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Modification of Abrasive Wear Testing Machine and Testing of Materials

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Abstract: *The* ***present work deals with modifying the existing abrasive wear testing machine by incorporating measuring instrument like thermocouple and to increase the scope of testing by using different lining materials. The wear of all specimens are compared and conclusions are drawn based on the data obtained. The change in wear with respect to time, different loads and lining materials are studied. The temperature variations in the materials under the different variables were studied and obtained results are reported.***

Keywords: Wear testing Machine, thermocouple, lining material.

1. Introduction

Wear testing is a method for assessing erosion or sideways displacement of material from its "derivative" and original position on a solid surface performed by the action of another surface.[1] Wear occurs to the hardest of materials, including diamond, wear studies having focused on surface damage in terms of material-removal mechanisms, including transfer film, plastic deformation, brittle fracture and tribo-chemistry [2]. Tests are used for quality control functions such as thickness, porosity, adhesion, strength, hardness, ductility, chemical composition, stress and wear resistance. Non-destructive tests include visual, penetrant dies, magnetic particle and acoustic techniques [3]. There are many types of wear that are of concern to the user of coatings, including sliding wear and friction, low- and high-stress abrasion, dry particle erosion, and slurry erosion [4]. The type of wear occurring under combined impact and sliding wear has hardly been studied according to Swick et al. [5]. In applications of material wear, one or more of the following will be operational [6, 7]: (i) abrasive wear; (ii) adhesive wear; (iii) erosive wear; (iv) fretting wear; (v) surface fatigue; and (vi) delamination. The ASTM G 76 [8] gives the standardized guide for testing wear/erosion using the method of jet-stream or gas blast. However, the standard [8] specifically states that only using one method of testing is not sufficient. The present work aims in modifying the existing abrasive wear testing machine by incorporating measuring instrument like thermocouple and to increase the scope of testing by using different lining materials.

2. Present Investigation

The present investigation deals with modifying the existing abrasive wear testing machine by incorporating measuring instrument like thermocouple and to increase the scope of testing by using different lining materials. The previous set up consists of pan through which weight can be added to bring about a desired normal pressure on specimen by varying the weight as shown in figure 1. A rotating steel disc is mounted with a lining material (Neoprene rubber). The specimen was pushed against the circumference of the disc by actuating the lever. Between the space of lining material and specimen, an abrasive media (olivine sand) was allowed to pass. This resulted in three body abrasion and the specimen wore out. The loss in weight between two successive measurements gave the wear of the specimen for a known time period of testing.

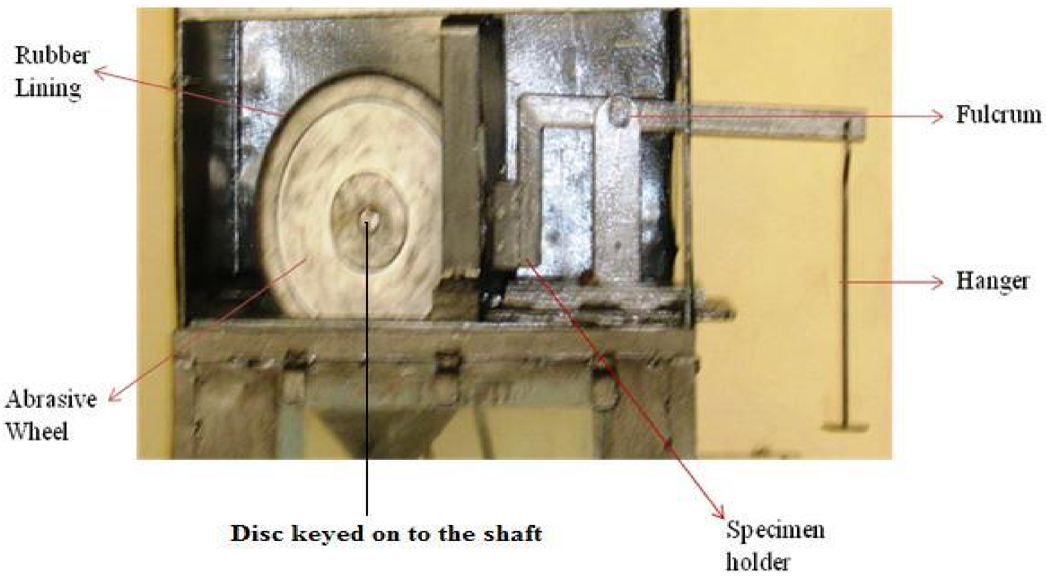

Figure 1: Previous setup with a keyed disc

In the present work the disc which was previously keyed on to the shaft was changed to a screw arrangement as shown in figure 2 which facilitated the mounting of different lining material (Neoprene rubber, teakwood, grinding wheel). A Thermocouple was fixed at the base of the specimen to measure the temperature during testing is shown in figure 3. The extensive wear test on different materials like Cast Iron, Mild Steel and Aluminium is performed using different lining materials (rubber, grinding wheel and wood), sands of different grain sizes (24, 28, 42) and different loads. The rises in temperature during testing are noted.

Figure 2: Modified shaft

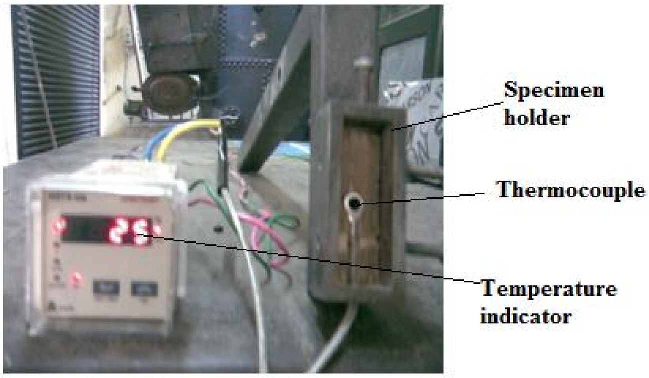

Figure 3: Thermocouple

3. Methodology

3.1 Test Specimen Details

The wear testing machine already existing was modified. Rectangular blocks of Square Cross section $55\ mm \times 19\ mm \times 19\ mm$ as shown in figure were machined from the standard bar made of Aluminium, Cast Iron & Mild Steel.

3.2 Abrasive Wear Testing (Existing) Setup

The previous setup consisted of a pan through which weights can be added to bring about a desired pressure on the specimen by varying the weight. A rotating steel disk mounted with Neoprene rubber was fixed on to the shaft. The specimen was to be pushed against the circumference of the disc by actuating the lever. Between the space of lining material and specimen an abrasive media (like silica sand, olivine sand, chromite sand) was allowed to pass. This resulted in a three body abrasion and specimen wore out. The loss in weight between two successive measurements gave wear of the specimen for time period of testing. Previously the shaft could accommodate only one lining material (the disc was keyed on to the shaft). Now the shaft has been provided with screw arrangement (thread M12) to facilitate mounting of non abrasive materials.

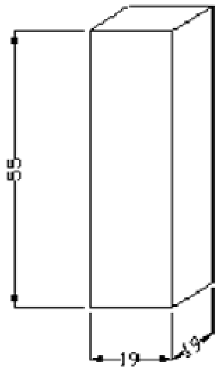

Figure 4: Abrasive wear specimen

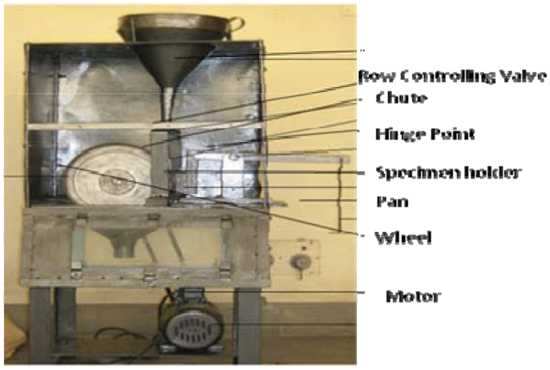

Figure 5: Existing setup

3.3 Test Procedure

1. The wheel of rubber/grinding/wood lining was selected and fixed into the shaft.
2. The abrasive media (olivine sand of GFN 42/28/24) was loaded into the funnel and the valve was closed.
3. The specimen was weighed and mounted on to the holder.
4. The load on the specimen was applied by adding weights on to the pan of the Lever Mechanism.
5. Lever mechanism helps to maintain constant load on the specimen.
6. The speed of the disc was maintained constant at 1085 rpm.
7. The abrasive media was allowed to fall between the gaps at a required constant mass flow rate by adjusting the control valve.
8. The testing duration was 10 min for every 100 gm weight on the pan, and it was continued up to weight of 400 gm in a step of 100 gm. Specimen is weighed at a successive interval of 5 min.
9. The difference in weights of the initial and the subsequent reading represents loss in weight, was taken as the measure of wear of material.

10. The temperature of specimen was noted at regular intervals of 1min up to 10 min indicated by the indicator by using thermocouple.
11. A graph of weight loss v/s time was plotted. From this, histogram showing maximum wear rate was determined by finding the maximum slope for each material.
12. A graph of wear rate v/s load was plotted.
13. A graph of temperature v/s time was plotted, and then the temperature gradient was calculated for each specimen.

4. Results and Discussions

The results of the abrasive testing of material have been presented below. The tests were carried out for Al, CI and MS using three different lining materials like teakwood, rubber and grinding wheel. The abrasive media used was Olivine sand of three different grain sizes (24, 28 and 42).

4.1 Weight Loss as a Function of Time

Using rubber as lining material and Olivine sand having grain size 24 as the abrasive media, the weight loss of the materials (Aluminium, Mild steel & Cast iron) with respect to time at different loads (2.583N & 7.753N) are shown in Figure 6 and 7 respectively. The wear rate of the materials is calculated using the slope obtained from the graphs. The wear rate is constant as the graph shows a linear plot.

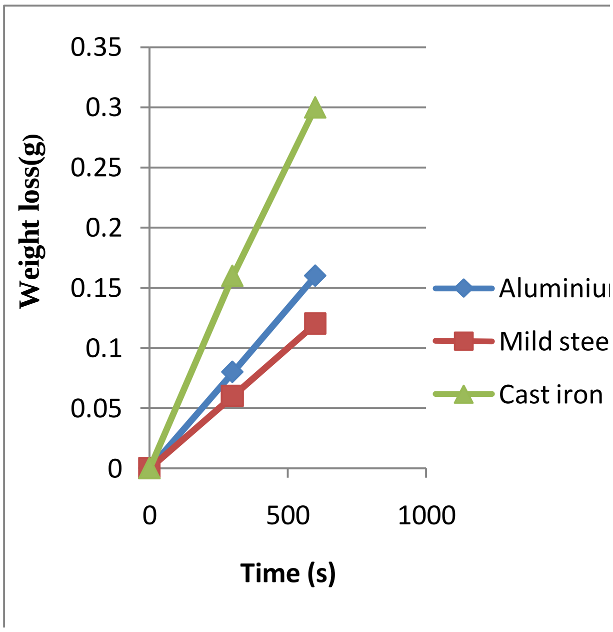

Figure 6: Weight loss v/s Time for a load of 2.583N

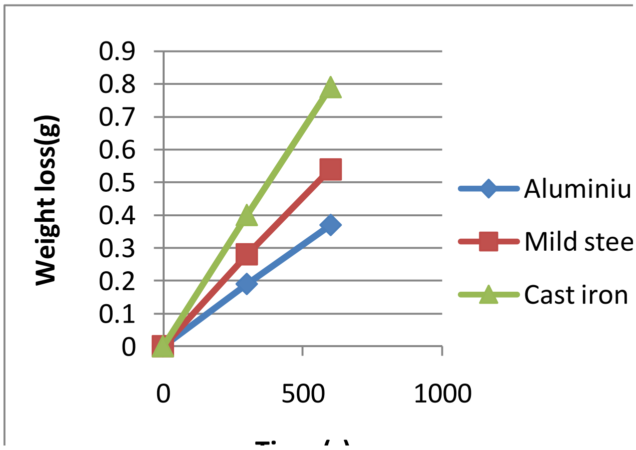

Figure 7: Weight loss v/s Time for a load of 7.753N

4.2 Wear Rate as a Function of Load

Table 1: Wear rate of a Aluminium as a function of load for different lining material

Sl no	Lining material	Normal load (N)	Weight loss Time in sec 300	600	Wear rate (N/s)*10^(-6)
1	Rubber	2.583	0.08	0.16	2.5506
		5.168	0.14	0.27	4.4145
		7.753	0.19	0.37	5.984
		10.337	0.24	0.43	6.965
2	Wood	2.583	0.12	0.25	4.087
		5.168	0.24	0.47	7.684
		7.753	0.22	0.49	8.011
		10.337	0.30	0.61	9.973
3	Grinding wheel	2.583	0.62	1.19	19.456
		5.168	1.25	2.45	40.057
		7.753	1.38	2.72	44.472
		10.337	1.26	2.46	40.221

Table 2: Wear rate of a cast iron as a function of load for different lining material

Sl. No.	*Lining material*	*Normal load (N)*	*Weight loss* Time in sec 300	600	*Wear rate (N/s)*
1	Rubber	2.583	0.16	0.30	4.905
		5.168	0.25	0.52	8.436
		7.753	0.40	0.79	12.850
		10.337	0.53	1.01	16.480
2	Wood	2.583	0.18	0.35	5.722
		5.168	0.37	0.75	12.262
		7.753	0.43	0.86	14.061
		10.337	0.50	1.02	16.667
3	Grinding wheel	2.583	0.84	1.63	26.650
		5.168	1.29	2.53	41.365
		7.753	1.81	3.72	60.822
		10.337	2.26	4.50	73.570

Table 3: Wear rate of a mild steel as a function of load for different lining material

Sl. No.	*Lining material*	*Normal load (N)*	*Weight loss* Time in sec 300	600	*Wear rate (N/s) *10^(-6)*
1	Rubber	2.583	0.06	0.12	1.962
		5.168	0.12	0.25	4.022
		7.753	0.28	0.54	8.829
		10.337	0.30	0.56	9.120
2	Wood	2.583	0.10	0.21	3.433
		5.168	0.22	0.44	7.194
		7.753	0.23	0.45	7.357
		10.337	0.27	0.53	8.665
3	Grinding wheel	2.583	0.55	1.11	18.148
		5.168	1.19	2.40	39.240
		7.753	1.26	2.56	41.856
		10.337	2.17	4.28	69.978

Wear rate of a selected materials Aluminium, Mild Steel & Cast iron as a function of load for different lining material and Olivine sand having grain size 24 as the abrasive media, are tabulated in table 1, 2& 3. The plot of Wear rate v/s load of aluminium, Cast iron & Mild steel for different lining materials are shown in figures8, 9 & 10 respectively. From the plots it is observed that, grinding wheel produces more wear as compared to wood and rubber for Aluminium, Cast iron & Mild steel, because of the grains in the wheel which assist the wear.

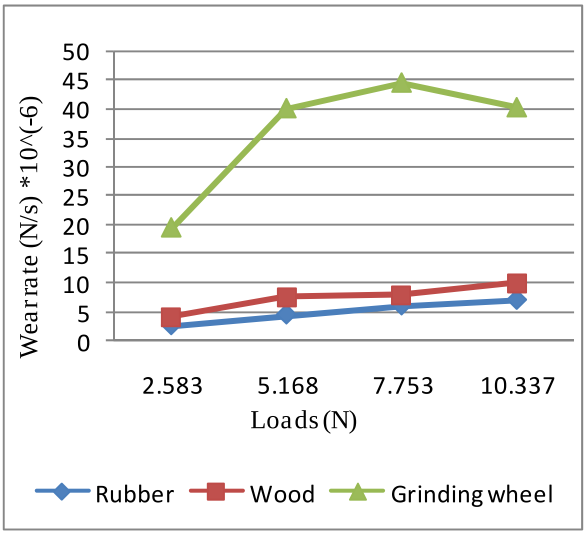

Figure 8: Wear rate v/s load of aluminum for different lining materials

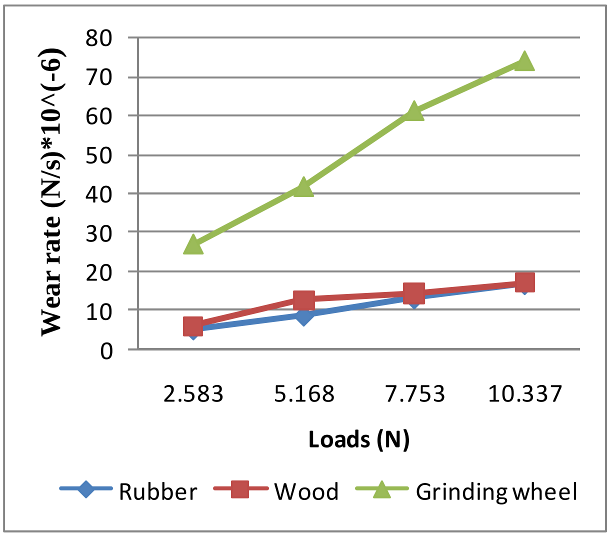

Figure 9: Wear rate v/s load of cast iron for different lining materials

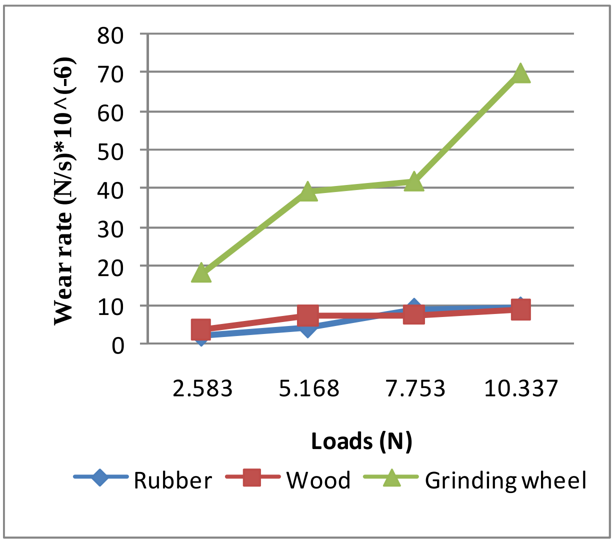

Figure 10: Wear rate v/s load of mild steel for different lining materials

4.3 Temperature as a Function of Time

Temperatures of a selected materials Aluminium, Mild Steel & Cast iron as a function of Time for different lining material at Normal Load of 10.337 N and Olivine sand having grain size of 24 as the abrasive media, are tabulated in table 4, 5& 6 respectively. The plot of Temperature v/s Time of aluminium, Mild Steel & Cast iron for different lining materials are shown in figures 11, 12 & 13 respectively.

Table 4: Temperature of aluminium as a function of time for different lining materials

Sl. No.	*Time in seconds*	*Temperature ˚C*		
		Lining material		
		Neoprene	*Teak*	*Grinding*
1	0	30	26	28
2	60	33	30	39
3	120	35	34	56
4	180	36	36	70
5	240	37	38	80
6	300	38	40	85
7	360	39	42	90
8	420	40	44	94
9	480	41	46	98
10	540	42	48	101
11	600	42	50	103

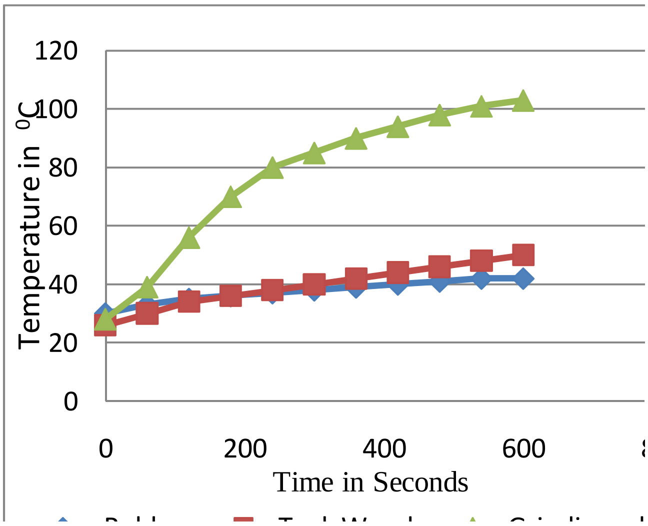

Figure 11: Temperature v/s Time for Aluminum

Table 5: Temperature of mild steel as a function of time for different lining materials

Sl. No.	Time in seconds	Temperature ˚C		
		Lining material		
		Neoprene Rubber	Wood	Grinding wheel
1	0	29	30	25
2	60	32	34	33
3	120	35	38	42
4	180	38	42	51
5	240	40	46	57
6	300	42	50	62
7	360	44	52	65
8	420	45	54	68
9	480	46	56	70
10	540	46	57	71
11	600	46	58	72

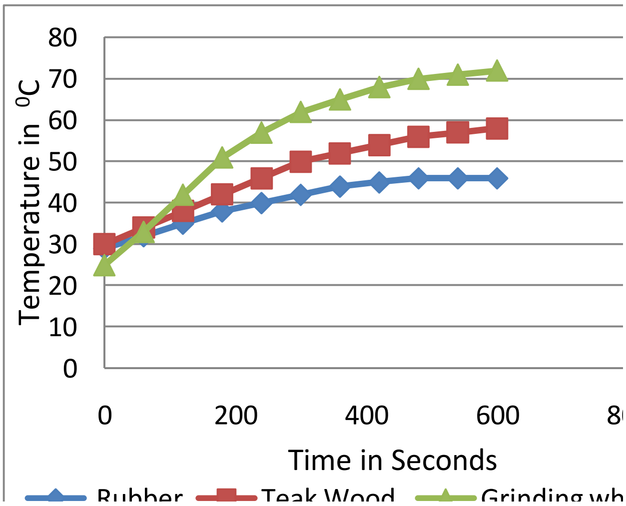

Figure 12: Temperature v/s Time for Mild steel

Table 6: Temperature of a cast iron as a function of time for different lining materials

Sl. No.	Time in seconds	Temperature ˚C		
		Lining material		
		Neoprene Rubber	Teak Wood	Grinding wheel
1	0	30	28	27
2	60	32	33	31
3	120	34	37	35
4	180	36	40	39
5	240	37	43	43
6	300	38	46	47
7	360	39	48	50
8	420	40	49	52
9	480	41	50	54
10	540	41	51	55
11	600	41	52	56

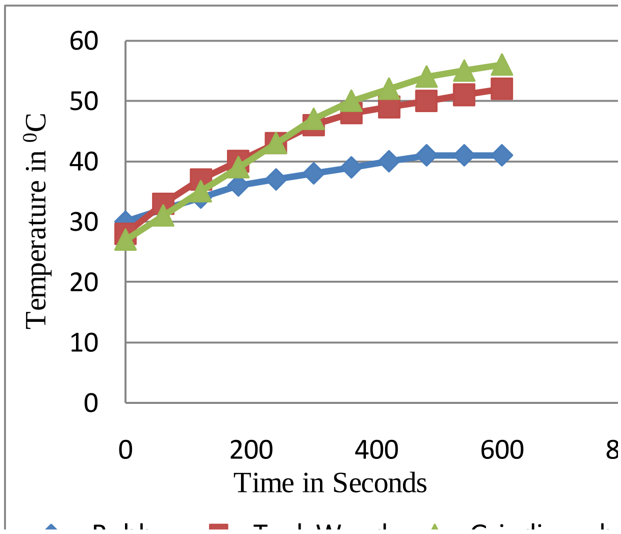

Figure 13: Temperature v/s Time for Cast iron

5. Conclusions

From the tests carried on different materials i.e., Aluminium, Mild steel and Cast iron the following conclusions were drawn:

- The wear rate (73.57E-6 N/s) was found high for cast iron because of its brittleness.

- The wear rate was high when the abrasive media used was coarse (GFN 24).
- The wear rate was high when grinding wheel was used as the lining material.
- For olivine sand of GFN 42, wear rate of all material tend to slow down at higher loads, since finer grains particles tends to slip through the mating surface without participating in wear.
- When grinding wheel was used with Aluminium specimen for all grain size of sands it was found that the wear reduces for higher loads. This was due to the aluminium particles getting embedded on the wheel.
- Temperature gradient was found to be the highest for Aluminium because of high thermal conductivity (k=204W/mK) compared to cast iron (k=52W/mK) and mild steel (k=54W/mK).

5.1 Future Scope

Further the work can be extended for different lining materials as well as for different abrasives.

References

[1] Amal Ebrahim Nassar and Eman Ebrahim Nassar, "Design and Fabrication of a Wear Testing Machine", Leonardo Electronic Journal of Practices and Technologies, Issue 19, pp. 39-48 July-December 2011.

[2] J.M. Martin, Th. le Mogne, "Interpretation of friction and wear of ceramics in terms of surface analysis", Surf. Coat. Tech. 49 pp. 427–434. (1991)

[3] D.M. Kennedy , M.S.J. Hashmi, "Methods of wear testing for advanced surface coatings and bulk materials", Journal of Materials Processing Technology (1998)

[4] J.E. Kelley, J.J. Stiglich Jr., G.L. Sheldon, "Methods of characterization of tribological properties of coatings", Surf. Mod. Tech pp. 169–187. (1988).

[5] K.J. Swick, G.W. Stachowiak, A.W. Batchelor, "Mechanism of wear of rotary percussive drilling bits and the effect of rock type on wear", Tribology Int.

[6] B.J. Gill, "Designing and producing engineering surfaces, Recent Development in Surface Coating and Modification Processes", Union Carbide UK Ltd, 1985.

[7] T.S. Eyre, "Friction and Wear Control in Industry", Surface Engineering Conference, Newcastle Upon Tyne, UK, 1992.

[8] "Standard Test Method for Conducting Erosion Tests by Solid Particle Impingement Using Gas Jets.", Annual book of ASTM Standards, pp. 311-317, 1999.

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