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A Novel Approach to the Refurbishment of Wind Turbine Gears

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A Novel Approach to the Refurbishment of Wind Turbine Gears

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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

Multi-megawatt wind turbine gearboxes operate under demanding environmental conditions including considerable variation in temperature, wind speed, and air quality. It is not uncommon for gearboxes rated for a maintenance free 20-year lifespan to fail after only a few years. These gearboxes experience several types of repairable damage including micropitting or “gray staining”, abrasive wear, foreign object debris (FOD) damage, surface corrosion and fretting corrosion. Wear is greatest on the input stage, especially on the sun pinion gear. Historically, grinding is utilized to refurbish these damaged gears. However, there are numerous drawbacks including but not limited to high capital investment and the extraordinary amount of time and skill involved in the grinding process. Moreover, nitrided gears cannot be ground and must be scrapped. However, chemically accelerated vibratory finishing, or isotropic superfinishing (ISF), represents a value adding, low-cost option for refurbishing both case carburized and nitrided gears. Isotropic superfinishing removes light to moderate gear flank surface damage. The result is a surface with a non-directional pattern with a roughness of approximately 0.08 mm or less. Moreover, evidence suggests that isotropic superfinishing imparts a finish that increases gear durability and service life in the field. A case study on a sun pinion gear is presented.

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Introduction

Typical multiple megawatt (MW) gearboxes, 1.5 MW and higher, are designed to operate for 20 years without requiring major maintenance to the drive train. However, many owners are experiencing gearbox failures after only a few years of service. Gearbox repairs may cost \$360,000 (USD) or more for a complete replacement by 2009 estimates [1]. Gears fail for several reasons. Wind turbine gears operate under extreme environmental conditions including highly variable temperature, wind speeds and air quality. These conditions cause variable high loading and torque. During periods of low or no wind, the loading on slowly moving or stationary gears is exacerbated. Moreover, moisture can contaminate the lubricant and condense on the gear surfaces forming sludge, corrosion and micropitting. Finally, dust and other foreign debris in the air can contaminate the lubricant during maintenance leading to abrasive wear. Fortunately condition monitoring systems allow gearbox problems to be discovered before serious gear damage occurs [2, 3].

Background

Wind turbine gears experience several types of repairable damage including micropitting or “gray staining”, abrasive wear, foreign object damage (FOD), surface corrosion and fretting corrosion. An example of each is depicted in Figure 1 [4, 5]. There are three main approaches to repairing gear damage: refurbishment by regrinding, refurbishment by surface finishing or replacement with a new gear. The refurbishment process is a combination of reclamation and reconditioning of a used gear or bearing [6]. New gearing is expensive which makes surface finishing and regrinding the preferred low cost alternatives. Regrinding is necessary when lead and profile corrections are required on the working surfaces of the gear teeth [7].



Figure 1a. Micropitting or gray staining on gear flanks

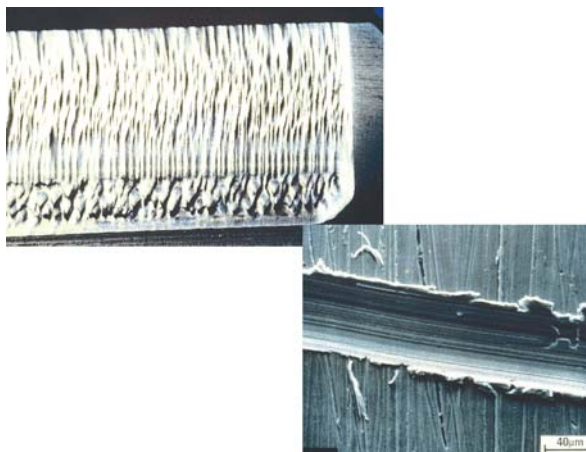


Figure 1b. Heavy abrasive wear on gear flank and a SEM image of trail left by an abrading particle [4]



Figure 1c. Foreign object debris (FOD) damage