"Premature" Gear Failure

Email your question — along with your name, job title and company name (if you wish to remain anonymous, no problem) to: *jmcguinn@geartechnology.com*; or submit your question by visiting *geartechnology.com*.

QUESTION

I would appreciate if you could assist with a gear failure (occurring) after just seven weeks in service, post installation. This driving gear wheel has been installed in a medium-speed engine with backlash present at four different positions; with additional backlash checked on the mating surfaces. All backlash was found within (OEM)-recommended values. Please note included photos — it seems that the crack has started at the root fillet. Any comments would be appreciated.

Expert response provided by Chuck Schultz (PE).

No simple answers — despite the excellent photographs and concise description of the problem, there is just not enough information to "solve" this mystery. At the risk of being accused of "running the meter," there are many more questions to ask and tests to run before we could claim to know why this part failed after "only seven weeks." What follows is the procedure I use when confronted with a failure analysis request.

Understand the application. Based upon your request, we will assume seven weeks is much less than the expected life of a part in this service. I mention this because due to the statistical nature of allowable stresses, short design lives have more risk of premature failure. We need to know if this is a new installation or a replacement part. How have similar machines performed? Were there design or material changes on this particular part? Has the duty cycle changed? Has the operation changed? Something as simple as number of starts-per-shift can change a reliable machine into a maintenance hog.

It is very easy to jump to conclusions when doing a failure analysis. It is noted that the crack seems to have started at the root; ANSI/AGMA 1010 (Appearance of Gear Teeth -Terminology of Wear and Failure) is an excellent resource for failure analysts, and most of the tooth breakage photos

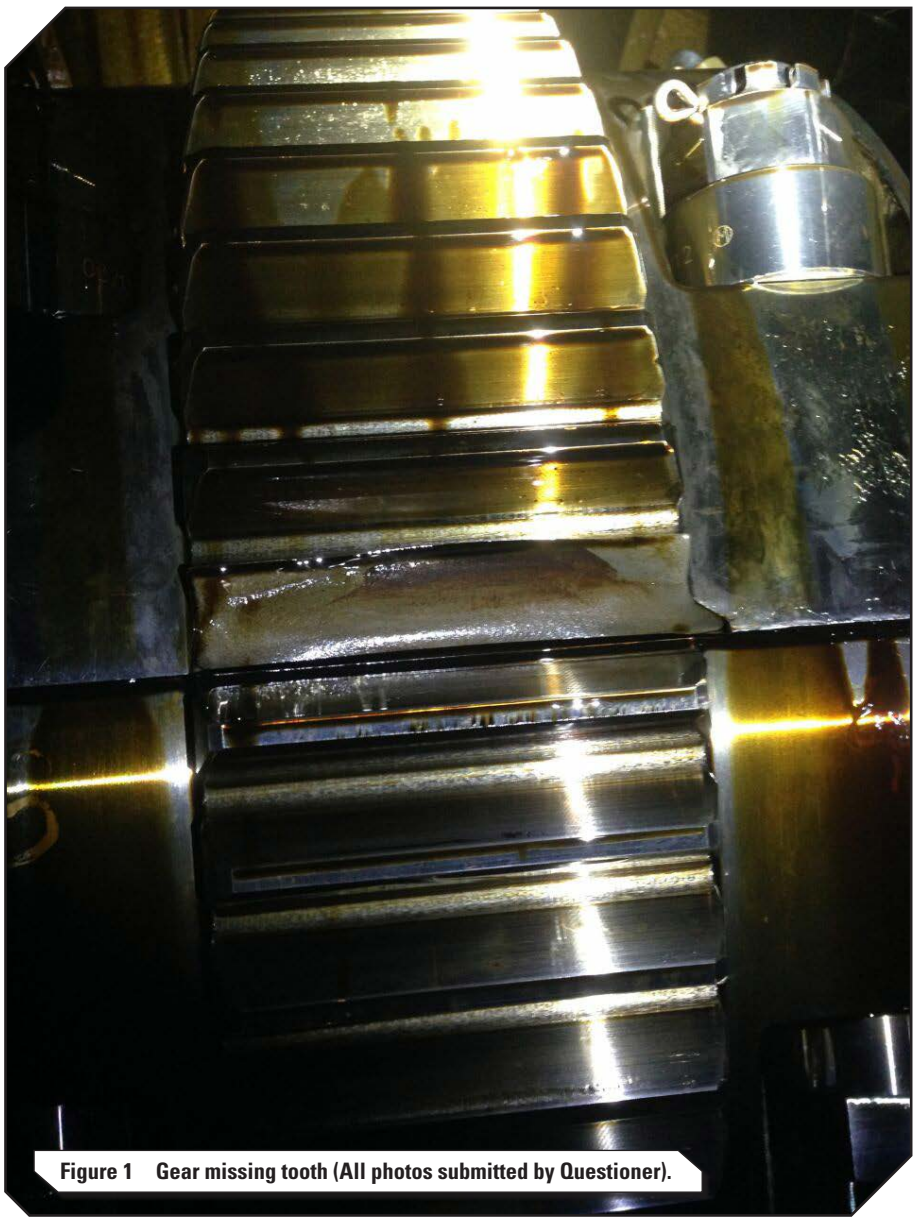

Figure 1 Gear missing tooth (All photos submitted by Questioner).

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show "activity" at the root. Each photo, however, has a different cause and suggested remedy. Applying the wrong remedy will just extend the failure and run up the cost.

Know the part's history. We once had a steel mill customer who was notorious for "re-cycling" used parts back into service. Used, as in "retrieved from the pile in back of the millwright's shop." I often tell people that if they could develop a way to accurately determine how much life was left in a part, they would be richer than King Midas. In the questioner's case we are told the part is new but there is still much to learn about what it was made of, what thermal processing it was subject to, and what quality control checks it had passed. Was it built to the right drawing? Was the material per the print? Was it checked for cracks along the way? Was it installed properly?

Verify the part's construction. Failed parts should be sectioned for tests at a qualified metallurgical laboratory. More than once the investigators have been shocked to discover the "wrong" material and heat treat were used to produce the component. "Wrong" could be a carburized part made on a through hardened base material, a through hardened part on a low- alloy material, or a strain hardened material that was thermally heat treated. Unfortunately, the world is awash in counterfeit parts that look just like the "real thing." Users do not know they have been bamboozled until a failure occurs and the met lab advises them that the base material doesn't match anything typically used for similar parts.

Some tests can be done in the field, without taking the machine further apart. The questioner reports checking backlash, yet nothing in the photos indicates poor assembly or misalignment. A quick check with crack detection compounds will reveal if the breakage is isolated to that particular tooth or if it had already spread to other teeth. While crack checking, examine the rest of the part closely for signs of poor heat treat, sloppy deburring, or damaged edges.

Talk to the operators and mechan-

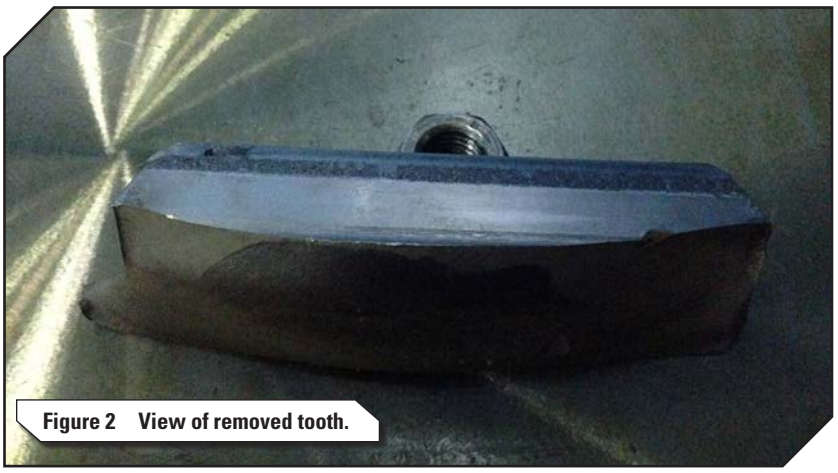

Figure 2 View of removed tooth.

ics. Experienced operators can often sense when a machine is ready to fail. Inexperienced operators are unfamiliar with the warning signs and may bring on the disaster by ignoring long established procedures. Important clues can tumble out during casual conversation, things like wrecks elsewhere in the plant or new millwrights on the job.

Notice I said "talk"—not interrogate. An adversarial relationship doesn't help get to the truth. We once received a warranty claim gearbox with all the load flanks worn off, the bottom coated with filings, and the sump filled with brand new hydraulic fluid. Someone was worried about losing their job for not filling the box with gear oil before start-up and dumped in the handiest barrel of "oil" around. That failure was

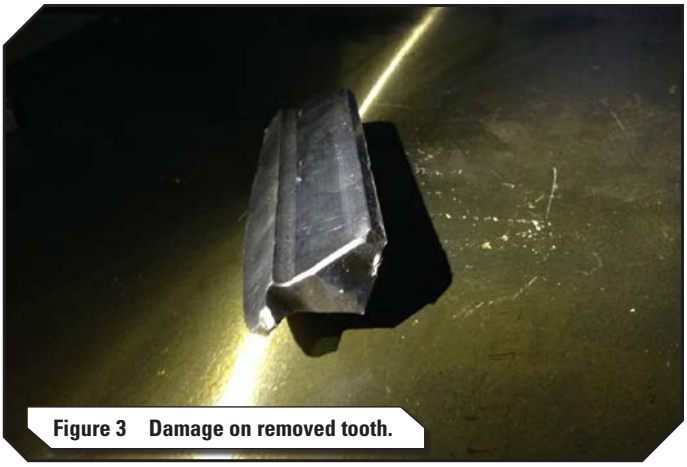

Figure 3 Damage on removed tooth.

the first of that type in the installation, yet "nobody" knew anything about it. I am not saying this is the case in the questioner's failure, but skepticism is the appropriate attitude for every investigator.

Review the facts. Once you have all the evidence in hand, go back again to ANSI/AGMA 1010 and review the photos, possible causes, and recommended remedies. Different causes can result in similar failures, but careful analysis of the evidence will usually result in a long-lasting solution.

Albert Einstein is famously quoted as saying "Things should be as simple as possible, but no simpler." It is tempting to rush to a conclusion based upon the appearance of a worn or broken tooth. Tempting—but expensive—in the long run. Unfortunately, three photos are not enough information to determine the cause of this failure.

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