

Crack Length and Depth Determination in an Integrated Carburized Gear/Bearing

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American Gear Manufacturers Association



TECHNICAL PAPER

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[The statements and opinions contained herein are those of the author and should not be construed as an official action or opinion of the American Gear Manufacturers Association.]

Abstract

During overhaul of a primary drive helicopter Spur Gear, which also serves as the outer race for an integral spherical bearing, magnetic particle inspection detected an approximately 0.3-inch long crack indication on the raceway surface. Subsequent metallurgical evaluation disclosed that the indication was a 0.028-inch deep, pre-existing grinding crack that had not been detected by the manufacturer during final inspection. A sample re-inspection of product that was currently in storage that had been shipped from this manufacturer revealed that additional components with grinding cracks. In an effort to determine if the processing cracks posed a safety of flight concern, several gears that contained cracks were designated to undergo a rigorous dynamic bench test. However, in order to insure that the bench test produced the maximum amount of relevant test data, it was necessary to document, nondestructively, all of the grinding crack dimensions (location, lengths, and depths) prior to the start of the test. The locations and lengths of the cracks were determined using a specially modified magnetic rubber inspection technique, which could reliably document crack lengths as short as 0.006 inch. A fixture was developed that made it possible to produce a magnetic rubber casting of the gear raceway, while simultaneously performing up to thirty, one second central conductor shots. To nondestructively estimate crack depths, a unique, highly sensitive, laboratory eddy current inspection technique was developed. Using a limited number of data points, a “response-to-depth” curve was generated that predicted the maximum crack depths to ± 0.002 inch. Using these two techniques, the “status” (i.e., growth) of each crack was monitored at various stages of the bench test. At the completion of the bench test, a detailed destructive metallurgical evaluation of each of the test gears was conducted and documented. The post-test data confirmed the accuracy of the nondestructive eddy current estimates, and provided additional data that will make future crack depth predictions more accurate.

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INTRODUCTION

During a scheduled overhaul of a military helicopter transmission, magnetic particle inspection revealed an approximately 0.30 inch long crack indication on the outer raceway of an Integrated Planetary Gear/Bearing Assembly. In this integral design, the gear manufacturer carburizes an approximately 7-inch pitch diameter spur gear (4 inch tooth width), including an approximately 5.7 inch diameter spherical bore. The gear manufacturer completes the gear teeth portion of the spur gear, and the spherical bore is subsequently ground by the bearing manufacturer. The raceway of this Gear/Bearing Assembly is carburized to a 50 HRC effective case

depth of 0.070-0.090 inch. After finish grinding of the raceway, the bearing manufacturer performs a 100% magnetic particle inspection and a surface temper inspection (i.e., Nital Etch) of the spherical raceway. If no indications are found, the gear is matched with a through hardened Inner Ring, Rolling Elements, and cage to complete the Integrated Planetary Gear/Bearing Assembly.

Both the Forward and Aft Chinook Transmissions contain six of these Planetary/Gear Bearing Assemblies comprising the Second Stage Planetary System. A schematic illustrating the location of the Second Stage Planet Gear/Bearing in the Forward Transmission Assembly is shown in Figure 1. A photograph showing the magnetic particle indication on the spherical raceway of the Planet Gear returned from service is shown in Figure 2.

