Engineered Surfaces for Weapon Systems Life Extension

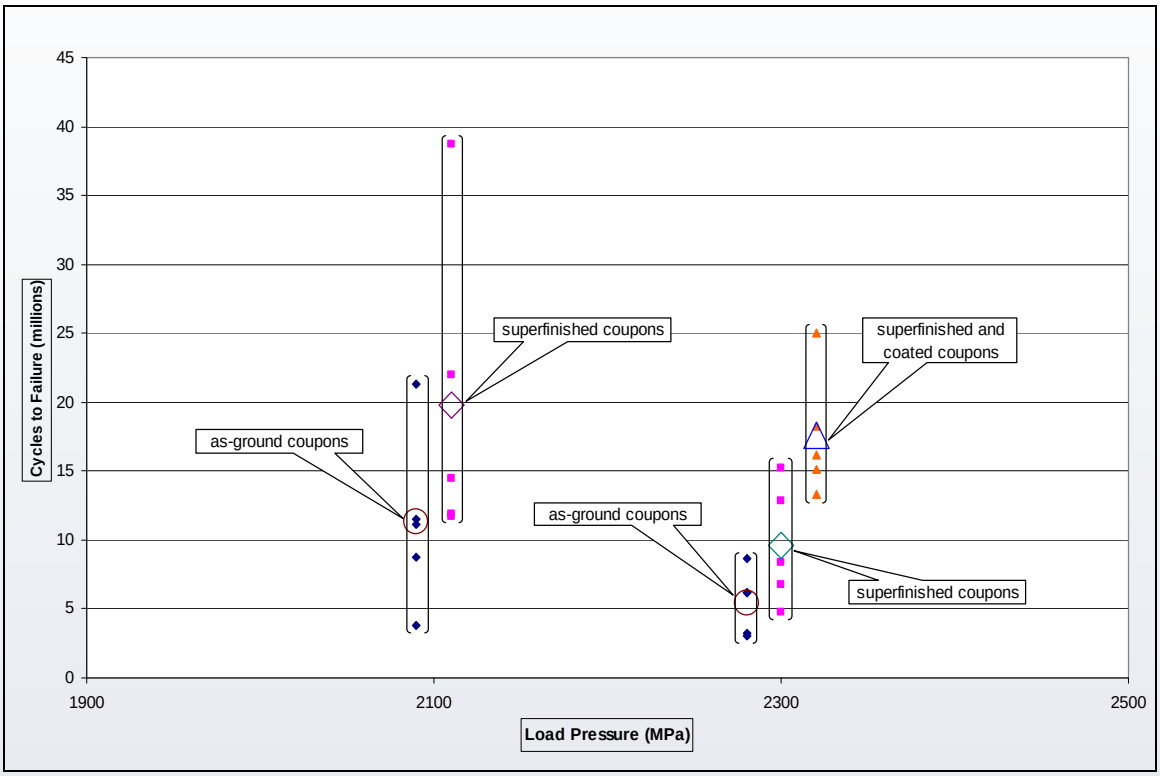
The AMMTIAC team of Alion Science & Technology and the University of North Dakota successfully completed the first phase effort of a multiphase program to increase the life and improve the reliability of Army aviation transmission, drive, and actuation systems through the application of advanced production process technology to the fabrication of replacement or new parts. The initial emphasis was on the application of isotropic superfinishing technology to improve lifetime of critical parts.

Metal gears are manufactured to their rough dimensions by some combination of metallurgical and machining steps. They are then heat treated to anneal and case harden (carburize) the metal. These thermal processes alter the gear's dimensions slightly, which is why standard industry practice calls for finishing operations to follow the heat treatment. Finally, gears are precision-ground after heat treating to obtain the necessary final tolerances required to provide higher power density levels without increasing component size or weight.

However, the grinding processes used to finish gears leave microscopic surface features that influence gear life. Therefore, additional processes are needed to eliminate these features while preserving the required geometric accuracy and surface finish. Recent experimental results indicate that improved part surface finish, via superfinishing, can reduce contact fatigue in gears by a factor of 3, as well as enhance the bending fatigue life of their teeth by at least 10 percent. Such improvements reduce the amount of frictional losses inherent in any power transfer system, which will lead to reduced operation and sustainment costs. Furthermore, this improved gear performance provides an opportunity to reduce component weight in new designs.

One project goal was to demonstrate the effectiveness of Houghton International's superfinishing technology as an additional source to improve the surface quality of gears, increasing the lifetime capability without changing the classification of aerospace gears. The objective was to select candidate parts, apply the surface treatment, and evaluate the effects of the treatment process. Based on the studies performed by AMMTIAC and the University of North Dakota, a consistent surface finish is achievable using Houghton International's superfinishing process. Preliminary results indicate that material removal rates are small, 0.00013 inches per hour, and uniform. In addition, the AMMTIAC team determined that superfinishing is able to remove grinding marks on finished parts and provide equal surface roughness values of 2 to 3 µin, when measured in perpendicular directions, indicating that an isotropic surface finish was achieved. Overall, by independent operation of the superfinishing processing at the Surface Engineering Center, it was determined that the Houghton International superfinishing process was robust, repeatable, and readily transferable.

To exhibit lifetime improvement by superfinishing, Rolling/Sliding Contact (RCF) fatigue test were conducted by V-Tech International in their ZF-RCF test bench. Results from ZF-RCF test indicate that superfinished coupons run longer without incurring damage as compared to as-ground parts. For the as-ground coupons, 10 tests were completed comprising in total 83.75 million stress cycles. For the superfinished coupons, 10 tests were completed comprising in total 146.75 millions stress cycles. The results from these tests show a 2x lifetime increase of the baseline on the superfinished coupons, and the superfinished with WS_2 coated coupons showed a 3x lifetime increase.



To learn more about this low cost method to extend weapon systems' service life, please contact:

Ben Hoiland
bhoiland@alionscience.com
701.757.5151