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An Investigation of Abrasive Wear in Rubber Material

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Abstract

The study of the processes of wear is a part of the discipline of tribology and the mechanism of wear is very complex. Under normal mechanical and practical procedures, the wear-rate normally changes through three different stages: primary stage or early run-in period, where surfaces adapt to each other and the wear-rate might vary between high and low; secondary stage or mid-age process, where a steady rate of wearing is in motion. Wear in rubber materials is one of a limited number of fault factors in which an object loses its usefulness and the economic implication can be of enormous value to the industry. This paper describes an approach to analyze of abrasive wear on soft material which as Styrene-butadiene copolymer or rubber. In this study, the abrasive wear behavior of rubber specimens are experimentally investigated in the laboratory with the help of 'Two body abrasion tester' machine and the wear results are compared with respect to load & speed. Finally specific wear rate is calculated experimentally and verified. At the end of the study, the observation is taken about wear behavior of rubber on different testing parameters. It is observed that the abrasive wear rate is increased with respect to load & speed.

Keywords Rubber, wear, abrasive papers & two body abrasion tester apparatus.

Introduction

Wear can be defined as the removal of material from a solid surface as a result of mechanical interactions. In materials science, wear is the erosion of material from a solid surface by the action of another solid.

There are two main types of wear found in the majority of industrial situations; abrasive (50 %) and adhesive (15 %) wear. Abrasive wear can be defined as the removal of material due to penetration of hard particles or surface asperities of a harder counter body into the softer surface of a solid in sliding contact. Abrasive wear processes are divided into two categories: two-body and three-body abrasive wear. Two-body abrasive wear occurs when a rough surface or fixed abrasive particles slide across a surface to remove material. In three-body abrasive wear, the particles are loose and may move relative to one another while sliding across the wearing surface.

Wear of rubber and its components is of great importance because rubber parts are widely used in different applications. Their use is limited by incomplete understanding of their abrasion wear resistance and the means by which this can be controlled and improved. A number of studies on Styrene-butadiene copolymer composites subjected to sliding and abrasive wear indicate that wear resistance depends on the detailed properties of the material as well as the external wear conditions such as applied load and speed. (1, 2, 3)

Experimental details:
Materials: rubber (Styrene-butadiene copolymer)
Composition:

Rubber, elastic substance obtained from the exudations of certain tropical plants (natural rubber) or derived from petroleum and natural gas (synthetic rubber). Because of its elasticity, resilience, and toughness, rubber is the basic constituent of the tires used in automotive vehicles, aircraft, and bicycles. The main chemical constituents of rubber are elastomers, or "elastic polymers, " large chainlike molecules that can be stretched to great lengths and yet recover their original shape. The first common elastomer was polyisoprene, from which natural rubber is made.

Polymer type – Polyisoprene (natural rubber, isoprene rubber) and styrene-butadiene copolymer (styrene-butadiene rubber)

Specification of two body abrasion tester-

Table no – 1

Parameter		Unit	Values
Diameter of abrasion wheel		mm	50
Width of abrasion wheel		mm	12
Test speed		Cycle/min	40, 50, 60
Length of abraded area		mm	35±1 mm
Indexing angle at end of each stroke		deg	0.9
Number of strokes per revolution of wheel			400
Abrasive wheel	Material		Silicon carbide waterproof paper
	Grade		60, 80, 100
Specimen size	Length x breadth	mm	70x20 mm

Abrasive Wear Test:
Abrasive wear tests were carried out with two body abrasion tester wear test machine. The abrasive wheel of wear test machine was covered with silicon carbide abrasive paper (60, 80, & 100 grades).

Weight the sample to an accuracy of 0.001 gm. The specimen was attached to reciprocating assembly. Open the hinge plate specimen and clamp firmly with backing bolt ensure specimen. This assembly serves the purpose of indexing and loading the abrasive wheel against the rigidly clamped specimen.

Firstly reciprocating assembly fixed on speed of 40cycle/minute. Abrasive paper of grade-60 is fixed by anabond compound on outer diameter of the abrasive wheel. Here five different loads are applied on the abrasive wheel which as 300, 500, 1000, 1200 & 1500 grams. Wheel starts rubbing against the specimen and at the end of fro motion, wheel lifts and indexes to engage a new abrasive face for the next stroke. Motor stops after completing set cycles. Remove the specimen again and find mass loss. The specimen was reciprocating with reciprocating assembly during the test and fresh abrasive paper was used for each wear test. Again this test were performed on speed of 50 and 60 cycles/minute respectively and found the 15 observations on grade-60 abrasive paper sheet. The similar method preformed on 80 and 100 grade abrasive paper and hence there were total 45 observations were performed. After each experiment the weight losses were measured. (2)

Results and discussion :
Calculation & formula:
compute the wear rate is from Archard wear equation by

$$V_i = k_i F s$$

Where F is the normal load, s the sliding distance, V_i the wear volume and k_i the specific wear rate coefficient. Index i identifies the surface considered. (5)

$$\frac{Vi}{ki} = F s$$

If specific wear rate coefficient is constant, then $V_i \alpha$ Fs. Hence the wear volume is directly proportional to the applied load.

Observation table of testing samples:

Sr. No.	Grade of paper	Load (in gm)	Speed	Initial weight (gm)	Final weight (gm)	Weight loss	$\frac{Vi}{Ki}$ = F.S
1	60	300	40	1.8275	1.7699	0.0576	0.01728
2	60	500	40	2.6646	2.6047	0.0599	0.02995
3	60	1000	40	3.4252	3.3430	0.0822	0.0822
4	60	1200	40	2.7443	2.6608	0.0835	0.1002
5	60	1500	40	3.1857	3.1026	0.0831	0.12465
6	60	300	50	2.9654	2.9008	0.0646	0.01938

7	60	500	50	2.2015	2.1358	0.0657	0.03285
8	60	1000	50	3.5286	3.4436	0.0850	0.0850
9	60	1200	50	2.4927	2.4098	0.0829	0.09948
10	60	1500	50	2.1244	2.0418	0.0826	0.1239
11	60	300	60	4.6467	4.5856	0.0611	0.01833
12	60	500	60	4.2037	4.1429	0.0608	0.0304
13	60	1000	60	5.0728	4.9863	0.0865	0.0865
14	60	1200	60	5.0061	4.9441	0.0620	0.0744
15	60	1500	60	15.3377	15.1535	0.1842	0.2763
16	80	300	40	2.6307	2.5602	0.0705	0.02115
17	80	500	40	2.2313	2.1294	0.1019	0.05095
18	80	1000	40	2.8656	2.7443	0.1213	0.1213
19	80	1200	40	3.2728	3.1857	0.0871	0.10452
20	80	1500	40	3.2720	3.1857	0.0863	0.12945
21	80	300	50	1.7928	1.7119	0.0809	0.02427
22	80	500	50	2.2191	2.1244	0.0947	0.04735
23	80	1000	50	2.6098	2.4927	0.1171	0.1171
24	80	1200	50	3.6529	3.5286	0.1243	0.14916
25	80	1500	50	2.3369	2.2015	0.1354	0.2031
26	80	300	60	4.2497	4.1799	0.0698	0.02094
27	80	500	60	7.3659	7.2856	0.0803	0.04015
28	80	1000	60	8.0565	7.9895	0.067	0.0670
29	80	1200	60	5.1534	5.0508	0.1026	0.12312
30	80	1500	60	7.5216	7.4070	0.1146	0.1719
31	100	300	40	3.0859	3.0273	0.0586	0.0586
32	100	500	40	4.3212	4.2476	0.0736	0.0736
33	100	1000	40	3.2591	3.1627	0.0964	0.0964
34	100	1200	40	2.2290	2.1253	0.1037	0.1037
35	100	1500	40	3.2899	3.1699	0.1200	0.1200
36	100	300	50	2.0927	2.0293	0.0637	0.0637
37	100	500	50	2.6266	2.5546	0.0720	0.0720
38	100	1000	50	3.8916	3.7946	0.097	0.0970
39	100	1200	50	2.6422	2.5431	0.0991	0.0991
40	100	1500	50	4.1157	4.0122	0.1035	0.1035
41	100	300	60	2.7990	2.7297	0.0693	0.0693
42	100	500	60	4.7424	4.6614	0.081	0.0810
43	100	1000	60	3.5495	3.4446	0.1049	0.1049
44	100	1200	60	3.8663	3.7604	0.1059	0.1059
45	100	1500	60	3.5857	3.601	0.1256	0.1256

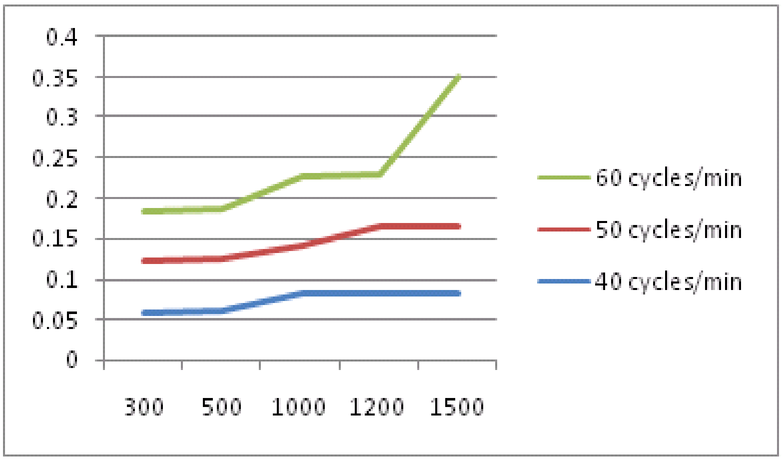

Fig – 1 Wear volume vs load graph for 60 grades

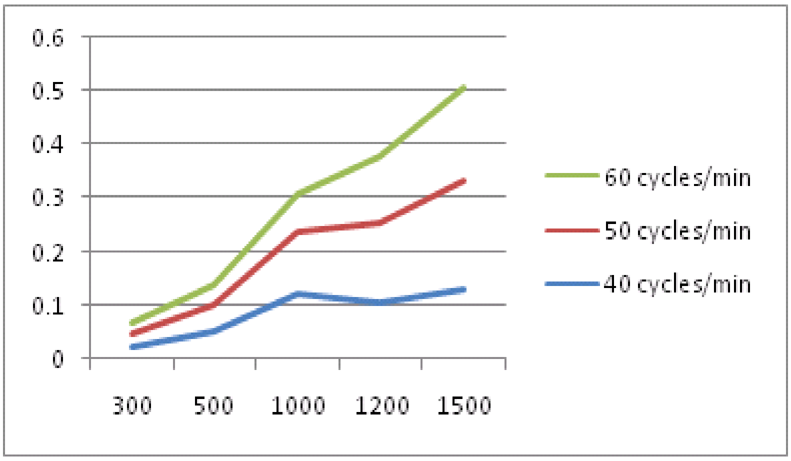

Fig – 2 Wear volume vs load graph for 80 grades

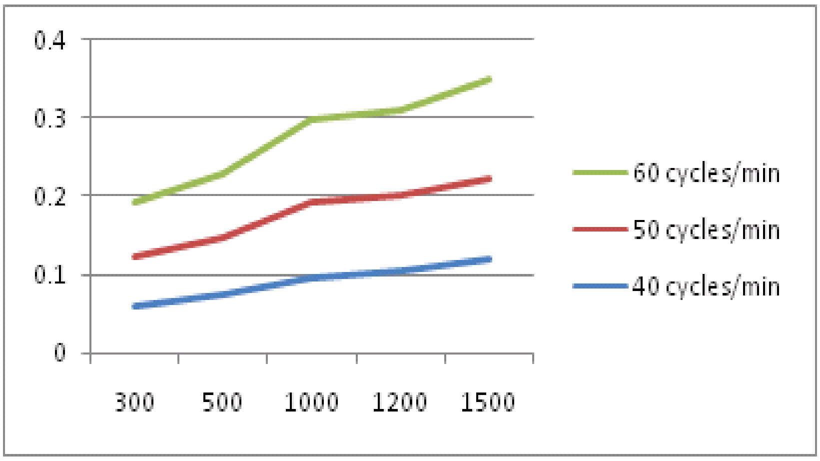

Fig – 3 Wear volume vs load graph for 100 grades

Conclusion :

We can observe that in 60 grade of abrasive paper the wear volume is higher (0.35 kg-mm) at 1500 gm, at speed 60cycles/minute. Similarly, in 80 & 100 grade of abrasive paper the wear volume is higher (0.5 kg-mm, 0.35 kg-mm respectively) at 1500 gm, at speed 60cycles/minute. The applied load is directly proportional to the wear volume. If we are increase the load then the wear volume is also increase. At the end of the study, the observation is taken about wear behavior of rubber on different testing parameters. It is observed that the abrasive wear rate is increased with respect to load & speed.

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