The Three Rs of Gearbox Repair: Repair, Refurbish, Replace

Jack McGuinn, Senior Editor

"If it ain't broke, don't fix it," goes the hoary bromide. But what if the time comes — and it most surely will — that in fact it *is* "broke"? Do you fix it — or replace it? And when does gearbox maintenance and repair arrive at a point of diminishing returns and buying new is the answer?

If it's an industrial gearbox that happens to be an essential component of the smooth running of a production line, repair is the likely — and typically cheaper — way to go (but this can be tricky). Cheaper in that — it's not new; cheaper because the lead (and/or down) time to repair a gearbox is typically shorter than sourcing, procuring and shipping the absolutely exact OEM gearbox — which also of course requires certification and installation.

Google "gearbox failure" and everywhere you look you'll find the main culprits to be over-heating, excessive vibration, bearing failure, lubrication failure and/or leakage, and oil contamination. But how do you define gearbox failure? What does it look — or sound — like?

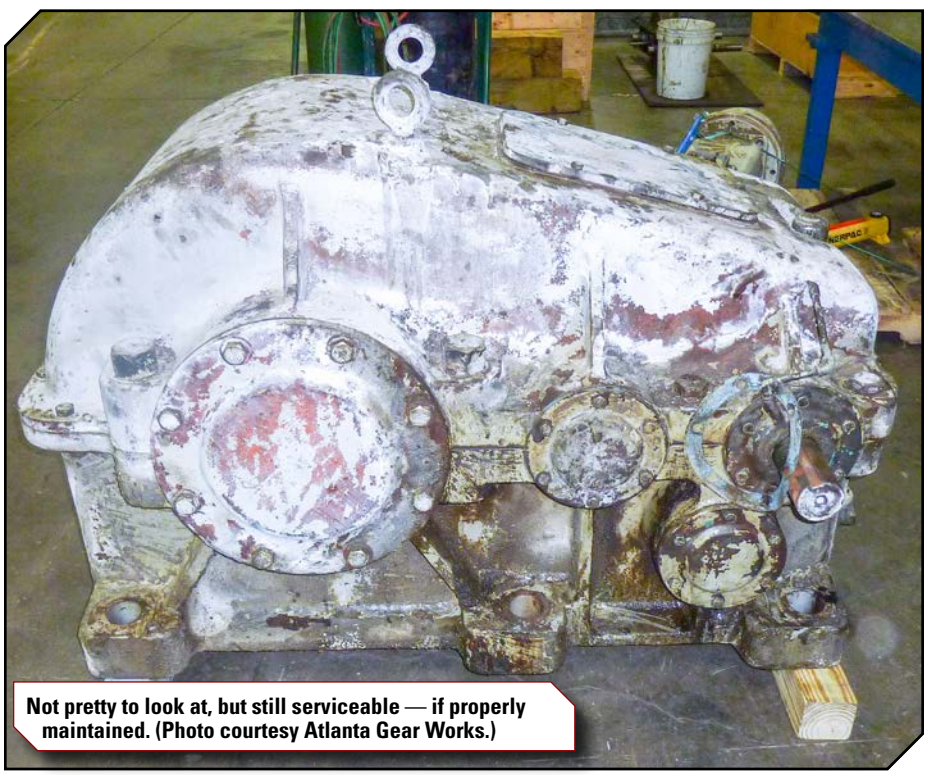
According to Chuck Schultz, chief engineer and owner of Beyta Gear, and longtime AGMA member and *Gear Technology* blogger, "Our customers have their own definition of "gear failure" and it has nothing to do with bending stress or durability rating. The average mill superintendent cares about only one thing: *Can the equipment work today?* If a little pitting or a small crack appears, the user couldn't care less if production can continue. While some of the more sophisticated plants are rapidly moving towards a "predictive maintenance" environment, the vast majority of mills react only to catastrophic breakdowns. We've seen some incredible performances by gearboxes run completely without oil for months or missing sizable tooth fragments due to bearing related misalignment. We have seen very few "failures" caused by over rating or misapplication, although overloads due to process line "crashes" and field modifications remain a significant problem. AGMA's standards writers and the application engineers can be justifiably proud of their work." (What makes this definition especially interesting is that it was taken from an AGMA paper — "Gearbox Field Performance from a Rebuilder's Perspective" — that Schultz wrote in 1999 and yet is still applicable applicable — and freely available in our *GT* Archive at *geartechnology.com*.)

Meanwhile, it appears that overheating is the most common of reasons and thus the primary cause for reduced gearbox life. Oil leaks pertain much as they do with the car you drive. If you are losing oil but continue driving — only bad (and expensive) things can happen. In a gearbox, leaks typically indicate that there is a gasket or seal issue. Aside from the fact that those issues lead to a drop in oil/lubrication levels, bad seals and gaskets can also lead to contaminated lubrication coursing through the gearbox. Bearings are also a typical casualty of low lubrication levels, another cause of premature gearbox failure. As for noise, if a gearbox starts sounding like a calliope or some other irksome sound, it usually means you have gear issues and possibly bearing problems as well.

The takeaway here is that all of the above can be avoided — or at least anticipated — with preventive maintenance.

But in an imperfect world, sometimes even preventive maintenance cannot predict when or if a gearbox will fail. So when that happens, repair is the viable option and usually puts things on the path of least resistance — and costly downtime.

So we asked a number of people intimately familiar with the rigors of preventive gearbox maintenance and timely repair — or replacement — a few



Not pretty to look at, but still serviceable — if properly maintained. (Photo courtesy Atlanta Gear Works.)

questions, looking for some repair-or-replace consensus regarding what is becoming an increasingly challenging endeavor as gearboxes and the sophisticated automation systems they are now being integrated into become increasingly complex.

We asked, for example, Craig S. Massa, vice president of sales for Atlanta Gear Works, Inc. — Accepting the premise, why do you think overheating is considered the most common issue regarding industrial gearbox repair and renewal?

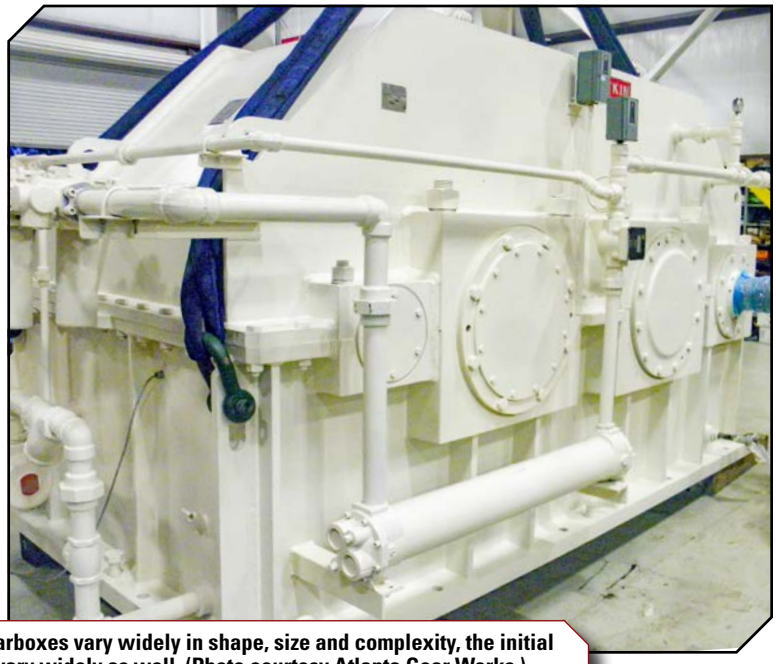
"We don't necessarily agree that overheating is the most common issue," says Massa. "Overheating is easily detected without any special monitoring equipment and therefore is usually caught and addressed before gearbox failure. We would say that more commonly industrial gearboxes are pulled for repair due to catastrophic failure, oil leaks or elevated vibration readings."

Chris Tegeder, marketing manager — wheels, gears and service for Xtek, Inc. — puts it this way: "Heat generation due to friction between moving components is the most common issue observed in gearbox repair. Proper lubrication keeps the heat within an acceptable level. However, there are many factors which can inhibit mating surfaces from seeing adequate lubrication. Some examples include poor design of the lubrication system, clogged or damaged lubrication lines, and even a human element in failing to initiate the lubrication of a gearbox after preventative maintenance."

Another explanation, supplied by Jim Petruga, sales manager for Northern Engineering, includes the observation that size does indeed matter.

"Gearboxes are getting smaller, which can make heat dissipation more challenging," Petruga explains. "Excess heat can degrade oil properties and destroy bearings. Overheating has become more of a problem since many newer gearboxes carry more horsepower-per-unit-of-mass, and use less oil, thus magnifying the results of an oil leak in terms of cooling capacity."

At Machinists Inc., Jason Jonson, assembly supervisor says that "Failure to change out old oil, keeping oil cool, filtering out particles in the oil are some failure modes that cause gearbox damage. Sometimes the design of the gearbox is the cause of the overheating. However most of the time it's the responsibility of the owner to make sure that the gearbox is properly maintained." Adds Jerry Magnuson, Machinists Inc.'s vice president, sales, "It is important to note that most of the time, a failing gearbox causes overheating, not vice versa. The user should evaluate the gearbox if overheating occurs and not wait for a catastrophic failure."



Because gearboxes vary widely in shape, size and complexity, the initial costs can vary widely as well. (Photo courtesy Atlanta Gear Works.)

As for Schultz, the overheating is merely a symptom of a bigger problem. "(Overheating) isn't (the cause); poor lubrication and maintenance are."

Gasket and/or oil seal leaks are also common contributors to gearbox failure. A problem like this seems to indicate that the gearbox receives less-than-robust preventive maintenance checks, that seal and gasket leaks are something that can be reasonably detected and remedied. After all, how difficult can it be to preventively monitor something as identifiable as a potential gasket or seal leak before real problems occur?

Tegeder isn't buying it. "Preventative monitoring of gasket and/or seal leakage is difficult. Other than periodic (daily/weekly/monthly) inspections for gasket/seal leakage, the only other thing that can be done is checking oil levels regularly and any oil pressure changes. Variances in pressure or oil level can be indicative of leakage. Often a small leak is very difficult to detect due largely to the environment that the gearbox resides in. Usually there is residual oil, dirt and grease around the gearbox that makes it hard to determine if there is a leak and where the oil is coming from. One method (And who hasn't done this in their own garage?) is to place an absorbent pad underneath a suspected leakage point and look for an oil spot on the pad. This is typically easier than looking for leaked oil on the ground or gearbox base."

While Massa explains that "Gasket and seal leaks are a visual thing; there really is no way to identify or monitor before a leak occurs," Petruga points out that "The operators might consider some smaller leaks a non-issue if the gearbox is well contained and the leak is managed with periodic additions of oil. However, this can be problematic if the rate of leakage increases or a periodic inspection is missed."

Simply put, Jonson states that "Proper maintenance is needed for oil leaks to be a non-issue. Depending on the accessibility of the gearbox, it should not be difficult to check for leaks with a good maintenance schedule." And Magnuson refers to another step in the process in that "All gearboxes should be spin tested after they're repaired to check for leaks. This should be required."

Also high on the list of contributors to gearbox failure are excessive noise

and/or vibration. But are those conditions — usual suspects — as impactful as is commonly believed?

"It is more complicated than just the 'usual suspects,'" says Tegeder. "Any change in noise or vibration is a cause for concern, but does not necessarily mean there is an imminent failure. It simply reflects a change of environment and/or operation. That is why a vibration and noise analysis is more of a study of the complete system over time to determine reliable indication of faults or failures."

For Schultz, it is in part a matter of being alert and paying attention. "*Changes* in noise, vibration, temperature, and amperage draw are what to look for."

Northern Engineering's Petruga points out "Almost every problem in a gearbox can be identified via vibration analysis. (Noise is just more audible vibration). As such, there are no real 'usual suspects' that are picked up solely because vibrations are being analyzed. Typical problems found would be things like bearing wear, gear tooth defects, misalignment, soft foot — or problems being introduced to the gearbox from the driving or driven machines."

"Noise or vibration can be caused by either something in the gear mesh or a bearing having an issue," says Machinists Inc.'s Jonson, while other reasons, according to Magnuson, are "improper alignment, lubrication, and harmonics."

Oftentimes, bearings are cited as the cause of gearbox failure. But isn't it really a question of what caused the bearings to fail?

Tegeder seems to agree in that "While there are bearings that fail due to under rating, or poorly manufactured bearings, the real root cause is often from sources other than the bearing itself. Since there are experts in the field of bearing failure modes, we often defer to them when analyzing bearing failures, but we often look at the complete assembly for indications, (rust/corrosion, contamination, loads, misalignments, etc.), that might provide insight into the cause of any bearing failure."

So let's say that a vitally important gearbox in a vitally time-sensitive production line is showing indications of imminent failure — or has stopped working altogether. The manager wonders — can it be repaired? Should it be repaired? Is refurbishment (reconditioning) an option? Or should it be replaced? How long will any of the above take? The answer, as one might suspect, can get complicated.

Extek's Tegeder:

Repair: "To us, a 'repair' is a specific issue or problem that is being addressed/fixed and not much else. For example, a gearbox comes to us with a broken shaft; our customer wants the shaft repaired. We would fix the shaft and send it back to the customer. We consider that a 'repair.' We basically fixed the known problem and not much else at the request of our customer."

Recondition: "We use the terms 'recondition' and 'refurbish' interchangeably at Xtek. In this instance we perform a full disassembly of all components (usually leaving gearing mounted on shafting). All of the components are cleaned thoroughly, full mechanical, metallurgical and hardness inspections are performed as well. We offer a detailed inspection report with our engineered recommendations, along with pricing. In this report we offer improvement suggestions regarding design, material type and hardness, as well as bearing upgrades or changes. After the 'reconditioning' or 'refurbishment' is complete, we perform a full no-load run test on every gearbox and record all the important run-off parameters electronically and keep them on file permanently."

Replace**:** "Replace is just what is says; we replace either components in the drivetrain or the entire drivetrain/gearbox assembly."

Taking issue with how the question is posed, Ramberg states that "This should (presented) as reuse/repair/replace. Reuse (means) OK to use as is. Repair involves refurbishing or repairing parts." Replace is full replacement of the part. Adds Magnuson, "Economics is the big factor in making the reuse, replace, repair calculus. (We) typically go beyond repairing the gearbox; we analyze the cause of failure and enhance the gearbox — either by design or production quality — to increase its service life."

At Northern Engineering, according to Petruga:

Repair**:** "A process carried out on a part or machine to fix a specific problem."

Recondition (refurbish)**:** Recondition and refurbish are basically the same thing. Taking an original part and fixing some defect with it to bring it to a level that meets or exceeds the OEM specifications.

Replace**:** A new part provided by the OEM or made to their specification.

A work of manufacturing art--a shiny-red industrial gearbox. (Photo courtesy Northern Engineering.)

Big or small, gearboxes overheat. The repair goal is to find out why. (Photo courtesy Atlanta Gear Works.)

Atlanta Gear Works:

Repair: "Simple oil seal change only. Typically done on a rush basis to keep equipment running."

Recondition (refurbish): "Change bearings, seals and potential replacement or kiss grind of gears and replacement of shafts."

Replace: "With OEM or drop in replacement; typically done if repair is equal to or more than 50-60% of new."

And Schultz qualifies it this way, adding a slight distinction regarding recondition vs. refurbish:

Repair: "Take out a worn or broken part; replace it with an OEM spare."

Recondition: "Strip down, clean, inspect, and replace worn bearings and seals, possibly re-cut or re-grind some gears."

Refurbish: "Same as recondition except more new parts and possible housing rework."

Replace: "Could be an OEM spare gearbox or similar."

Now that we have the repair-refurbish-replace nomenclature more or less defined, let's see how these various steps are priced. When does the meter start running? One assumes there's an evaluation of the problem process; and then a fix the problem process; and then some sort of post-fixing monitoring process. When does buying new become the best option? What determines the point of diminishing returns for repair vs. replace?

"The best results are often seen when Northern Engineering provides on on-site assessment, rebuilds the gearbox in-shop, then installs and aligns the rebuilt gearbox at the customer's location (to the proper OEM specifications)," says Petruga. "Ensuring that the gearbox is properly installed is key as misalignment and soft foot can be real gearbox killers. 'Post fix,' Northern Engineering will run a rebuilt gearbox on a no-load test table for several hours. Smaller gearboxes, shaft-mounted gearboxes, for example, are often not cost-effective to rebuild. The less expensive gearboxes are easily replaced with a new gearbox that is available off-the-shelf."

Atlanta Gearworks' Massa puts it this way:

"Our typical process is as follows:

- Receive gearbox for evaluation
- Disassemble and inspect at no charge
- Evaluation of gearing by MPI etc.
- Provide detailed inspection report/ quotation to customer
- After customer approval proceed as quoted
- No-load, spin test of gearbox
- Prepare for return shipment

Massa adds, "buying new is at the customer's discretion, which is typically 50-60% cost of new."

At Machinists Inc., Magnuson explains, "The repair or buy option has many factors. What is the availability of a new unit? Sometimes they're not available or the lead times are too long. Each repair has its own recipe. If too many parts need replacement, replacing the unit becomes more common. This is where a vertically integrated company like Machinists Inc. has an advantage. We have the ability to refurbish gears, oftentimes by re-grinding the teeth. Typically, the larger gears, which see fewer revolutions, can be saved by reconditioning — saving the customer money without sacrificing quality. The pinions that are driving them see more revolutions. These are replaced more often. Smaller units tend to be replaced more often. If a person can pick up a unit on their own, it would be a likely candidate for replacement."

Xtek's Tegeder: "Typically, the gearbox comes to us; we perform all of the disassembly/inspection/evaluation, and then provide our engineering report/proposal. We look at how many hours it took to perform all the aforementioned tasks, consider inbound freight and what the repair scope is, and determine the pricing from there. Gearboxes vary widely in shape, size and complexity, so the initial costs can vary widely as well. Buying new usually occurs when the recondition price reaches around 60-70% the cost of a new unit. Keep in mind that when comparing the price of reconditioning of a unit versus buying new, the new unit does not have the freight/disassembly/inspection/evaluation costs that a reconditioned option carries."

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