ANALSYS OF WEAR BEHAVIOUR & FRICTION COEFFICIENT OF CP TITANIUM

Ajay varma kovvuru[1], Salavath Gopal[2], Shike Irfan[3], M. Suneetha[4]

[1,2,3]*Final year B.Tech, Mechanical Engineering, St.Martin's Engineering College, Secunderabad, Telangana, India*
[4]*Associate professor, Mechanical Engineering, St.Martin's Engineering College, Secunderabad, Telangana, India*

---***---

Abstract - The aim of this study is to evaluate the friction coefficient and wear behaviour of commercially pure titanium by using pin-on-disc tribometer. These tests are carried out in accordance with ASTM (American society for testing and materials) and G-99 standards under the load conditions of 200 kgf and sliding speed of 100 rpm. As counter pairs, a tungsten ball with 25 mm diameter and EN (European norms) steel disc was used. Results shows that two samples had different coefficient of friction and wear behaviour, Although they are similar metals.

***Key Words*: Pin-on-disc tribometer, ASTM & G-99 standards, commercially pure, European norms, friction coefficient.**

INTRODUCTION:

CP Titanium or commercially pure titanium is represented by four distinct grades, specifically 1,2,3 and 4. It is pure and unalloyed. It has better corrosion resistance, formability (ductility) and strength, which requires for any specific application. It ranges from grade 1, which has the very best corrosion resistance, formability and lowest strength, to grade 4, which has the highest strength and moderate formability. End users make use of these qualities such as, excellent corrosion resistance, formability and weldable characteristics for many applications.

Grade 1 titanium is the first of 4 commercially pure titanium grades. It is softest and most ductile of these grades. It possesses the best formability, excellent corrosion resistance and high impact toughness. Because of all these qualities, Grade 1 CP titanium is choice for many of the application where ease of formability is required and is commonly available as titanium plate and tubing. It found applications in various fields include chemical processing, chlorate manufacturing, dimensional stable anodes, desalination, Architecture, medical, marine, Automotive, Aerospace industries.

Grade 2 titanium is named as the "workhorse" of the commercially pure titanium industry, because of its usability and wide availability. It shares many of an equivalent qualities as of Grade 1 titanium, but it is slightly stronger. Both are equally corrosion resistant. It has good strength, ductility and formability. It has applications in various fields include Architecture, power generation, medical, hydro-carbon processing, marine, Airframe skin, desalination, chlorate manufacturing.

Grade 3 is least used of all commercially pure titanium grades, but that does not make it any less valuable. It is stronger than Grades 1 and 2, similar in ductility and only slightly less formable. Grade 3 is employed in all the applications where moderate strength and major corrosion resistance are required. It has applications in various fields include Aerospace, chemical, medical, marine industries.

Grade 4 is the strongest of the four grades of commercially pure titanium. It is well known for its excellent corrosion resistance, good formability and weldability. Even though it is normally used in subsequent industrial applications, but Grade 4 has recently found a niche as a medical grade titanium. It is employed in applications where high strength is required. It has applications in various fields include Airframe components, cryogenic vessels, Heat exchangers, CPI equipment, condenser tubing, surgical hardware, pickling baskets.

Fig.1. CP Titanium specimens

Properties of CP Titanium grade wise

Material	Modulus of elasticity (Gpa)	Ultimate tensile strength (Mpa)	Yield strength (Mpa)
CP Titanium Grade 1	102	240	170
CP Titanium Grade 2	102	345	275
CP Titanium Grade 3	102	450	380
CP Titanium grade 4	104	550	483

Coefficient of Friction plays an crucial role in productiveness and efficiency of many materials (eg: Titanium, Aluminium and steel etc.) with respect to the changes in material and thermal losses. Coefficient of friction affects the reliability of materials, formability, fatigue, hardness, wear resistance and other properties of material. To determine the behaviour of friction and wear rate many factors taken into consideration like load geometry, surface roughness, temperature, slip, humidity, lubrication, speed etc. There are few heat transfer enhancement methods includes imparting turbulence by roughening the surface and introducing the inserts for increasing heat transfer coefficient. The Coefficient of friction becomes important in each and every devices. The study analysis on reducing friction by using appropriate lubricant is also important aspect. The current review is aimed at emphasizing the importance of Coefficient of friction in CP titanium at different conditions in various fields and summarizing the project is carried out to analyse the coefficient of friction, wear resistance and factors affecting the friction in various applications and improve friction charecteristics according to the requirement.

2. METHODOLOGY

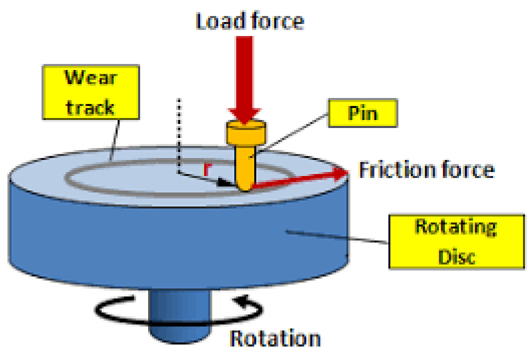

Fig. 2.Schematic representation of pin-on-disc tribometer

In order to determine the wear behaviour and coefficient of friction of commercially pure titanium, we have adopted a methodology called Pin-On- Disc Tribometer. The apparatus involved in this methodology are:

1. Loads according to the condition

2. Rotating disc of choosen material according to the condition

3. Pin of choosen diameter

4. lubricant according to the condition

In the pin-on-disc wear test method, we require two specimens. One, a pin with radiused tip, is positioned perpendicular to the disc, usually a flat Circular one. A ball with certain diameter used as the pin specimen. In this method either the disk specimen or the pin specimen is revolve about the disk center. In both the cases, the sliding path is a circle on the disk surface. The plane of the disc either horizontally or vertically. The pin specimen is in contact against the disk at a specified load usually by means of an arm or lever with attached weights. Other loading methods have been used, such as hydraulic or pneumatic. Wear results should be in terms of volume loss(in cubic millimeters) for the pin and therefore the disk separately. When two different materials are tested, it's recommended that every material are tested in both pin and disk positions. . If the linear measures of wear are used, the length change or shape change the disc wear track (in millimeters) are obtained by any suitable metrological methods, such as electronic distance gaging or stylus profiling. Linear measures of wear and tear are converted to wear volume (in cubic millimeters) by using appropriate geometric relations. If the loss of mass is measured, the mass loss value is converted to volume loss (in cubic millimeters) using an appropriate value for the specimen density. The amount of wear in any of the system is depends on the number of factors such as applied load, machine characteristics, sliding speed, sliding distance, environment, and the material properties.

2.1. APPARATUS

Motor Drive—A variable speed motor drive, should have capacity of maintaining constant speed (± 1% rated full load motor speed) under load is required.

The motor should be mounted in such a way that its vibration do not affect the test. Rotating speeds are vary in between 0.3 to 3 rad/s (60 to 600 r/min).

Revolution Counter— The machine should be equipped with a revolution counter that will record the number of disk revolutions, and it has the ability to terminate the machine after a pre-selected number of revolutions.

Pin Specimen Holder and Lever Arm— In this method the specimen holder is attached to the lever arm that has a pivot. Adding weights is one option of loading, produces a test force proportional to the mass of the weights applied. The pivot of the arm should be located within the plane of the wearing contact to avoid extra loading forces due to the sliding friction. The pin holder and arm must be of considerable construction to reduce vibrational motion during wear test.

Wear Measuring Systems— Instruments used to obtain linear measures of wear should have a sensitivity around 2.5 μm or better. Any balance used to measure the mass losss of the test specimen should have a sensitivity should be around 0.1 mg or better in low wear situations greater sensitivity may be needed.

3. EXPERIMENT:

3.1. SAMPLE PARICULARS:

Sample details	CP Titanium
Sample description	With grease, without grease
Quantity	02 no's
Test required	Wear index & friction coefficient

3.2. TEST CONDITIONS:

Load	200 kgf
Disc material	EN Steel
Speed of disc	100 rpm
Tungsten ball (PIN)	2.5 mm diameter
Lubricant used	grease

3.3. PROCEDURE:

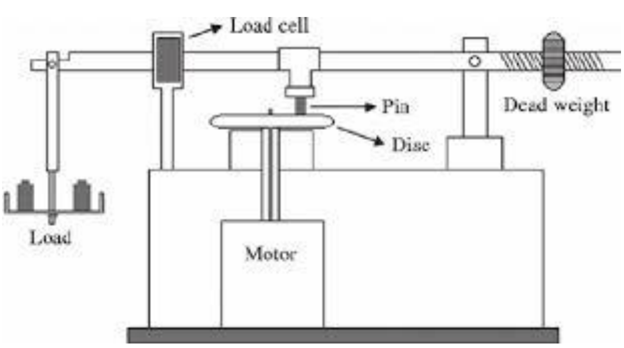

Fig.3. Line diagram of pin-on-disc tribometer

Before starting the procedure make sure to remove all the dust and foreign particles from the specimens. Use non-chlorinated, non-film forming, cleaning, agents and solvents. Specimens which are having residual magnetism should be demagnetized. Measure appropriate dimensions of two specimens and weight the both specimens before performing the test and note down the values. Insert the ENsteel disc properly in the holding device such that the disc is fixed perpendicular to axis of resolution

Insert the pin specimen (Tungsten ball) of 2.5 mm diameter properly in its holder and, if necessary, adjust so that the specimen is perpendicular to disc surface, in order to maintain the necessary contact conditions. Apply grease to the one of the two samples in order to determine the volume loss and friction coefficient of two samples. Add the mass of 200 kgf to the system lever to develop the selected force which presses the pin against the disc.

Fig.4. Adding weights to the system

Start the motor and adjust the speed to desired value while holding the pin specimen out of contact with the disc. Set the revolutions counter (or equivalent) to the desired number of revolutions i.e., (100 rpm). Begin the test with the specimens by applying given load. The test is stopped when the desired number of revolutions is completed. The test should not be interrupted or restarted. Remove the specimens and clean off any loose wear particles on it. Note the existence of features on or near the wear scar such: such as protrusions, displaced metal, dislocation, microcracking or spotting. Remeasure the two specimens dimensions after the test and compare it with the data of the specimen before the test. Repeat the test with additional specimens to obtain better results.

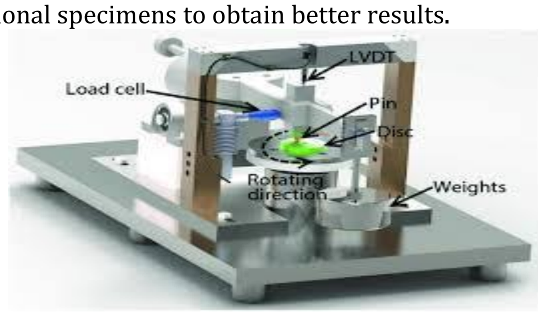

Fig.5. complete view of pin-on-disc tribometer

4. RESULTS:

After completion of the test, we found that there is a considerable volume loss of 0.193 mm^3 in one of the CP titanium samples to which grease is not applied and on the other hand, volume loss in negligible for the sample to which grease is applied. Co-efficient of friction for greased sample is 0.17 and 0.42 for ungreased sample.

5. CONCLUSION:

The commercially pure titanium was observed to exhibit excellent tribological properties while performing pin-on-disc test. Fluctuations in the value of coefficient of friction is because of lubricant used. It is found that coefficient of friction is 0.17 for lubricated specimen and 0.42 for un lubricated specimen at 200 kgf load. We come to know that, even though CP Titanium has low wear resistance, we can improve it by proper lubrication, Such that it can be employed in all the applications where wear resistance is crucial.

REFERENCES:

1. EHKT Technologies (2002), “Opportunities for Low Cost Titanium in Reduced Fuel Consumption, Improved Emissions, and Enhanced Durability Heavy-Duty Vehicles”.

2. Heinicke G (1984), Tribochemistry, Carl Hanser Verlag Munchen Wien, Berlin.

3. Gordo,“Mechanical properties and microstructural evolution of vacuum hot-pressed titanium and Ti-6Al-7Nb alloy,” Journal of the Mechanical Behavior of L. Bolzoni, E. M. Ruiz-Navas, E. Neubauer, and E. Biomedical Materials, vol. 9, pp. 91–99, 2012.View at: Publisher Site | Google Scholar

4. T. Kawazoe and K. Suese, “Clinical application of titanium crowns,” Journal of Medical and Dental Sciences, vol. 30, no. 3, pp. 317–328, 1989.View at: Google Scholar

5. A. Kuroiwa and Y. Igarashi, “Application of pure titanium to metal framework,” The Journal of the Japan Prosthodontic Society, vol. 42, pp. 547–558, 1998.View at: Google Scholar.