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Efficiency of low friction (TI-GE-CN) nano composite thin film coating for piston ring

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ABSTRACT

To minimize the frictional losses and wear of piston rings in an automotive engine, thick low friction TiGECN nanocomposite coatings have been developed. The substrates were AISI 304 stainless steel coupons and piston rings with bore diameters of 137 mm and 86 mm. The elemental composition and microstructure of the coatings were optimized by varying the Ge to achieve a combination of good mechanical properties and wear rate. The optimized TiGECN coatings exhibited a typical nanocomposite structure performance of the coated piston rings was evaluated using pin on disk tests in SAE 10W-30 diesel engine oil. Finally, the coated rings were evaluated in a single cylinder petrol engine using SAE 5W-20 engine oil and SAE 10W-30 engine oil. In addition, the cylinder liner, which was not coated, showed an average 40% lower wear than that in the uncoated baseline engine test.

INTRODUCTION

To meet the future Fuel Economy standards automotive manufacturers are trying to increase fuel efficiency of vehicles, in which reducing the coefficient of friction of any moving components is critical. Therefore, reducing at the interface between the piston rings against cylinder liners plays a critical role in reducing fuel consumption and improving engine efficiency. Significant efforts have been made towards developing new energy conserving engine lubricants, anti-wear additives, and low friction coatings to reduce friction and increase service life.

LITERATURE SURVEY

Kevin Radii Reciprocating wear tests were performed to investigate the effects of honing on the wear of ceramic coated piston rings and cylinder liners. The baseline or control cases consisted of testing ceramic coated rings against ceramic coated liner specimens whose surfaces were ground and lapped smooth. A second series of tests were performed with liner specimens with base and plateau honed surfaces. Test conditions were chosen to simulate the temperatures, pressures, and boundary lubricated conditions present at top ring reversal in a conventional diesel engine. Wear factor comparisons between the baseline cases and the tests with the honed liner specimens indicate that honing alone is not sufficient to ensure an improvement in ring and liner wear [1-5].

Amirabbas Akbarzadeh and M. M. Khonsari the running-in behavior and the associated transient friction characteristics of a piston ring with different surface treatments are experimentally evaluated using a custom-made engine testing apparatus. Results are reported for a series of running-in and steady-state experiments on piston rings with different combinations of coated and textured surfaces. Comparisons are provided between five different types of piston rings: (1) with no textures; (2) with textures only; (3) with coating only; (4) first textured and then

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coated; and (5) first coated and then textured. A combination of the texturing and coating showed 12.5% improvement in the frictional behavior and up to 50% improvement in break-in time compared to cases when only one surface treatment was applied [6-10].

Yubin Penga, Yufu Xua, Jian Genga, Karl D. Dearnb, Xianguo Hua to alleviate high friction and corrosive wear in piston ring and cylinder liner friction pairs lubricated with bio-oil, four kinds of coatings: Ni-P, Ni-P-MoS2, Ni-P-GO and Ni-P-MoS2-GO have been prepared via chemical nickel plating technology. A multi-functional engine piston ring-cylinder liner tribometer was employed to evaluate their Tribological behaviors. Furthermore, the changes of the bio-oil under different frictional conditions were analyzed by Fourier transform infrared spectroscopy. The results show that adhesive wear, scratching, spalling and mild wear took place respectively on the worn surfaces of piston rings with Ni-P, Ni-PMoS2, Ni-P-GO, and Ni-P-MoS2-GO coatings. Ni-P-MoS2-GO coated piston rings showed excellent friction reducing and anti-wear performance and subsequently have great potential for accelerating the application of bio-oil in IC engines.

Ekrem Buyukkaya, functionally graded coatings are coating systems used to increase performances of high temperature components in diesel engines. These coatings consist of a transition from the metallic bond layer to cermet and from cermet to the ceramic layer. In this study, thermal behavior of functional graded coatings on AlSi and steel piston materials was investigated by means of using a commercial code, namely ANSYS. Thermal analyses were employed to deposit metallic, cermet and ceramic powders such as NiCrAl, NiCrAl +MgZrO3 and MgZrO3 on the substrate. The numerical results of AlSi and steel pistons are compared with each other. It was shown that the maximum surface temperature of the functional graded coating AlSi alloy and steel pistons was increased by 28% and 17%, respectively. © 2008 Elsevier B.V. All rights reserved

T. Hejwowski*, A. Weronski, an experimental study of the effects of thin thermal barrier coatings on the performance of a diesel engine was conducted. Results obtained from the engine with thermally insulated pistons were compared with the baseline engine data. Engine trials demonstrated good properties of both coating systems. Temperature and stress distributions within the pistons were evaluated analytically by means of the Cosmos/Works FEM code. Results of a road test on a gasoline engine-driven car are also reported. The performance of the modified engine-driven car was found satisfactory. The ceramic coating did not produce observable knock in the engine, no significant wear of piston skirts or cylinder liners was found. R, Elsevier Science Ltd. All rights reserved.

Rishabh Singh1, Rohit2, Akshay Gupta3, Prabhakar Chaudhary4, Kalpana Gupta5, this paper deals with the resistance behavior of ion plasma hard chromium coating, which is used for piston ring. Wear resistance tested by the pin-on-disk method. Coating for pin-on-disk deposited on a steel plate. Cast iron ball used for the counterpart. The evaluation performed by Simple Electron Microscope (SEM). The hard chromium shows low wear rate as compare to parent material and the wear rate calculated by weight loss method

Mohsin Attar1, Prof.Mr. Ajay Bhongade2 conventionally, the small portion of the total energy produced in internal combustion engine is converted to useful work. More than half of this energy is expelled from the system through frictional losses, cooling the engine components, exhaust, etc. The most effective way of increasing the percentage of useful work is to reduce the energy loss. One way of reducing the energy loss or increasing the efficiency of the engine is by using thermal barrier coatings (TBC) on the various elements of the combustion chamber like valves, piston, cylinder surfaces, and rings. This work presents the design and analysis of an IC engine piston coated with thermal barrier material (yttiria stabilized zirconia) so as to understand the performance of piston and study its heat resistant behavior in comparison with a non-coated thermal barrier piston [11].

Engine Nishant Varshney1, Divyansh Mishra2, Pawan Kumar Agrahri3, Subhash Gupta4, Chandan B.B.5, Abhishek Kumar6, The goal of this paper is to determine both temperature and stress distributions in a plasma sprayed magnesiastabilized zirconia coating on an AlSi alloy piston head to improve the performance of a diesel engine. Effects of the coating thickness on temperature and thermal stress distributions are investigated, including comparisons with results from an uncoated piston by means of the finite element method. This paper deals with such type of challenges and can be tackled by coating the piston crown using ceramics. With the help of further analysis using ANSYS on these type of engines, we can increase the thermal efficiency along with reduction of harmful emissions. This project therefore aims at converting conventional engine into Low Heat Rejection engine.

Ronghua Wei, Daniel Christopher Bitsis, Peter M. Lee, To minimize the frictional losses and wear of piston rings in an automotive engine, thick low friction TiSiCN nanocomposite coatings have been developed. The coatings were deposited by sputtering titanium targets in argon, nitrogen, hexamethyldisilazane (HMDSN), and acetylene (C2H2) using plasma enhanced magnetron sputtering (PEMS). The substrates were AISI 304 stainless steel coupons and piston rings with bore diameters of 137 mm and 86 mm. The elemental composition and microstructure of the coatings were optimized by varying the HMDSN and C2H2 flow rates separately to achieve a combination of excellent adhesion, good mechanical properties, low coefficient of friction (COF) and wear rate. The optimized TiSiCN coatings exhibited a typical nanocomposite structure which showed excellent adhesion and dry COF in the range of 0.17 to 0.2 using a ball-on-disk tribometer. The Tribological performance of the coated piston rings was evaluated using Plint TE77 tests in SAE 10W-30 diesel engine oil. The TE77 tests showed a 10% reduction in the COF (0.058) of the optimized coating compared to the uncoated baseline (0.065) at test conditions of 20 Hz, 30 N, and 25 mm stroke length. Finally, the coated rings were evaluated in a single cylinder gasoline engine using SAE 5W-20 engine oil and in a heavy duty diesel engine using 4.1% soothed SAE 10W-30 diesel engine oil. The gasoline engine test showed that the uncoated piston rings contributed 25% to 34% of the frictional loss in two separate baseline engine tests. In contrast, the coated rings contributed to 18% of the total frictional loss in the engine test. The diesel engine durability test showed a 28% and 40% lower ring weight loss for the coated top and second rings, respectively, as compared to the uncoated baseline. In addition, the cylinder liner, which was not coated, showed an average 50% lower wear than that in the uncoated baseline engine test

Wölfle1 , Torben Müller1 , Hans-Jürgen Füßer1 , Dirk Bartel2, A reciprocating model test has been developed, which reproduces real load situation of the contact condition between the piston-ring and cylinder liner at fired top dead center (FTDC) of internal combustion engines. Friction, wear, and load carrying capacity (LCC) were studied as a function of temperature, oil supply rate, and normal force for a honed grey cast iron liner and a chromium plated piston ring. The results show similar liner wear to the ones in actual fired engine tests were obtained as long as normal forces that correspond to engine combustion pressures were applied. Also, a considerable dependency of the LCC on temperature and oil supply rate was found. However, oil supply rate did not influence coefficient of friction (COF) as much as expected

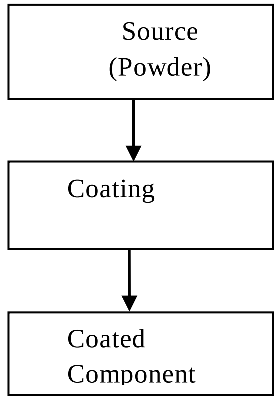
P. M. Pierz, Specific outputs of some diesel engine applications have produced thermal loadings in excess of the strength of typical aluminum piston alloys. Thermal barrier coatings are being evaluated to return the component durability to acceptable levels, as well as providing a means of lowering heat rejection. This paper discusses the use of a finite element model to analyze these thermal barrier coating systems, including the impact of material properties, coating thickness, residual stress and boundary conditions. Given the resulting predicted temperatures and stresses, together with material strength information, the primary cause of coating failure is proposed to be low cycle fatigue resulting from localized yielding when the coating is hot and in compression. This has been confirmed with engine testing

OBJECTIVES

- Study the wear progression on piston ring.
- Study the change of surface finish throughout the tool life of piston ring.

- Analyse the results obtained for piston ring, and evaluate their performance based on the effects of the coating materials used.

PROCESS FLOW



PROBLEM IDENTIFICATION

- Increasing wear of the piston ring
- Time Increased in change to piston ring

WORKING

Coating

A coating is a covering that is applied to the surface of an object, usually referred to as the substrate.

Types of coatings

Coating processes may be classified as follows:

- Chemical vapor deposition
- Physical vapor deposition
- Chemical and electrochemical techniques
- Spraying
- Roll-to-roll coating processes
- Physical coating processes

Plating is a surface covering in which is applied in our work. Plating is used to decorate objects, for corrosion inhibition, to improve solder ability, to harden, to improve wear ability, to reduce friction, and for other purposes.

PROPERTIES OF TITANIUM

- Density – 4.506 g/cm³;
- Color – white;
- Titanium is a low-melting metal, with a melting point of 917 °C;
- The elasticity and malleability of the metal increases when it is heated to 100 °C;
- The boiling point of the simple substance is 3287 °C;
- The metal has a high heat capacity and heat conductivity;
- Titanium is a good conductor

PROPERTIES OF NICKEL

- Density -8.90 g/cm^3
- Nickel is silvery-white, hard, malleable, and Ductile metal.
- It is a good conductor of heat and electricity.
- It is bivalent, that is it has a valency of two.
- The metal dissolves slowly in dilute acids.
- It's melting point is 1453 °C and boiling point is 2913 °c
- Properties of germanium
- Melting point -938.2°C
- Boiling point -2833°C
- Chromium is a white and gray color.
- Its crystal structure is cubic.

TESTING

The hardness test is a micro hardness test a test for mechanical hardness used particularly for very brittle materials or thin sheets, where only a small indentation may be made for testing purposes. A pyramidal diamond point is pressed into the polished surface of the test material with a known (often 100g) load, for a specified dwell time, and the resulting indentation is measured using a microscope. The geometry of this indenter is an extended pyramid with the length to width ratio being 7:1 and respective face angles are 172 degrees for the long edge and 130 degrees for the short edge. The depth of the indentation can be approximated as 1/30 of the long dimension

WEAR TESTING

Wear is the damaging, gradual removal or deformation of material at solid surfaces. Causes of wear can be mechanical (e.g., erosion) or chemical (e.g., corrosion). The study of wear and related processes is referred to as tribology. Wear in machine elements, together with other processes such as fatigue and creep, causes functional surfaces to degrade, eventually leading to material failure or loss of functionality. Wear of metals occurs by plastic displacement of surface and near-surface material and by detachment of particles that form wear debris. The particle size may vary from millimeters to nanometers. This process may occur by contact with other metals, nonmetallic solids, flowing liquids, solid particles or liquid droplets entrained in flowing gasses. The wear rate is affected by factors such as type of loading (e.g., impact, static, dynamic), type of motion (e.g., sliding, rolling), and temperature. Depending on the tribo system, different wear types and wear mechanisms can be observed. Several standard test methods exist for different types of wear to determine the amount of material removal during a specified time period under well-defined conditions. ASTM International Committee G-2 standardizes wear testing for specific applications, which are periodically updated. The Society for Tribology and Lubrication Engineers (STLE) has documented a large number of frictional, wear and lubrication tests.

Standardized wear tests are used to create comparative material rankings for a specific set of test parameter as stipulated in the test description. To obtain more accurate predictions of wear in industrial applications it is necessary to conduct wear testing under conditions simulating the exact wear process.

An attrition test is a test that is carried out to measure the resistance of a granular material to wear.

Formula calculate wear rate,

$$V_i = k_i F s$$

Where

F is the normal load

S is the Sliding distance

V is the wear volume

K is the specific rate coefficient

i is the identifies the surface considered

The k-value is given in m^3/Nm or m^2/N, sometimes in mm^3/Nm.

CONCLUSION

The paste has been made from TiGECN with stirrering process and coated as a thin nanocomposite film on piston ring and respective wear test and frictional loss tests have to be performed. Finally, the coated rings were evaluated in a single cylinder petrol engine using various types of engine oil. Hardness test were conducted after heat treatment on the coated rings In addition, the cylinder liner, which was not coated, showed an average 35% lower wear than that in the uncoated baseline engine test.

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