WEAR BEHAVIOUR FOR HEAT TREATED SPECIMEN Of STEEL SAE 1117 FOR BEARING CUP

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ABSTRACT

To Find wear behavior of steel SAE1117 specimen .Specimens of diameter 12 and length 25 mm were cut of SAE 1117 material and subjected to different heat treatment procedures like carburizing, carbonitriding and liquid nitriding were prepared for microstructural analysis. The samples were etched using 3% natal (3% conc. Nitric acid in methanol solution). Then the microstructures were taken for different heat treated specimen by using optical microscopy.

Keyword: *Carburising, Carbonitriding, Friction, Heat Treatment, Liquid Nitriding, Specimen*

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1. INTRODUCTION

1.1 Wear Test Rig: Pin on Disc

To compare wear properties of selected processes it was decided to conduct wear test of selected processes with the help of Pin on disc tribo-meter TR-20LE at Amrutvahini College of Engineering. Fig. 01 shows construction of wear test rig the TR-20 LE Pin on disc wear test rig is advanced regarding the simplicity and convenience of operation, ease of specimen clamping and accuracy of measurements.

The machine is designed to apply loads up to 20 Kg and is attended both for dry and lubricated test conditions. It facilitates study of friction and wear characteristics in sliding contacts under desired test conditions within machine specifications. Sliding occurs between pin and rotating disc. Normal load, rotational speed and wear track diameter can be varied to suit the test conditions. Tangential frictional force and wear are monitored with electronic sensors and recorded on PC. These parameters are available as a function of load and speed.

The machine consists of spindle assembly, loading lever assembly sliding plate over structure made up of steel tubes which absorbs entire force and load acting during testing. To minimize the vibrations during testing, it is fitted with four numbers of adjustable anti-vibration pads at base. Some items like AC motor, variable frequency drive and all electrical items are fitted inside the structure and sides of it are covered with panels.

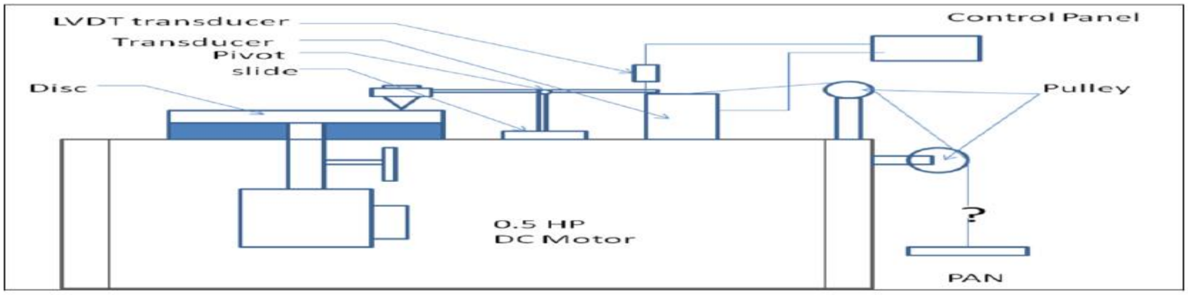

Fig 01: Experimental Set Up of Pin on Disc Tribometer

The wear disc is mounted on the spindle top and is driven by an AC motor through timer belt, which provides high torque drive with low vibrations. The loading lever with specimen holder is fixed at one end and at other end it carries a wire rope for suspending dead weights to apply normal load on specimen. The frictional force produced between specimen pin and disc is directly measured by the load cell at other end. The specimen pin inside the hardened split jaw and clamped to specimen holder. To clamp different sizes of specimen individual jaws are provided. The oil for lubrication is provided by a lubrication fixed at base of machine.

The wear between specimen pin and disc is measured by LVDT and is sensed by sensor mounted on lever. The friction between specimen pin and rotating disc is measured by strain gauge type load cell mounted on bracket. The spindle speed is measured by proximity sensor through a rpm sensor disc. The machine operation is controlled by a electronic controller through a set of cables, control cables and signal input cables. The signal passes from machines to controller processed signals to connected PC. The signals from wear and frictional force sensors are sent to instrumentation card, the output from which is sent to data acquisition card and the output from it is sent to display on controller and to PC.

1.2. WORKING PROCEDURE

1. Connect the power input cable to 230V 50 Hz and 15 Amp supply, switch ON controller. Allow 5 minutes for normalizing all electrical items.

2. Using dial indicator, clamp disc within 10 µm run out.

3. Thoroughly clean specimens, remove burrs from the circumference using 2000 grit fine silicon carbide abrasive paper.

4. Insert specimen pin inside the hardened jaws and clamp to specimen holder set the height of specimen pin above the wear disc using height adjustment block. Ensure that the loading arm is always horizontal. Tighten clamping screws on jaws to clamp specimen pin firmly. Swivel off the height adjustment block away from loading arm.

5. Set the required wear track diameter according to sliding velocity by moving the sliding plate over graduated scale on base plate. Tighten both the clamping screw to ensure assembly is clamped firmly.

6. Wear display: Loosen LVDT lock screw, rotate thumbscrew to bring LVDT plunger visually to mid position, the wear reading display on controller should be as near to zero. Initialize wear display to‘0‘ by pressing _ZERO‘ push button on controller.

7. Frictional force display: Move loading arm away from frictional force load cell and set frictional force display _0‘ by pressing relative _ZERO‘ button on controller.

8. Place required weights on loading pan to apply normal Load.

9. Setting disc speed: Set 10 minutes time on controller, press test, start push button and rotate. Set by rotating rpm knob on controller till required test speed is displayed. Continually run for the remaining time to observe any fluctuation. Press STOP button.

10. Setting test duration on controller: Test duration is set either in time mode (set in hr ,min,sec) or counter mode (set in no. of cycles, max. is 100000 cycles). Mode selection is by toggle switch below timer display, the switch position indicates selection as either time or counter. Test duration of 30 minutes is selected.

2. SETTING OF COMPUTER FOR TESTING AND DATE ACQUISITION

• Connect the data acquisition cable from controller PC.

• Open the software winducom 2008 on PC.

• Click on ACQUIRE tool bar at screen to open acquiring screen.

• Enter a name on file name window.

• In the cell for for sample ID, enter the material and its dimensions.

• Fill the remaining empty cells for speed, load wear track and data sampling rate.

• In the remark cell, enter dry test duration of test speed etc.

• Click START push button on controller front panel to commene the test and send data to PC.

• Set the required rpm by rotating slowly the rpm knob in clockwise direction.

• Measurement rpm is displayed on the SPEED window of the controller front panel.

• Click Zero button on PC screen and initialize all sensor values to zero.

• Click SAVE button on PC screen to save data.

On controller the acquired test parameters like wear, frictional force, speed and temperatures are displayed, the same values are displayed on PC screen with graph [3].

TABLE I: Specifications of Wear test rigMake - TR 20 LE

Item	Specification
Over all size	630 x 630x 860 mm (L x b x h)
Pin size	3,4,6,8,10 and 12 mm diameter.
Disc size	165 mm diameter x 8mm thick
External interfaces	PC connection: USB connector (type B)
Wear track (mean)	15mm to 130 mm
Loading lever length	394 mm.
Sliding speed range	0.05 m/sec. 10m/sec.
Disc rotation speed	20-2000 rpm with LC 1 rpm
Normal Load	5N to 200 N
Friction Force	0 to 200 N digital recorded output
Wear measurement range	+/- 2mm LC 0.1 um digital recorded output
Power	1.5 KW, 230V, 15A, 1 phase, 50Hz.

Material And Test Condition In Wear Test

Variables in wear testing:

The Variables In Wear Test Are As Follows.

A) Normal Load- In Drive Shaft Assembly Bearing Cup Assembly Is Subjected To Load Which Is Distributed To Each Needle Roller In Contact Hence It Is Essential To Contact Load On One Needle Roller.

Input:

- Needle Roller Dia.- 0.0929 In.
- Effective Length Of Needle Roller- 0.264 In.
- Needle Roller Quantity- 21 No.
- Journal Peak Dia.- 0.505 In.
- Span of journal (2R) – 1.582 in.
- Continuous Torque- 10.3 Kgm (894.306 lb in.)

F = T / 2R [1]

Where

F = Torque couple force lb

T = Torque lb in.

R = Torque radius in.

F = 894.306/1.582

F = 565.3 lb = 2515N

For load on one needle F= 2515/21 = 119.76 N

Hence load selected from available range are 98.9N (10 kg) ,117.7 N (12 kg) and 147.1N (15kg)

B) SLIDING VELOCITY-

To calculate sliding velocity at bearing cup assembly actually in UJ assembly. Maximum RPM of Shaft is 2027 hence we need to calculate sliding velocity at this RPM.

w2/w1=cosβ/(1-sin2β*sin2α1) [2]

Where W2, W1 = angular velocities of driving and driven shaft

α1, α2 = Rotation angle

β= Deflection angle

For maximum angular velocity.

w2/w1=1/cosβ bei α1=900 and α1=2700 [3]

Max. Deflection angle for this assembly β= 28º

W2 = 1.13 W1

W= [2 π N/60]

Rpm range for drive shaft assembly is 149- 2027.

W1= 212.26

W2= 1.13 X 212.36 = 239.8

Sliding velocity = W X R = 239.8X0.008 = 2.11 m/s

So we selected two sliding velocities 2.51 and 4.08 m/s which are as per standard track diameter available. Based on above calculations table 2 summarizes running parameters for experimental analysis for wear test.

TABLE II: Running Parameters Selected for Experimental Analysis

Sr. no.	Sliding Velocity (m/s)	Load N (Kg)	Test Duration (min)
1	2.5	98.9N (10 kg)	30
2	2.5	117.7 N (12 kg)	30
3	2.5	147.1N (15kg)	30
4	4.08	98.9N (10 kg)	30
5	4.08	117.7 N (12 kg)	30
6	4.08	147.1N (15kg)	30

c) temperature- the experimental work need to carried out at room temperature.

d) contact area- contact area between pin and disc is 113.09 mm2

e) sliding time- sliding time is kept 30 min for all test.

f) surface finish- surface finish of disc is kept r_a=0.48μm

g) material- counterface-1 is nothing but the pin material it was changed according to pin used in table III

TABLE III: Details of Sample for Wear Test Sample

Sample	Sample HT process details
A	SAE 1117 Untreated (without HT)
B	SAE 1117 Carburising & Hardening
C	SAE 1117 Nitriding
D	SAE 1117 Carbontriding
E	SAE 1117 Untreated (without HT)
F	SAE 1117 Carburising & Hardening
G	SAE 1117 Nitriding
H	SAE 1117 Carbontriding

Eight sample pins as described above are prepared to take test on each normal load and sliding velocity. Counter face 2 – is the disc made of En-31 steel with surface finish Ra= 0.48μm its material composition is listed in Table IV

Content	**C**	**Si**	**Mn**	**P**	**S**	**Cr**	**Mo**	**Ni**
Percentage	0.71	0.26	1.26	0.04	0.02	1.25	0.03	0.07

h) Lubricant- No lubricant was used during test. As application is also in dry condition.

Measured parameters

A) Friction Measurements

The lever transmits a signal through load cell for determining frictional force. Load cell is connected to digital panel, which displays the frictional force and also connected to pc where it is recorded. The readings are recorded normally for every 5 minutes of interval.

B) Wear Measurement

Electronic LVDT wear measurement is used for permanently recording wear. The readings are recorded manually for every 5 minutes of interval.

C) Test Time

Digital timer/controller for automatic shut off.

D) Cycle counter

Panel mounted cycle counter gives the RPM of rotating disc.

Calculations of wear rate factor

The contact between two sliding surfaces, because of inevitable friction generated in the contact zone, results in a certain wear whose magnitude depends on load, speed and time of sliding contact. Wear can be quantitatively measured as specific wear rate, which is the volumetric loss of material over a unit time. Theoretically, between these parameters and the resulting wear exists relation proportional to

$V_i = K_i x F x v x\ t$ [4]

Where ,V_i = wear volume in mm3

TABLE V: Specific Wear Rate for Different Surface Treated Samples

HT Process	Load N (Kg)	Specific wear Rate (mm3/Nm) (V1- 2.51 m/s)	Specific wear Rate (mm3/Nm) (V2- 4.08 m/s)
Untreated	98.9N (10 kg)	6.9446 X10-4	3.4598 X10-4
	117.7 N (12 kg)	3.4819 X10-4	1.8377 X10-4
	147.1N (15kg)	1.9719 X10-4	9.5884 X10-5
Carburising	98.9N (10 kg)	8.9948 X 10 -5	2.3827 X 10 -5
	117.7 N (12 kg)	1.4834 X 10 -5	3.3139 X 10 -5
	147.1N (15kg)	7.8968 X 10 -6	8.1338 X 10 -6
Carbonitriding	98.9N (10 kg)	5.1291 X 10 -5	1.7998 X 10 -5
	117.7 N (12 kg)	5.5108 X 10 -5	1.0896 X 10 -5
	147.1N (15kg)	4.3951 X 10 -5	2.3060 X 10 -5
Nitriding	98.9N (10 kg)	1.3387 X 10 -5	6.5237 X 10 -6
	117.7 N (12 kg)	2.8484 X 10 -5	1.3949 X 10 -5
	147.1N (15kg)	1.6560 X 10 -5	1.0993 X 10 -5

Experimental tests were carried out on each sample test pin for each normal load and sliding velocity as per experimental plan decided. Experimental data of slide wear and coefficient of friction of each sample pin against EN31 disc (surface roughness Ra= 0.48 μm) for each sliding velocity of 2.51 m/s and 4.08 m/s and normal loads 98.9N (10 kg) ,117.7 N (12 kg) and 147.1N (15kg) under dry condition using pin-on-disc tribometer (TR-20LE) at NTP was tabulated. Using this data for each sample pin graphs of variation of wear in micrometer with time and variation of coefficient of friction were plotted.

3 Comparison of Specific Wear Rate for Different Heat Treated Samples.

The specific wear rates in mm3/Nm or wear factors of different surface treated test samples against En31 disc is tabulated in 8.9 for each sliding velocity 2.51 m/s and 4.08 m/s and each normal load 98.9N (10 kg) ,117.7 N (12 kg) and 147.1N (15kg)

F = Force in N
v = Sliding speed in m/sec
t = Time in sec
K_i = Wear factor in mm^3 / Nm
Lower the value of K_i, more the resistance to wear.
Both contact pressure (P) and the sliding speed (V) strongly influence material rates. Each material has wear rates. Each material has a PV limit. Above this limit, a material will fail, the PV limit is however more conceptual than practical. Higher PV values indicate an ability to operate under heavy loads and faster surface velocities. An increase in pressure increases the wear rate and decreases the friction, whereas higher sliding speed increases both wear and friction.

The value of factor PV after which the coefficient of wear loses its linear behavior, it can be easily perceived, the wear factor and the PV limit of the same material varies with different heat treatment, hardness, surface finish, contact pattern cooling and lubricating fluids etc.

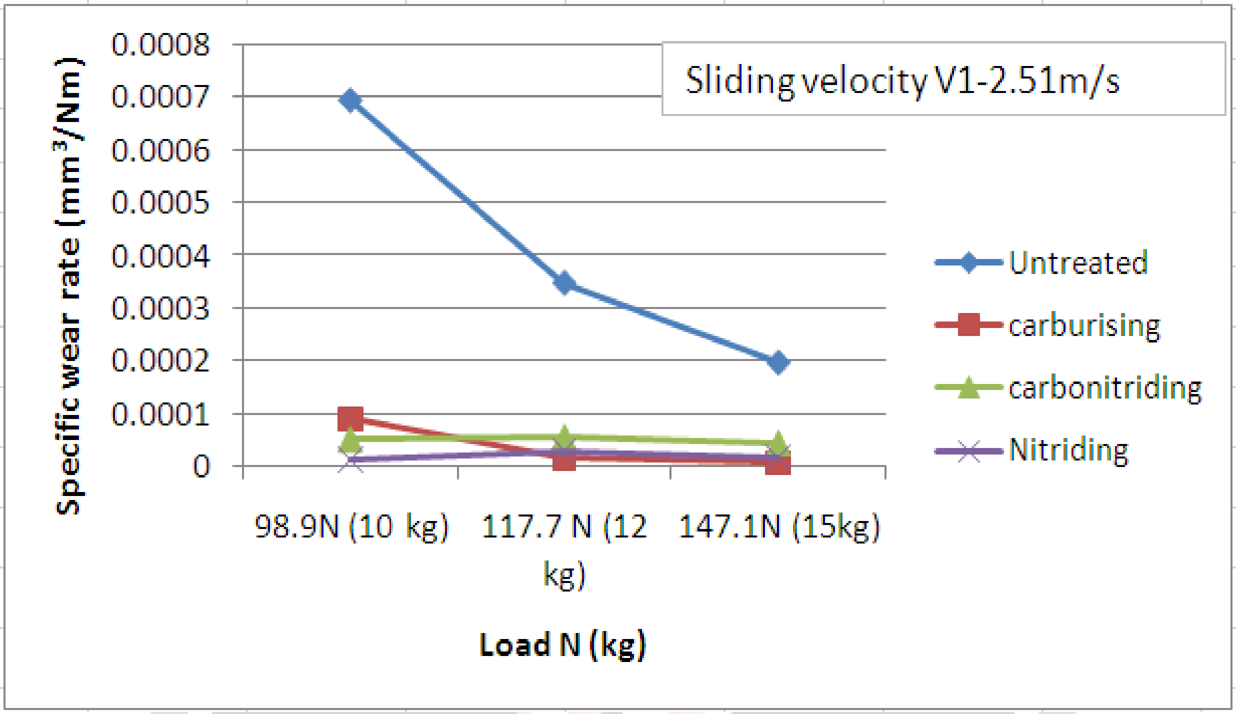

Fig. 2: Comparison of Specific Wear Rate of Different Surface Treated Samples at Sliding Velocity of 2.51 m/s

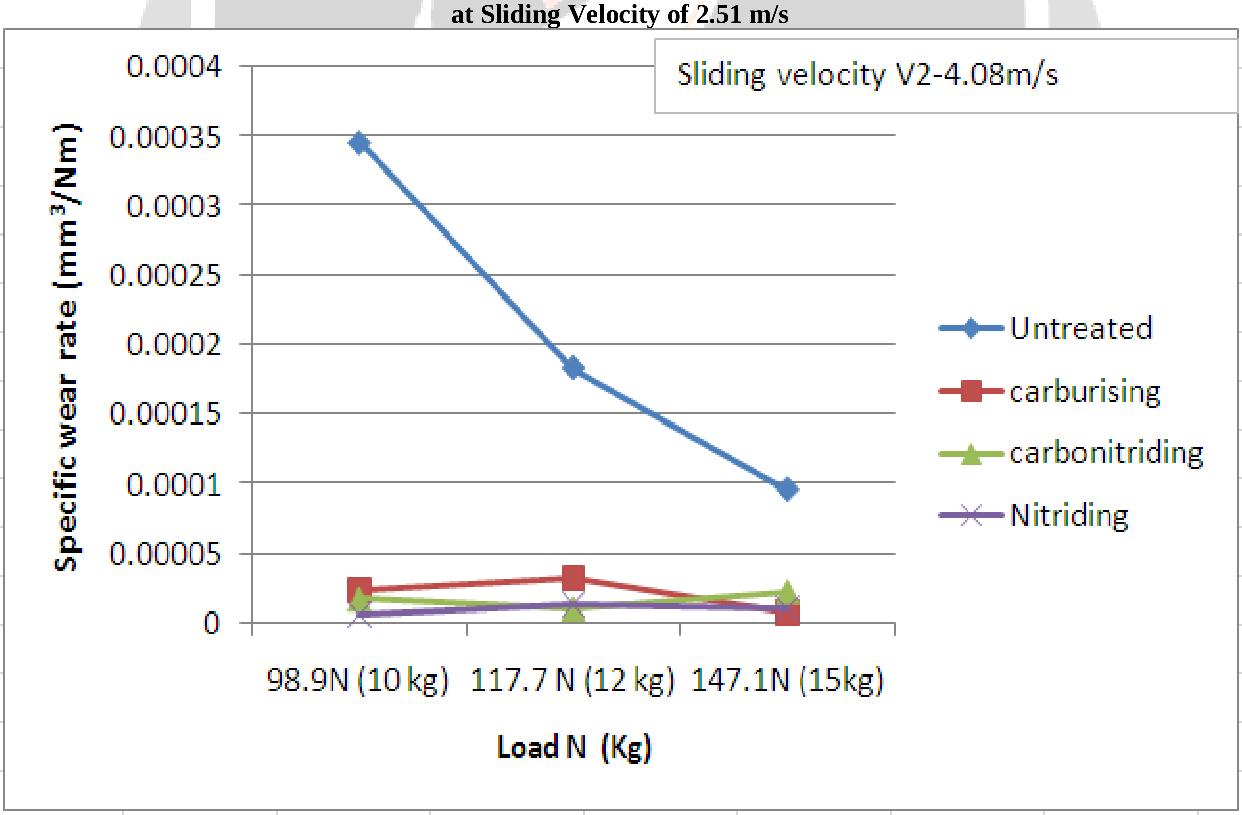

Fig. 3: Comparison of Specific Wear Rate of Different Surface Treated Samples

at Sliding Velocity of 4.08 m/s

4. CONCLUSIONS

From Table Fig. II andIII, it can be concluded that wear rate was much less for surface treated samples than untreated sample test pin and all were comparable and almost shows similar result in terms of wear loss, however for nitriding the wear loss was minimal and at lowest of all the samples compared. Carbonitriding shows consistent wear rate. These results were similar for sliding velocities i.e. 2.51 m/s and 4.08 m/s

Carbonitriding and hardening processes show good results to achieve martensite structures which gives good wear resistance. Hardness achieved at surface was within range of 58-62 RC; case depth achieved was less (0.3-.045mm) as compared to that achived by carburising and hardening (0.8 to 1.1mm). Push out force was high as compared carburised and hardened samples which was average 885 kg. Specific wear rate was in the range of 4.39 X 10 -5 to 5.51 X 10 -5. Endurance test also found satisfactory; float value was within acceptable limit giving an alternative process to carburised and hardened samples.

5. REFERENCES

[1] M .Izciler, et. al. ‖Abrasive wear behavior of different case depth gas carburized AISI 8620 gear steel‖ Elsevier-Wear, 2006, PP 90-98.

[2] H sert, A. can et. al. ―Wear behavior of different surface treated cam spindles‖ Elsevier- Wear, 2006, pp 1013-1019.

[3] A. Ben Cheikh Larbi et al. ―Improvement of the adhesive wear resistance of steel by nitriding quantified by the energy dissipated in friction‖ Elsevier- Wear 2005,PP 712-718

[4] Mohamed Ali et al in ―Fatigue life evaluation of 42CrMo4 nitrided steel by local approach: Equivalent strain-life-time‖ Elsevier- Material and Design 33,2012

[5] M. Elmadagli et.al. ‒A parametric study of the relationship between microstructure and wear resistance of Al–Si alloys‖ Elsevier-Wear, 2007, pp 79-92.

[6] T. Slatter et al. ‒The influence of induction hardening on the impact wear resistance of compacted graphite iron (CGI)" Elsevier- Wear 270,2011, PP 302-311.

[7] Mustafa Ulutan, Osman N. Celik, etal. ‒ Effect of Different Surface Treatment Methods on the Friction and Wear Behavior of AISI 4140 Steel‖ Elsevier -J. Mater. Sci. Technol., 2010, pp 251-257.