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Investigations and Analysis of Tribological Properties for Engineering Materials

M. Ateeb Razvi, Dr. Ashesh Tiwari

Abstract— Literature data and original research in the field of the technology and tribology for the properties of various engineering materials are investigated. Tribology is defined as the science and technology of Interacting surfaces in relative motion and of associated subjects and practice. It was coined after the Greek word "tribos" which means "rubbing". Tribology is an interdisciplinary field ranging from fundamental research to industrial applications. In order to analyze the nature of the engineering materials experiments were conducted with the help of Pin-on-Disc friction and wear Apparatus. The behaviour like friction and wear are discussed with the load parameter. The comaparative analysis is also completed in between the materials seaparated by heat treatment.

Index Terms— Engineering Materials, Heat Treatment, Friction, Tribological Properties, Wear

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1 INTRODUCTION

With the increment of engineering applications, it is important to understand the properties of new materials which can sustain the various working conditions.The tribological properties plays an important role in the application of engineering materials[4]. Tribological properties of materials are determined by either measuring of friction force in contact area or by measuring wear of one element of tribo- mechanical system [3]. The Parametric study of materials provided the implementation of the same.
The objective of the Paper is to analyze the tribological properties of engineering materials. In the first phase we have determined the behavior of materials and compare with the exixting one then in the second phase the properties of new materials were found and compare with same when they were heat treated.

1.1 Industrial Significance of Tribology

Tribology is defined as the science and technology of Interacting surfaces in relative motion and of associated subjects and practice [2]. Mechanical properties, machinability and the ability to change the properties of surface layers by physical-chemical and other procedures are the reason why metal materials are most commonly used for making the solid elements of a tribomechancal system [4]. Tribological characteristics are relative and depend on the location within the elements of a tribo-mechanical system where contact is realized [5,6]According to some estimates, losses resulting from ignorance of tribology amount in the United States to about 6% of its gross national product (or about $200 billion dollars per year in 1966), and approximately one-third of the world's energy resources in present use appear as friction in one form or another.

According to Jost (1966, 1976), the United Kingdom could save approximately 500 million pounds per annum, and the United States could save in excess of 16 billion dollars per annum by better tribological practices[1].

Potential Saving's (in US $ billion) by correct use of tribological knowledge (1.6% of GDP 2008)[1]

Country	Saving (US $ billion)
• Europeon Union	303
• United States	186
• China	68

2 EXPERIMENTAL PROCEDURE

First of all three materials namely Brass, Aluminium and Mild Steel were used for obtaining the nature.With the help of Wear and Friction Monitor – ED 201 machine .The friction and wear characterstics were obtained. The generated data were ploted on graph which shows indivisual nature and compare both properties by plotting on same graph.Then compared the results with the exixting one, this indicated that our procedure obtaining the results were right.
On the second phase EN-8, EN-21, EN24, BB (Bright Bar) and MS (Mild Steel) were choosen.For each and every specimen the friction and wear nature were generated by ED-201 machine. Every specimen was subjected for annealing, normalizing, water quenching and oil quenching. Again the friction and wear nature were obtained and compare with previous one.

2.1 Introduction of Machine

The Wear and Friction Monitor – ED 201 machine is basically used for the measurement of friction and wear. The machine consists of rotating disc against which the specimen pressed with known load.The LVDT (linear voltage differential transduser) is used to measure the wear rate .The maximum wear rate measured by +\-2mm. While the beam type load cell (strain gauge type) is used to measure the friction force. The range of friction force measurement is upto 30N.

- *M. Ateeb Razvi is currently pursuing masters degree program in Specilization in Design and Thermal Engineering in DAVV University, Indore (M.P.),452001 PH-09584283898. E-mail: ateeb.razvi@gmail.com*
- *Dr. Ashesh Tiwari is currently Head of department in Mechanical engineering in DAVV University, Indor(M.P.),452001 PH-9826941506 E-mail:asheshtiwari@rediffmail.com*

Table. 1 Specification of Machine

Parameters	**Unit**	**Min**	**Max**
Pin Size	mm	6	6
Disc Size	mm	100X6	100X6
Wear track Diameter	mm	20	80
Disc Rotation	RPM	480	480
Normal Load	N	5	30
Wear	Micrometer	0	2000

2.2 Friction Force Measurement

A beam type load cell with capacity of 3kg is mounted over sliding plate to measure frictional force form 0.1N to 30N. This is a strain gauge type of load cell; it is primarily a column of corrosion resistant super alloy of high tensile strength steel that deforms very minutely under load. This deformation is sensed by foil type strain gauges bonded on to the column and connected to form balanced wheat Stones Bridge. The electrical output from Whetstones Bridge is proportional to the load acing on column. The extremely rugged and hermetically sealed construction makes them the ideal choice for the application.

2.3 Wear Rate Measurement

The plunger moment as an indication of wear rate is sensed by LVDT . As wear occurs its plunger lifts up and this movement is displayed as wear on controller. The least count of LVDT is 1 micrometer, the initial position of plunger measurement is kept at mid point of to have both +ve & -ve wear readings.The maximum wear rate measurement possible is +/-2mm. In addition to the wear as indicted by LVDT, the wear on specimen may also be computed by measuring the initial & final length of specimen using Digital vernier caliper or micrometer.

Figure 1. Pin on Disc Wear Apparatus

Figure2. The Muffler Furnace

Table. 2 Comparative Composition

The following materials were considered for our specimen

%	*Bright bar*	*EN 8*	*EN 21*	*EN 24*	*Mild steel*
C	0.15 – 0.25	0.35/0.45	0.33	0.36/0.44	0.42/0.48
Si	≤ 0.35	0.05/0.35	0.23	0.10/0.35	0.15% – 0.35%
Mn	0.30 - 0.90	0.60/1.00	0.74	0.45/0.70	0.6% – 0.9%
Ni	-	-	3.47	1.30/1.70	-
Cr	-	-	0.07	1.00/1.40	-
Mo	-	-	0.11	0.20/0.35	-
S	0.050	0.06Max	0.027	0.040 Max	0.035% Max
P	≤ 0.050	0.06Max	0.031	0.035 Max	0.030% Max

3. Results and Discussion

3.1 Results of Friction

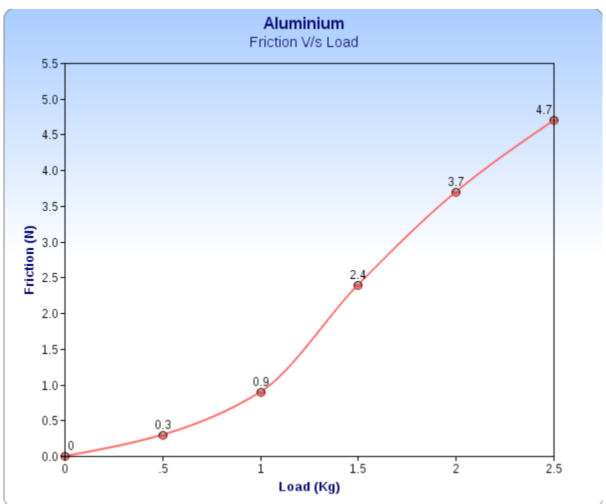
It has been noticed that when we increase the load the friction was found to be increase. In case of Aluminium, friction increases in small amount at starting after that the rate was increased. In Brass the increasing rate of friction was constant and in Mild Steel the friction was increasing at starting and then shows the small change in friction with the increment of load. Also, in Mild Steel the change in friction was minimum as compare to others specimen, Bright bar shows little bit more friction.

EN-24 shows the maximum friction. But after heat treatment the friction reduces in the entire specimen. The maximum friction shows in the annealing process. Bright (BB)bar shows maximum friction in annealing and the oil quenched specimen followed the annealing (furnace cooled) specimen .The water quenched and air cooled specimen follow the same pattern at starting and then water quenched specimen shows higher friction rate.EN-8 indicate the reduces friction in annealing as compare to normal. The lowest friction was obtained by oil quenching.EN-21 shows some contradiction; it shows the maximum friction in normalizing process and minimum friction in oil quenching. The effect of heat treatment was clearly shown in EN-24. The maximum friction was reduces from 20N (normal EN-24) to 8N(specimen subjected to annealing). In Mild Steel the friction reduces from 3.5N to 2N when subjected to heat treatment.

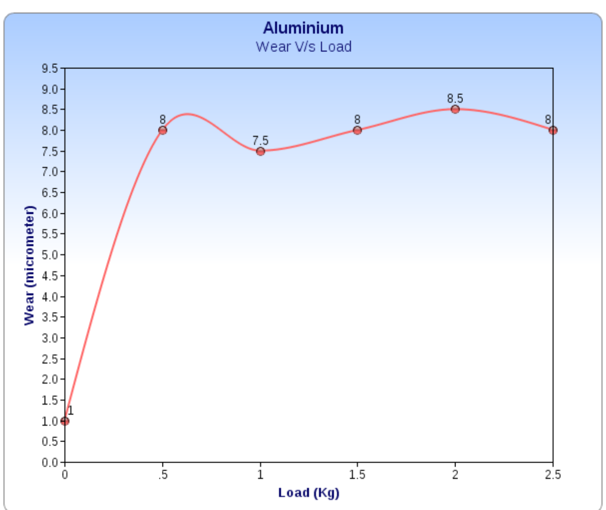
3.2 Results of Wear

It has been noticed that when we increase the load the wear was found to be increased. In case of Aluminium, wear increases at starting and then retarded. In Brass, the wear was increasing linearly and in Mild Steel the wear was increasing at starting and then remains constant with the increment of load. Also, in Mild Steel the increase in wear was minimum as compare to others specimen, Bright bar (BB) shows the reduction in wear when it was subjected to heat treatment, the mininmum wear shows in normalized specimen.EN-8 indicated the reduction in wear preferably the oil quenched specimen retarded the wear amount from 25 micrometer (normal specimen) to 17 micrometer.EN-24 shows the great redution from 34 micrometer (normal specimen) to 17 micrometer (oil quenched specimen) and Mild steel shows the minimum wear 14 micrometer in oil quenched specimen.

Aluminium Behaviour



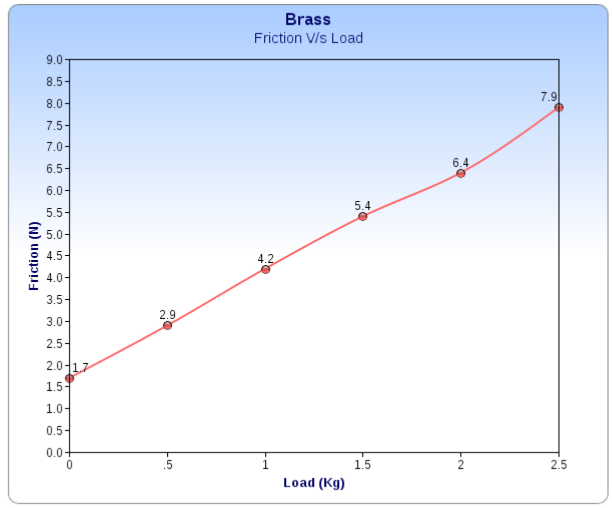
(a) Friction V/s Load



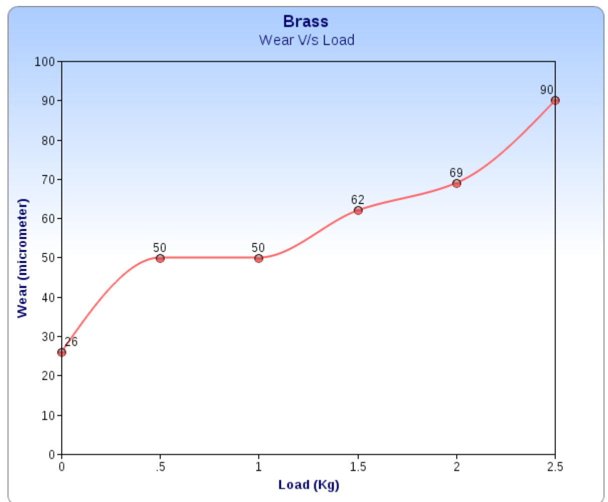
(b) Wear V/s Load

Fig. 3. Aluminim Behaviour of friction and wear with load

Brass Behaviour



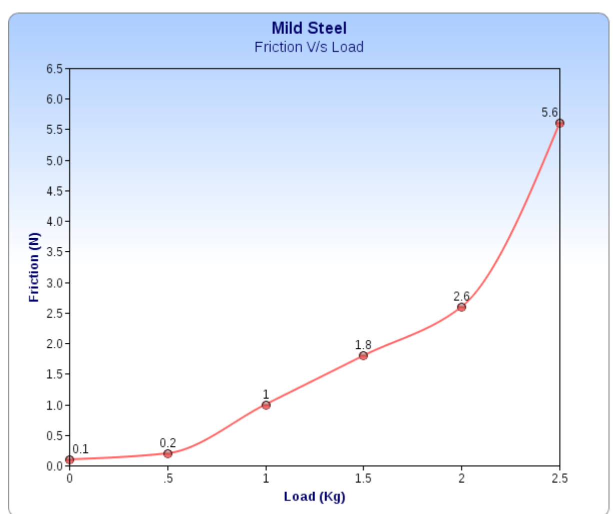
(a)Friction V/s Load



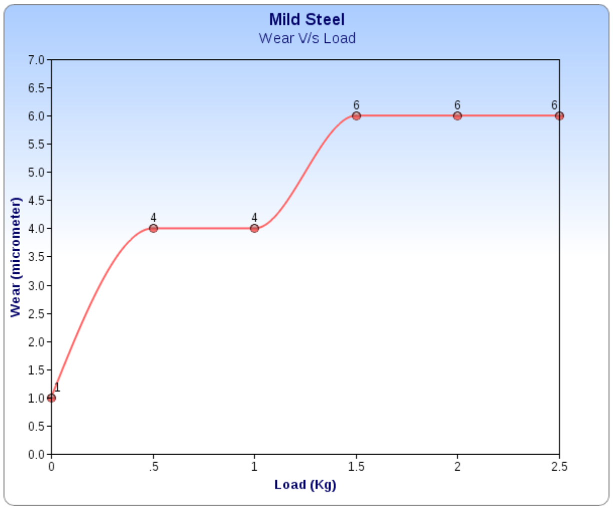
(b)Wear V/s Load

Fig. 4. Brass Behaviour of friction and wear with load

Mild Steel Behaviour



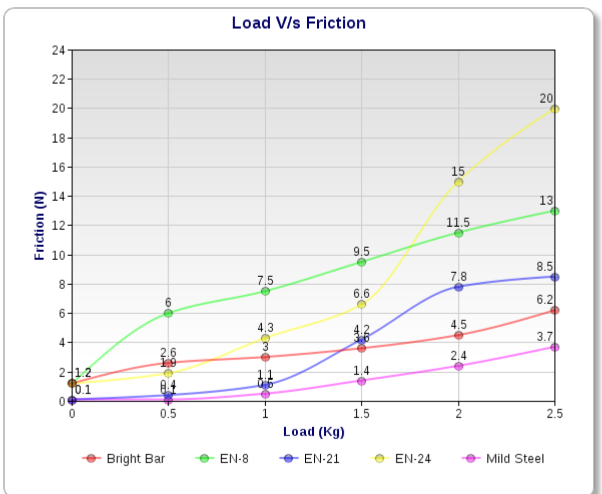
(a)Friction V/s Load



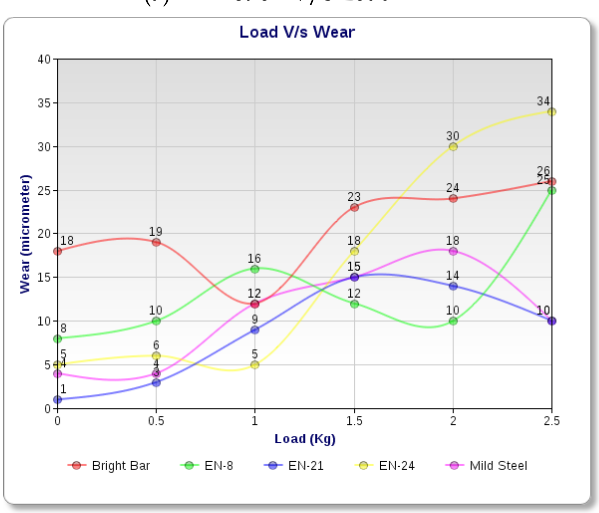
(b) Wear V/s Load

Fig. 5. Mild Steel Behaviour of friction and wear with load

Comparative Behaviour of Bright Bar, EN-8, EN-21, EN24 and Mild Steel before Heat treatment



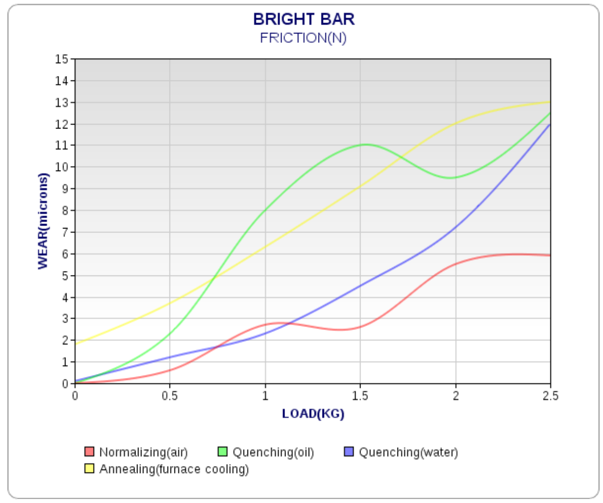
(a) Friction V/s Load



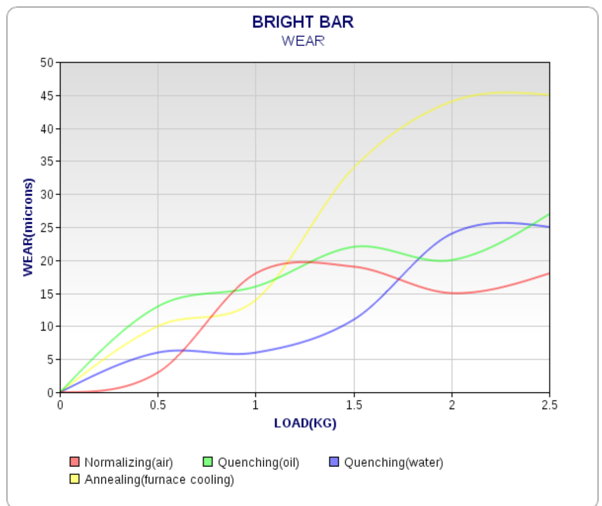
(b) Wear V/s Load

Figure 6. Comparative Behaviour of Bright Bar, EN-8, EN-21, EN24 and Mild Steel before Heat treatment

Comparative Behaviour of Bright Bar after Heat treatment



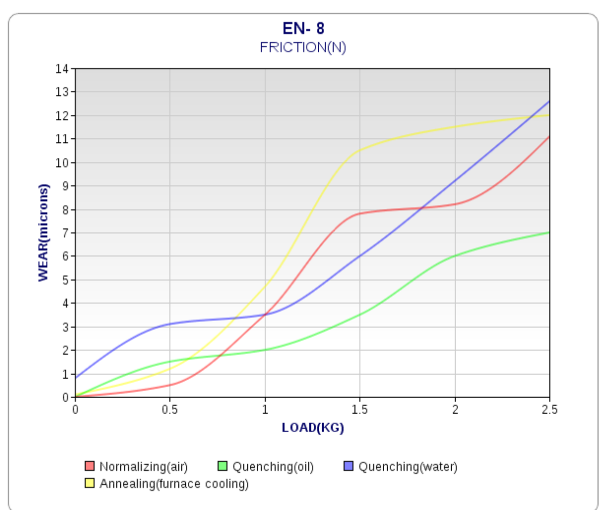
(a) Friction V/s Load



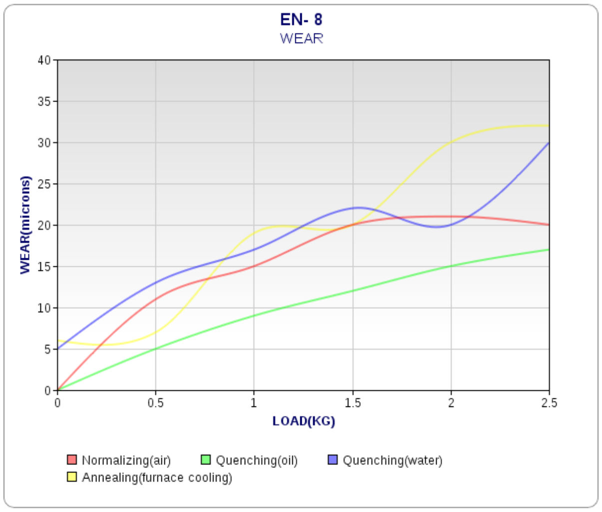
(b)Wear V/s Load

Figure 7. Comparative Behaviour of Bright Bar after Heat treatment

Comparative Behaviour of EN-8 after Heat treatment



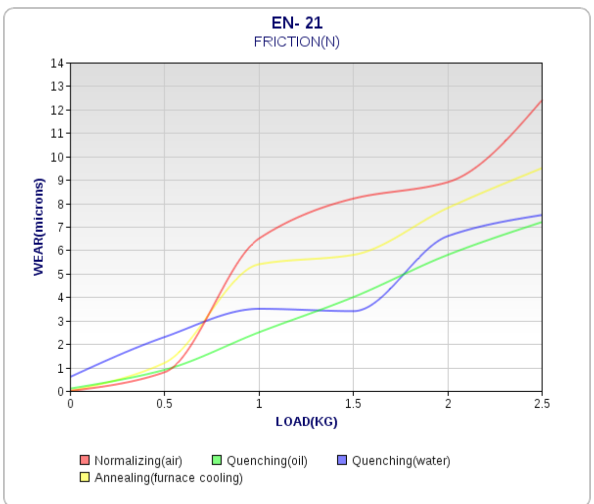
(a) Friction V/s Load



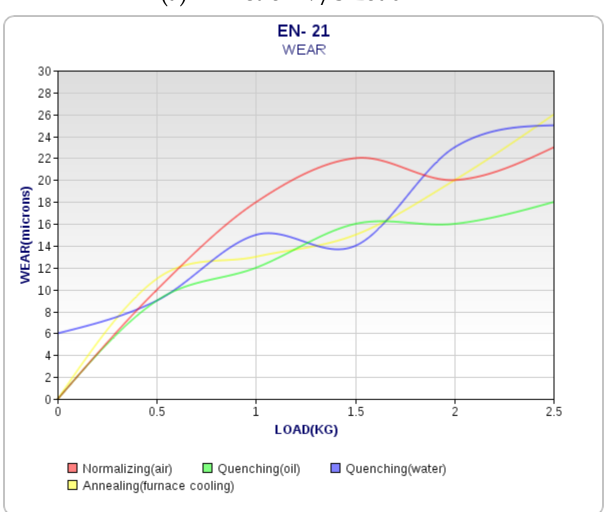
(b) Wear V/s Load

Figure 8. Comparative Behaviour of EN-8 after Heat treatment

Comparative Behaviour of EN-21 after Heat treatment



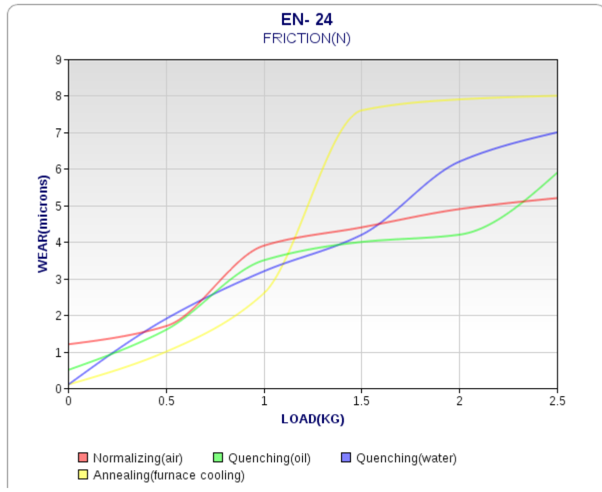
(a) Friction V/s Load



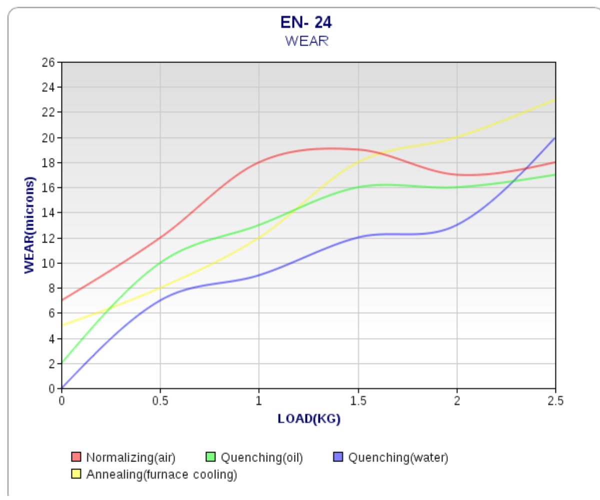
(b)Wear V/s Load

Figure 9. Comparative Behaviour of EN-21 after Heat treatment

Comparative Behaviour of EN-24 after Heat treatment



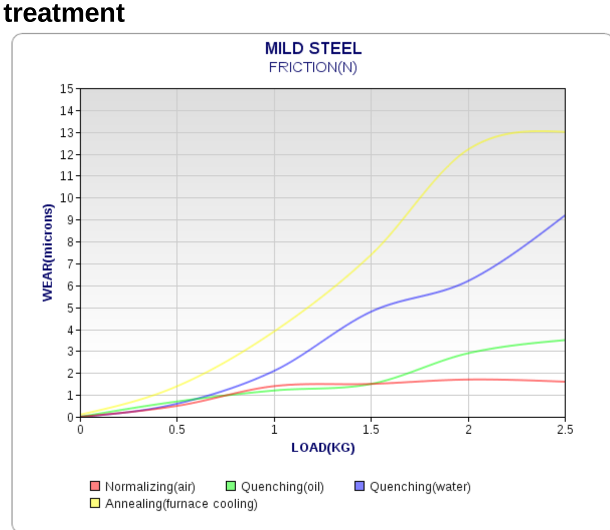
(a) Friction V/s Load



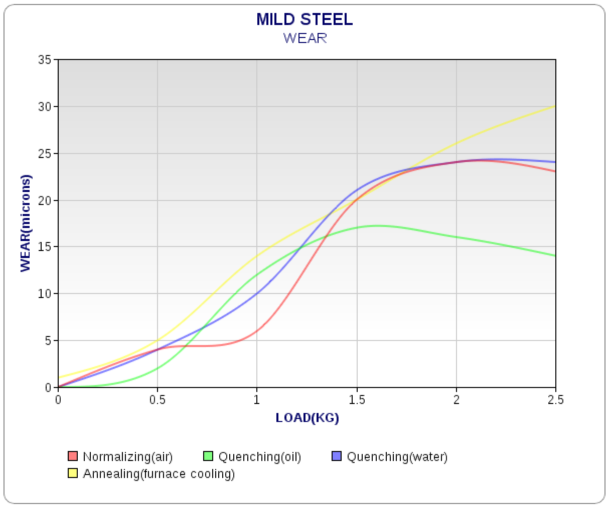
(b) Wear V/s Load

Figure 10. Comparative Behaviour of EN-24 after Heat treatment

Comparative Behaviour of Mild Steel after Heat treatment



(a) Friction V/s Load



(b) Wear V/s Load

Figure 11 . Comparative Behaviour of Mild Steel after Heat treatment

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Conclusions

Engineering materials like Bright Bar, EN-8, EN-21, EN-24 and Mild Steel have been widely used for many industrial applications. In order to subjecting the material into action, it is essential to look into their characterstics property which includes friction and wear. Hence it has become objective of the present work. Based on trials on the variation of load the properties like friction and wear vary, the following assumptions are made

1. As per the experimental work performed, Brass shows the higher wear rate with respect to Aluminium and Steel.
2. Experimental results shows EN-24 shows the maximum friction and maximum wear while Mild steel shows the minimum friction and wear among the available specimen.
3. Heat treatment reduces the friction as well as wear in a respective amount. It will increase the machinability and formability.
4. With the help of results obtained describing the nature of Brass, Aluminium, EN-8, EN-21, EN-24. Bright Bar and Mild Steel, we can predict the nature which is helpful to understand the behavior of material at different conditions.
5. The similar studies can be made for other types of materials etc.
6. The studies on friction and wear properties of sample can also be performed by varying its rotational speed and time.

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