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Effect of Heat Treatment on Wear Behavior of High Silicon Steels

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ABSTRACT

In the present work the effect of heat treatment on wear behavior of AISI310, AISI253ma and AISI410 Silicon steels are investigated. The chosen materials were heat treated at 850^{0}C and kept at this temperature for a soaking period of 60 minutes, cooled by quenching in air until the room temperature is attained. As-cast materials were also taken for tests for comparison. The wear tests were carried out on above three materials with three parameters viz., velocity, load & time by keeping two of the parameters as constant and varying the other one in each test.

Introduction

Frictional wear of a given material depends upon several parameters such as normal load, velocity and time. For sliding applications, low friction materials are preferred, for which various material combinations and alloys have been investigated by researchers. In the present investigation influence of different normal loads and sliding velocities on the wear behaviour of the chosen materials has been undertaken so as to explore the possibility of fixing range of normal load and sliding velocity to achieve improved performance in wear applications of these materials.

Heat treatment is the method of heating and cooling of metals to attain the desired physical and mechanical properties through modification of their crystalline structure. The temperature, time duration, and cooling rate after heat treatment will have their impact on properties. The most important and also common reason to heat treat includes increasing strength or hardness, increasing toughness, improving ductility and maximizing corrosion resistance [1, 2].

Numerous investigations [3-6] showed that Coefficient of friction depends on a number of parameters such as normal load, geometry, sliding velocity, surface roughness of disc. Among these factors normal load and sliding velocity are the two major factors that play significant role for the variation of friction.

Chowdhury et al. [7-9] researched the effect of normal load and sliding speed of friction and wear on the property of an aluminum disk against stainless steel pin. The wear rate was also found to increase with the increase in sliding speed and normal load.

Ramachandra et al. [11] found that wear increased with increase in normal load and sliding velocity. Hardness increases with continuous or intermittent increase in SiC particles and is related to friction and adhesion. Thus, the wear rate for each metal is affected by heavy load conditions and is not associated with resistance to corrosion under less severe conditions. The parameters that affect wear are loads, speed, time, contact type, type of environment, and so on. Kumar et al. [10] researched the wear behavior of zinc–aluminum. The wear increased with increase of reinforcement in load and sliding speed. In a few cases, the effect of speed on the rate of wear is due to the circumstances mentioned and their connection to the velocity of these factors [15].

Experimental Details

The Specimens of size Ø10x30 mm were prepared for wear test as per ASTM G99.

Table 1. Chemical composition Silicon Steels

Element / Grade	C	Mn	Si	P	S	Cr	Ni
	Weight %						
M1	0.25	2.0	1.50	0.045	0.03	26	22
M2	0.10	0.8	2.00	0.040	0.03	20-22	10-12
M3	0.15	1.0	1.00	0.040	0.03	11.5-13.5	0.75

M1-AISI 310, M2-AISI253ma, M3- AISI 410

A pin on disc wear apparatus TR-201 was used for experiment. The test specimen was clamped in jaw. Wear track diameter was fixed at 25 mm. The rotational speed of disc was fixed at 800 rpm. Timer was set for three minutes for each set of loads.

Initially each specimen was tested with the normal load of 10N. Disc was run for three minutes; readings were taken from the digital display. Then normal load was increased to 15N, 20N, 25N and 30N. Specimens from all the three materials were tested with loads from 10N to 20N to know the effect of load on the wear of materials. The wear tests were conducted under three condition, initially by keeping speed of disc and time constant, load is varied from 10N to 30N. In second case load and time were constant and speed of disc varied from 600rpm to 1000rpm. In third case load and speed were constant, time was varied from 3 minutes to 7 minutes.

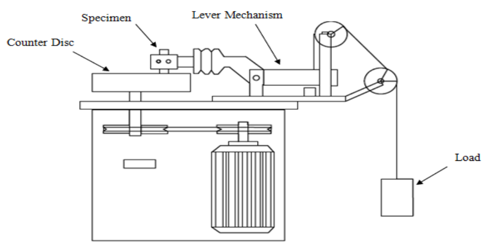

Fig 1. Set up of pin on disc wear apparatus

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Results and Discussion

The results of the experiments are tabulated which are presented in Tables No. 2 to 5 and for all the materials graphs are drawn for

a) Wear v/s Load (Fig No. 2)
b) Wear v/s Velocity (Fig No. 3)
c) Wear v/s Time (Fig No. 4)

The same is repeated for the specimens of the materials that are air cooled and graphs are presented from Fig no. 5 to 8.

Table 2. Rate of wear at different load for as cast and air cooled specimens

Load N	Rate of Wear					
	As-Cast			Air-Cooled		
	M1	M2	M3	M1	M2	M3
10	42	50	58	22	42	45
20	50	68	82	25	58	78
30	78	82	100	40	80	100
40	100	125	148	65	98	140
50	100	155	165	82	135	162

Table 3. Rate of wear at different Velocities for as cast and air cooled specimens

Velocity m/s	Rate of Wear					
	As-Cast			Air-Cooled		
	M1	M2	M3	M1	M2	M3
1	90	63	44	40	62	40
2	110	90	58	100	81	44
3	118	98	60	112	96	54
4	142	105	72	124	98	60
5	147	118	97	141	103	82

Table 4. Effect of Time on Rate of wear for as cast and air cooled specimens

Time (Min.)	Rate of Wear					
	As-Cast			Air-Cooled		
	M1	M2	M3	M1	M2	M3
1	148	80	71	140	60	63
2	152	92	80	147	82	68
3	185	104	91	151	103	73
4	226	128	102	197	113	87
5	250	147	115	213	121	98

Comparison of as Cast Materials

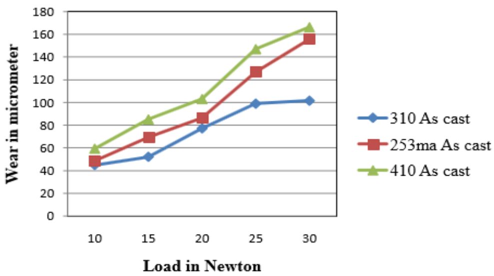

Fig 2. Wear v/s Load

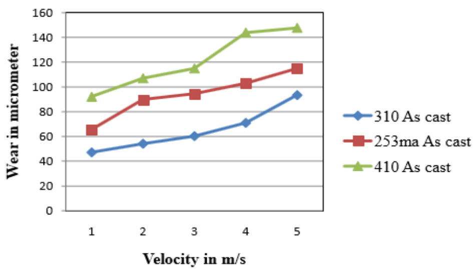

Fig 3. Wear v/s Velocity

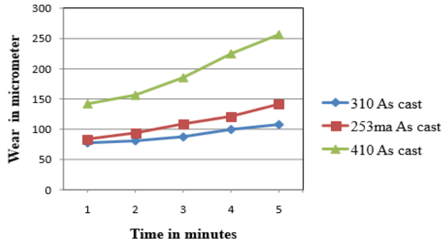

Fig 4. Wear v/s Time

Comparison of Air Cooled Materials

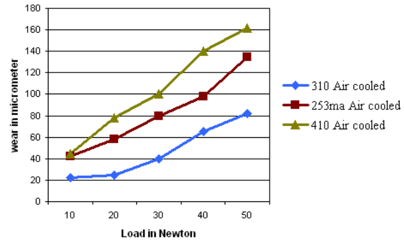

Fig 5. Wear v/s Load

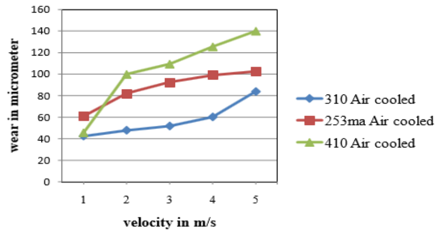

Fig 6. Wear v/s Velocity

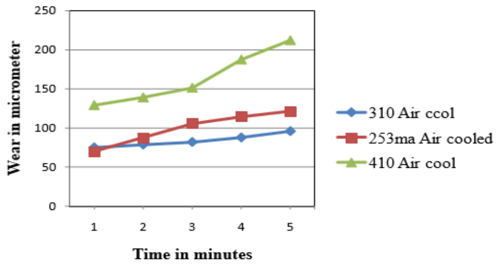

Fig 7. Wear v/s Velocity

From the SEM images of worn surfaces, we can observe that the wear volume increases linearly as load increases, as the load increases the co- efficient of friction will also increase. The wear volume is highest for as cast material when compared to all the test condition. From this we can also conclude that the effect of load on wear of material is higher than that of the velocity on wear. Fig (8-10) shows the worn surface of as cast AISI 310 at load of 30N the adhesive traces resulting from the shear and the rapture of adhesive junction between metal contacting surfaces. Large delimitation and craters are seen on the surfaces which are in the range of several hundred microns in size as compared to AISI 410 and AISI 253ma. This is due to high stress concentration.

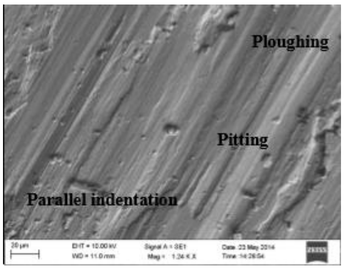

Fig 8. SEM image of AISI 310

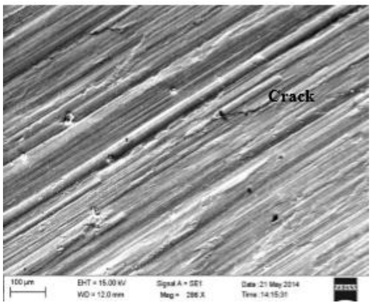

Fig 9. SEM image of AISI 253ma

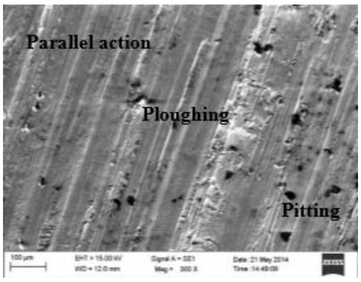

Fig 10. SEM image of AISI 410

Conclusion

• From the results it can be concluded that during tests varying load leads to high wear volume compared to varying velocity. From the results it is concluded that the wear rate is maximum in all the three as-cast samples.

• The wear rate is maximum in all the as-cast samples compared to air cooled specimens.The microstructures have been identified with the help of Photo images for samples of AISI 310, AISI 410 and AISI253ma, and changes in grain sizes are noted in specimens that are air cooled.

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