Surface Modification of Piston Ring for Improvement of Wear Resistance using Liquid Nitriding

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Abstract— The research is to optimize metallurgical properties and to improve the manufacturing route of the piston ring. Salt bath nitriding or liquid nitriding process was used in this work for surface treatment of gasoline engine piston ring. Piston ring in an engine makes an important contribution to high volumetric efficiency by properly sealing the cylinder bore and piston. The main function of piston ring is to seal between the combustion chamber and the crankcase of the engine. Selective nitriding of thin wall gasoline piston ring is very important because the surface side are deleterious to the engine performance. Nitriding provide that selective nitriding is possible using a simple mounting system, leading to homogeneous properties on both inner and outer diameter surface. Only a diffusion zone without grain boundaries nitrides, composes of nitride microstructure.

Key words: Surface Modification of Piston Ring, Improvement of Wear Resistance using Liquid Nitriding

I. Introduction

A piston ring is a split ring that fits into a groove on the outer diameter of a piston in a reciprocating engine such as an internal combustion engine. The main functions of piston rings in reciprocating engines are to seal the combustion chamber so that there is minimal loss of gases to the crank case. Improving heat transfer from the piston to the cylinder wall. Regulating engine oil consumption by scraping oil from the cylinder walls back to the sump. The gap in the piston ring compresses to a few thousands of an inch when inside the cylinder bore. Piston rings are a major factor in identifying if an engine is two stroke or four stroke. Three piston rings suggest that it is a four-stroke engine while two piston rings suggest that it is a two-stroke engine. Most piston rings are made of a very hard and somewhat brittle cast iron but in this research, we are using low alloy steel as piston rings. Piston rings are subject to wear as they move up and down the cylinder bore due to their own inherent load and due to the gas load acting on the ring. To minimize this, they are made of wear-resistant materials, such as cast iron and steel, and are coated or treated to enhance the wear resistance. Typically, top ring and oil control rings will be coated with chromium or Nitrided. Three-piece oil rings, i.e. with two rails and one spacer, are used for four-stroke gasoline engines. Salt bath nitriding the nitrogen donating medium is a nitrogen-containing salt such as cyanide salt. The salts used also donate carbon to the work piece surface making salt bath a nitrocarburizing process. The temperature used is typical of all nitrocarburizing processes: 550–570 °C. The advantages of salt nitriding is that it achieves higher diffusion in the same period time compared to any other method. The advantages of salt nitriding are: Quick processing time - usually in the order of 4 hours or so to achieve, Simple operation - heat the salt and workpieces to temperature and submerge until the duration has transpired.

II. Methodology

Salt bath ferritic nitrocarburizing most commonly used on steels, sintered irons, and cast irons to lower friction and improve wear and corrosion resistance. The process uses a salt bath of alkali cyanate. This is contained in a steel pot that has an aeration system. The cyanate thermally reacts with the surface of the workpiece to form alkali carbonate. The bath is then treated to convert the carbonate back to a cyanate. The surface formed from the reaction has a compound layer and a diffusion layer. The compound layer consists of iron, nitrogen, and oxygen, is abrasion resistant, and stable at elevated temperatures. The diffusion layer contains nitrides and carbides. The surface hardness ranges from 800 to 1500 HV depending on the steel grade. This also inversely affects the depth of the case; i.e. a high carbon steel will form a hard, but shallow case. The intermediate quench is an oxidizing salt bath at 400 °C (752 °F). This quench is held for 5 to 20 minutes before final quenching to room temperature. This is done to minimize distortion and to destroy any lingering cyanates or cyanides left on the workpiece. The first stage occurs at 625 °C (1,157 °F), while the second stage occurs at 580 °C (1,076 °F).The coating procedure itself requires some basic preparations.

III. Testing and Result

Wear test is carried out to predict the wear performance and to investigate the wear mechanism. From a material point of view, the test is performed to evaluate the wear property of a material so as to determine whether the material is adequate for a specific wear application. From a surface engineering point of view, wear test is carried out to evaluate the potential of using a certain surface engineering technology to reduce wear for a specific application, and to investigate the effect of treatment conditions (processing parameters) on the wear performance, so that optimized surface treatment conditions can be realized.

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A. A3 Abrasive Wear Test Result

Rubber wheel abrasion test specification:

Description	Specification
Abrasive	Silica
Particle size	120 - 180 mesh
Load	10 N
Duration	20 minutes
Speed	240 rpm
Wheel diameter	230 mm
Backing material	Butyl

Material: piston ring stock

Material description	Initial weight	After test weight	Wear loss
Nitrided Piston ring abrasive wear specimen	193.5	190.7	2.8
Untreated piston ring abrasive wear specimen	192.1	188.7	3.4

Fig. 1: A3 Abrasive Wear Test Result

B. B3 Hardness Test Result

Hardness testing specimen

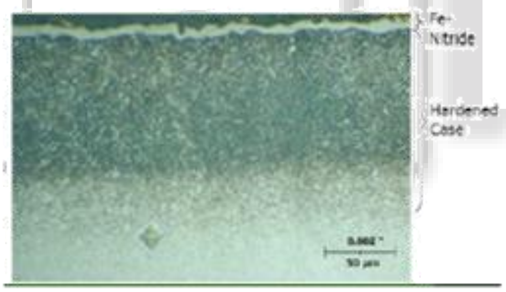
Description	Specification
Machine	Micro vicker hardness tester
Load	0.1 Kg
Dwelling	15 Second

Material Process	Hardness
Nitrided Piston ring case	538
Nitrided piston ring core	330
Untreated piston ring case	204
Untreated piston ring core	213

Fig. 2: B3 Hardness Test Result

C. C3 Diffusion depth result

Micro photograph



Description	Specification
Case depth or diffusion	41 micrometer

Fig. 3: C3 Diffusion depth result

IV. Conclusion

By Salt bath nitriding it's proved that we can optimize metallurgical properties of piston rings. The surface hardness is increased up to 1100 HV0.1.The mechanical tests showed that the performance of salt bath nitrided rings is superior to the untreated counterpart. Benefits that is achieved through liquid nitriding treatments include:

- Superior wear resistance
- Excellent friction properties
- Good scuffing/seizure protection
- Excellent corrosion protection
- Good surface fatigue resistance
- Decorative black surface
- No deformation or distortion of the part
- Environmentally sound
- No changes to core property

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