Manufacturing **Strong**

Thoughts on Big Gear Production in 2019

Matthew Jaster, Senior Editor

For this year's exercise in large gears, we're not going to dwell on size range or length, merely look at the fundamental challenges and latest technologies required to manufacture large parts in the gear industry. This could be a gearbox assembly for the construction, mining or oil and gas industries or simply a large standalone gear pinion set for a custom application. Whatever the industry or application, large gears require more preparation, planning and precision than other areas of gear manufacturing.

HMC FOCUSES ON HIGH-QUALITY GEARING

HMC Gears (Princeton, Indiana), focuses on advanced technology in gear cutting, gear grinding and custom machining with an emphasis on large gear manufacturing. Some of the biggest challenges in manufacturing large gears include the size/weight of the part versus the accuracy and tolerances required to make an exceptional quality product.

According to Robert J. Smith III, president at HMC Gears, the precision planning and preparation required to manufacture these products always involves correct rigging, materials, fixturing, and tooling, technologically advanced machines, specialized processes and highly trained personnel.

A perfect example of this was a most recent project HMC completed for the Arkansas Dam Project. This low-speed gear and pinion set was large, heavy and required exact high precision tolerances and finishes.

"The low speed gear in this project was 173.2" diameter with a 49.5" face-width. HMC assembled a 61.75" diameter × 142.25" long low speed shaft into this gear and performed all of the necessary pre and post assembly machining including grinding of the teeth to AGMA Class 12. With the size, exact high precision tolerances, finishes and 126,000 lb. weight of this assembly, HMC's planning and preparation had to be spot on. The gear set was installed and is running with no issues to date," Smith said.

Smith said that the primary change in large gear manufacturing has been an increased demand for higher quality gearing.

"A few years ago AGMA 8 was considered high quality. Many users today recognize that high quality on their gears and even higher on their pinions equates to longer life due to increased contact between the gear and pinion. Example: AGMA specifications require approximately 60 percent contact for Q8. Q12 is required to have 85 percent or better. The method for achieving higher quality gearing was very difficult and expensive due to the previous technology. However, today with the updated tooling and machine tool technology higher AGMA qualities can be accomplished on gears of six and seven meters," Smith said. (See sidebar)

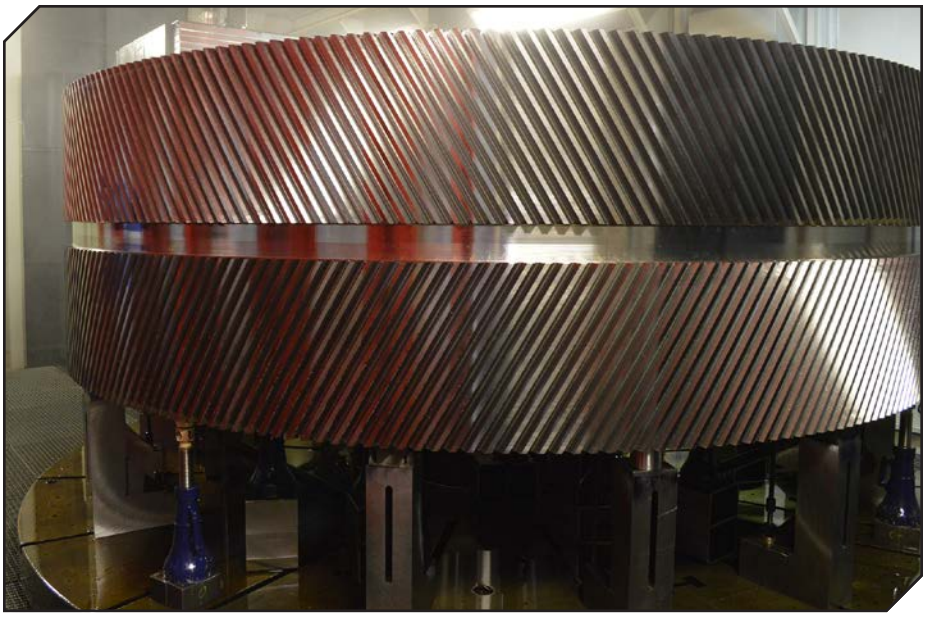
In order to run the latest machine tool technology and keep the tooling current, it's vital to have a qualified staff that is capable of growing with the company. Replacing these skilled workers, however, is still a challenge.

"The search for qualified skilled help in large gear manufacturing isn't a new problem. It's something manufacturers have had to deal with for decades. Gear making requires people with knowledge and skill. These people have been and continue to be hard to find. Therefore, it is important to nurture your program with the training of new hires and interns," Smith added.

According to Smith, another important area is the training and skill needed to handle and lift these very large components.

"Lifting and handling are not a

Recent upgrades in tooling and machine tool technology have made it easier to manufacture higher quality gears in 2019 (photo courtesy of HMC).



Advanced gear manufacturing capabilities and engineering knowhow are keys to meeting the unique challenges of large gear assemblies today (photo courtesy of HMC).

problem for a gear maker that has prepared their infrastructure for the handling and facilitating of eight meter and larger gears weighing as much as 75 to 80 tons. The key element is the training that must go into those that handle and lift these very large components with cranes capable of such size and weight. With respect to shipping there are several trucking companies with trailers capable of hauling very large heavy gearing," Smith said.

The following is an example of some of the unique manufacturing challenges and engineering expertise needed when HMC worked with a customer on a large mill gear. HMC Gears was contracted by a lime producer to provide dimensional verification of a spare mill gear that was being slated for installation during the year.

"Upon completion of our visit, it was determined that many of the necessary dimensions were incorrect and the gear would not physically fit their mill," Smith said. "There was no documentation available for the mill, the gear or pinion. Using our WEKO tracking arm and Faro laser, our field engineers compiled enough data to design and manufacture a new gear and pinion set, but would have to verify bolt circle dimensions once the old gear had been removed. The HMC forged gear dimensions were 5.5 meters in diameter and weighed in just under 30,000 lbs.

The uniqueness of this project was the many unknown design variables of the process and the limited timeline both in manufacturing time and outage schedule. The gear was manufactured (without the flange bolt holes) just prior to the customer's outage. Upon approval of the final outage plan and mobilization of HMC's crew, the new gear was setup on a vertical lathe awaiting final dimensions.

"With the first half of the gear off of the mill, our engineers verified the needed dimensions and relayed that information to the shop. The bolt circle was then machined on the second day of the outage and by the third day was prepped and ready for shipment. The gear was then loaded and shipped, arriving on site at noon on the fourth day of outage. Our crew had the first half of the gear bolted on by that night, and finished the install and alignments ahead of schedule. Our cutting-edge gear manufacturing capabilities coupled with our knowledgeable staff made this project a success," Smith said.

So what exactly does the future hold for large gearing applications?

Advances in technology never cease to amaze Smith.

"We machine very large gears today in less than half the time we were making them 10 years ago. But it is doubtful that those same increases in efficiently can be appreciated again in 10 years if we are still using the conventional manufacturing tools and machine currently used. However, if some type of laser or other exotic technology comes along then the game might change dramatically," he added.

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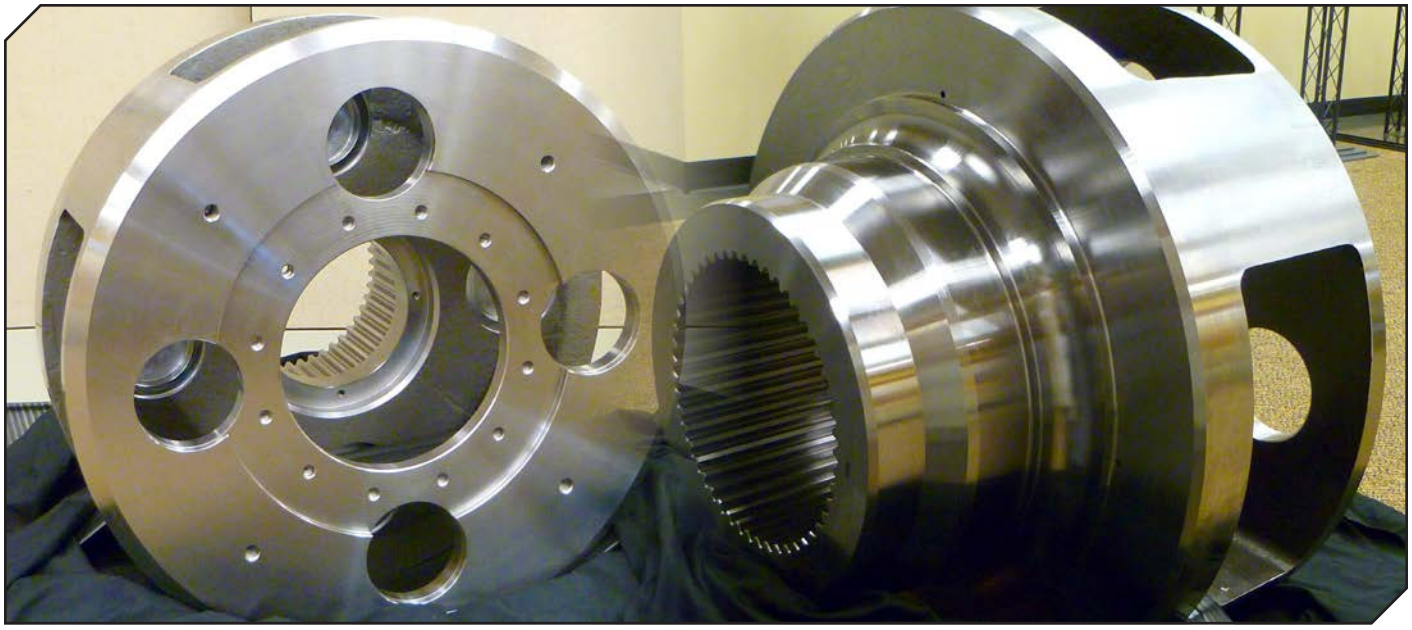
FAIRFIELD TOUTS ENGINEERING EXPERTISE AND PRODUCTION CAPABILITY

The large gear market appears to be making a bit of a comeback in 2019 after several years in a down cycle, according to Lou Gilbert, director of sales at Fairfield Manufacturing. Markets like oil and gas, mining and locomotive are ramping up in areas where the gearing is large and requires specialized equipment and heat treatment to produce. Gears produced in markets like military, commercial vehicle and construction are also stronger though these are typically higher in volume and have smaller requirements.

"The challenges in large gear manufacturing today include operational routings, planning/sequence, material availability



A recent collaboration between Oerlikon Fairfield and Scot Forge involved developing a process for large forged carrier assemblies (photo courtesy of Oerlikon Fairfield).

and machine capacity. Since Fairfield has been in business for nearly 100 years, we have some advantages. Fairfield can often handle these large fluctuations in business due to having the floor space (over 600,000 sq.ft) to handle large amounts of material and inventory, as well as already having the production equipment in place and heat treatment on site. We control our own destiny in this way. The rest comes from internal teamwork between planning, manufacturing engineering, operations, purchasing and sales… not to mention daily customer communication," Gilbert said.

A recent collaboration between Oerlikon Fairfield and Scot Forge involved developing a process for large forged carrier assemblies. In the past, many customers have complained about a series of similar problems when it comes to cast planetary carriers including excessive scrap, redundant inspections, expedited freight costs, overtime labor costs, wasted floor space, lead time increases, on-site travel costs, opportunity costs and more.

The forged solution—compared to castings—offers a complete planetary carrier solution that meets the individual requirements of each customer. Oerlikon Fairfield and Scot Forge offer design for the forging process, the machining concept, complete FEA analysis and forge simulation, material selection, material testing and NDT testing criteria as well as future design improvements.

These two partners have been validating the process for a few months and are in the early stages of offering it to the general public. (*Editor's Note: Stay tuned for updates on this collaboration in future issues of* ***Gear Technology***).

In regards to technology advances in gear manufacturing, Gilbert said there are two key trends the organization is keeping an eye on that are driving long-range future gear demand. The first is electrification. As this technology continues to develop, in all industries, and capability increases, power transmission will evolve.

"For example, typical "T-drive" (engine, transmission, drive shaft, axle, wheel) applications, that are dominant today in transportation, could develop into axle drive's, or, as e-drive power density increases, individual wheel drives may be common place. This could completely change transmissions as we know them today," Gilbert said.

The second is an increase in horsepower and torque requirements.

"Many industry trends continue to show a demand for more horsepower and torque to be transmitted through the same sized gear/transmission system/envelope. This is always a challenge as OEM's must ensure durability in a more severe duty cycle. To remain competitive, OEM's and gear manufacturers will need to explore special coatings, material types and processing steps. This could help to minimize investment for manufacturers and well as minimize change management for OEM's downstream," Gilbert added.

All in all, the company is optimistic about 2019. "Our commitment is proven by continued capital investment, hiring and production optimization," Gilbert said.

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CONDITION MONITORING WITH DB SANTASALO

DB Santasalo in the U.K. boasts a 3.5 m gear diameter Klingelnberg machine, which uses state of the art technology to check the profile, lead and pitch of some of the largest high quality gears in the world, following machining. It can also be used as a coordinate measuring machine, performing basic NDT checks for fabrications, gear cases and gears all on the same machine. These checks are completed to ensure that the gear teeth have been machined correctly and that the gearbox meets strict design criteria. This, alongside the company's stringent test processes ensures that David Brown Santasalo gearboxes are robust and reliable.

These checks are vital as the gears are being produced, but what happens when the gears have left the production line and are in their natural habitat? According to a recent news release from DB Santasalo, the company has recently developed a new system to monitor the health of the gearbox during operation. Utilizing this method, the company can spot issues before they become a problem helping you to avoid minor repairs and prevent gearbox failure.

Developed by a team of specialists with a deep understanding of drive system technology and rich heritage of designing and manufacturing gear units, this condition monitoring method examines oil particle counting. Particle counting gives a warning of the failure at a much earlier stage than gearbox vibration can, especially on low speed applications. By adding oil particle counting into the mix, along with 24/7 remote monitoring and cloud based technology, it adds a new dimension that will support customers' process reliability. This can essentially provide proactive maintenance that detects defects at such an early stage using sensor technology.

Having the ability to monitor the health of the oil in the gearbox, means potential gear unit failures can be detected months, or even a year in advance. This enables the user to plan maintenance activities around operational requirements. This is an interesting concept considering the time and cost involved in building a new gearbox. Additionally, if a shutdown does occur, the effect on a company's production capabilities can lead to a huge impact on revenue.

The operation and longevity of a gearbox requires the lubrication and related monitoring and maintenance operations to be carried out correctly. The main function of lubrication is to provide a metal contact preventive oil film on the rolling surfaces of bearings and gear wheels. In addition, it transfers the heat generated by the bearings and the gears to the environment and removes impurities and wear particles. In addition, the oil film between the tooth flanks is essential for the operation of the gear unit.

Small metal particles in the lubrication oil are the first indicators of initial damage. Online monitoring and trending of the metal particle's quantity and size, enables the early detection of damage in gear teeth or roller bearings.

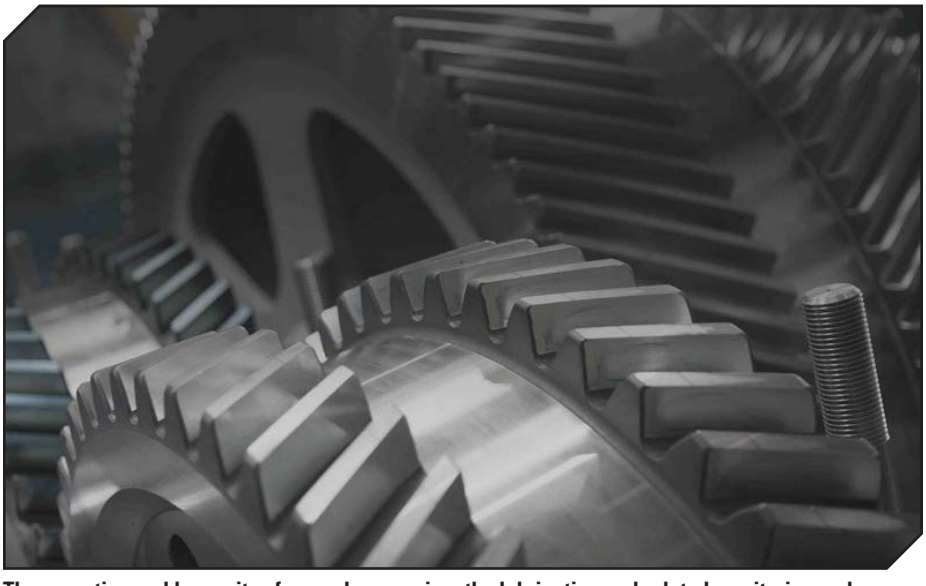
Typically, hundreds of liters of oil circulate through a gearbox. The GearWatch oil particle counter is placed on the pump-filter-unit of the gear, whilst an inductive sensor detects oil circulation from both ferromagnetic and non-ferromagnetic particles. The particle counter is also immune to air bubbles and other dust present in the oil, ensuring it provides an accurate reading.

The next step in lubrication condition monitoring is through an oil quality sensor, which enables online monitoring of the gear unit's lubrication oil condition. The user is kept informed of changes in fluid condition, as it occurs and can react to unpermitted operating conditions. Analysis can then be made about the condition of the oil, for example ageing or mixing with other fluids.

On a general level, the infrastructure for digitalization has been significantly improved, while today it's considered "normal" to be able to handle large amounts of data and use it remotely. As DB Santasalo begins to understand the capabilities and opportunities of these developments; suppliers, manufacturers and customers can all benefit.

GearWatch delivers a "one-shop-service" meaning they monitor, analyze the findings, and propose a course of action to rectify the issues. If necessary, the company then provides the repair or maintenance to get the machine up and running. This is available in three packages: DBS GearWatch Standard, DBS GearWatch Oil Monitoring and DBS GearWatch Pro, giving customers several options to adapt to their specific requirements.

The latest phase of this condition monitoring technology was launched in the fall of 2018. The company will continue to offer customized solutions for gear units and drivetrains in the future.



The operation and longevity of a gearbox requires the lubrication and related monitoring and maintenance operations to be carried out correctly (photo courtesy of DB Santasalo).

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