Fail Better

Phillip Olson, Director, AGMA Technical Services

> "Ever tried. Ever failed. No matter.
> Try Again. Fail again. Fail better."
> —Samuel Beckett

This month's issue of *Gear Technology* covers a subject engineers love to learn about from others but hate to learn about through firsthand experience: gear failure. In a broad sense, all engineering is concerned with failure. Eventually, all parts fail, so engineers need to determine the limits of their design and ensure that it will meet the requirements of the particular application. How do they do this? One option is trial and error; despite being expensive and slow, it is a good way to test things that have never been done before. Another option is studying academic papers and textbooks, which is good for building your base knowledge. But in my opinion, designing to industry standards, and learning directly from experts that have already seen what can go wrong, is the best way for engineers to avoid unexpected failures.

Standards are based on proven and verified practices and capture years of industry knowledge in two ways. First, the authors of the standards bring all their knowledge of what works—and just as important, what doesn't work—to the table. And second, because the first AGMA standards were published over 100 years ago, countless gears have been designed using these standards—and revisions to the standards have been made where necessary—so the engineer can have confidence that these established practices work.

Broadly speaking, all AGMA standards and information sheets are concerned with gear failure, but in the narrow sense, AGMA has two gear failure-specific definition documents that need to be mentioned. Every gear engineer should be familiar with ANSI/AGMA 1010-F14, *Appearance of Gear Teeth—Terminology of Wear and Failure*. This standard identifies and describes common gear failures and offers recommendations to avoid the failure modes. The current, 6th edition was published in 2014 with 89 detailed color figures showing gear failures over 81 pages. This is quite the leap from the first edition, titled AGMA 110.01, published in 1943 with 20 black and white pictures within 10 pages. AGMA's other failure nomenclature document is AGMA 944-A19, *Mechanisms of Powder Metal, PM, Gear Failures*. It is written similarly to ANSI/AGMA 1010-F14 but covers powder metal gear-specific failures over 30 pages and includes 11 detailed color figures. AGMA's goal for the next revision of ANSI/AGMA 1010 is to incorporate powder metal gear failures and expand the standard to include plastic gear failures—definitions never published by AGMA before.

On the ISO side, ISO 10825-1:2022 and ISO/TR 10825-2:2022 are very similar to ANSI/AGMA 1010-F14. This is due to AGMA being a member of the ISO working group that published both documents and due to AGMA offering ANSI/AGMA 1010-F14 to the working group as the starting point. A main difference with the ISO version is that the subject has been split into two documents, with ISO 10825-1 covering definitions of gear failures and ISO/TR 10825-2 covering recommendations to avoid the failures.

I should also mention AGMA's top-notch gear education program, where you can learn directly from experts in the industry. Similar to standards, one could argue that most education courses are concerned with failure. But specifically, the gear failure topic is front and center in two of AGMA's most popular courses: Gear Failure Analysis, and Gearbox CSI.

In the Gear Failure Analysis course, students not only see slides of failed gears but can also hold and examine over 130 specimens with the same failure modes covered in the seminar. Approximately half of the course time consists of groups of students identifying failure modes on failed gears and working on a case study.

In the Gearbox CSI course, students define and explain the nature of many gear and bearing failures, and they also discuss and describe various actual failure scenarios. In addition, a detailed primer on bearing technology prefaces the failure scenario discussions. Students gain a better understanding of various types of gears and bearings, learn about the limitation and capabilities of rolling element bearings and the gears that they support, and grasp an understanding of how to properly apply the best gear–bearing combination to any gearbox, from simple to complex.

In conclusion, I encourage you to take advantage of the information out there, to learn from others, and to "fail better" which means avoiding repeating the mistakes of the past and then making and sharing the new ones that are an inseparable part of pioneering progress.

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