Effect of Shot Penning on Wear rate of Eggshell natural composite Materials

Fadhel Abbas Abdulla and Ahmed Hadi Abdullah
Al-Mustansiriyah University, College of Engineering
farhan14.aa@gmail.com

ABSTRACT

The effect of shot penning on wear rate of natural materials was investigated experimentally. Egg shell - polyester was used in this experiment using (30% and 55%) weight fraction. The samples were affected on shot penning for two different times (2 min and 6 min) with variation of solidification times (six, four and two days). The wear rate and mechanical properties of natural composite samples (with and without shot penning) were found. The hardness tester for natural composite samples was done. The resultant shows that, the increasing weight fraction causes increasing of solidification of natural composite materials. The egg shell-polyester (55%) weight fraction samples have mechanical properties and reduction wear rate better than egg shell – polyester (30%) weight fraction samples. The increasing time of shot penning causes reduction in wear rate. The egg shell (55%) weight fraction natural composite material has good resistance to wear rate under shot penning. The suitable shot peening time for fiber egg shell natural composite materials is equal or less than 6 min.

KEYWORDS: wear rate, Natural Materials, shot penning Egg Shell.

1. Introduction

Natural fibers were used in asian markets for many years. Being completely renewable, biodegradable, abundant, inexpensive, low-density, and environmentally friendly. The annual production of natural fibers in India is about 6 million tons compared to the global production of about 25 million tons, at the present time [1]. In the past few years, the focus has been on natural reinforced plastics. It has been observed that it is a reasonable mechanical exposure [2]. However, its poor wear resistance and low tribo-corrosion performance has severely limited their use in engineering applications where friction is involved [3]. Ibrahem (2016) [4] studied experimentally that the friction coefficient for carbon or coir powder filled polyester less than friction coefficient of carbon or coir fiber reinforced polyester. and wear
resistance of carbon or coir fiber reinforced polyester is higher than wear resistance of carbon or coir powder reinforced polyester. Mohammed et al. (2019) [5] Studied the effect of independent factors like filler (3%, 6%, 9%, 11% weight fraction), time sliding (9, 7, 5 min), and normal load (5N, 10N, 15N) on wear behavior of unsaturated polyester resin reinforced with jute fiber and waste eggshell and, rice husk powder composites by utilizing a statistical approach. Kwon-yeong Lee et al. [6], evaluated the effects of distance and temperature on the metal-to-metal wear behavior of (Fe-20Cr-1.7C-1Si) in the distance up to 18 m at 300 and temperature range from 25 to 450 C. the wear rate increased significantly from the beginning of the wear test and became almost saturated over the 3.6m distance. S. Narendranath et al. [7], investigated the applied load effect on dry sliding wear property of aged TiNiCu alloy. It was found that increasing the aging temperature leads to an increased wear rate. This is due to decrease in hardness of the Ti50Ni45Cu5 alloys. Abrasion, adhesion, brinelling and surface fatigue are main mechanisms that they have important contributions to the wear characteristics of the aged Ti50Ni45Cu5 alloys. In this work, a natural composite consists of eggshell/polyester (30 and 55%) weight friction and the shot penning effect on wear behavior for natural composite materials are investigated experimentally.

2. EXPERIMENTAL WORK

2.1. Natural Fiber Preparation:

The natural reinforcements to make the composite materials were used in this experiment, which is egg shells. The natural fibers are cleaned with water well. The natural fibers that have been cleaned are dried by sun light. After drying the natural fibers are made as a micro powder by using a mixer, see figure (1)

![Figure (1) preparing of eggshell powder](image)

2.2. Composite Materials Preparation

In this experiment part, the hand lay-up technique was used to prepare the samples. In this experiment, the hand lay-up technique was used to prepare the samples [8]. A glass mold of (10 mm diameter and 70 mm length) with unlocked end is used in this work. Lubricating the pipe from inside by oil and placing the fibers in glass-mold in homogenous shape to cover most sample volume, as shown in figure (2). The Natural powder mixed with polyester resin (which first mixes with a hardener by 2%) according to the desired (30 and 55%) weight friction. Then the mixture is
placed in the glass mold and leave the sample to dry for a period of (2, 4 and 6 days) at room temperature, until the sample is ready for use, as shown in the figure (3).

Figure (2) Desired Samples

2.3. Hardness Test

This test used hardness and depending to (ASTM DI-2242) standard [9]. Tests have been cut with a diameter of (10mm) and a length of (40mm). Experimental specimens are the same used in (Pin on Disc) and (shot penning) device.

2.4. The Process of Shot Peening

This process has been used to evaluate effect in improve mechanical properties and wear behavior for all prepared specimens for all shot peening times. Also, SP was achieved by Sintokogio LTD machines, STB-OB model. The shot peening machine used for this purpose is located in the Institute of Technology in Baghdad, The shooting machine consists of a rotary cylinder with an inner diameter of 590 mm and a depth of 740 mm, where the samples. For three time periods (2, and 6 min) was use the shot peening process [10] [11]. Figure (4) shows Ball used in shooting, figure (5) shows the device used in this work (shot penning).

Figure (4) Ball used in Shooting
2.5. Device of Wear Measurement

To measure wear rate, pin on disc device according to ASTM G-99 standards [12] was used. Figure (6) shows (pin on disc) device schematic diagram. Figure (7) shows the device used in this work (pin on disc). Lastly, the natural composite samples were cutting into Dimensions (10mm diameter and 40mm length) for use in (Pin on Disc) device, as shown in the figure (8) [13] [14].

3.4. Plan of Experiments

The experimental plan was formulated considering five parameters. The five independent variables considered for this study which is (load, sliding speed, sliding distance, Shot peening time and Solidification time) [15][16]. The levels of these variables chosen for experimentation are given in Table (1).
Figure (7) (pin on disc) Device

Figure (8) Samples of wear test

Table (1): Parameters and their levels

| Levels | Sliding speed, (rpm) | Load, (N) | Sliding distance, (m) | Shot peening time, (min) | Solidification time, (day) |
|--------|----------------------|-----------|-----------------------|--------------------------|---------------------------|
| 1      | 100                  | 10        | 500                   | 2                        | 2                         |
| 2      | 200                  | 20        | 1000                  | 4                        | 4                         |
| 3      | 300                  | 30        | 1500                  | 6                        | 6                         |

3. RESULTS AND DISCUSSION

Figure (9) shows the relationship between hardness of egg shell natural composite with the time of solidification during different weight friction (30% and 55%) [17]. This figure shows that the eggshell composite (30%) weight friction needs six days to be at full solidification, the hardness increases by 91.43% from the first day until the composite material reaches the full solidification (six days). While the eggshell composite (55%) weight friction needs six days to be at full solidification, the hardness increases by 76.2% from the first day until the natural composite material reaches the full solidification (six days).

Figure (10) gives the relation between wear rate of egg shell natural composite with the time of solidification during different shot peening, and for three times of
solidification for the (30%) weight friction natural composite material. This figure shows, Variation of wear rate with time of solidification at load=20N, (speed=200rpm) and (distance=1000m) natural composite materials at 30% weight fraction with different shot peening time (2min, 6 min and without shot peening) [18]. The maximum value of the wear rate was (0.0067 g and 0.0041 g) for two min and six min respectively (2 days solidification), the minimums value of the wear rate was (0.0054 g and 0.0033 g) for two min and six min of shot peening respectively (at six days solidification), the time of solidification treatment will cause a decrease in the wear rate and the maximum value of wear rate was (0.0062 g) at six days which is the value of the sample without shot peening. effect for (distance 1000m) and (speeds 200rpm) at load of 20N. Also, there in a high decrease in the wear rate for each period of SPT state when increasing solidification more than 6 days. The maximum value decrease on wear rate was (46.77%) and (12.9%) for 6 min and 2 mint commend with sample (without shot peening).

Figure (11) shows the relationship between wear rate of egg shell natural composite with the time of solidification during different shot peening, and for three times of solidification for the (30%) weight friction natural composite material. This figure shows, Variation of wear rate with time of solidification at load=30N, (speed=300rpm) and (distance=1500m) natural composite materials at 30% weight fraction with different shot peening time (2min, 6 min and without shot peening). the maximum value of the wear rate was (0.00921 g and 0.00769 g) for two min and six min of shot peening respectively (at two days solidification), the minimums value of the wear rate was (0.0081 g and 0.0063 g) for two min and six min of shot peening respectively (at six days solidification), the time of solidification treatment will cause a decrease in the wear rate and the maximum value of wear rate was (0.009 g) at six days which is the value of the sample without shot peening. effect for (distance 1500m) and (speeds 300rpm) at load of 30N [19]. Also, there in a high decrease in the wear rate for each period of SPT state when increasing solidification more than 6 days. The maximum value decrease on wear rate was (30%) and (10%) for 6 min and 2 min commend with sample (without shot peening).

Figure (12) gives the relation between wear rate of egg shell composite with the time of solidification during different shot peening, and for three times of solidification for the (55%) weight friction natural composite material. This figure shows, Variation of wear rate with time of solidification at load=20N, (speed=200rpm) and (distance=1000m) natural composite materials at 55% weight fraction with different shot peening time (2 min, 6 min and without shot peening), the maximum value of the wear rate was (0.0059 g and 0.0027 g) for two min and six min of shot peening respectively (at two days solidification), the minimums value of the wear rate was (0.0031 g and 0.00159 g) for two min and six min of shot peening respectively (at six days solidification), the time of solidification treatment will cause a decrease in the wear rate and the maximum value of wear rate was (0.0042 g) at six days which is the value of the sample without shot peening [20]. effect for (distance 1000m) and (speeds 200rpm) at load of 20N. Also, there in a high decrease in the wear rate for each period of SPT state when increasing solidification more than 6 days. The maximum value decrease on wear rate was (62.14%) and (26.2%) for 6 min and 2 min commend with sample (without shot peening).

Figure (13) gives the relation between wear rate of egg shell composite with the time of solidification during different shot peening, and for three times of solidification for
the (55%) weight friction natural composite material. This figure shows, Variation of wear rate with time of solidification at load=30N, (speed=300rpm) and (distance=1500m) natural composite materials at 55% weight fraction with different shot peening time (2min, 6min and without shot peening). the maximum value of the wear rate was (0.0077 g and 0.0043 g) for two min and six min of shot peening respectively (at two days solidification), the minimums value of the wear rate was (0.0068 g and 0.0034 g) for two min and six min of shot peening respectively (at six days solidification), the time of solidification treatment will cause a decrease in the wear rate and the maximum value of wear rate was (0.0073 g) at six days which is the value of the sample without shot peening. effect for (distance 1500m) and (speeds 300rpm) at load of 30N. Also, there in a high decrease in the wear rate for each period of SPT state when increasing solidification more than 6 days [21]. The maximum value decrease on wear rate was (53.42%) and (6.85%) for 6 min and 2 min commend with sample (without shot peening).

Figure (9) Hardness of eggshell composite samples with different weight friction.

Figure (10) Variation of wear rate with time of solidification at load=20N, (speed=200rpm) and (distance=1000m) Natural composite Materials at 30% weight fraction with different shot peening time (2 min, 6 min and without shot peening).
Figure (11) Variation of wear rate with time of solidification at load=30N, (speed=300rpm) and (distance=1500m) natural composite materials at 30% weight fraction with different shot penning time (2 min, 6 min and without shot penning).

Figure (12) Variation of wear rate with time of solidification at load=20N, (speed=200rpm) and (distance=1000m) natural composite materials at 55% weight fraction with different shot penning time (2 min, 6 min and without shot penning).

Figure (13) Variation of wear rate with time of solidification at load=30N, (speed=300rpm) and (distance=1500m) natural composite materials at 55% weight fraction with different shot penning time (2 min, 6 min and without shot penning).
Figure (14) illustrates the relation between wear rate of egg shell composite with time of solidification with shot penning effect, (SPT= 2min) and (Distance=1000m) for different sliding speed of (200 and 300rpm) and different (30% and 55%) weight friction at load of (20N). From figure, the maximum wear rate of (30%) weight friction was (0.0071 g and 0.0067 g) for speed of (200 and 300rpm) respectively, (at 2 days solidification) [22]. The minimums value of the wear rate of (30%) weight friction was (0.00615 g and 0.0054 g) for speed of (300 and 200rpm) respectively, (at 6 days solidification). Also, the maximum wear rate of (55%) weight friction was (0.0062 g and 0.0059 g) for speed of (200 and 300rpm) respectively (at 2 days solidification). The minimums value of the wear rate of (55%) weight friction was (0.0043 g and 0.0031 g) for speed of (300 and 200rpm) respectively, (at 6 days solidification). The maximum value decrease on wear rate was (47.45%) for (55%) weight friction and 200rpm. The maximum value decrease on wear rate was (13%) for (30%) weight friction and 300rpm. Also, there is a high decrease in the wear rate for each period of solidification state when increasing SPT more than 6 min.

Figure (15) shows the relationship between wear rate of egg shell composite with time of solidification with shot penning effect, (SPT= 6min) and (Distance=1000m) for different sliding speed of (200 and 300rpm) and different weight friction (30% and 55%) at load of (20N). From figure, the maximum wear rate of (30%) was (0.00473 g and 0.0041 g) for speed of (300 and 200rpm) respectively, (at 2 days solidification). The minimums value of the wear rate of (30%) weight friction was (0.00355 g and 0.0033 g) for speed of (300 and 200rpm) respectively, (at 6 days solidification). Also, the maximum wear rate of (55%) weight friction was (0.0032 g and 0.0027 g) for speed of (300 and 200rpm) respectively (at 2 days solidification) [23]. The minimums value of the wear rate of (55%) weight friction was (0.00265 g and 0.00159 g) for speed of (300 and 200rpm) respectively, (at 6 days solidification). The maximum value decrease on wear rate was (41.11%) for (55%) weight friction and 200rpm. The maximum value decrease on wear rate was (24.95%) for (30%) weight friction and 300rpm. There is a high decrease in the wear rate for each period of solidification state when increasing SPT more than 6 minutes.

Figure (16) illustrates the relation between wear rate of egg shell composite with time of solidification with shot penning effect, (Distance=1000m) and (Speed=200rpm) for different loads of (20 and 30N) and different (30% and 55%) weight friction at SPT= 2min. The maximum wear rate of (30%) weight friction was (0.0067 g and 0.00697 g) for different loads of (20 and 30N) respectively, (at 2 days solidification). The minimums wear rate of (30%) weight friction was (0.0054 g and 0.0057 g) for speed of (20 and 30N) respectively, (at 6 days solidification). Also, the maximum wear rate of (55%) weight friction was (0.0059 g and 0.0063 g) for different loads of (20 and 30N) respectively (at 2 days solidification). The minimums value of the wear rate of (55%) weight friction was (0.0031 g and 0.0052 g) for different loads (20 and 30N) respectively, (at 6 days solidification). The maximum value decrease on wear rate was (47.45%) for (55%) weight friction and 200N. The maximum value decrease on wear rate was (26.14%) for (30%) weight friction and 300N. Also, there is a high decrease in the wear rate for each period of solidification state when increasing SPT more than 6 min.

Figure (17) illustrates the relation between wear rate of egg shell/polyester with time of solidification with shot penning effect, (Distance=1000m) and (Speed=200rpm) for different loads of (20 and 30N) and different (30% and 55%) weight friction at different weights of (30% and 55%) at load of (20N). From figure, the maximum wear rate of (30%) weight friction was (0.0071 g and 0.0067 g) for speed of (200 and 300rpm) respectively, (at 2 days solidification) [22]. The minimums value of the wear rate of (30%) weight friction was (0.00615 g and 0.0054 g) for speed of (300 and 200rpm) respectively, (at 6 days solidification). Also, the maximum wear rate of (55%) weight friction was (0.0062 g and 0.0059 g) for speed of (200 and 300rpm) respectively (at 2 days solidification). The minimums value of the wear rate of (55%) weight friction was (0.0043 g and 0.0031 g) for speed of (300 and 200rpm) respectively, (at 6 days solidification). The maximum value decrease on wear rate was (47.45%) for (55%) weight friction and 200rpm. The maximum value decrease on wear rate was (13%) for (30%) weight friction and 300rpm. Also, there is a high decrease in the wear rate for each period of solidification state when increasing SPT more than 6 min.
(SPT= 6 min). It can be seen that the maximum value of the wear rate of (30%) weight friction was (0.0041 g and 0.0057 g) for different loads of (20 and 30N) respectively, (at 2 days solidification). The minimums value of the wear rate of (30%) weight friction was (0.0033 g and 0.00421 g) for different loads of (20 and 30N) respectively, (at 6 days solidification). The maximum wear rate of (55%) weight friction was (0.0027 g and 0.0038 g) for different loads of (20 and 30N) respectively (at 2 days solidification). The minimums wear rate of (55%) weight friction was (0.00159 g and 0.0028 g) for different loads (20 and 30N) respectively, (at 6 days solidification). The maximum value decrease on wear rate was (23.88%) for (55%) weight friction and (load= 20N). The maximum value decrease on wear rate was (13%) for (30%) weight friction and (load= 30N). Also, there in a high decrease in the wear rate for each period of solidification state when increasing SPT more than 6 min.

![Graph](image1.png)

Figure (14) Variation of wear rate with time of solidification at load=20N, (SPT=2min) and (distance=1000m) during different (30 and 55%) weight friction of egg shell composite.

![Graph](image2.png)

Figure (15) Variation of wear rate with time of solidification at load=20N, (SPT=6min) and (Distance=1000m) during Different weight friction of egg shell composite.
11

Figure (16) Variation of wear rate with time of solidification at Speed=200rpm, (SPT=2min) and (Distance=1000m) during Different weight frication of egg shell composite.

Figure (17) Variation of wear rate with time of solidification at Speed=200rpm, (SPT=6min) and (Distance=1500m) during Different weight frication of egg shell composite.

4. Conclusions

The main concluded points of this study may be summarized as follows:

1- Increasing the speed, load, and distance will be increases the wear of egg shell/polyester.
2- Increasing shot peening time will be causes decreases of wear rate at six days solidification, at 6 min of shot peening, the maximum decreases in wear rate will be found.

3- For the same time of shot peening and same solidification time, the weight frication (55%) natural composite material has better wear rate properties compared to wear rate properties of the weight frication (30%) natural composite material.

4- The shot penning has a considerable effect on the wear of egg shell fiber/polyester. Therefore, wear without shot penning effect is lower than wear with shot penning effect

5- The suitable shot peening time for fiber egg shell natural composite materials is equal to or less than 6 min.

5. References

1. Taj, S., Munawar, M. A., & Khan, S. (2007). Natural fiber-reinforced polymer composites. Proceedings-Pakistan Academy of Sciences, 44(2), 129.
2. Sonar, T., Patil, S., Deshmukh, V., & Acharya, R. (2015). Natural Fiber Reinforced Polymer Composite Material-A Review. IOSR Journal of Mechanical and Civil Engineering, 2278-1684.
3. Pawlak, W., Kubiak, K. J., Wendler, B. G., & Mathia, T. G. (2015). Wear resistant multilayer nanocomposite WC1− x/C coating on Ti–6Al–4V titanium alloy. Tribology International, 82, 400-406
4. Ibrahim, R. A. (2016). Friction and wear behaviour of fibre/particles reinforced polyester composites. International Journal of Advanced Materials Research, 2(2), 22-26.
5. Mohammed, R. A., Raheem, R. H. A., & Khazaal, S. H. (2019). Wear Behavior Performance of Polymeric Matrix Composites Using Taguchi Experiments. Al-Khwarizmi Engineering Journal, 15(4), 33-44.
6. Kwon-yeong Lee, Kang Hee Ko, Ji Hui Kim, Gyung Guk Kim and Seon-jin Kim, “Effects of Temperature and Sliding Distance on the Wear Behavior of Austenitic Fe-Cr-C-Si Hardfacing Alloy”, Tribology Letters, Vol. 26, No. 2, May 2007.
7. S. Narendranath, S. Basavarajappa, K.V. Arun and S. Manjunath Yadav, “Effect of Applied Load on Dry Sliding Wear Property of Aged TiNiCu Alloy” Journal of minerals and materials characterization and engineering, Vol. 9, No.9, pp.811-817, 2010.
8. Al-Ameen E S, Abdulhameed J J, Abdulla F A, Ogaili A A F and Al-Sabbagh M N M 2020 Strength characteristics of polyester filled with recycled GFRP waste J. Mech. Eng. Res. Dev. 43 178–85
9. Tariq S Z and Abdullah F A 2020 Effect of wood ash additive on the thermal stresess of random fiberglass/polyester composite pipes IOP Conf. Ser. Mater. Sci. Eng. 745
10. Abdul-Kareem H S, Abdulla F A and Abdulrazzaq M A 2019 Effect of Shot Peening and Solidification on Fatigue Properties of Epoxy Base Composite Material IOP Conf. Ser. Mater. Sci. Eng. 518
11. Abdulla F A, Fadhil H A and Abdulwahid J N 2018 Experimental Study of the Creep Behaviour of Nano-Composites Carbon Fibres IOP Conf. Ser. Mater. Sci. Eng. 454
12. Mahdi Q S, Abbas F and Mahdi H S 2018 Heat transfer investigation in a circular
tube fabricated from nano-composite materials under a constant heat flux Int. J. Mech. Mechatronics Eng. 18 44–52
13. Abdullah F A and Khalaf W A 2018 Experimental investigation of composite materials subjected to torsional stresses at high shear strain rate Int. J. Mech. Mechatronics Eng. 18 64–75
14. Hamdan Z K, Abdalla F A and Metteb Z W 2020 Effect of acids salts and water on natural composite materials AIP Conf. Proc. 2213
15. Metteb Z W, Abdalla F A and Al-Ameen E S 2020 Mechanical properties of recycled plastic waste with the polyester AIP Conf. Proc. 2213
16. Qasim S M, Mohammed F A and Hashim R 2015 Numerical investigation of the thermal behavior of heated natural composite materials IOP Conf. Ser. Mater. Sci. Eng. 95
17. Chiad J S and Abdulla F A 2018 Effect of number and location of dampers on suspension system for washing machine Int. J. Mech. Eng. Technol. 9 794–804
18. Jebur N A, Abdulla F A and Hussein A F 2018 Experimental and numerical analysis of below knee prosthetic socket Int. J. Mech. Eng. Technol. 9 1–8
19. Moustafa N M, Abdulla F A and Nori A F 2018 PID control system for a variable speed horizontal axis wind mill Int. J. Mech. Eng. Technol. 9 1080–7
20. Khalid Hamdan Z and Abdullah F A 2018 Investigation of the adding nano particles to composite material under high strain rate torsion with hygrothermal effect Int. J. Mech. Eng. Technol. 9 1098–114
21. Abdulla F A, Moustafa N M and Hussein A F 2018 Effect of uv- radiation on fatigue behaviour of natural composite materials Int. J. Mech. Prod. Eng. Res. Dev. 8 727–40
22. Ogaili, A. A. F., Al-Ameen, E. S., Kadhim, M. S., & Mustafa, M. N. (2020). Evaluation of mechanical and electrical properties of GFRP composite strengthened with hybrid nanomaterial fillers. AIMS Materials Science, 7(1), 93.
23. Kamal Abdulkareem Mohammed, Muhanad Nazar Mustafa Al-Sabbagh, Ahmed Ali Farhan Ogaili and Ehsan Sabah Al-Ameen" Experimental Analysis of Hot Machining Parameters in Surface Finishing of Crankshaft" Journal of Mechanical Engineering Research and Developments Vol. 43, No. 4, pp. 105-114