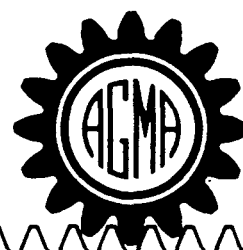


The Effect of Material Defects on Gear Performance - A Case Study

by: R.J. Drago, Mechanical Power Transmission Systems
Consultants and A.F. Filax, University of Chile

American Gear Manufacturers Association



TECHNICAL PAPER

The Effect of Material Defects on Gear Performance

**Raymond J. Drago, Mechanical Power Transmission System Consultants and
Alejandro Font Filax, University of Chile**

[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

The quality of the material used for highly loaded critical gears is of primary importance in the achievement of their full potential. Unfortunately, the role which material defects play is not clearly understood by many gear designers. The mechanism by which failures occur due to material defects is often circuitous and not readily apparent. In general, however, failures which are associated with material defects show characteristics which point to the source of the underlying problem, the mechanism by which the failure initiated, and the manner in which it progressed to failure of the component.

In this case study, the authors examine the failure of a medium sized pinion used in a mining application. The mode of failure was rather catastrophic in nature but did not follow any of the typically understood mechanisms such as tooth bending, surface distress, wear, etc. Often, as was the case for the subject pinion, material defects do not manifest themselves in these more typical tooth oriented failure modes, though the initial presentation of the failure often suggests more classical origins.

A complete shaft fracture was the ultimate cause for the pinion's removal from service. Initial inspection of the failed pinion indicated the presence of cracking in the toothed area. This cracking appeared to have progressed through the pinion and resulted in the shaft fracture which caused the pinion to cease transmitting torque. In order to avoid a recurrence of the problem in this very critical application, it was very important to understand the failure fully including its cause and progression mechanism.

This paper presents a summary of the failure, its investigation, and the methods proposed for its resolution. The data is presented in tutorial format so that the basic effect of the identified material defects can be better understood and used in future designs.

Copyright © 1999

American Gear Manufacturers Association
1500 King Street, Suite 201
Alexandria, Virginia, 22314

October, 1999

ISBN: 1-55589-752-5

AVA Documents
Document Sharing Hub

The Effect of Material Defects on Gear Performance

— A Case Study —

Raymond J. Drago, P. E.
Chief Engineer
Drive Systems Technology, Inc.
Mechanical Power Transmission Systems Consultants
24 Marlborough Lane
Glen Mills, PA 19342-1519

Professor Alejandro Font Filax, PhD
Department of Mechanical Engineering
University of Chile
Beaucheff 850 - 5 Piso
Casilla 2777 Correo 21
Santiago, Chile

The quality of the material used for highly loaded critical gears is of primary importance in the achievement of their full potential. Unfortunately, the role which material defects play is not clearly understood by many gear designers. The mechanism by which failures occur due to material defects is often circuitous and not readily apparent. In general, however, failures which are associated with material defects show characteristics which point to the source of the underlying problem, the mechanism by which the failure initiated, and the manner in which it progressed to failure of the component.

In this case study, the authors examine the failure of a medium sized pinion used in a mining application. The mode of failure was rather catastrophic in nature but did not follow any of the typically understood mechanisms such as tooth bending, surface distress, wear, etc. Often, as was the case for the subject pinion, material defects do not manifest themselves in these more typical tooth oriented failure modes, though the initial presentation of the failure often suggests more classical origins.

A complete shaft fracture was the ultimate cause for the pinion's removal from service. Initial inspection of the failed pinion indicated the presence of cracking in the toothed area. This cracking appeared to have progressed through the pinion and resulted in the shaft fracture which caused the pinion to cease transmitting torque. In order to avoid a recurrence of the problem in this very critical application, it was very important to understand the failure fully including its cause and progression mechanism.

This paper presents a summary of the failure, its investigation, and the methods proposed for its resolution. The data is presented in tutorial format so that the basic effect of the identified material defects can be better understood and used in future designs.

Introduction

In 1992, two new single helical gear sets were installed as part of a new mill system at a mine site. The pin ion and gear sets are used to drive essentially identical ball mills used for processing ore from the mine.

After some relatively minor start up problems, the gear sets were placed into normal service and performed without significant incident until some pitting was discovered during a visual examination conducted late in 1994. At that time, we noted only very minor surface distress, as Figures 1 and 2 show. The distress was located at about the middle of the face width and had been slightly ground out at the time of my November 1994 visit.

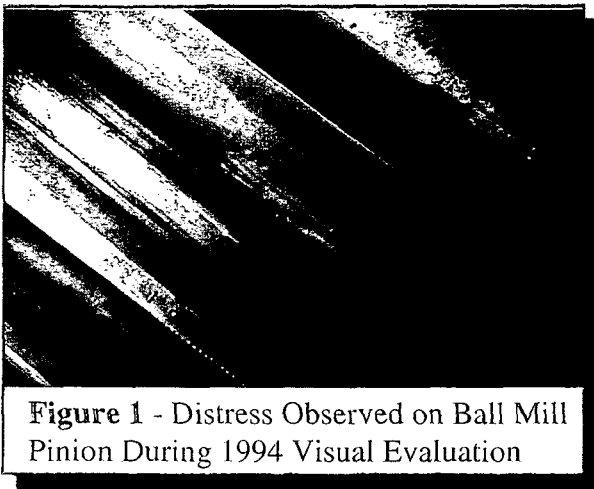


Figure 1 - Distress Observed on Ball Mill Pinion During 1994 Visual Evaluation



Figure 2 - Close View of Distress Observed on Ball Mill Pinion During 1994 Inspection

The pinion shown in Figures 1 and 2 was in service until removal in August 1995 because of severe surface damage. It was reinstalled in mid 1998 and failed catastrophically in 1998, approximately three working years after startup. The number of cycles accumulated by the pinion at the time of failure was something lower than 3×10^8 . This, therefore, was certainly not a low cycle failure, but one third of the total design life.

The failed pinion was replaced and the mill restarted. During a visual inspection conducted in early 1999, the new, replacement pinion was found to be exhibiting pitting very similar in both extent and location as the original pinion. This pitting was hand dressed out and was found to have not progressed significantly during a visual inspection which was conducted during April 1999, as Figure 3 shows.

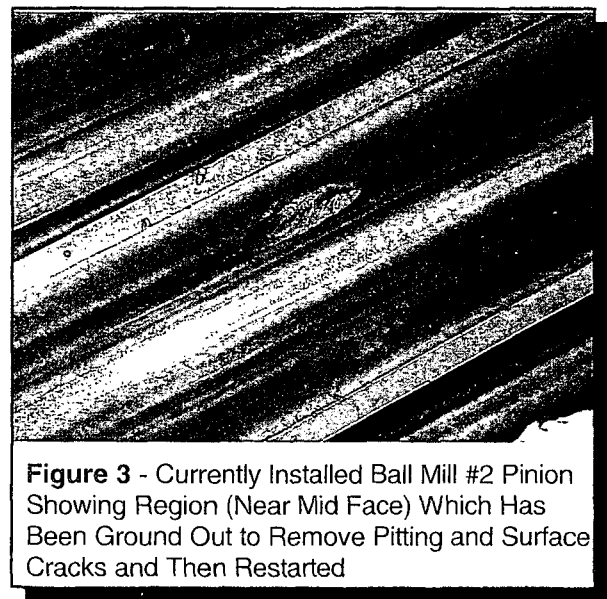


Figure 3 - Currently Installed Ball Mill #2 Pinion Showing Region (Near Mid Face) Which Has Been Ground Out to Remove Pitting and Surface Cracks and Then Restarted

During an inspection in April 1999 we did not observe any cracks on this pinion (we were unable to dye check it) but it was reported to have some cracks in the pitted region which were discovered during a previous dye check inspection. The cracks were ground out and the pinion was returned to service. At the time of our inspection, it appeared that only minor progression of the pitting was occurring.

Second Helical Gear Set

As noted above, there are two identical mill gear systems on line at this site. The second mill was running at the time of our visit and we were unable to shut it down for a good look at the teeth. We were able to visually examine the teeth through the inspection port with the aid