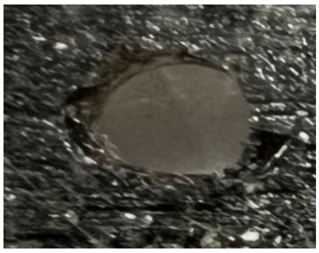

Fig. (5) Push out delamination factor

Fig. (5) Different feed rates effect on delamination factor

The following Table (2) consist of the different results of diameters with different feed rates and the effect of this parameters on the delamination factors for the first sample.

All the diameters measured by scanning the samples and from the ImageJ program to scale the max. and nom. diameters as shown in the table

From the data the relation between Delamination Factor and the different feed rates in the 4 mm diameter twist drill shown in Fig. (6) which analyze the effect of high feed rate which lead to high difference between max. and nom. Diameters in drilling process. Fig. (7) shows the same effect but in 5mm diameter twist drill, and Fig. (8) for 6 mm diameter twist drill.

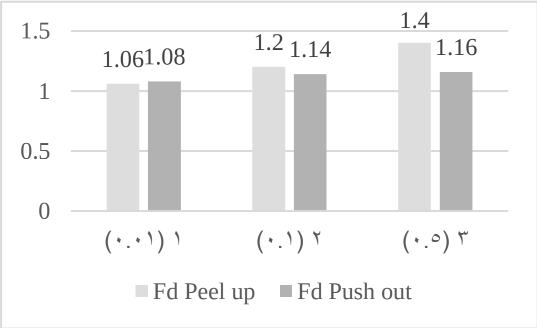

Fig. (6) Variation on Fd with Feed rate in 4 mm dia. Twist drill

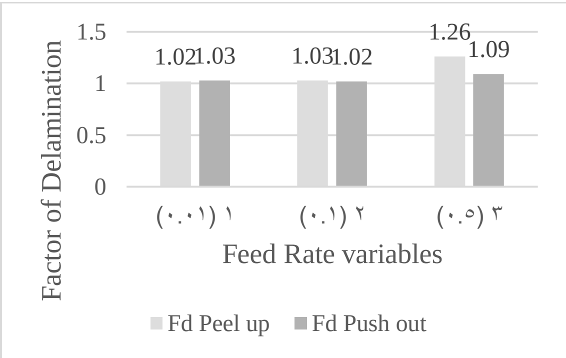

Fig. (7) Variation on Fd with Feed rate in 5 mm dia. Twist drill

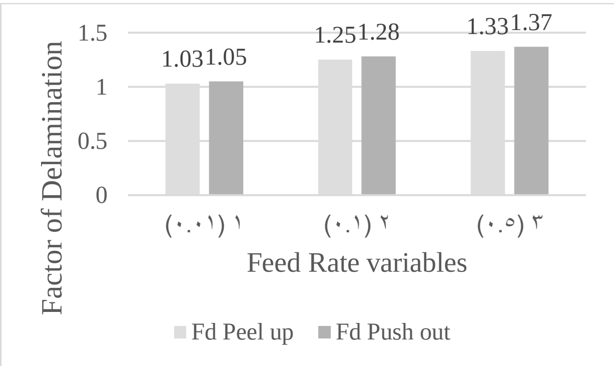

Fig. (8) Variation on Fd with Feed rate in 6 mm dia. Twist drill

pressure of 3 to 5 mm Hg, indicates elevated RV systolic and PA pressure [9].

6-minute walking test (6 MWT) : The test was performed according to American Thoracic Society (ATS) statement 2002, after history taking, examination, ECG & performing an Echocardiography for the patient, immediately after stabilization of the patient, the test was performed [10]. 6MWT was done for every patient before starting ivabradine intake and 3 months after starting ivabradine intake to measure the distance that can be walked by patients. The object of this test is to walk as far as possible for 6 minutes.

Instructions given to patients: Patient was informed to walk back and forth in this hallway. Six minutes is a long time to walk, so you would be exerting yourself. You would probably get out of breath or become exhausted, you are permitted to slow down, to stop, and to rest as necessary. You could lean against the wall while resting, but resume walking as soon as you are able. You might be walking back and forth around the cones. You should pivot briskly around the cones and continue back the other way without hesitation. I was going to show to show the patient. Please watch the way I turn without hesitation. We would avoid having a conversation so that you could save your wind for walking. You could begin when I say 'go'". At the end of the 6 minutes: Have participant sit down (portable chair).

After that, vital signs were assessed, starting with HR (resting &maximum) (because it drops more quickly than SBP and Recovery time (Time taken for heart rate to return to resting HR) should be taken. Calculate and record the distance walked, dyspnea at rest or with minimal exertion, auscultate the lung bases for new or increased crackles and also auscultate the heart apically to detect an S3 heart sound [11].

New York Heart Association Functional Classification

The New York Heart Association (NYHA) Functional Classification provides a simple way of classifying the extent of heart failure. It places patients in one of four categories based on how much they are limited during physical activity; the limitations/symptoms are in regards to normal breathing and varying degrees in shortness of breath and/or angina pain [12].

Class I: Cardiac disease, but no symptoms and no limitation in ordinary physical activity, e.g. shortness of breath when walking, climbing stairs, etc.

Class II: Mild symptoms (mild shortness of breath and/or angina) and slight limitation during ordinary activity.

Class III: Marked limitation in activity due to symptoms, even during less-than-ordinary activity, e.g. walking short distances (20–100 m).Comfortable only at rest.

Class IV: Severe limitations. Experiences symptoms even while at rest. Mostly bedbound patients.

2.4. Statistical analysis

Data were collected, revised, coded and entered to the statistical package for social science (SPSS) version 17. Qualitative data were presented as number and percentages while quantitative data were presented as mean, standard deviations and ranges. The comparison between two groups with qualitative data was done by using Chi-square test and Mann Whitney test and Wilcoxon signed rank test. The comparison between two paired groups with quantitative data and normally distributed was done by using paired sample t-test. The confidence interval was set to 95% and the margin of error accepted was set to 5%. The p-value was considered significant as follows: $P > 0.05$: Non significant, $P < 0.05$: Significant and $P < 0.01$: Highly significant.

2.5. Ethical considerations

A brief appropriate explanation of the aim of the study was given to patients stressing on the importance of data they are going to offer. Personal consent was obtained to enroll patients in the study. Safe guards were taken to protect the confidentiality of personal & clinical data. No risk to the patients enrolled in the study.No obligation on patient to participate in the study.

3. Results

The current study was conducted on 50 cases whose age distribution is shown in table (1) and baseline and clinical characteristics is shown in table (2).

The most prevalent cause of PH in the studied population was chest causes and collagen causes were the least prevalent as shown in table (3), their baseline ECG parameters are shown in table (4) and their baseline left sided echo parameters are shown in table (5).

High statistically significant differences were found between baseline and after 3 months clinical characteristics including HR and 6MWT results as shown in table (6) as well as in NYHA class as shown in table (7).

Comparison of baseline and after 3 months right sided echo parameters revealed statistically significant differences as regards RV mid diameter, TAPSE and PASP. Meanwhile, no statistically significant differences were found between baseline and after 3 months right sided echo parameters as regards as RV basal or long diameters shown in table (8).

Table (1) Experimental plan

Factors	# Levels	Levels
Twist Drill size [mm]	3	4 – 5 – 6 mm
Feed per revolution "f" [mm/rev]	3	0.01 – 0.1 – 0.5 mm/rev
Sample Materials	1	Polyester resin, fiber glass, and waste tire rubber particles
Replications	3	

. **Table (2)** Experimental results

Twist drill size	Feed rate	D nom Peel up	D max Peel up	Fd	D nom Push out	D max Push out	Fd
	0.01	4.05	4.31	**1.06**	4.08	4.4	**1.08**
4mm	0.1	4.08	4.9	**1.2**	4.12	4.68	**1.14**
	0.5	4.2	5.88	**1.4**	5.1	5.9	**1.16**
	0.01	4.8	4.9	**1.02**	5	5.15	**1.03**
5mm	0.1	4.85	5	**1.03**	5.1	5.2	**1.02**
	0.5	4.9	6.2	**1.26**	53	5.8	**1.09**
	0.01	5.89	6.05	**1.03**	5.9	6.2	**1.05**
6mm	0.1	5.9	7.4	**1.25**	5.95	7.6	**1.28**
	0.5	6.1	8.2	**1.33**	6.05	8.3	**1.37**

4. CONCLUSIONS

From the previous data, the optimum drilling parameter which leads to the minimum delamination factor value.

Drilling analysis shows that feed rate affects the delamination zone of the drilled holes in rubber polyester composite.

There are no problems with increasing the twist drill size as long as the feed rate in minimum value.

Increasing the feed rate leads to high delamination factor with constant cutting speed.

References

[1] G.M.S.Rahman, Enhanced physico-mechanical properties of polyester resin film using CaCO3 filler. Fibers Polym. Vol.17, pp.59–65, 2016.

[2] K.F.A.Elenien, A.Abdel-Wahab, R.ElGamsy, M.H.Abdellatif, Assessment of the properties of PP composite with addition of recycled tire rubber. Ain Shams Eng. J. vol.9(4), pp.3271–3276, 2018

[3] A.A.Alshukri, Mechanical and curing properties of crumbrubber irradiated in polar media filled the tire tread blend. J. Comput.Theoret. Nanosci. Vol.14(11), pp.5253–5260, 2017.

[4] B.Abu-Jdayil, A.H.Mourad, A.Hussain, Thermal and physical characteristics of polyester–scrap tire composites. Constr. Build.Mater. vol.105, pp.472–479, 2016.

[5] B.S.Rao, Effect of drilling induced damage on notched tensile and pin bearing strengths of woven GFR-epoxy composites. “Mater. Sci. Eng. “A vol.472(1–2), pp.347–352, 2008.

[6] U.A.Khashaba, M.A.Seif, M.A.Elhamid, “Drilling analysis of chopped composites”. Composites A vol.38(1), pp.61–70, 2007.

[7] Bassant Hany Mousa, N.A.Azab, Ghada Bassioni1, Mohamed Hazem Abdellatif, “Assessment of the Damage Resulting from Drilling Holes in Waste Tire Rubber Polyester Composite Laminates” Waste and Biomass Valorization, Vol.12(4), pp. 4069–4080, 2009.

[8] JP.Davim, JC.Rubio, AM.Abrao, A novel approach based on digital image analysis to evaluate the delamination factor after drilling composite laminates. Compos Sci Technol vol.67, pp.1939-1945, 2007

[9] L.M.P.Durão, Delamination in carbon/epoxy plates drilling: tool and feed rate effect. Int. J. Mater. Prod. Technol. Vol.49(4), pp.267–284, 2014.