International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 - 5161

Available at http://inpressco.com/category/ijcet

Research Article

Effect of Dry Sliding on Cast Iron Wear

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Accepted 10 July 2014, Available online 01 Aug2014, **Vol.4, No.4 (Aug 2014)**

Abstract

Effect of load ,sliding velocity ,material ,hardness of disks and roughness of the sample surface on coefficient of friction and wear rate were studied in this work .Pin on disk technique was used to satisfy the required aims ,and the testing samples were subjected to various conditions of velocities and loads. The results showed that, the coefficient of friction was inversely proportional to sliding velocity at constant loads and directly proportional to hardness and surface roughness of the disks. Wear rate was found to be directly proportional to hardness and surface roughness of the samples.

Keywords: *Spherical Cast Iron, Dry Sliding, Wear, Pin on disk.*

Introduction

Grey cast iron is an inexpensive and really available material and its specific characteristics such as low melting point, excellent castability along with no freezing contraction have given it decent capability for fabrication of complicated components by using the simplest and most economic methods (H. Mohamadzadeh *et al*,2009) . The properties of grey cast iron primarily depend on its composition which is influenced by both the normal elements present in plain irons such as carbon, silicon, phosphorus, sulfur and manganese, and the presence of alloying additions and other trace elements (I.Miller, J. Freund ,2001). In alloy cast iron, the graphite morphology can be divided into three types: flake-like, vermicular-like and spherical-like.

Other factors that influence the properties of cast iron include the chemical composition of the matrix, and the size, distribution, volume fraction and morphology of the individual microstructure constituents (T. Alp *et al*,2005). Graphite flakes are interacted together and disposed in the form of plates, constituting an easy path for fast heat dissipation, good ability for vibration damping and excellent machinability (J. Agunsoye*et al*,2012) .

These properties mainly make grey cast iron as a desirable option for fabrication of the parts which are in the exposure to the repeated local thermal stresses. Some examples of their applications in auto-motive industries are cylinder blocks, break disks and exhausts (W. Wang *et al*, 2007) . They are generally used in mechanical (pumps, valves etc:), chemical and food industries, and armament and oil industry (C. Kowandy*et al*,2007).

Wear is a persistent service condition in many engineering applications with important economic and technical consequences. In terms of economics, the cost of abrasion wear has been estimated as ranging from 1to 4% of the gross national product of an industrialized nation (R. Bayer,2002) . The effect of abrasion is particularly evident in the industrial areas of agriculture, mining, mineral processing, and earth moving. Likewise, wear is a critical concern in many types of machine components; in fact, it is often a major factor in defining or limiting the suitable lifetime of a component. An important example is the wear of dies and molds (K. Budinski ,1981).

Wear generally is manifested by a change in appearance and profile of a surface. Some examples illustrating these types of changes are shown in Fig. 1. Wear results from contact between a surface and a body or substance that is moving relative to it. Wear is progressive in that it increases with usage or increasing amounts of motion, and it ultimately results in the loss of material from a surface or the transfer of material between surfaces. Wear failures occur because of the sensitivity of a material or system to the surface changes caused by wear (P. Ik-Min, K. Shin,1995).

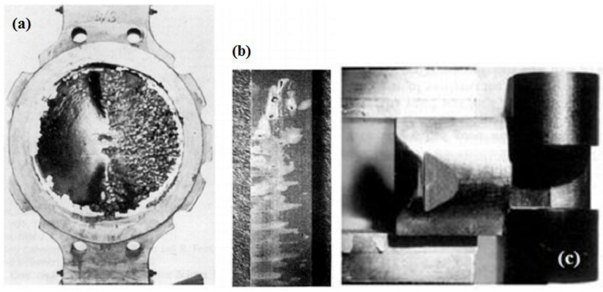

Fig.1: Examples of wear, (a) Erosion damage on a butterfly valve component. (b) Fretting damage on a friction band. (c) Sliding wear on a cam follower

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Materials and Method

Material: Spherical cast iron with two different chemical composition has been used in this study as shown in Table.1 . Samples was manufactured as a cylinder with (6mm) diameter and (15mm) high .

Wear Test: The wear test conducted according to ASTM G99-04 Standard . The wear test was carried out on a 200 mm diameter surface 150 µm mesh emery paper mounted on pin-on-disk apparatus to investigate the dry sliding wear characteristic of grey cast Iron. Pin-on-disk testing consists of a rotating disk in contact with a fixed pin with a spherical top (see Fig.2).Various wear parameters such as velocity, time and load were varied during the experiment. Each sample was placed at 90mm diameter from the centre of emery paper during the test. The initial weight of the samples was measured before and after each test .

Table.1: Chemical composition of cast iron

Element	Sample.1	Sample.2
C	3.39	3.49
Si	2.97	3.07
Mn	0.157	0.159
S	0.006	0.006
P	0.0399	0.52
Cr	0.094	0.25
Ni	0.074	0.028
Mg	0.0407	0.0327
Ce	4.38	4.51
Ferrite %	85-98	95-98
Pearlite %	2-15	2-5

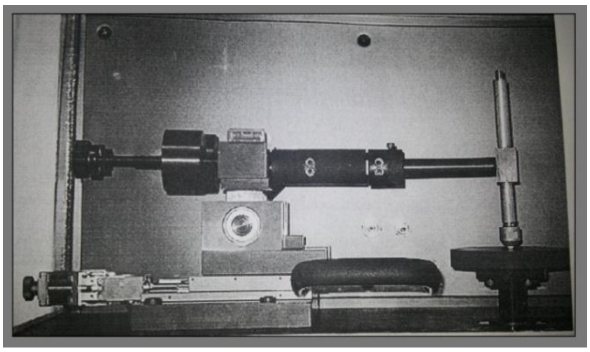

Fig.2: Pin-on-disk apparatus

Wear rate was measured by the equation

$$\frac{dV}{dl} = \frac{W}{\pi.\rho.D.N.t}$$

Where:
dV/dl= volume of wear rate as a function to sliding distance ($cm^3.cm^{-1}$).
V= volume(cm^3).
W= lost weight (g).
ρ= density (g/cm^3).
D= diameter of rotating circle for sample on disk (cm).
N= sliding velocity (rpm).
t= sliding time (min).

Measuring of friction force: Exact values of strain extracted from the chart recorder and special digital HPA were used to calculated friction force, where a variable loads were applied with fixed period of time (30 min)for each experiment. And from obtained results of the calibration curve shown in Fig.3 was drawn, which offers the possibility of calculating friction force.

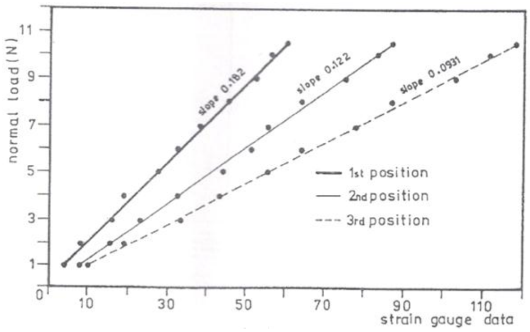

Fig.3: Calibration curve

Results and discussion

Fig.4 shows that the coefficient of friction when large loads be less than the coefficient of friction in the case of the use of low loads, because the large loads increase the real contact area due to the plastic deformation of projections heads over time, thus increasing the density of contact Graphite particles. And the existence of sliding movement between the disk surface and pin, the graphite layer separates these sliding surfaces and works as a lubricator which lead to reduced coefficient of friction (J.Sugishita ,Fujiyoshi ,1981).Also from this figure we see that ,the increasing of sliding velocity cause increase in flash temperature for each of the pin and the disk (M. Kawamoto ,K. Okabayashi ,1980), and lead this rise in temperature to transfer the projections on the surfaces of sliding to the case of the softer , thus a few shear force required to separate the overlap between the projections leading to reduce the coefficient of friction.

From Fig.5 we see that, the wear rate increases with increasing applied load for various sliding velocity used during the test, and the reason for this is due to the plastic deformation in projections tops by increasing applied load and thus increasing the real area of contact between the sliding surfaces. projections Adhesive Process of sliding surfaces depending heavily on the applied load.

In the case of low load, the connection between projections of sliding surfaces is weak because these surfaces are covered with a thin layer of oxide which prevent direct contact between surfaces projections. But when the we increases the used load ,the layer of oxide will breaks up due to its brittleness and occurs strong metallic connection which makes the force required to cut the connected projections higher than in the metal atoms and thus to an increase in the wear rate, as well as break the oxide layer in the case of higher applied load and thrown out of the sample surface leads to an increase in the wear rate.

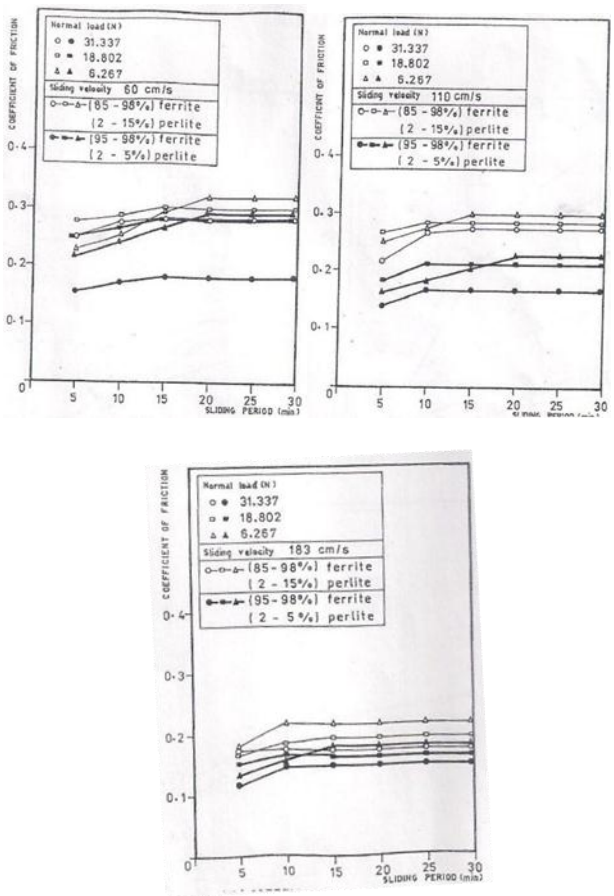

Fig.4: Coefficient of friction vs. sliding period

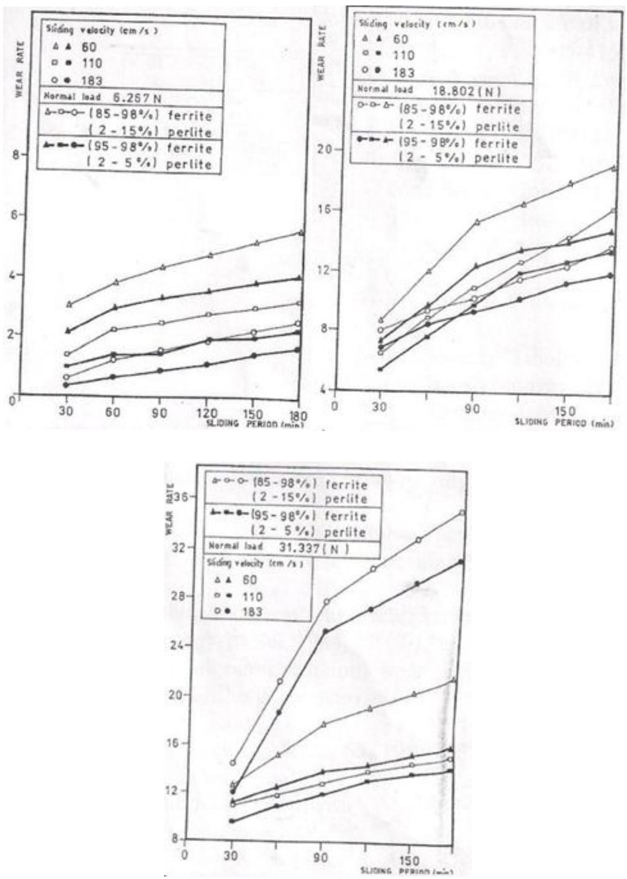

Fig.5: Wear Rate vs. sliding period

The Fig.5(a,b) show that the wear rate was decreased with increase the sliding velocity ,when the velocity (60cm/sec) or (110cm/sec) .The reason for this is due to the difference in the time period of exposure projections to the stresses resulting from applied load where the ductility of projections will decrease in low at velocity as a result of leakage of heat from the surface of the sample than in the case of high velocity (M. Kawamoto ,K. Okabayashi ,1980). But in Fig.5(c) and at sliding velocity of (183cm/sec) and load (31.337N), the temperature of the sliding surfaces rising dramatically lead to a change in hardness and flexibility of projections in addition to higher load used leads to break the surface oxide layer and the occurs a strong contact and large plastic flow between projections of sliding surfaces, leading to the result of the debris of the oxide layer of the disk and the wear debris from the surface of the sample and thus in general increasing the total wear rate during the test.

The coefficient of friction increases with higher hardness of the disk as shown in Fig.6 and, on the contrary, the wear rate decreased with increasing dick hardness as shown in Fig.7. The high hardness of disk leads to increase the amount of shear on projections of sample surface, which leads to obtain a flat surface causes increased coefficient of friction due to the increase in real area of contact and, by contrast, the flattening process lead to reduced wear rate because of the decrease in projections amount and finally decreased amount of shear for these projections.

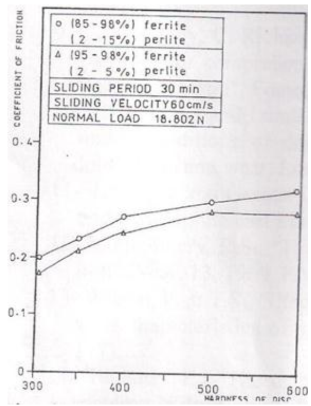

Fig.6: Coefficient of friction vs. Hardness of Disk

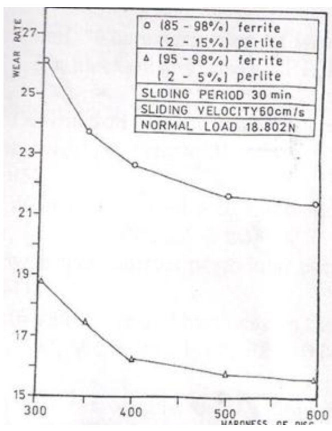

Fig.7: Wear Rate vs. Hardness of Disk

Conclusions

1. Coefficient of friction will Decrease as increasing sliding velocity with fixed applied load .
2. Coefficient of friction in fixed sliding velocity and high loads will be small than in low loads.
3. Increasing dick hardness will increase coefficient of friction.
4. Increasing load will increase wear rate.
5. Wear rate and sample hardness proportions reversely.

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