WEAR AND FATIGUE ANALYSIS OF EN-19 STEEL

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Abstract- *Wear has direct influence on the finishing andefficiencyof products. Therefore, at this critical point, when considered the aspects of tool components recovery and undesirable production line stops. Moreover, the industry production growing speeds push the search for higher efficiency level of manufacturing. Main cause of wearing is the friction between contact surfaces by relative sliding motion with some exceptions of braking, the wear coefficient and pressure must be as low as possible to reduce wear.*

The objective this paper is to find wear and fatigue behavior of En-19 steel material. This work involves Chemical Composition testing of substrate steel material to get exact composition of En-19 steel and it is used for wear and fatigue testing. This paper work also involves wear test on Pin-on-Disc set up.

The work uses ANSYS WORKBENCH-12 software to derive the finite element model of the standard specimen. Based on this model, Fatigue life of standard specimen is found.

Keywords:*, Static structural analysis, Wear, Fatigue,FEM*

1. Introduction

Wear has direct influence on the finishing and efficiency of products. Therefore at this is critical point of any component. Moreover, the industry production growing speeds requires the search for higher efficiency level of manufacturing. One of the main causes of tool wearing is the friction between contact surfaces by relative sliding.

The mechanical forming industry is continually investing on the development of wear resistant materials. The objective is the improvement of materials properties and new materials development. New materials are developed and upgraded for different applications.

Metal Fatigue is a phenomenon which gives in the sudden fracture of a component after a period of cyclic loading in the elastic regime. Failure is the final result of a process involving the initiation and growth of a crack, usually at the site of a stress concentration on the surface. Occasionally a crack may initiate just below the surface. Eventually the cross sectional area is so reduced that the component ruptures under a normal service load, but one at a level which has been satisfactorily withstood on many previous occasions before the crack propagates. The final fracture may occur in a ductile or brittle mode depends on the characteristics of the material. Fatigue fractures have a characteristic appearance which reflects the initiation site and the progressive development of the crack front.

Nitriding and Physical Vapor Deposition (P.V.D.) coating techniques is used for some time and is still on development. These processes are extensively used to change any component surface strength. Coating materials deposited on the surface of metals are extensively used in aerospace, automotive and oils fields, to improve the corrosion and wear resistance.

Damage occurring when two bodies are in contact and in relative motion, produces debris. Wear is produced when this debris is removed from the contact. The rate of removal of the debris depends on the contact geometry. Confined or conforming contact will not allow debris to displace. The wear partials act as weak layers which reduce friction. They have a much more complex effect such as making the counterpart smoother. The contact area is seen as having changing morphology, structure, chemistry, particle size and aspect ratio. It will be stretched, compacted and rolled by the repeated deformations in the contact

2.Wear Consideration

The wear is erosion or sideways movement of material from its "derivative" and original position on a solid surface performed by the action of another surface. Wear is related to interactions between surfaces and more clearly the removal and deformation of material on a surface as a result of mechanical action of the opposite surface. The need for relative motion between two surfaces and initial mechanical contact between asperities is an important distinction between mechanical wear compared to other processes with similar outcomes.

Wear may include loss of dimension from plastic deformation if it's originated at the interface between two sliding surfaces. But, plastic deformation such as yield stress is excluded from the wear definition if it doesn't incorporates a relative sliding motion and contact against another surface irrespective of the possibility for material removal, because it then lacks the relative sliding action with another surface. Impact wear is in reality a short sliding motion where two solid bodies interact in veryshort time interval.

Aspects of the working environment which affect wear include loads and features such as unidirectional sliding, reciprocating, rolling, and impact loads, speed, temperature, but also different types of counter-bodies such as solid, liquid or gas and type of contact ranging between single phase or multiphase, in which the last multiphase may combine liquid with solid particles and gas bubbles

3.Mechanisms of Wear

According to the former DIN 50320, wear mechanisms are classified into four basic categories under the headings of adhesion, abrasion, and surface fatigue and tribochemical reactions. These are given in table

Table 1 : Wear Mechanisms According To Former Din 50320

Wear mechanism	
Adhesion	Formation and breaking of interfacial adhesive bonds
Abrasion	Removal of material due to scratching
Surface fatigue	Fatigue and formation of cracks in surface regions due to tribological stress cycles that result in the separation of material
Tribochemical reactions	Formation of chemical reaction products as a result of chemical interactions between the elements of a tribosystem initiated by tribological action

A. Stages of Wear:

Under normal mechanical and practical procedures, the wear-rate normally changes through three different stages:

1. First stage: First stage or early run-in period, where surfaces adapt to each other and the wear-rate might vary between high and low.

2. Second stage: Second stage where a steady rate of ageing is in motion. Most of the components operational life is comprised at this stage.

3. Third stage: Third stage where the components are subjected to rapid failure due to more rate of ageing.

The second stage is shortened with increasing severity of environmental conditions such as higher temperatures, stress,strainrates and sliding velocities etc. In explicit wear tests simulating industrial conditions between metallic surfaces, there are no clear chronological difference between different wear-stages due to big overlaps and symbiotic relations between various friction mechanisms. Surface engineering and treatments were used to minimize wear and extend the components working life.

4. Material Properties of En-19

Table 2 :. Material Properties of En-19

Content	ChemicalComposition
%cr	0.95
%si	0.2
%p	0.014
%s	0.003
%c	0.39
% Mo	0.20

5. Pin-On-Disc apparatus

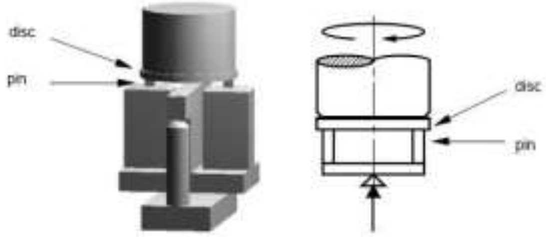

Fig.1. Pin-on Disc apparatus

The pin-on-disc apparatus consists of a fixed 2-pins holder continuously sliding against a rotating disc. The rotation is transmitted through a rotary vacuum feed through to a shaft with the sample disc at the lower end. Loading is established by pressurized He-gas acting on a piston which presses a lever with the sample holder upwards against the lower face of the rotating disc. Polymer composites are cut into pins. In order to reduce the time of the running-in period, specimens are pre-worn with grinding paper (Grid 800) against the disc counterpart and then carefully cleaned with ethanol

6. Experimental Result

(a)

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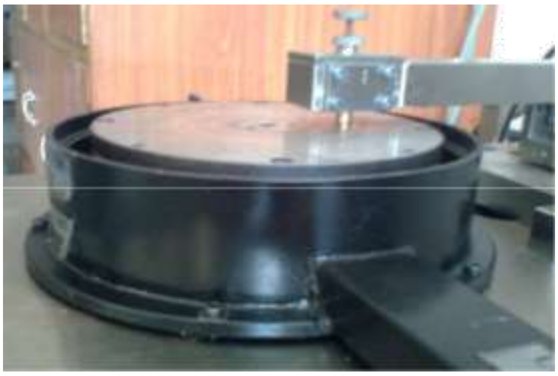


(b)
Fig.2. Pin and disc experimental set up

Working conditions taken during test are as follows:
Normal load applied in steps = 20N, 30N, 40N, 50N, 60N. Duration considered = 3 Minutes
Rotations of disc =700 RPM

A. Performances Characteristics Wear Vs Load

Wear verses load characteristic was drawn for different load conditions for the duration of 3 minutes and plotted on the graph .

Load conditions taken for material En 19 are 20N, 30N, 40N, 50N, 60N.

B. *Performances Characteristics Coeff. Of Friction Vs Load*

Keeping above working conditions this performance was plotted. Wear behavior against time was also observed and plotted as shown in figure 5.

Coeff. of friction against time was also observed and plotted as shown in figure 3.

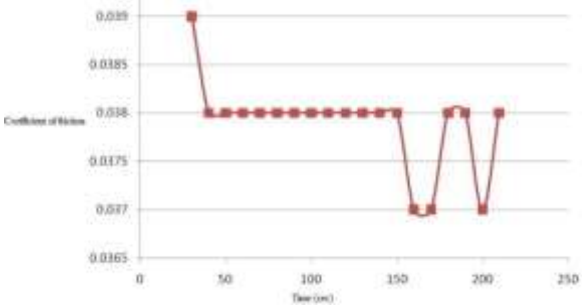
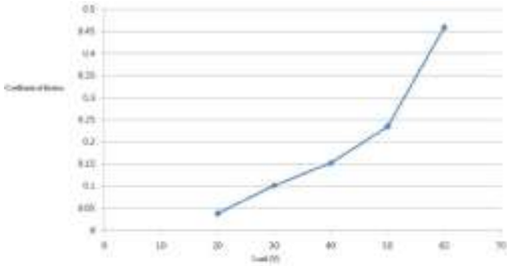


Fig. 3. Coeff.of Friction Vs Time



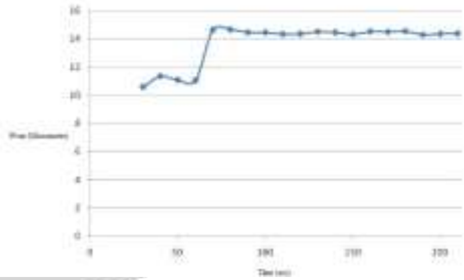


Fig. 4 . Load Verses Coeff.of Friction, **Fig. 5.** Wear Verses Time

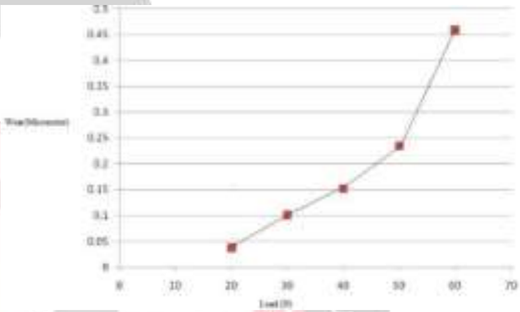


Fig. 6. Load Verses Wear

7.Experimental Set-Up

Fig. 7. Wear and friction monitor.

The tribometer uses a pin-on-disc system to measure wear. The unit consists of a gimbaled arm to which the pin is attached, a fixture which accommodates disks up to 165 mm in diameter & 8 mm thick, an electronic force sensor used for measuring the friction force, and a computer software (on Lab view platform) for displaying the parameters, printing, or storing data for analysis. The motor driven turntable produces up to 700 rpm.

Wear was quantified by measuring the wear groove with a profilometer (to be ordered separately) and measuring the amount of material removed. Users just simply specify the turntable speed, the load, and any other desired test variables such as friction limit and number of rotations. Designed for unattended use, a user need only place the test material into turntable fixture and mention the test variables.

A pre-determined Hertzian pressure was automatically applied to the pin using a system of weights. Rotating the turntable while applying this force to the pin includes sliding wear also a friction force. Since pins can be fabricated from a wide range of materials virtually any combination of metal, glass, plastic, composite, or ceramic substrates can be tested.

Software included with this model provides for quicker calculation of the Hertzian pressure between the pin and disk.

8. Experimental Machine

Different equipment were used to measure Wear rate & coefficient of friction with respect load & time. They are,

A. *Pin:* The circular pin was used having diameter 8 mm andlength 30 mm. The suitable clamping arrangement was provided for making surface contact between pin and rotating disc. The pin was made up of steel material. The following fig.8 shows the pins.

Fig.8. Pins

B. *Circular disc:* The disc was always in contact with face of pinto measure of wear rate. The diameter of a disc was 165 mm and thickness was 8 mm. The following fig.9 shows the sample of rotating disc.

Fig.9. Rotating disc

C. Dead Weights: There were different weights used for measurement of wear rate and coefficient of friction. These dead weights were available in several categories such as 1Kg, 2Kg, and 5Kg.

D. Wear and friction controller:

The following fig.10 shows the wear and friction controller. With the help of controller different input parameter was set such as frictional force, wear, temperature, RPM indicator and On-off option. According to this input parameter software generated the wear graph, so from that graphs, user can get useful information related to the tribological properties of material such as coeff.of friction and wear

Fig.10. Friction and wear controller

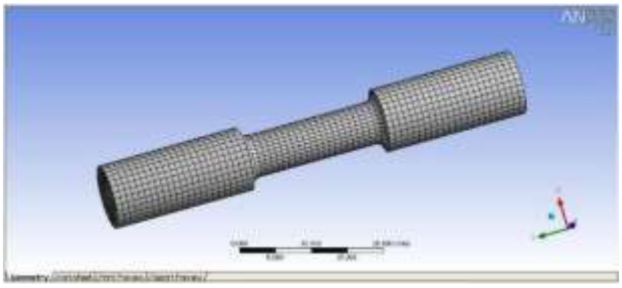
E. *Display Unit:* A computer with the control software was usedto monitor the signal. Here all the data can be stored in the computer for future references. This was mainly in the form of PC (Laptop) when the wear occurs then the signals were transferred to the software and after conversion we got in graphical form through the software. Generally, the data includes graphs of wear vs. time, coefficient of friction vs. time

Megview Software was used as tribological software for generating the following graphs:

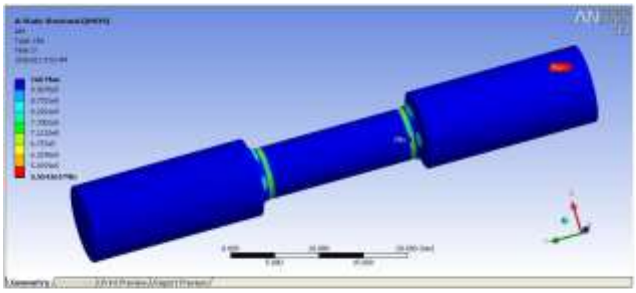
A) Performances characteristic of wear vs load.
B) Performances characteristic of coefficient of friction vs load.
C) Performances characteristic of wear vs time
D) Performances characteristic of coeff. of friction vs time.

9. Static Structural Analysis of Standard Component

The solid model of standard component for axial fatigue testing was made with the help of ANSYS WORKBENCH -12 software. Static structural analysis of standard specimen was carried with the help of ANSYS WORKBENCH -12 software. The static structural analysis module was selected for evaluating maximum stress induced in the specimen



(a)



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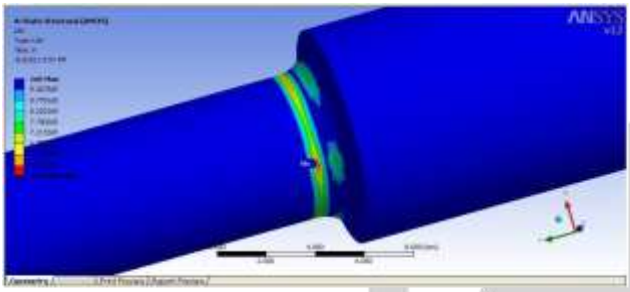

(c)

Fig.11. Static structural analysis of component

Fig. 11 shows the static structural analysis of standard specimen. In this analysis, the standard specimen was meshed with the help of Quad element. The numbers of nodes were 34,261 & numbers of elements were 7,632.The different boundary conditions were used such as applying fully reversed cyclic load 2000 N at one end and applied fixed support at other end. Fatigue tool was selected the output of structural module. The output results shows that minimum value of fatigue life induced at neck region of specimen is 5.55×10^5.

Conclusion

From the above work and wear testing we conclude that the wear and coefficient of friction are increasing with increase in load. From the results of wear test it is concluded that wear is increases initially up to 70 seconds and becomes nearly constant for further duration. Coefficient of friction decreasing significantly initially up to 50 seconds and remains nearlyto constant value for further duration.

From static structural analysis, we have seen minimum fatigue life of the specimen which occurs at the neck region for fully axial reversed cyclic load.

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