Supporting Information

Comparative Study of Tribological Properties of Multilayers Laminate Nanocomposites

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Abstract

Wear resistance study for the multilayer laminate nanocomposite experimentally needs a lot of time and money to investigate the effects of different parameters over it. Furthermore, the impact of these parameters on the surface occurs within a microsecond making the investigation very difficult. Statistical methods such as response surface methodology can be an effective technique in this matter. In the current work, the response surface methodology and the artificial natural network were used to design and analyze the weight loss at different temperatures, sliding speeds, applied loads, and weight percentages of Graphene Nano Platelet for multilayers laminate composite consists of Polyurethane resin and anhydride hardener reinforced with 30 volume fraction of random fiber-glass. It was found that increasing in GNP content could effectively increase friction coefficient and reduce wear rate of multilayer laminate nanocomposite. The predicted values of artificial neural networks and experimental are found very close to each other.

Section 1. Multilayer Laminate Composite

It is consist of polyurethane resin and anhydride hardener reinforced with 30 volume fraction of random glass fibers. Resin Polyurethane PX-225 and hardener acid-anhydride were supplied from Axson Middle East, Egypt. The mixing ratio between resin and hardener was 1:0.75.

Section 2. Graphene Nanoplatelet GNP

Graphene is a two-dimensional sheet of sp 2 bonded carbon atoms. It was purchased from Asbury Inc, U.S.A., in a powder form with a thickness less than 8 nm.

Section 3. Composite Preparation

It is prepared according to the following sequences
1 – composite preparation (maxing epoxy and hardener).
2- placed fiber layers and used roller after each layer
3- left it to dray under pressure force (hydraulic press)

(Appendix A)

Table A1. Parameters used in mathematical models.

Run	Temperature	load	speed	GNP%	Experimental W. L.	Experimental Coefficient of friction
1	35	12.5	300	0.1	1.9	1.12
2	35	12.5	300	0	3.29	2.093
3	65	12.5	300	0	3.5	2.24
4	35	12.5	1200	0.5	2.43	1.491
5	65	12.5	900	0	7.7	5.18
6	45	12.5	1200	0	7.66	5.152
7	45	12.5	600	0.5	1.88	1.106
8	35	12.5	1200	0.3	3.38	2.156
9	35	12.5	1200	0.3	3.08	1.946
10	65	12.5	1200	0.1	7.2	4.83
11	65	12.5	300	0.1	3.1	1.96
12	55	12.5	600	0.3	2.53	1.561
13	55	12.5	600	0.3	2.53	1.561
14	55	12.5	900	0.5	5.7	3.78
15	55	7.5	900	0.5	2.07	1.239
16	55	7.5	300	0	2.42	1.484
17	65	7.5	1200	0	6.5	4.34
18	35	7.5	1200	0.5	1.32	0.714
19	45	7.5	300	0	2.35	1.435
20	65	7.5	300	0.3	1.4	0.77
21	65	7.5	1200	0.3	4.1	2.66
22	35	7.5	300	0.3	0.04	0.18172
23	35	7.5	300	0.5	0.21	0.063
24	35	7.5	900	0	4.78	3.136
25	65	7.5	600	0.5	0.9	0.42
26	45	7.5	600	0.1	2.43	1.491
27	35	7.5	1200	0.1	2.39	1.463
28	65	7.5	300	0.1	1.7	0.98
29	45	7.5	1200	0.3	1.88	1.106
30	65	10	600	0	5.11	3.367
31	35	10	300	0.1	2.59	1.6065
32	55	10	1200	0.1	5	3.29
33	65	10	1200	0.5	4	2.59
34	45	10	1200	0	7.06	4.732
35	45	10	900	0.5	2.14	1.288
36	45	10	900	0.3	2.69	1.673
37	35	10	300	0.3	0.85	0.3878
38	55	10	300	0.5	1.06	0.532
39	55	10	600	0.3	2.43	1.491

40	65	10	600	0.3	1.66	0.952
41	65	10	1200	0.1	5.2	3.43
42	45	10	600	0.1	2.87	1.799
43	35	10	600	0	4.92	3.234
44	55	12.5	900	0.1	5.7	3.78
45	35	12.5	1200	0	7.11	4.767
46	35	12.5	900	0.1	5.63	3.731
47	45	12.5	600	0.5	1.88	1.106
48	55	12.5	900	0	7.3	4.9
49	65	12.5	300	0.3	6.5	4.34
50	45	12.5	900	0.3	3.36	2.142
51	55	12.5	1200	0.5	4.67	3.059
52	65	12.5	300	0.5	2	1.19
53	35	12.5	900	0.3	2.76	1.722
54	55	12.5	600	0.1	4.42	2.884
55	65	12.5	300	0	3.5	2.24
56	35	12.5	300	0.5	0.87	0.399
57	65	12.5	1200	0.3	6.5	4.34
58	65	15	1200	0.5	6.5	4.34
59	35	15	600	0	5.29	3.493
60	65	15	1200	0.3	7	4.69
61	65	15	300	0.4	2.27	1.379
62	35	15	600	0.4	1.68	0.966
63	35	15	1200	0.1	3.78	2.436
64	35	15	300	0.3	1.35	0.735
65	55	15	300	0.3	2.45	1.505
66	45	15	1200	0.1	5	3.29
67	45	15	300	0.1	2.13	1.281
68	45	15	300	0	3.88	2.506
69	65	15	600	0.1	2.45	1.505
70	35	15	1200	0.4	2.7	1.68
71	55	15	1200	0	8.94	6.048
72	65	15	900	0	8.3	5.6