

Abrasive wear, as it turns out, is a much more complicated and multifaceted condition than many people realize. In this installment the author provides a helpful review.

A common mistake is to relate surface hardness to wear resistance. Other factors are also involved, such as ductility; the balance of free carbides in a soft matrix that can be secure or easily detached. In wear tests, case-hardened carburized gears partnered with softer through-hardened gears developed the most wear. Even when profile ground with a high surface finish, the surface still reacted like a file on the softer mating gear. The presence of carbide near the surface may be a contributory cause. Of all types of failures, wear is probably the most easily recognized. Wear can be considered in several different modes: polishing, fretting, spalling/macropitting, micropitting/gray staining/frosting, scoring/scuffing, scratching/streaking, electric discharge, and corrosive. A wear mode is either adhesive or abrasive. Gear tooth durability rating methods are based on preventing pitting failures and are not able to adequately calculate for the previously mentioned surface damage possibilities.


Abrasive wear leaves its own distinct marks, such as grooves and scratches. This type of wear is caused by a cutting or plowing action created by a chip or fragment that has parted from the tooth flank. The type of particle can be normal, severe, cutting, chunky, laminar, normal spherical, or associated with the breaking-in of the gears. They are therefore a variety of shapes, thicknesses, and lengths that can act as a guide to their source. Flat platelets are found in the lubricant from the rubbing action, and cutting chips are usually curved. Abrasive wear has also occurred when the contacting flanks have the appearance of being lapped and have radial scratch marks that, under the microscope, appear as grooves. Plastic deformation in varying amounts is also associated

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with this type of wear. Typical causes are the mating of a hard surface gear with a softer gear surface or hard particles from an exterior source in the mesh. Another abrasive wear phenomena is a polished surface on the tooth flanks. It is not unusual for gears that have been well lubricated and run for many cycles to show a polished surface. If the polishing is uniform and extensive on the tooth flank, it indicates a properly designed, manufactured, and maintained gear with a low rate of wear, and there is no cause for concern. The slow progressive wear can be classed as mild when it is confined to the surface peaks and ceases before the original machining marks have been removed. This condition is common after the initial run-in and is not sufficient a problem as to have an adverse effect on the gear. A continuing stage removes all the original machining marks, leaving what may be an undulating surface and steps—this is severe polishing and is detrimental to the operation of the gears. Polishing is classed as a failure mode when it results in gear inaccuracies or a reduc-

tion in critical dimensions. Polishing can lead to an increasing amount of uniform wearing of the tooth profile. It is sometimes observed as a ridge at the operating pitch line of the teeth. The viscosity must not be too low or too high, and the additives must have the right balance. An ineffective lubricant increases the heat and thereby the efficiency losses, reduces the oil film, and increases the chances of detrimental polishing. The primary cause is by abrasion from minute particles carried in a combination of gear oil with chemically active additives. Gear oil contaminated with iron oxide particles is a leading cause of these phenomena.

Polishing wear is generally found on low-speed applications (< 4,000 fpm), when the oil film is too thin or the lubricant is performing near its limit. This type of wear can be prevented by the use of borate anti-scuff additives and removing abrasives from the lubrication. More frequent oil changes and finer filters will also alleviate the problem. The problem will not arise if the oil does not contain abrasive particles. For splash lubricated gears this means frequent oil changes. Using a high-viscosity lubricant that develops a thicker oil film can also reduce the wear. The inside of any enclosed gear drive should be thoroughly cleaned and the filters carefully selected. When cleanliness procedures have been adopted, the wear will stabilize.

In a study by Bhachu at the Imperial College, London, in 1981, it took only 30 minutes for wear damage to occur in a gear unit with 40µm filters because the filters were not fine enough to keep out the debris. When there is extreme wear in case-hardened gears, it results in a rapid reduction in case thickness. In such a situation the result will be another kind of failure, spalling, which will be terminal for the gear teeth. 

ABOUT THE AUTHOR:

William P. Crosher is former director of the National Conference on Power Transmission, as well as former chairman of the AGMA's Marketing Council and Enclosed Drive Committee. He was resident engineer-North America for Thyssen Gear Works, and later at Flender Graffenstaden. He is author of the book *Design and Application of the Worm Gear*.