LAMBDA Technologies Group

Diffraction Notes

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RESIDUAL STRESS AND RETAINED AUSTENITE IN CARBURIZED 8620H STEEL COMPONENTS (PART 1 OF 2)

INTRODUCTION

AISI 8620H steel is used for a variety of medium-strength applications including gears, camshafts, fasteners, chains, and pins. Flexibility in carburizing treatments allows not only for various case depths to be achieved, but also for adjustments of other material properties, such as residual stress and retained austenite content.

Compressive residual stresses are generated by the carburizing process due to a gradient in carbon content. Residual compression can significantly improve the fatigue property of a component. Compressive residual stress depth and magnitude needed for optimal fatigue performance will vary depending upon the application.

Retained austenite can also be generated by the carburizing process. A low amount of retained austenite in martensitic structures is desirable because the body centered cubic ferrite and body centered tetragonal martensite phases are more stable than the face centered cubic austenite phase. High service temperatures can cause dimensional changes and out-of-bounds tolerances due to isothermal transformations from austenite to ferrite or martensite. Retained austenite also lowers the compressive yield and ultimate tensile strengths and lowers the hardness and resistance to scuffing while increasing susceptibility to heat checking in grinding operations. The carburization process can be chosen to achieve the desirable compressive depth with minimal retained austenite.

The purpose of this investigation was to demonstrate how residual stress, retained austenite and hardness vary with different carburization treatments. This investigation is Part 1 of 2 that will be presented. Part 1 will show how the hardness, compressive residual stress and retained austenite vary with different carburization processes. Part 2 will present rolling contact fatigue results for the various carburization processes.

TEST SAMPLES & CARBURIZING PROCESS

8620H steel in the form of a 0.5 in. diameter bar was purchased and machined into 6 in. long test samples 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. The full carburization process is illustrated in Figure 1. After carburization, the samples were low-stress ground to a final diameter of 15/32 in. that allowed for the samples to be tested in rolling contact fatigue. The low-stress grind was chosen to be similar to that used in a typical finish grinding process used in gear applications.

HARDNESS

Microindentation hardness measurements were performed on samples from each of the five carburization groups after low stress grind using a Knoop style indenter and a 500 kg load. The microhardness measurements were converted to Rockwell HRC values and are shown in Figure 2. The hardness distributions are comparable near the surface for samples carburized between 8 and 24 hours. The effective case depth increases as carburization time is increased.

RESIDUAL STRESS

X-ray diffraction residual stress measurements were performed in accordance with SAE HS-784. The longitudinal residual stress distributions measured as functions of depth are shown graphically in Figure 3. The residual stress distributions all indicate fairly high compression at the surface as a result of the low stress grinding and moderate subsurface stresses due to the carburization process. The depth of compression increases as a function of increasing carburization time.

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VOLUME PERCENT RETAINED AUSTENITE MEASUREMENTS

Lambda determined the volume percent retained austenite based upon first principles using a Bragg-Brentano diffractometer. The volume percent retained austenite was determined by the direct comparison method of Averbach and Cohen in accordance with ASTM E975 and SAE SP-453. The intensity factors, "R," were calculated using the unit cell volume and chemical composition of the AISI 8620H steel. Subsurface measurements were accomplished by removing material electrolytically.

Figure 4 shows the mean volume percent retained austenite distributions plotted as a function of depth. Retained austenite content generally increases as a function of increasing carburization time. The surface retained austenite is as high as 16% for the sample carburized for 24 hours and as low as 6% for the samples carburized for 2 and 4 hours.

SUMMARY

Near surface hardness increases up to an 8 hour carburization time. Near surface hardness remains relatively unchanged at carburization times greater than 8 hours. The depth of hardness continuously increases as carburization time was increased.

The compressive residual stress depth increases with an increase in carburization time. However, the maximum compressive residual stress magnitude is similar for all of the carburization times investigated.

The volume percent retained austenite depth and magnitudes both increased as carburization times increased.

A wide array of material properties such as hardness, volume retained austenite and compressive residual stress can be achieved through adjustments to the carburization process. These material processes can be adjusted to provide optimal component performance.

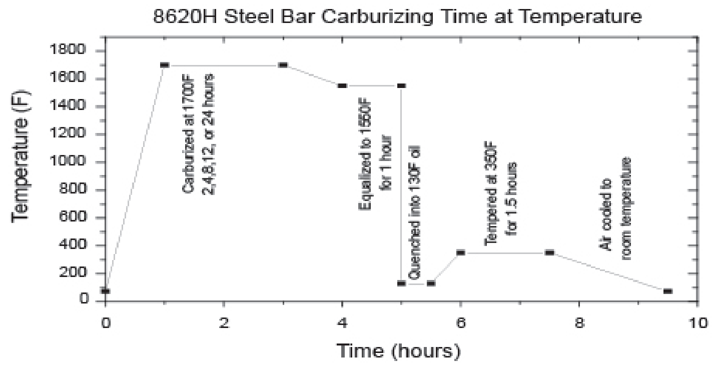

Figure 1: Carburization Processing for 8620H Steel Bars

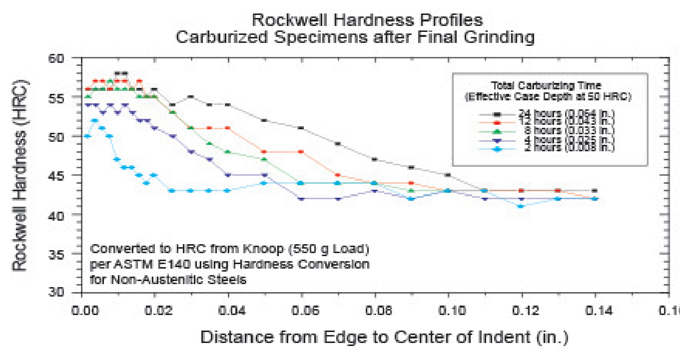

Figure 2: Rockwell Hardness Distributions

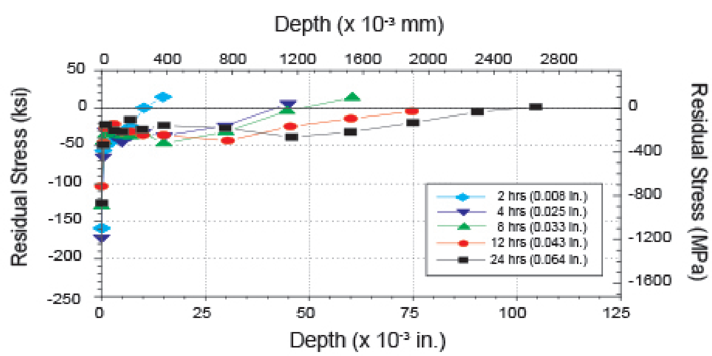

Figure 3: Residual Stress Distributions

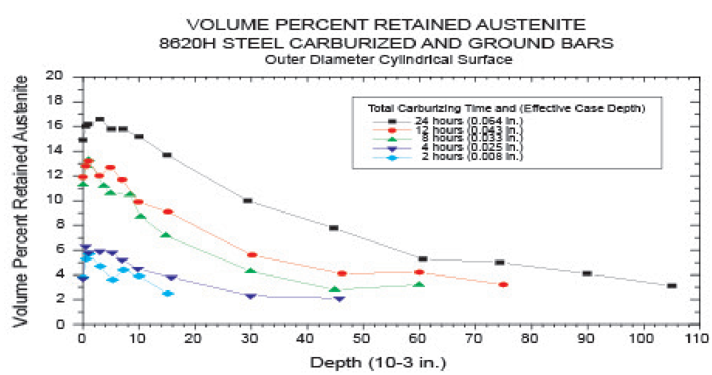

Figure 4: Retained Austenite Distributions