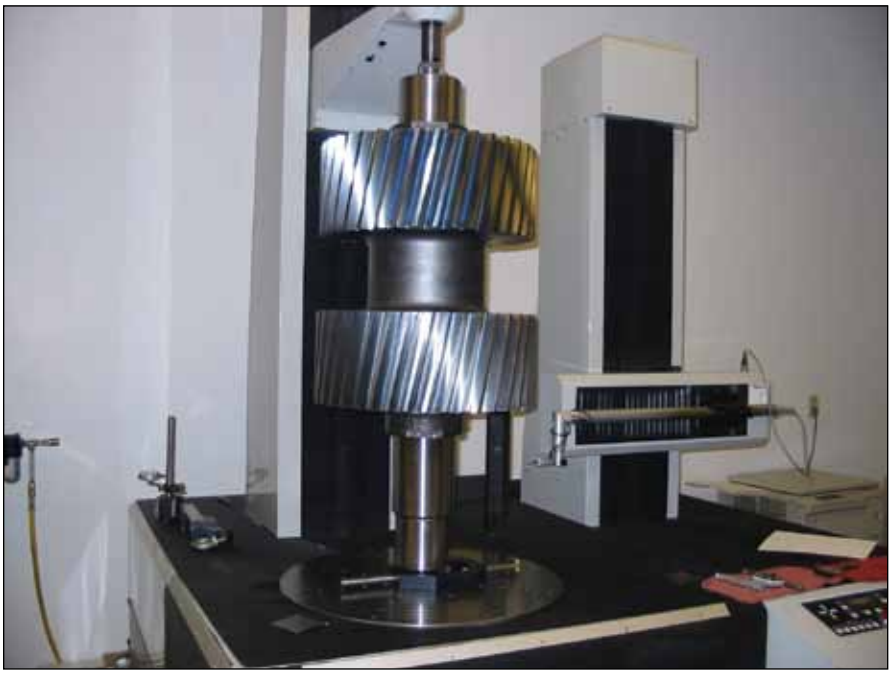
Considerations for Gearmaking

IN WIND TURBINE APPLICATIONS

A Q & A with N.K. Chinnusamy, president of Excel Gear, Inc., Roscoe, IL



CMM inspection of the complete gear and spindle must be done to achieve the proper parallelism. (All photos courtesy Excel Gear, Inc.)

What are the challenges when machining gears for wind turbines?

Gears for wind turbine applications are typically large in diameter and have wide face widths, requiring very exacting material composition and heat treatment processing. The gear design must be optimized to ensure low rolling resistance and long life—owing to the extreme costs of maintenance, down time and repair of the gearbox assemblies—once they have been commissioned in the field. Every step in the manufacturing phase of these gears must be carefully processed, documented and controlled to achieve the high quality, consistency, accuracy and reliability that are demanded for operation in these environments.

The use of carburized steel for these gears is common, and the associated heat treatments and stress relief operations have to be exacting to minimize part distortion and growth, as well as to achieve the proper metallurgical properties required. Oftentimes, a preheat treatment of the forging or bar stock is necessitated on these large gears to minimize part distortion. In addition, one of the seemingly small but critical techniques to minimize distortion on gears is the vertical insertion of the gear into the quench tank during the hardening phase.

Heat treatment can cause cracks as well, so careful processing with predetermination of stock allowance for grinding and final case depth must be considered. Inspection for cracks with magnetic particle inspection and for grinding burns utilizing nital etching is an important inspection tool.

Finally, off-center crown grinding of the tooth geometry may be needed to properly distribute the load on the gear teeth.

Given the precision required for large-gear applications, and the sophistication of the equipment required in making them, is there ever a problem in hiring and retaining workers with sufficient skill sets?

Yes. Finding experienced people with sufficient skills and good work ethics is definitely a problem. We cross train our employees on a variety of machines and use the best ones for grinding operations. When hiring, we place a great deal of importance on a potential employee's attitude and willingness to learn. Fortunately, we do not have any problem in retaining skilled and productive employees, as the local area of Rockford, IL abounds in machining talent.

What modifications, if any, are needed in the tooling or the machine tool, to make gears for this application?

Rigid, heavy-duty hobbing machines are needed for the coarse-pitch gears, using roughing hobs or gear milling (gashing) cutters. Likewise, coarse-pitch diamond dressing rolls and special grinding wheel abrasives are required for the large, high-accuracy gear grinders to produce efficient, accurate results and to prevent grinding burns and cracks.

The cutting fluids used must have the proper viscosity, the right amount of extreme pressure additives and must be directed to the exact location of the

workpiece and cutting tool interface to maximize results. These fluids have to be routinely sampled and adjusted for optimum results.

Likewise, in building the gearbox, what special considerations must be taken into account?

Establishing the correct bearing clearances/preloads is critical to long life and proper gearbox operating temperature. Only sophisticated measuring techniques with bearing inspection gages can ensure these results. The type and method of lubrication and proper sealing weighs heavily on the performance of a gearbox. The verification of gearbox performance through computerized analysis and testing is a crucial step to ensuring long life.

What are some of the ancillary requirements in gear prep for wind turbines?

Special workholding and fixturing is an obvious consideration to bear the weight and to reduce the vibration and movement of the gear blank while hobbing or roughing. Careful and uniform torquing of the clamping fasteners during these operations prevents workpiece movement and distortion of the gear blank during the roughing operation. The gear blank must have accurate mounting and indicating surfaces to control the pitch line runout to critical features (bearing journals, splines, etc.) and for minimal lead error.

Have there been advances in workholding technology/equipment that facilitate the manufacture of large gears?

Nothing unusual, really. Workholding techniques are an important part in the manufacturing process for all large gears. We design and build our own special fixtures for most of our larger gears, and we constantly update our fixturing to be able to handle the larger parts, such as those found on wind turbines and the gearboxes in them.

Gear grinding using special fixturing to support weight and torque.

How does moving into the large-gear market impact a shop's QA department, in terms of added responsibilities and skill levels?

We already make very large gears for battleship gun turrets and cranes, and we have people with sufficient skill level and responsibility to handle all QA functions on small, as well as large gears. Grinding and inspection of larger gears require patience and special care in handling parts from one work center to another, without damaging the product.

Is meeting increasingly robust standards for large-gear applications something you write off as simply the cost of doing business?

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Not really. The prices of gears are dictated by size, material and heat treat specifications, as well as the applicable quality requirements. We must remain competitive but also very technology-oriented to stay in the big gear business, so some of that internal cost must be written off as the cost of doing business in this arena.

Do supply chain issues (quality steel) continue to hamper large gear production?

Not at this time. Aircraft quality and VAR (vacuum arc remelting) steels are readily available. Ultrasonic testing of forgings and bar stocks is an added requirement for any critical applications. Qualities of steels that are available now are much better than what were available 15 or 20 years ago. We work with several suppliers who have proven track records for quality, delivery and performance requirements.

Last thoughts?

The critical factor here, as with all similar power transmission applications, is that the gears are properly designed and manufactured. The other mechanical components that make up the assembly, along with the gearing, must be applied/designed so the overall system performance does not have any shortcomings that could affect the performance and life of the unit. If the sub-assembly/assembly is carried out with real precision and care, a favorable outcome is sure to follow.

Helical gear grinding of large wind turbine gearbox components often requires off-center crowning to center load the gear in operation.

For more information:
N.K. Chinnusamy, president
Excel Gear, Inc.
11865 Main Street
Roscoe, IL 61073
Phone: (815) 623-3414
Fax: (815) 623-3314
sales@excelgear.com
www.excelgear.com

N.K. Chinnusamy, Excel Gear president.