LAMBDA Technologies Group

Diffraction Notes

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Issue No. 46 Improving Component Life and Performance 2018

OPTIMIZING CARBURIZATION OF 8620H STEEL COMPONENTS (PART 2 OF 2)

INTRODUCTION

In Part 1 of this study, the influence of various carburization treatments on the residual stress, retained austenite, and hardness distributions was shown. In Part 2, rolling contact fatigue tests were conducted on the same carburization treatments. Rolling contact fatigue (or contact fatigue) failure, a surface-pitting-type failure, results from the contact or Hertzian stress state when curved surfaces are in contact under normal load. Contact fatigue is a common cause of failure in components such as gears, cams, railroad wheels, and bearings. Components manufactured from carburized steels are especially prone to contact fatigue type failures. By characterizing fatigue performance as a function of carburization case depth, hardness, residual stress, and retained austenite, an optimized carburization process can be engineered to meet specific application requirements.

MATERIAL PROCESSING & FATIGUE TESTING

A single 0.5 in. diameter bar manufactured from 8620H steel was purchased and machined into 6 in. test specimens before carburization and testing. The carburization process was performed in an integral quench furnace in an exothermic atmosphere with methane as an enrichment gas for 2, 4, 8, 12, or 24 hours. After carburization, the specimens were low-stress ground to a final diameter of 15/32 in. for use in specially designed RCF testing units. The low-stress grind also simulates the finish grinding that is typical of carburized components.

Rolling Contact Fatigue (RCF) testing was performed using three identical test units. The RCF testers rotate a cylindrical test specimen that is stressed in rolling contact by three balls. The three balls, separated by a bronze retainer, are radially loaded against the test specimen by two tapered bearing rings that are thrust-loaded by three compression springs. The compression spring loads were calibrated, prior to testing, using a load cell. The material bench testers were specially designed to utilize a specimen with a simple cylindrical geometry in order to expedite testing by minimizing the many complex variables inherent in full scale component tests. A picture of an RCF tester is shown in Figure 1.

RESULTS AND DISCUSSION

The fatigue results were analyzed using a Weibull probability distribution. Weibull distributions provide accurate predictions of failure probability and allow life cycle and reliability comparisons between differing population groups (materials, processes, etc.). The L10 life, the life at which 10% of the population will fail, is commonly used for performance comparisons in bearings and many other components.

The Weibull Probability Distributions for the RCF tests performed during this investigation, comparing 8620 steel bars carburized for different times (various case depths), are shown in Figure 2. Weibull probability L10 lives are shown in Figure 3. The curved trend of the RCF data for the 2 hour carburization indicates a minimum failure life of about 2 million cycles. The 4, 8, and 12 hour carburization groups all have an L10 life within 10% of 3.7 million cycles. The 24 hour carburization showed the greatest performance life with a nominal L10 of 18.5 million cycles – an increase of 400% over the average L10 life of the 4, 8, and 12 hour groups.

This data, along with the hardness, residual stress, and retained austenite data discussed in our previous Diffraction Notes, demonstrates how process optimization can be achieved when multiple variables are measured and studied as a whole. An outline summarizing the comprehensive results of the study is shown below. Leveraging experience and expertise in residual stress, retained austenite, and fatigue testing, Lambda Technologies can aid in the process optimization of specific applications, such as the carburization of steels.

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SUMMARY OF ALL RESULTS

Hardness

- Comparable near surface hardness for samples carburized more than 4 hours
- Effective case depth increases as carburization time is increased

Residual Stress

- Fairly high compressive surface stress from grinding
- Moderate compressive residual stress magnitude, comparable for all samples, due to carburization
- Depth of compression increases as a function of carburization time

Retained Austenite

- Both the amount and depth of retained austenite generally increases as function of carburization time

Rolling Contact Fatigue

- Best fatigue life for longest carburization time.
- Comparable RCF performance at intermediate (4, 8 and 12 hr.) carburization times

Overall Summary

The 4 hr. carburization time produced fatigue life, residual stress and hardness comparable to the 8 and 12 hr. carburization times while producing relatively low austenite content. The 24 hour carburization provided the highest fatigue life, however, it also produced the highest retained austenite content. The 2 hour carburization samples had the lowest fatigue life of the group.

By characterizing fatigue performance, residual stress, retained austenite and hardness of various carburization processes a heat treatment can be designed to meet the custom requirements for a specific application.

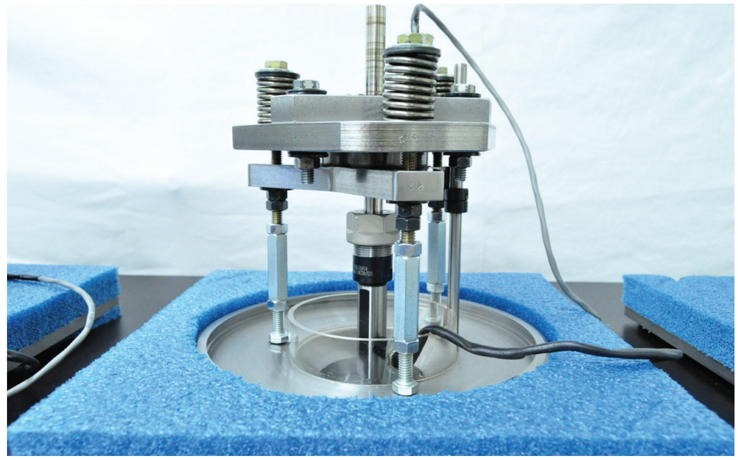

Figure 1: Rolling Contact Fatigue Testing Unit

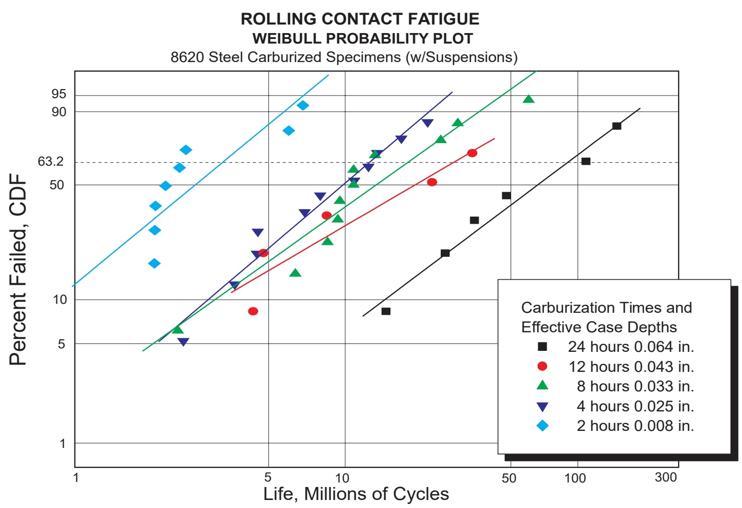

Figure 2: Weibull Probability Plot of 8620 Steel Carburized Rolling Contact Fatigue Specimens

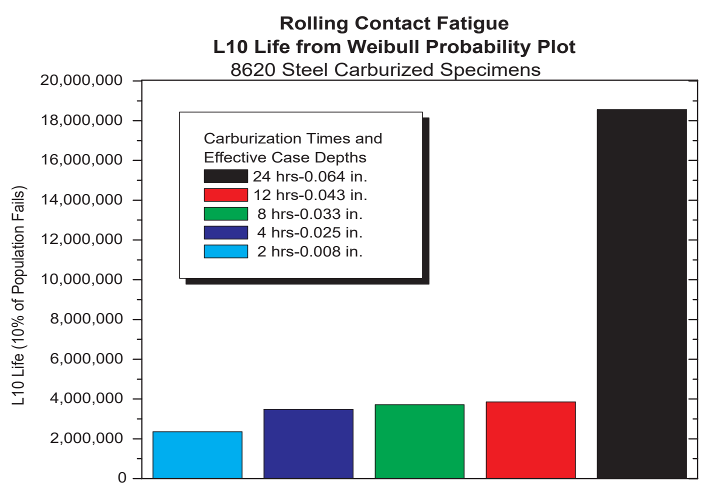

Figure 3: Unit L10 Life from Weibull Probability Plot of 8620 Steel Carburized Rolling Contact Fatigue Specimens

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