Shot Peening – A Tribological Approach

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Abstract
Shot peening is best known for its capability of introducing compressive strength on the machine elements to combat fatigue related failures. In the present study, this conventional application is introduced into Tribology – the science of friction, lubrication and wear. More specifically, shot peening effect is investigated by evaluating the tribological performance of an elastomer shaft seal. It was found that shot peening stabilizes the friction coefficient, which implies a better lubrication was generated.

Keywords: Tribology, seal, friction coefficient

Introduction

Shot peening has gained popularity as a powerful tool of combating fatigue since its successful application in automotive springs in the United State in early 1930s. The plastic deformation in the surface layer of metal creates compressive residual stress which, is credited for fatigue resistance. While the peening process changes the mechanical properties of the surface layer, it alters its surface topography as well. Micro indentations are generated, as shown by Fig. 1. The difference of surface topography between machined surface and peened surface is illustrated by Figs. 2 and 3. The machining marks are substituted by isotropic indentations. These indentations are actually micro-dimples. In recent years, manipulating the surface topography of friction couples to gain optimal tribological performance has become increasingly important in order to reduce energy consumption. Laser texturing [1], machining [2], etching [3] and burnishing, etc have been explored to implementing patterned profiles on the tribological parts. Inspired by the results of micro-dimples from shot peening [4,5,6,7], a seal shaft is peened to investigate the tribological performance of an elastomer seal. Its methodology and result are presented in this paper.

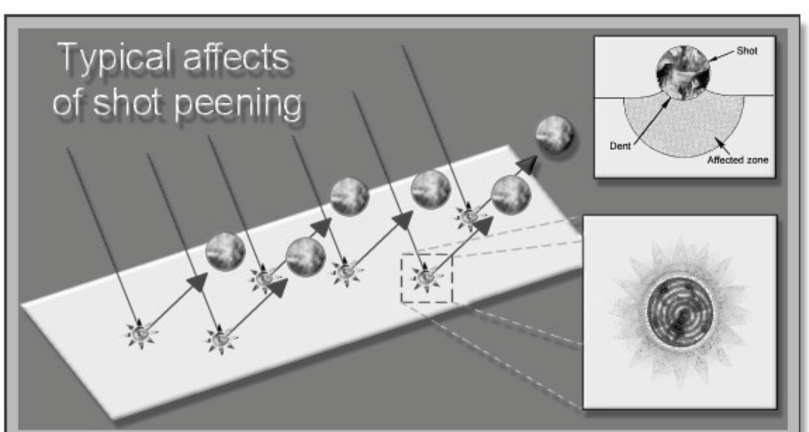

Figure 1 – Shot peening effect (Courtesy of Abrasive Finishing Company)

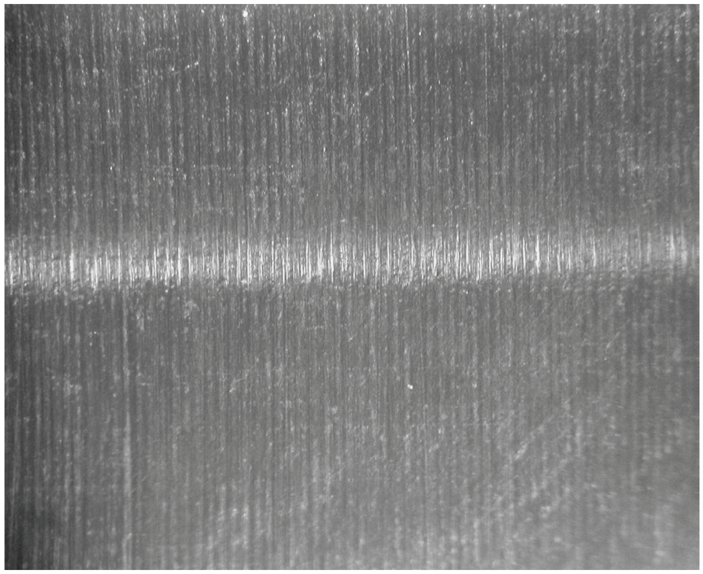

Figure 2 – machined surface (100 X magnification)

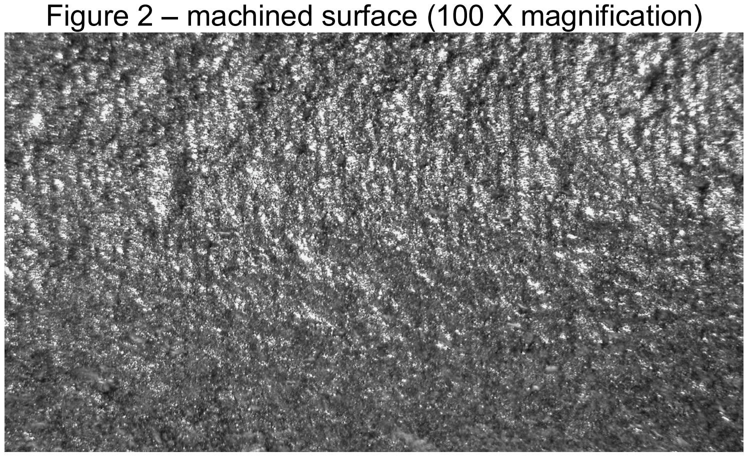

Figure 3 – peened surface (100 X magnification)

Experimental Methods

A seal shaft is shot peened after machining to create isotropic micro-dimples. These dimples will work as lubricant reservoirs and wear debris traps. Their overall purpose is to reduce the friction coefficient and elongate the seal life.

The seal ID is about 33 mm. It is made of HNBR elastomer and has an elongated o-ring shape in cross section. The cross section squeeze is 10%~15%. The shaft is made of 8720 steel. It is heat treated to hardness HRC~58. It has a surface finish of R_a ~ 0.3 µm before shot peening.

A dual peening process is applied to the shaft. The shot is cast steel shot. In the first peening step, 460/550 shots are used. The intensity is 0.007~0.010C. The coverage is 300%. In the second step, 110/110 shots are used. The intensity is 0.007~0.010A. The coverage is 100%. Two shafts sit side by side in Fig. 4. One can easily tell which part is peened.

The shaft and the seal are assembled into a test fixture, demonstrated by Fig. 5. Calcium complex grease is carefully packed around the seal gland. Thereafter, the test fixture is attached to Lewis Research LRI-8a Tribometer. The seal has an ID of 1.600". The shaft runs at a speed of 150 rpm. The friction coefficient and the temperature in the seal vicinity are recorded into computer.

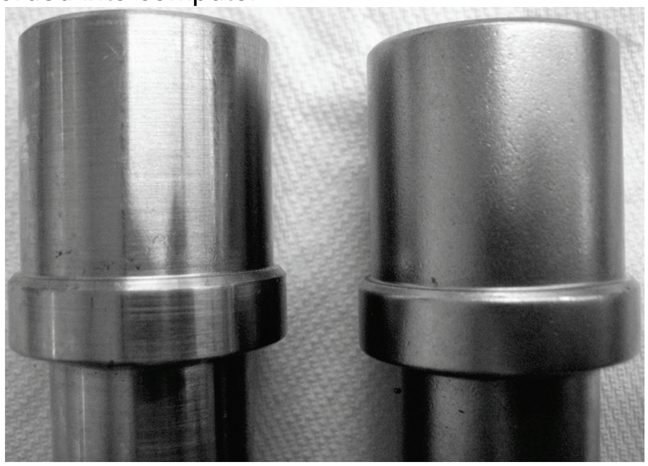

Figure 4 – Appearance of peened and machined shafts

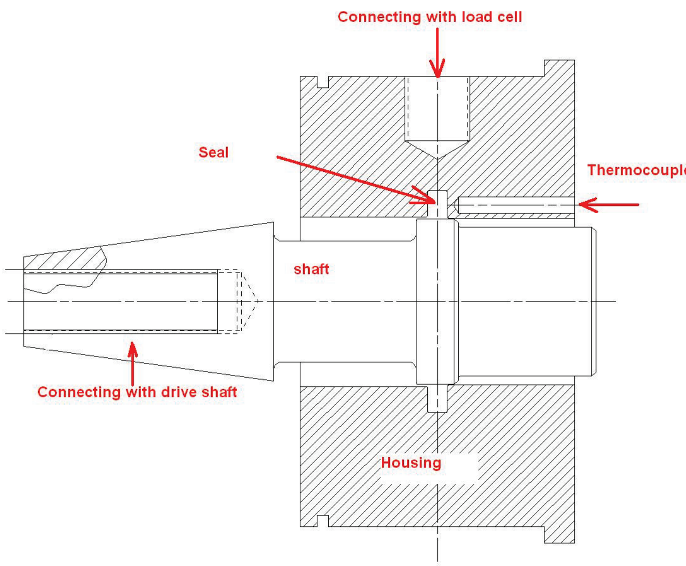

Figure 5 – Seal test fixture (no scaling)

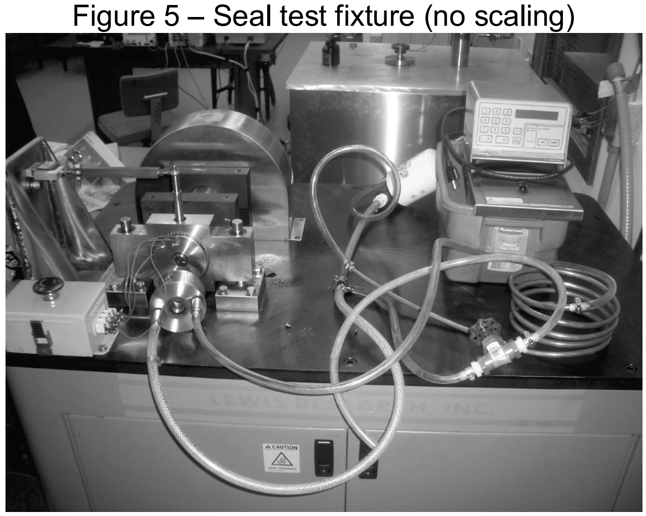

Figure 6 – Lewis Research LRI-8a Tribometer (Courtesy of Center for Rotating Machinery, Louisiana State University)

Experimental Results

The regular shaft and the shot peened shaft are tested three times respectively. Shafts and seals are brand new in each test to start with. Each test lasts two hours. The comparison of their friction coefficients is shown by Fig. 7. Although the average friction coefficient of the shot peened shaft is not evidently lower than that of the regular shaft, but its standard deviation is lower. The high-and-low friction variation represents the stick-slip behavior of the seal when it slides against the shaft. It is detrimental to the seal performance and life. With reduced stick-slip behavior by the shot peened shaft, the seal are expected to perform better and longer.

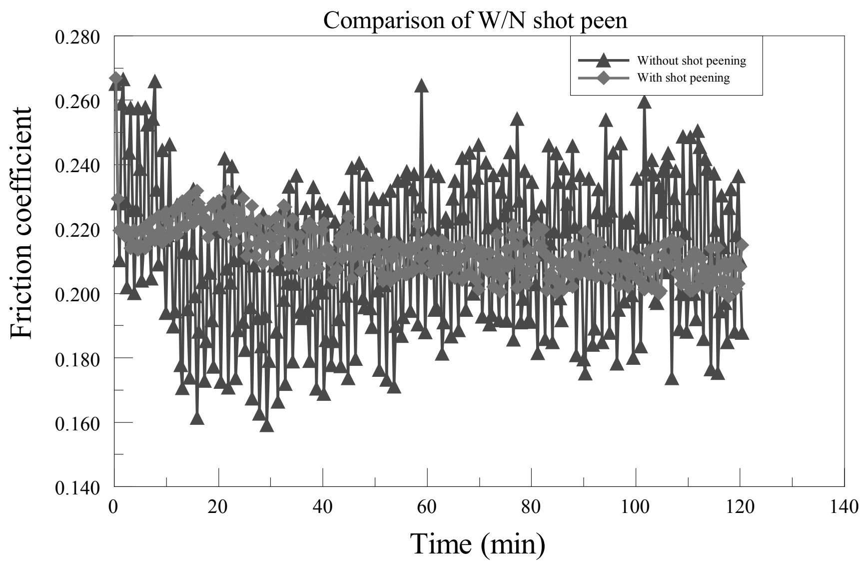

Figure 7 - Comparison of friction coefficient with/without shot peening

Discussion and Conclusions

The objective of introducing shot peening to the seal shaft is clear – to create micro-dimples on the part surface in an economic and effective way. Those micro-dimples behave as lubricant reservoirs and wear debris traps, which are essential to mixed lubrication regime where lubricant starvations happens more than often. The elastomer seal in the current study operates in the mixed lubrication regime. The experimental results demonstrated the altered surface topography by shot peening, which generates beneficial effects on the friction coefficient. Therefore, the seal life is expected to be extended.

While the friction coefficient of the seal is improved, the author is aware that the lubricant leakage is not monitored. The concept of shot peening on tribological performance is justified. Future work is needed for completing the seal test.

Reference:

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