

WIND TURBINE GEAR REPAIR

Due to the large installed base of wind turbines, demand for gearbox repairs has risen steadily in recent years. Isotropic superfinishing is an ideal process for repairing damaged gear flanks and bearing surfaces found on used wind turbine gears.

WIND TURBINE GEARBOX DURABILITY HAS IMPROVED

significantly over the past ten years. The days of early gearbox failure due to epidemic micropitting are largely in the past. Improved gear design and manufacturing have made these gearboxes much more reliable. However, wind turbine gears remain expensive and are manufactured by a limited number of gear producers. Spare parts are not readily available in most instances; replacement of damaged gears is costly and often requires long lead times. Ultimately, wind turbine gearbox repairs typically result in several months of downtime for the turbine, which, in turn, is lost revenue for the owner operator.

Today, wind turbine gearbox repairs tend to occur in the fifth to tenth year of the turbine's operation. Best practice dictates that when a gearbox is removed from a turbine for maintenance, any gears showing damage will be repaired or replaced. Typical gear tooth damage will be in the form of FOD (foreign object debris) damage — causing tooth denting or abrasion — fretting, scuffing, and/or corrosion. Given the obvious disadvantages of turbine downtime, damaged wind turbine gears need to be repaired and returned to service as quickly as possible.

REGRINDING

The aforementioned damage to gear teeth can typically be repaired via flank regrinding. However, regrinding has certain disadvantages and limitations. First, regrinding can easily remove too much metal, or if set up improperly, can cause a loss of tooth profile. Both of these occurrences would result in the scrapping of the gear. Second, wind turbine gear repair tends to occur in small lots. The common 1.5–2.5 MW gearbox is composed of nine gears: an input planetary stage (containing three planets) and two parallel axis stages. These small quantities of differing gear types are ill-suited for the modern CNC grinding machines found at most manufacturers as these machines are intended for large serial production runs. Third, temper burn inspection is an issue in wind turbine gear regrinding. This process is both expensive and dangerous to the operators as well as the environment. Repair procedures are not always clear about the need to conduct this inspection after regrinding. Temper burn inspection is required with OEM wind turbine gear

production; therefore, temper burn inspection should always be carried out after regrinding as well. Fourth, there are two situations in which regrinding of wind turbine gears is particularly problematic: nitrided ring gears and separately, gear “assemblies.” Nitrided ring gears are not permitted to be reground due to the thin case layer on the flanks. Assemblies, such as intermediate assemblies, compound planet gears, and hollow shaft gear assemblies, generally cannot be reground in their assembled state. Disassembling these components requires sophisticated tooling and often results in the scrapping of one of the two primary components. Reassembly is a similarly complicated process. These challenges create higher costs in association with the repair of these assemblies or the replacement of the nitrided ring gears.

ISOTROPIC SUPERFINISHING

A growing preference in the repair industry is to use isotropic superfinishing to repair damaged wind turbine gears. This surface engineering technique, described in the October 2015 Materials Matter article, “Isotropic Superfinishing,” can repair all of the typical types of damage found in modern wind turbine gearboxes. It is ideal for handling the low volumes and multiple gear types found in a typical repair job due to its process flexibility. Moreover, isotropic superfinishing does not require gear engineering drawings and carries none of the scrapping risks associated with regrinding. Chemically accelerated isotropic superfinishing processes, such as those used by REM Surface Engineering, are approved for use on nitrided components. These chemically accelerated isotropic superfinishing processes are also capable of repairing assemblies, eliminating the need to disassemble/reassemble or scrap the components. Figure 1 shows an intermediate assembly after it has undergone an isotropic superfinishing repair process.

Also, the tooth flank finish generated from isotropic superfinishing will exhibit higher performance in terms of surface durability when compared to regrinding. Gear Research Institute has published articles showing that damaged, flight-critical gears can be returned to better than original performance condition via the use of isotropic superfinishing. These isotropically superfinished, repaired gears were shown to be superior to new ground gears in terms of performance [1, 2]. As such, isotropic superfinishing when applied to used gears is often considered to be a gearbox upgrade in the wind turbine industry.

INITIAL INSPECTION

Simple profilometry (see the January Materials Matter article, “Roughness Measurement of Precision Gear Teeth,” for more information) can be used as an incoming inspection tool prior to establishing the isotropic superfinishing cycle time. Measurement of the Rz or Rt across the damaged tooth surface will determine how much material needs to be removed. Scuffing, FOD, fretting, or corrosion damage will typically be on the order of 0.0001–0.0005 inches in depth. See Figures 2a and 2b for a before and after sun pinion that had FOD damage.



Figure 1: Used intermediate assembly after isotropic superfinishing

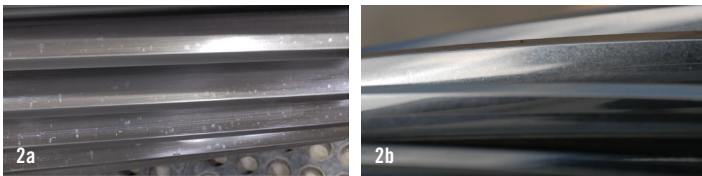


Figure 2a: Sun pinion with FOD damage
 Figure 2b: Sun pinion with FOD damage after isotropic superfinishing

PROCESSING

For wind turbine repair, the components are typically processed individually except for the planet gears, which are processed as a set. All nine gears from a wind turbine gearbox can be processed in one to two shifts in a well-equipped facility allowing for round-trip lead times of less than a month. As noted, because chemically accelerated isotropic superfinishing removes material in such a controlled fashion, even nitrided ring gears or complex gear assemblies can be repaired. The process is carried out at room temperature with water-based chemicals. Thus, temper burn inspection is not necessary. The cost of isotropically superfinishing all wind turbine gears is typically less than the replacement cost of any one wind turbine gear itself. Additionally, isotropic superfinishing results in a clean, reflective tooth surface that is easy to visually inspect for any residual damage. Figure 3 shows a tooth crack found on a nitrided ring gear after isotropic superfinishing that was not visible prior to the repair processing.

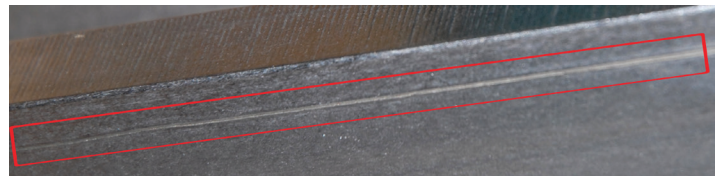


Figure 3: Nitrided ring gear crack revealed after isotropic superfinishing

CONCLUSION


Isotropic superfinishing has proven to be an efficient and cost-effective method for repairing wind turbine gear surface damage. This process is able to repair components not suitable for regrinding and is considered to be a gearbox upgrade over ground gear teeth. The flexibility of this type of process lends itself to the small volume environment of most wind turbine repair jobs. Given the need to minimize turbine downtime as well as current and future repair costs, isotropic superfinishing would seem to be a preferred option in the wind turbine gear repair market. 🐾

REFERENCES

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ABOUT THE AUTHOR: Mark Michaud, president of REM Surface Engineering, is a leading expert in the field of isotropic superfinishing of engineered metal components. During his 35-year career at REM, he has worked in research, operations, sales, and management. Michaud has been granted over 100 patents, published numerous technical articles, and given lectures in the United States, Europe, and Asia. He has degrees in chemistry from Reed College and an MBA from the University of Hartford. He can be reached at mmichaud@remchem.com.

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