

PAPER • OPEN ACCESS

QPQ salt bath composite processing on microstructure and property of certain type aviation piston engine ring

To cite this article: Fajun Ding *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **493** 012119

View the [article online](#) for updates and enhancements.

QPQ salt bath composite processing on microstructure and property of certain type aviation piston engine ring

Fajun Ding *, Kun Liu, Junwen Lu

Civil Aviation Flight University of China, Chengdu, China

*Corresponding author e-mail: jackycafuc@163.com

Abstract. QPQ treatment was carried out on the circulation of a certain type of aero-piston engine. Nitriding treatment of 570 °C and 180 min was performed first, oxidation treatment of 400 °C and 20 min was performed, and secondary oxidation of 370 °C and 20 min was performed after polishing. The surface characteristics of the high cycle treated by QPQ were studied by optical microscope, micro hardness tester and friction and wear tester. The results show that the surface of the rising ring after QPQ treatment forms an oxidation film, a Nitriding layer and a diffusion layer from the outside to the inside. The maximum hardness of the ring surface treated by QPQ is 592 HV, which is nearly twice as high as before untreated, and its wear resistance is nearly five times higher than before untreated.

1. Introduction

At present, the technology of the surface treatment of piston ring mainly includes: electroplating, thermal spraying molybdenum layer, plasma spraying ceramic layer, intruding treatment, active treatment and gas phase deposition. QPQ technology refers to the compound treatment technology of no pollution salt bath nitro carburizing and quenching - polishing quenching technology, which belongs to intruding treatment. QPQ can greatly improve the wear resistance and corrosion resistance of the metal surface, and the distortion of the treated parts is small, pollution-free and pollution-free.

Due to the fact that most of the salt used by QPQ is a secret formula, there are few studies on the effect of QPQ treatment process on the performance of aero piston engine at home and abroad. The QPQ technology is used to restore the surface performance of the rising ring of the used aero piston engine. The effect of QPQ on the wear resistance, hardness and surface recovery of the rise ring is studied, and the utilization rate of the rise ring is improved, the cost is saved and the reliability of the rise ring is enhanced.

2. Test samples and experimental methods

The test sample is the used piston ring of the piston engine, 50. Figure 1 is a sample of the rise ring before processing. After being used, the surface of the ring has worn out the bare metal surface. There are signs of erosion and erosion on the surface. The samples were cleaned by ultrasonic cleaning machine, then dried and ready for use. The process of QPQ processing is: 370 degrees Celsius preheating 30 minutes, intruded temperature is 570 degrees Celsius, time for 3 hours, and then 400 degrees, 20 minutes of intruding, polishing, 370 degrees centigrade, 20 minutes two times initiation. The cyanide root concentration of intruded salt is 34%.



After treatment, a section was selected for WEDM. After grinding, polishing and 4% nitric acid alcohol corrosion, the depth of the composite layer was observed under the metallographic microscope. Using nitrite corrosion cross section, the total thickness of the infiltrated layer was observed by metallographic microscope. During the observation, the TMMM-240F metallographic microscope was used uniformly to observe the depth of the seeping layer. The hardness of the sample is measured by 402MVA Vickers hardness tester, the degree of the reading microscope is 0.01mm, and the magnification of the measurement and observation is 400 times. The hardness of the layer is measured directly by the 100g load, and the loading time is 15s. The sliding friction test was carried out on the MMW-1A universal wear tester, and the wear resistant specimens were tested by butterfly test. Experimental environment: dry friction, no lubrication, low speed of movement mode (200r/min at shaft speed). The samples were first tested with 20N load for 10H and then 40N grinding 65H. Before and after the wear test, the electronic analysis balance of 1mg is used to measure the sample quality and wear volume. 5 times of repeated wear tests under the same test conditions, the average wear volume was finally obtained.



Fig 1. Piston ring before QPQ treatment



Fig 2. Piston ring after QPQ treatment

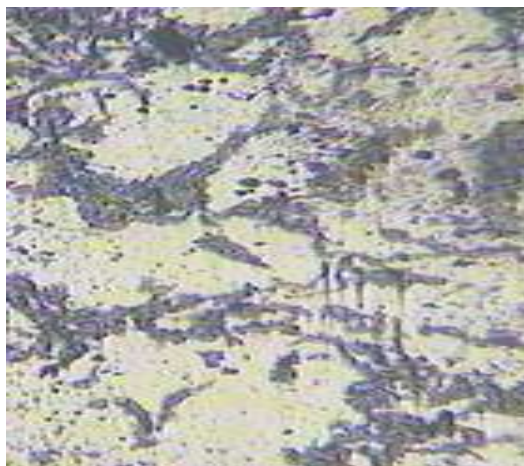


Fig 3. Microstructure of piston ring
before QPQ treatment

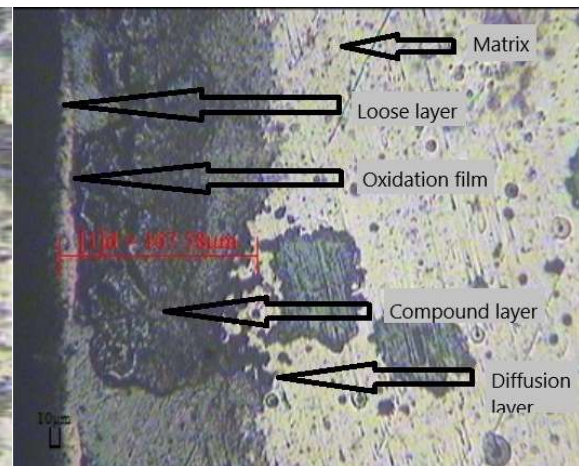


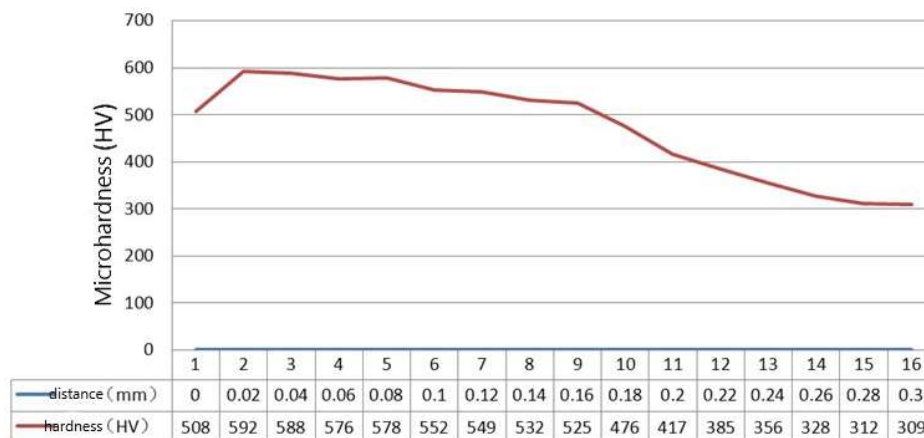
Fig 4. Microstructure of piston ring
after QPQ treatment

3. Experimental results and analysis

3.1. Microstructure observation

Fig. 2 is the microstructure of the ring winding specimen without QPQ treatment. Fig. 3 is the cross-section microstructure of the ring after QPQ treatment, and the thickness of the permeation layer is about 0.167mm, refer Fig.4. We can see that the outer surface of the rising ring after QPQ treatment is divided

into 3 layers: oxide film, compound layer and diffusion layer. The black oxide film on the surface of the expansion ring is formed during the oxidation process. The thickness of the oxide film is only a few microns, which is beneficial to improving the appearance and wear resistance of the work piece. The compound layer is a key part after QPQ treatment. It is a major part of enhancing the wear resistance, hardness and corrosion resistance of the ring. The dark layer observed by metallographic is a compound layer with high hardness, good wear resistance and corrosion resistance.



The green line is the distance from the surface of the high circle specimen, and the red line is the hardness curve.

Fig 5. Hardness Profiles of piston ring after QPQ treatment

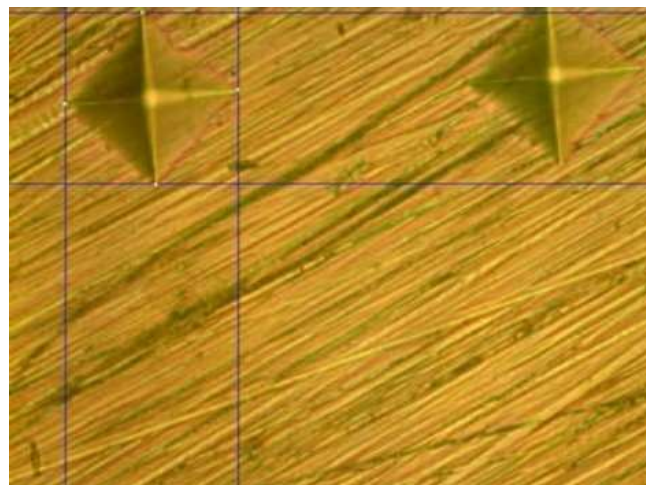


Fig 6. Hardness measurement of piston ring after QPQ treatment

3.2. Hardness analysis of the rise ring treated by QPQ

Fig. 5 is the section hardness curve of the ring specimen after QPQ treatment. It can be seen that after QPQ treatment, the hardness of the raised ring surface has been significantly improved, which is 1 times higher than that before the treatment. The curve is relatively smooth, indicating that the effect of hardness increase is good. At the same time, with the increase of the distance from the surface of the ring, the hardness decreases and there is obvious diffusivity. Fig. 6 shows the measured hardness of the high circle specimen.

3.3. Analysis of wear resistance

Fig. 7 describes the wear and friction coefficient curve of the high cycle sample treated with QPQ, where μ is the friction coefficient. As shown in Figure 8, the wear of samples not treated with QPQ was approximately 0.28 g, the wear of samples treated with QPQ was 0.05 g, and the wear resistance of the QPQ-treated high cycle samples was significantly improved. The amount of wear is almost 1/6 of the sample without QPQ treatment.

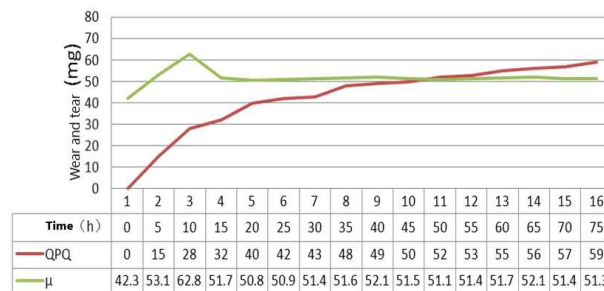


Fig 7. Wear profiles of piston ring after and after QPQ treatment

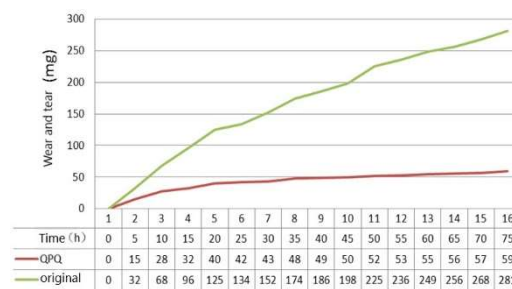


Fig 8. Comparative wear diagram of piston before QPQ treatment

4. Conclusion

(1) After the samples were treated by QPQ, the surface layer was composed of loose layer, oxide film, compound layer, diffusion layer and matrix.

(2) After the treated ring has been treated by QPQ, the permeable layer with high hardness and high wear resistance can be formed on its surface, and its performance has been restored.

(3) After QPQ treatment, the hardness of the ring is increased by 1 times than that of the original sample, and the wear resistance is increased by more than 5 times.

References

- [1] Haojianjun, Mayuejin, Duan Baihua. Application of Surface Engineering Technology to Vehicle Engines[J]. Car engine. 2001, 6:13 -15.
- [2] Xiong Guangyao, Zhao Mingjuan, Zhao Longzhi, et al. Influence of RE on microstructure and properties of die Steel by QPQ Salt-bath treatment[J]. Material & Heat Treatment, 2010, 39(4):117-119.
- [3] Luo Defu, Li Huiyou, Lin Xun-hua. Principle and application of QPQ technique[J]. Beijing: China Machine Press; 2007:1-4.
- [4] Luo Defu, Li Huiyou. Current situation and prospect of QPQ technology[J]. Heat Treatment of Metals, 2004, 29(1):39-43.