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FRICTIONAL ANALYSIS OF ION CHROME COATING ON PISTON RING AND CYLINDER LINER PAIR

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***Abstract*— This paper deals with the wear resistance behavior of ion plasma hard chromium coating, which is used for piston ring. The functions of a rings used between cylinder liner and piston are to seal off the combustion pressure, to distribute and scrap the oil back to sump simultaneously to transfer heat and stabilizing the piston in its position. Most piston rings and metallic sealing rings for modern uses where running conditions are severe, require some form of coating to reduce abrasion and corrosion. The ring coating improves the life of engine in addition to fuel efficiency. In this work, Physical Vapour Deposition (PVD) with ion chrome plating was studied; plates with composition as the ring material were made by the casting process using induction arc furnace. Wear test was conducted on Pin on Disc Equipment in laboratory mainly in dry conditions. The damage due to friction was calculated using mass loss methods on an electronic balance.**

***Keywords*— PVD, PISTON RINGS AND LINER PIN ON DISC TRIBOMETER, SEM, etc.**

I. INTRODUCTION

The As the piston and its rings move in the cylinder, so cylinder liner has an important tribological phenomenon as a surface sliding against the piston of cylinder and piston rings of engine. The cylinders are made of cast iron which may contain phosphorus, manganese, chromium, molybdenum, vanadium and titanium as its alloys, or sometimes steel or aluminium. Cast iron is commonly used material in the cylinder liners of heavier engines.

Nodular cast-iron cylinders with ceramic-metal composite have been used in some low-speed two-stroke engines. The liner surface is coated with a hard chromium layer to enhance the wear resistance of the cylinder liners of piston.

The ring area, consisting the top land with the first piston ring, is thermally exposed directly to the gases of chamber and hence subjected to changing temperature variations in the rings.

The changing peak temperatures of the gas in the chamber during the combustion inside cylinder of an engine can rise to near 2600°C. The mechanical loads are combined with thermal stresses. The temperature rise of the land of piston is generally more than the piston rings rise so the frictional contact between the piston rings and cylinder liner has important role due to friction losses within the combustion engine related to the piston ring assembly The sliding contact present between a piston ring and a cylinder liner has various friction process during one working cycle. Due to the fluctuations in load, speed and surface effects, the lubrications in a ring/liner contact are transient, which is shown by variations in the friction, and wear phenomenon.

1.1 Analysis of coatings for piston rings

Coatings and various surface treatments provide several possibilities to enhance the sliding properties of metal surfaces in contact. In engines, coatings and surface enrichments are commonly applied on one or many components of the piston, piston ring and cylinder liner system of engine parts. Surface coating and treatment techniques are being continuously developed and several kinds of coatings are introduced presently, and even many methods are being developed and experimentally analyzed. Different types of coatings are presently being used for the deposition of wear-resistant layers over the piston rings, named thermal spraying coating and galvanic coating.

II. EXPERIMENTAL DETAILS

2.1 PVD coating

When a component is electroplated by this technique, it is inserted into a tank containing solution of the material which is to be deposited, whereas PVD coating is a vacuum deposition process that has got an increasing application in recent years and is not limited to be seen as a laboratory process.

It has been scaled up to handle large complex part geometries at a reasonable cost. Such coatings are generally deposited in normal temperature to as high as 500°C depending on the substrate material and also on the type of application.

The modern PVD processes provide greater uniform deposit of coatings, improved adhesion property many times greater, different choice of materials to be deposited and also there are no harmful chemicals which adversely affect it, because PVD coating is more environmentally friendly in nature and chemical disposal are also minimal.

2.2 Pin on disk Tribometer

A tribometer is a mechanical system which determines tribological properties like coefficient of friction with force of friction, and also the wear volume between two surfaces in contact while both are in motion.

A tribo-tester is the common name given to a machine which is used to perform tests and simulations of wear phenomenon, friction and lubrication phenomenon which are the area of the study under tribology. Generally, tribometers are highly specific in their function and are made by manufacturers who wish to test and analyze the long-term performance of their products under run.

In the pin on disc test setup, a pin which is subjected to given load is pressed onto a rotating disc and wear is determined by motion of the disc. Pin in contact with the disc, is given with a radius into it. This results in point contact between pin and disk at the start of the test which concludes into an increasing area during the test under some load. The pin may also be replaced by a ball, setup been called as ball-on-disk. The loading conditions in the pin-on-disc test is designed by the selected parameters like the normal load, velocity of sliding, initial temperature of the test site and the sliding distance between the wear components

In the pin-on-disc test setup, the wear volume can be evaluated by the changed geometry of the specimen under test, i.e.- by decreasing length of the pin and analysis of the wear track volume of the disc or by the mass loss of the specimen under test. Its purpose is also to record friction and wear in sliding contact of running materials under dry, sometimes lubricated, in controlled environment and preferably in partial vacuum condition.

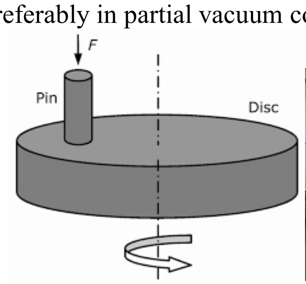


Fig-1

Fig -2

2.3 Specifications

Pin diameter :6mm

Applied load :5,6,7kg

The dimension of the plate sample used is 70x80 mm with the thickness of the coating about 250 µm.

Pin length :50mm

Disc thickness :10mm

S.No.	Diameter (mm)	Load(N)	R.P.M
1	50	50	322
2	40	60	408
3	30	60	408

Table 1 Track diameter and load at different rpm

S.N.	Radius(m)	R.P.M	Time(min.)
1.	0.025	322	49.42
2.	0.020	408	48.76
3.	0.015	550	48.22

Table 2 Time for run at different rpm.

III. RESULTS AND DISCUSSION

While rubbing between pin and disc, friction heat generated which results to the loss of both materials taken into consideration i.e. wear loss.

In this analysis, It was found that the wear loss of disc material is slightly decreased on increasing the load while keeping the sliding distance same.

Further, On increasing the load, the wear loss of pin material was observed to be increased for the same sliding distance into running conditions.

During the test, some of chips were formed, got deposited on the pin in the shape of a thin tribo-layer, these chips on the pin were cleaned to maintain a direct contact between the pin and the coating surface always. The variables for the test required are speed (in rpm) and load (in Kg).

Based on these given parameters the system of analysis generated the values of coefficient of friction for the given time-period of test in machine.

Experimental Analysis of coefficientof friction of the coated specimen

Comparison of coefficient of friction on different load-

Loss of material for pin and parent material disc with their corresponding coefficient of friction is found to be more in comparison to coated pin and disc and also the coefficient of friction was high for parent material (about 0.5).

The analysis of frictional coefficient at different load conditions is given below.

The coefficient of friction between disc and pin increases with time. The coefficient of friction is increases with the increasing of load.

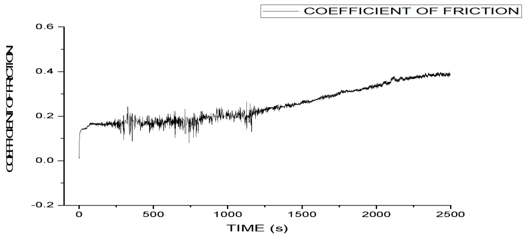


Fig.3 On load 50N and track diameter 50 mm at 322 rpm

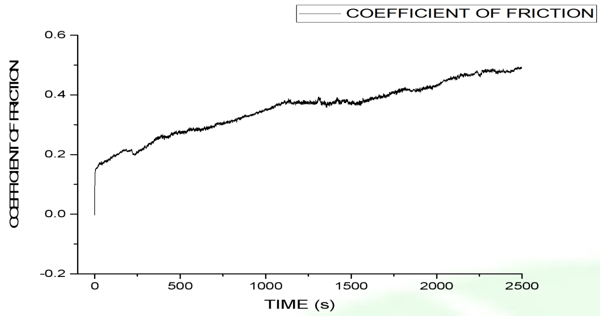


Fig.4 On load 60N and track diameter 40 mm at 408 rpm

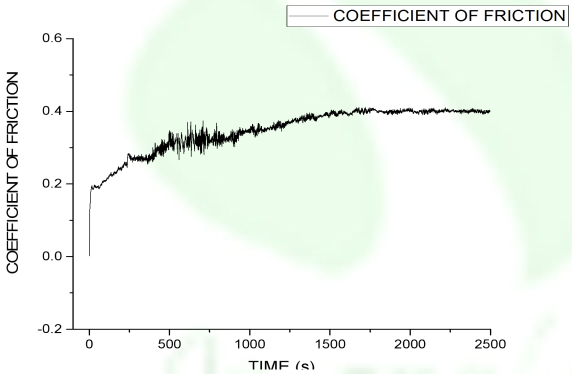
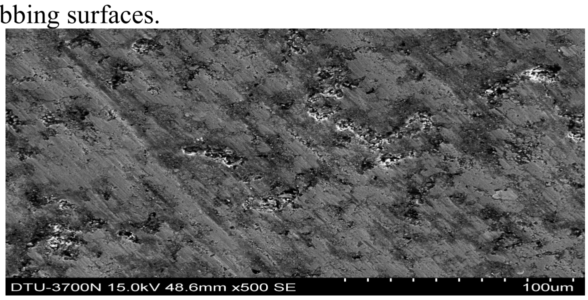


Fig.5 On load 70N and track diameter 30 mm at 550 rpm

Images of wear of disc examined by SEM at different resolutions

It is visible from a microstructure of the image that micro cracks will develop a long the columnar grains. Micro dislocations produce fine wear particles by brittle fracture as shown in fig.4.7. During the process, tribo-chemical reaction may occur due to frictional heating at the contact interface and this leads to high temperature in the surface region, which facilitates the formation of smooth layer. Tribo-chemical layer is formed due to presence between the rubbing surfaces.



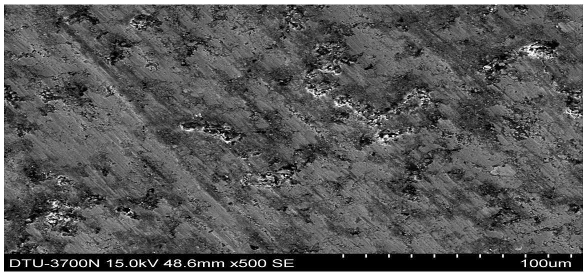


Fig-6 SEM images of plate after test run

IV. Conclusion

The following conclusions are drawn from the analysis:

1. The wear rate of the coating in less testing time can be found using pin on disc test under dry sliding conditions.
2. The Experimental setup of the analysis was such that the variables which chosen were load (50, 60 & 70 N) and sliding speed (322, 408 &550 rpm) and their interaction is significant for proper results.
3. The wear rate was found to be highly dependent on the load and the sliding speed under run. With increase of the load, the wear rate of plate is found to be decreased.
4. The wear resistance is found to be increased with the chrome ion coating on the substrate material for piston ring and cylinder liner pair.
5. The coefficient of friction is found to be increased with increasing the load to higher values.

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