International Journal of Modern Trends in Engineering and Research
www.ijmter.com
e-ISSN No.:2349-9745, Date: 2-4 July, 2015

Wear Behavior of SAE 4340 Steel – Single Specimen

Nadendla Srinivasababu[1]

[1]*Department of Mechanical Engineering, Vignan's Lara Institute of Technology and Science, Vadlamudi-522213, Andhra Pradesh, India, cnjlms22@yahoo.co.in*

Abstract- In entire engineering wear plays a very vital role in the selection of materials for different fields of application viz. automobile, aircraft and space craft. An attempt is made in this work to do review on the mechanical behavior of the material. Then using Pin-on-Disc machine wear, frictional behavior of SAE 4340 steel is tested on single specimen at different conditions of speed, time and load. The obtained results are graphically plotted.
Keywords- SAE 4340 steel; wear; pin-on-disc machine; cylindrical specimen;

I. INTRODUCTION

Tribology term is derived from the Greek tribos (rubbing) which uses the science and technologies of the interacting surfaces in relative motion. In United Kingdom the money spent towards the friction and wear was reported by Jost and used this term firstly in 1966 in his report. The history of tribology is as old as history of mankind, the main driving force being the facilitation of daily activities by reducing friction. The first man made bearings to be identified date back to the middle stone age with the use of stone door sockets, bearings for wheeled vehicles and bearings for stone potters wheels.

These wheels were lubricated with bitumen. Initial scientific developments of tribology began during the Renaissance (1450-1600 AD) with the most important studies conducted by Leonardo da Vinci (1452-1519). Many investigators have performed the basic trobological studies during 1850 and 1945 viz. rolling friction – Reynolds (1975), contact between the elastic materials – Heinrich Hertz's (1881), unloaded journal bearings – N. P. Petrov's (1883), viscometer – Engler, Saybolt and Redwood (1884-86), hydrodynamic theory – Tower and Reynolds (1865), friction measurement on journal bearing – Richard Stribeck (1902) etc. [1].

Wear is a progressive damage to a surface caused by relative motion with respect to another substance. DIN 50320 stipulates various processes of wear depending on its mechanism as adhesion, abrasion, surface fatigue and tribological reaction [2]. N. R. Dhar et al. [3] studied the role of minimum quantity lubrication on tool wear and surface roughness in turning AISI-4340 steel at industrial speed, feed combination by uncoated carbide insert. The transfer of material and on debris particles is observed by P. Heilmann et al. [4]. Ernest Rabinowicz [5], described the three types of adhesive wear viz. severe wear, moderate wear and burnishing.

A sequence of events in sliding wear is described by D. A. Rigney et al. [6]. He further conducted review on and taken some experimental results which have contributed to improved understanding of sliding wear processes [7]. Nam P. Suh et al. [8], proposed theory that predicts qualitatively that the wear particle shape is likely to be thin flake-like sheets and that the surface layer can undergo large plastic deformation. The analysis of the mechamsm of wear between metal surfaces is dependent on the distribution of the real area of contact, i.e. the mechanism of contact [9]. In this work an attempt is made to understand the wear behavior of SAE 4340 steel at different conditions on Ducom Wear Testing Machine.

II. MATERIALS AND TEST PROCEDURE

The material i.e. SAE 4340 steel is procured from KALVA Enterprises Private Limited, Plot No. 17, Mamta Nagar Colony, Nagole, Hyderabad, Telangana, India. The specimens are of cylindrical in shape with 6 mm diameter, 27 mm length. The specimen is weighed using the electronic balance and is of 6.32 gm. In this work single specimen is used for the entire experimentation to assess how the performance of the material is under dry sliding condition.

The test is conducted according to ASTM G99–05 on Wear Test Machine supplied by Ducom Instruments Pvt. Ltd., Bangalore at different conditions described in Table 1. In this work wear test machine of TR-20 model is used.

Single specimen is considered throughout the wear test and is shown in Fig. 1. The disc is cleaned at each time with the help of a soft clean cloth to remove the particulate from the zone of experimentation to avoid their adherence with the specimen.

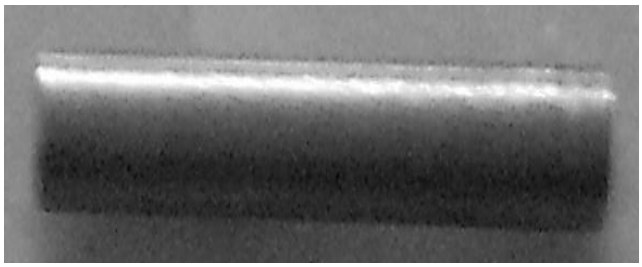

Fig. 1 SAE 4340 steel specimen for wear test

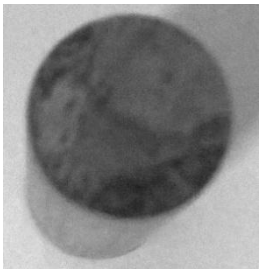

Fig. 2 Top view of wear tested specimen

Table 1 – Conditions during the wear test

S. No.	Notation for speed	Speed (rpm)	Load (kg)	Notation for time	Time (s)
1	N1	225	2	t1, t2, t3, t4	200, 600, 800 and 900
2	”	”	3	”	”
3	”	”	4	”	”
4	N2	450	2	t5	300
5	”	”	3	”	”
6	”	”	4	”	”
7	N3	675	2	t6	200
8	”	”	3	”	”
9	”	”	4	”	”
10	”	”	2	t7	333
11	”	”	3	”	”
12	”	”	4	”	”

III. RESULTS

AISI/SAE 4340 steel combines deep hardenability with high ductility, toughness and strength. The material has high fatigue and creep resistance. It finds application in the areas where it needs high strength, severe conditions. It does not soften readily at elevated temperatures. It is especially immune to temper embrittlement. The 4340 steel is usually forged at 1056 to 1230 ^{0}C. After forging the parts may be cooled in a dry place or preferably furnace cooled. Typical mechanical properties of

4340 steel are, tensile strength 1980 MPa, yield strength 1860 MPa, hardness 53 HRc, Izod impact energy 20 J [10].

The wear tested specimen in its top view is shown in Fig. 2. After conducting the wear test the graphs are plotted for wear, frictional force against load at different speed and time of test and are shown from Fig. 3 to 8. From the experimentation it is clear that the increase in load resulted in clear increase in wear and is varied for the SAE 4340 at the conditions of N2t2, N3t6 and N3t7. The material had shown the wear ranges from 2 to 190 µm. More wear is observed at 4 kg load, 900 s of test, at 225 rpm whereas least wear is identified at 2, 4 kg of load 800, 200 s of test time at 225, 675 rpm respectively.

Increase in wear testing time leads to increase in wear and is true in case of the conditions of test i.e. N1t1, N1t4. At 225 rpm of disc speed and 600 s of test time, the wear of the material falls from 17 to 11 µm. Further it is visible from Fig. 7 that at the disc speed of 675 rpm the material exhibited decrease in wear and then increases and increase in wear and decreases at 200 s, 333 s of test speed respectively.

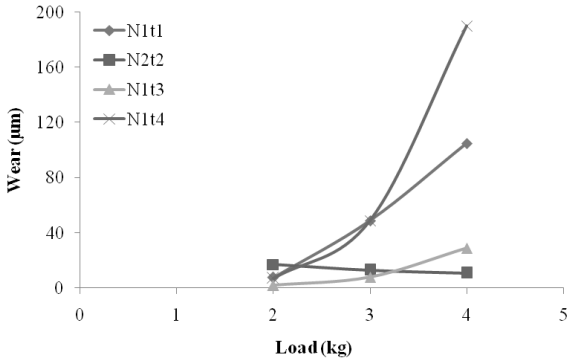

Fig. 3 Wear of SAE 4340 Steel at N1 Speed

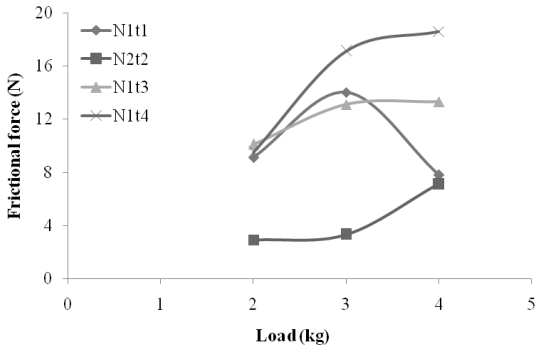

Fig. 4 Frictional behavior of SAE 4340 Steel at N1 Speed

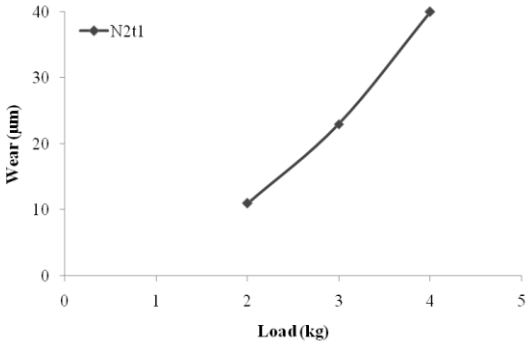

Fig. 5 Wear of SAE 4340 Steel at N1 Speed

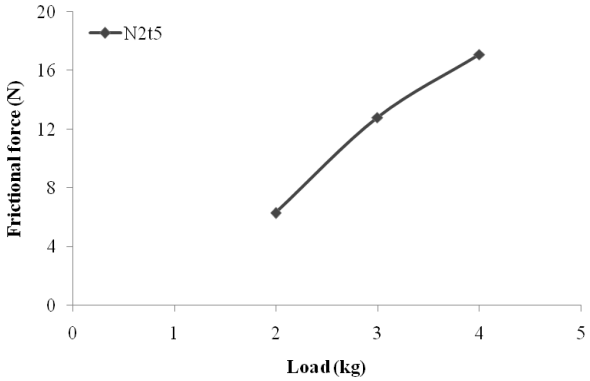

Fig. 6 Frictional behavior of SAE 4340 Steel at N1 Speed

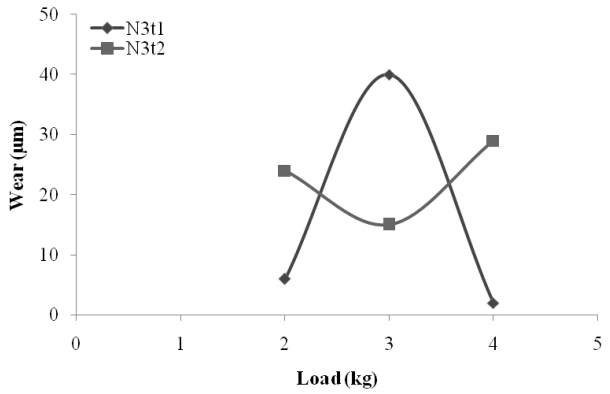

Fig. 7 Wear of SAE 4340 Steel at N1 Speed

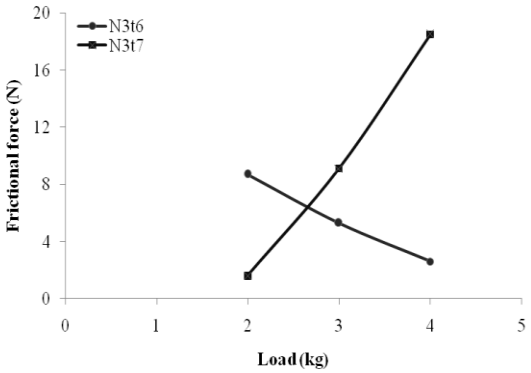

Fig. 8 Frictional behavior of SAE 4340 Steel at N1 Speed

The frictional force during the test of the material is increased in all the cases except N1t1, N3t6. The frictional force varies from 1.6 – 18.6 N from the Fig. 1 it is observed that the frictional force initially increased with load and then decreased at N1t1. A quite opposite phenomenon is observed for SAE 4340 specimen during the test condition N3t6 where the frictional force decreased from 8.7 to 2.6 N and is evidenced from the Fig. 7. The experimental set up of wear test is shown in Fig. 9.

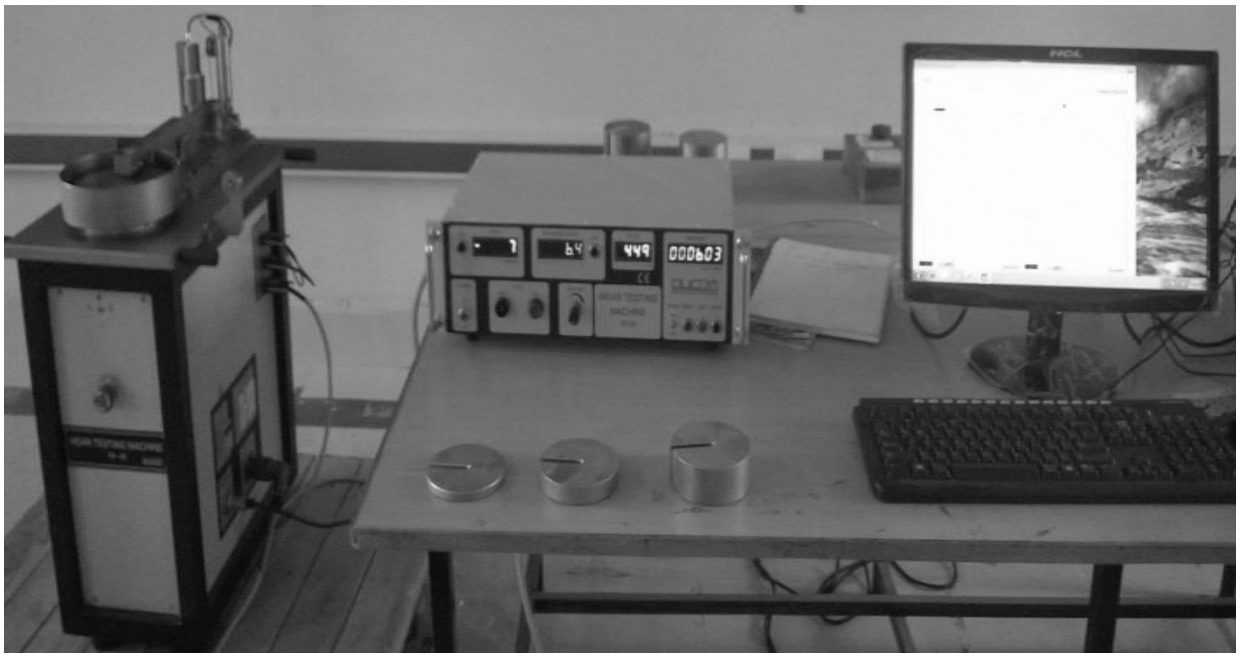

Fig. 9 Wear testing setup

IV. CONCLUSIONS

The wear of the material is not only influenced by the speed of testing but also with load and testing time and is evidenced from the experimentation. SAE 4340 has shown reasonably low wear when compared with other materials and find application in heavy automobiles, aircraft. A further analysis is required to understand the behavior of the specimen under various conditions (with and without lubrication).

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