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Effect of Varying Load on Wear Characteristic of Ti-6Al-4V Alloy

Arpit R Patil
College of Engineering Pune.
Shivajinagar Pune, India.
arpitrpatil@gmail.com

Ketki R Patil
Mauli college of Engineering and Technology
Shegaon, India
ketkirpatil@gmail.com

S T Vagge
College of Engineering Pune.
Shivajinagar Pune, India.
stv.meta@coep.ac.in

Abstract: Ti-6Al-4V alloy is a grade 5 titanium alloy having vast application in both defence as well as in medical (bio-implant) field. When any bioimplant material is planted into patient's body it undergoes wear. This wear varies according to the amount of load applied on the material. Thus in this paper we tried to study the variation of wear with change in load such as 3Kg, 5 Kg, 7 Kg, 10 Kg. For this purpose we used pin-on-disk machine. The results obtained during the study are correlated to get the results.

Keywords:- *Ti-6Al-4V alloy, Wear, biomaterial, Optical microscopy.*

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I. INTRODUCTION

Every material is unique in its properties, thus having their application in different fields. Titanium and titanium alloys have a wide range of applications in aerospace, energetic, chemical and automobile industry. Some titanium alloys are excellent materials for biomedical use, especially for orthopedic alloys[1,2]. The most important characteristic features of these biomedical titanium alloys are high strength, low density, excellent corrosion resistance and the best biocompatibility among the metallic biomaterials. The Ti6Al4V alloy, originally having been developed as a construction alloy for aircraft industry, belongs to the most significant alloys within the implant alloys for hard tissue replacement.

As the wear is the most important factor in implant study, we tried to obtain the result on effect of variation of load on wear behaviour of the Ti-6Al-4V alloy.

II. Methods and Material :-

2.1 Composition of Ti-6Al-4V and Electrolyte:-

Fig.1 shows the equiaxed microstructure of as received Ti-6Al-4V alloy consisting of α plates (white colour) within β (black colour) matrix[3]. The etchant used for obtaining microstructure is Kroll's Reagent[3, 4] with 3ml HF and 6ml HNO_3 in 100ml distilled water.

Table 1 shows composition of Ti-6Al-4V alloy used for the present study. The metal under study was purchased from Bharat aerospace materials Ltd. Disk used for carrying out wear test is of En31 steel which is hardened to 60HRc and ground to 1.6Ra with diameter 165mm and thickness 8mm.

2.2 Sample preparation and parameters for Wear study

Ti-6Al-4V samples of height 35mm were prepared from cylindrical rod of 8mm diameter by referring standard ASTM G-99[5]. The surface in contact with the disk is made flat. For each experiment 3 samples were tested. The disk is made clean and smooth by polishing it with 800, 1200grit size paper. The Ti-6Al-4V pin with 8mm diameter remains stationary for entire span of experiment while disk keeps rotating till the completion of experiment. The pin is applied with 3 Kg load and it is set in such a way that, it will make a track diameter of 100mm on the disk. While the disk is given with speed of 300RPM to rotate for completing wear path of 3Km.

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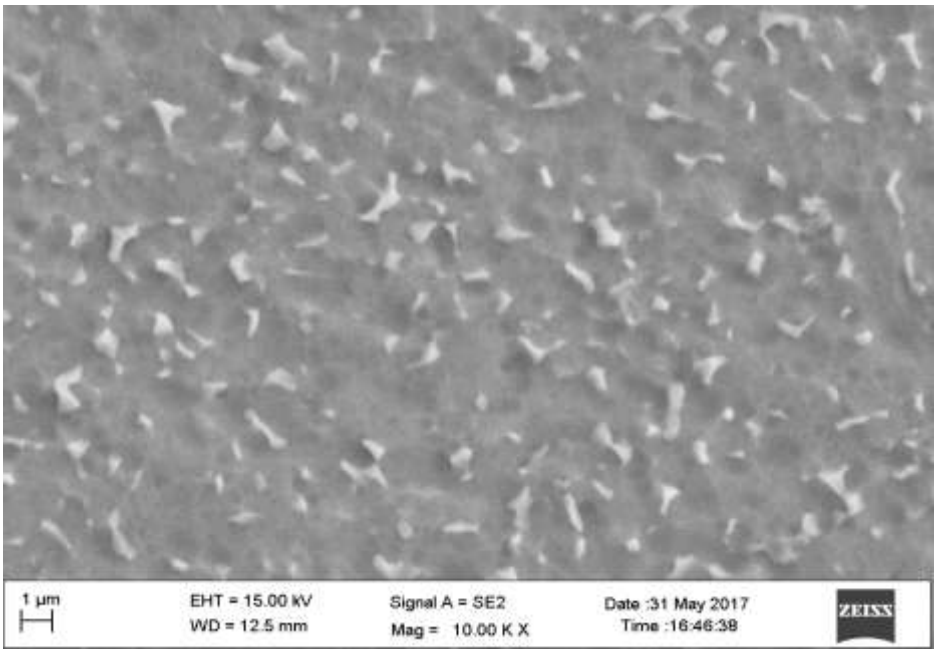


Fig1.As received Ti-6Al-4V sample.

Table1. Composition of Ti-6Al-4V alloy under study

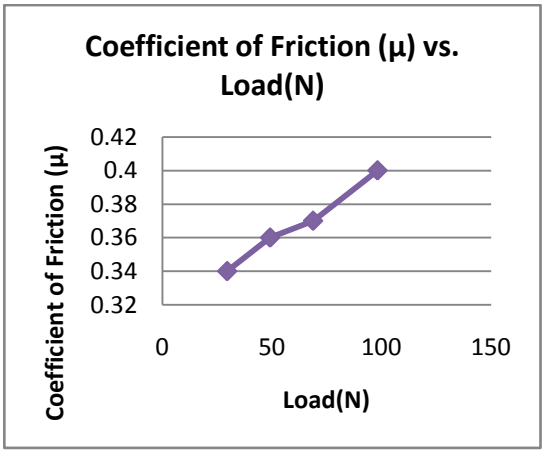
Element	Al	V	C	Fe	Ti
Weight %	5.92	3.62	0.041	0.27	Balanced

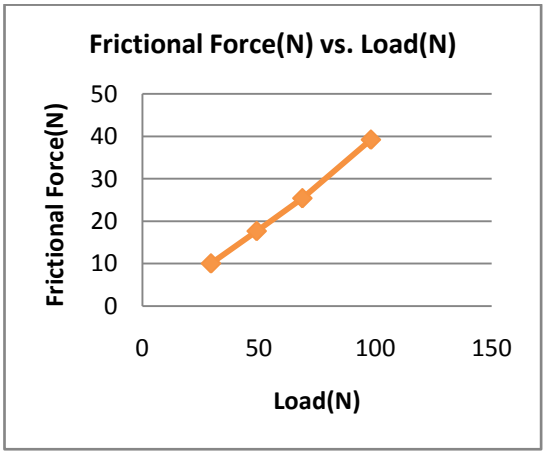
(Manufactured by Bharat Aerospace Metals Pvt. Ltd)

III. Results and Discussion

Table2. Wear test results.

Load(Kg)	Load(N)	Coefficient of friction	Frictional Force(N)	Wear(cc)
3	29.43	0.34	10.0062	0.0187
5	49.05	0.36	17.658	0.0342
7	68.67	0.37	25.4079	0.051
10	98.1	0.4	39.24	0.0663





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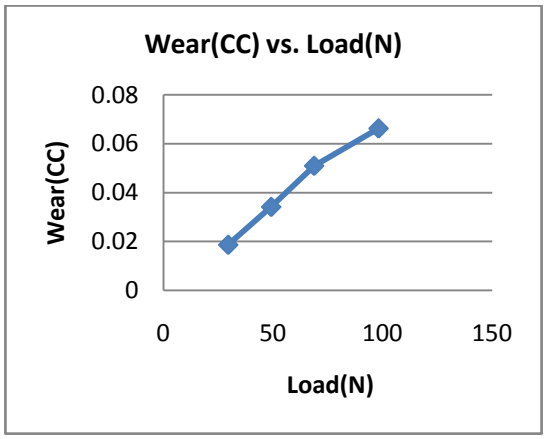

Fig. 2(a, b, c) Variation of Coefficient of friction, Frictional force and Wear with Load.

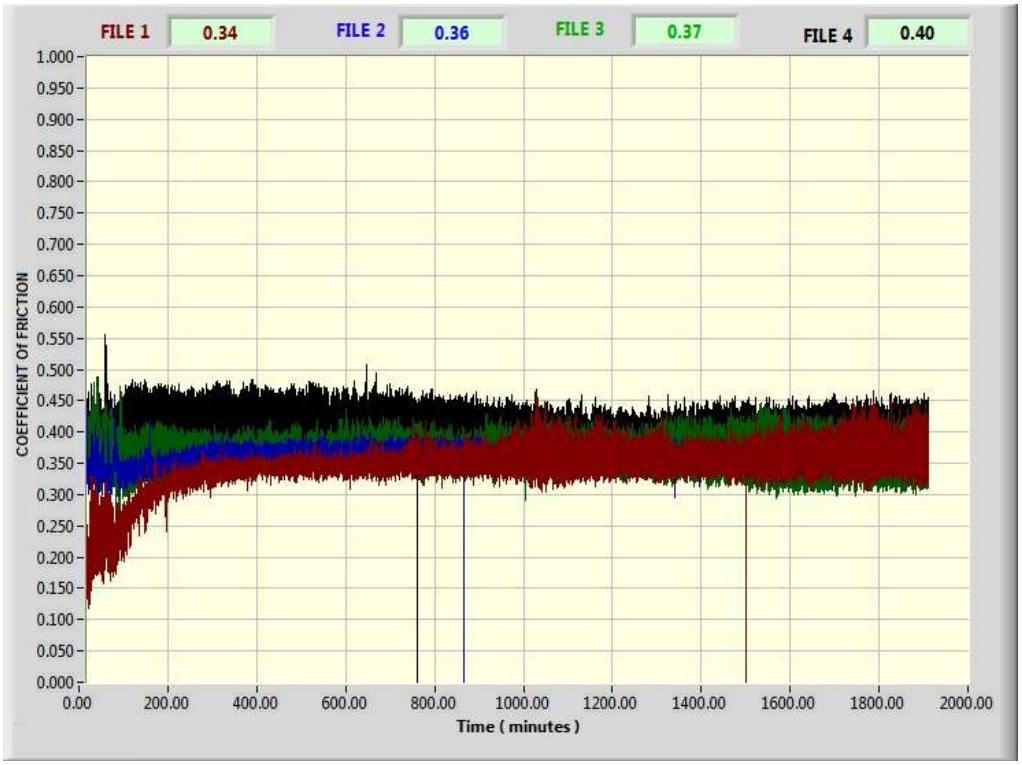

Fig 3:- Coefficient of Friction vs. Time

Here, File 1(Red) = Graph for 3Kg load
File 2(Blue) = Graph for 5Kg load
File 3(Green) = Graph for 7Kg load
File 4(Black) = Graph for 10Kg load

Fig 3 shows the graph of coefficient of friction Vs. Time and Table 2 and fig 2 shows the results of wear test obtained on pin on disk experimental setup. The graph and results in table 2 clearly shows the increase in coefficient of friction with increase in load. Although initially the 3 Kg line had shown narrow appearance, it get widen afterward. This is because of increased striations which further increased the coefficient of friction [6, 7, 8]. Due to striations and wear debris, the fluctuation shown by the sensor were high [9, 10]. The Fluctuations in the coefficient of friction was decreased as the load was increased, this is due to the increased load because of which, wear striations were deforming [11, 12] and thus the surface in-homogeneity due to striation marks was also getting removed. But when there was low load such as 3Kg, the load was not enough to deform the wear flanks (chips).

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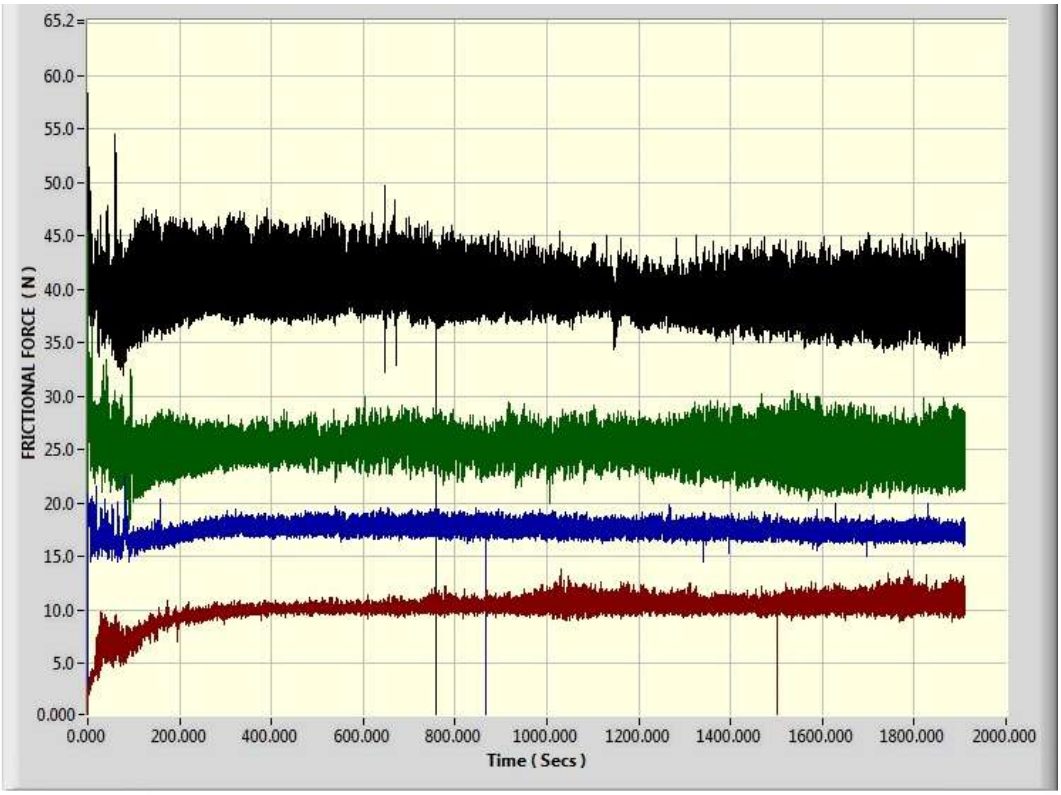

Fig 4:- Frictional force Vs. Time

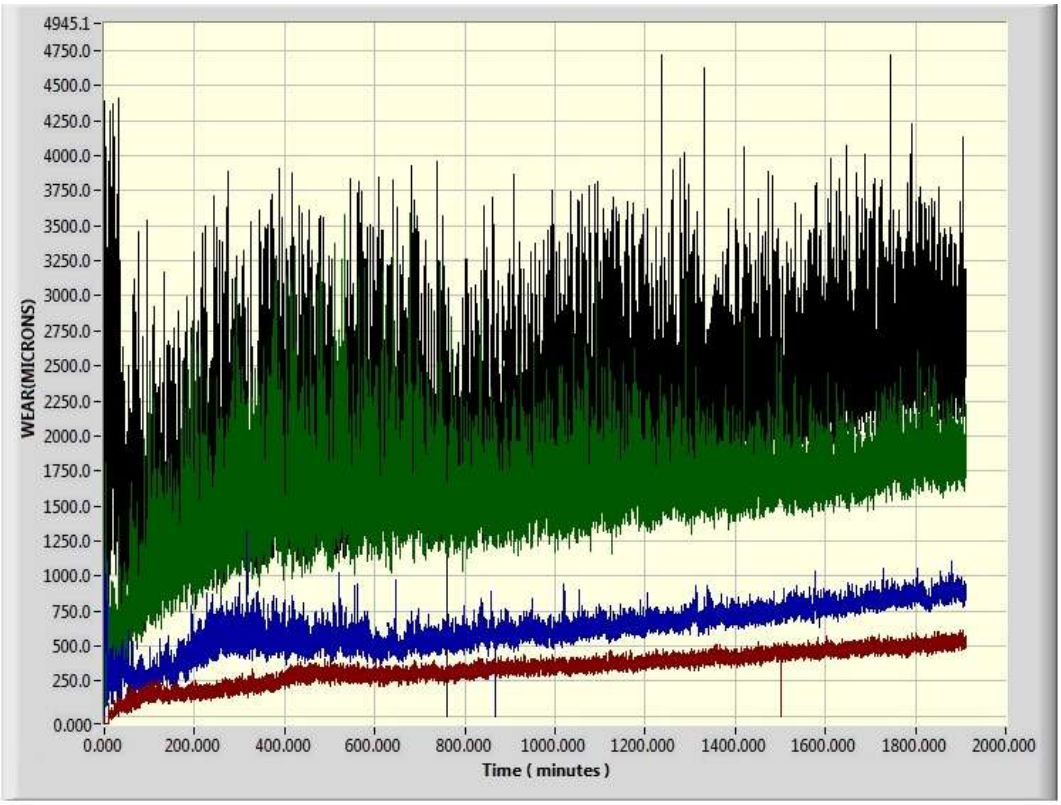

Fig 5:-Wear Vs. Time

Fig 4 shows the plot of frictional force vs. Time. The frictional force increased as the load is increased (Table.1). This is because of increased load as well as due the wear chips which are accumulating inside the wear debris and striations present on the pin surface and on the disk [13, 14]. Thus, as the load is increased, the wear is also increasing and thus thickness of the graph is also increasing with increased frictional force.

Fig 5 shows wear vs. Time. As the plot is the combination of instantaneous wear at each time, thus when the wear is very

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high the wear sensor has shown higher fluctuations which indicates large removal of material for heavy load [14].

The highest wear loss was obtained for 10Kg load which is 0.0663 cm^3.

IV. Conclusion:-

(1)The highest value of Coefficient of friction (0.4) is obtained for 7Kg load.

Coefficient of friction between disk and the Ti-6Al-4V pin decreased as the load is decreased.

(2)The gradual increase in frictional force has been observed as the load is increased. The highest value of frictional force is 39.24N for 10Kg load.

(3)Wear loss is also increased with increase in amount of load. Highest wear loss (0.0663cm^3) is obtained for 10 Kg load.

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