



Gleason - PFAUTER  
P 2400

## Faster Worm Gear Production at Cleveland Gear

Worm gears have come a long way since the Greek mathematician Archimedes pioneered in screw design some 2,200 years ago. For example, worm gearing today is a key component in hydraulic fracturing, a process that has unlocked vast reservoirs of natural gas and unleashed a new energy boom in the U.S. Worm gearing is used in this process to transmit power from large diesel engines to the pumps that inject high volumes of fluid at very high pressure into a drilled hole. In the power generation industry, worm gears are used in coal pulverizers to deliver the torque required to produce the enormous pressure to crush coal into fine powder so it can burn more efficiently. For these and many other heavy-duty applications requiring speed reduction, from hot metal cranes in steel mills to material handling and mass transit systems, worm gears have never been in greater demand.

It's a good problem to have, acknowledges Bill Hupp, Manager of Manufacturing Engineering at Cleveland Gear

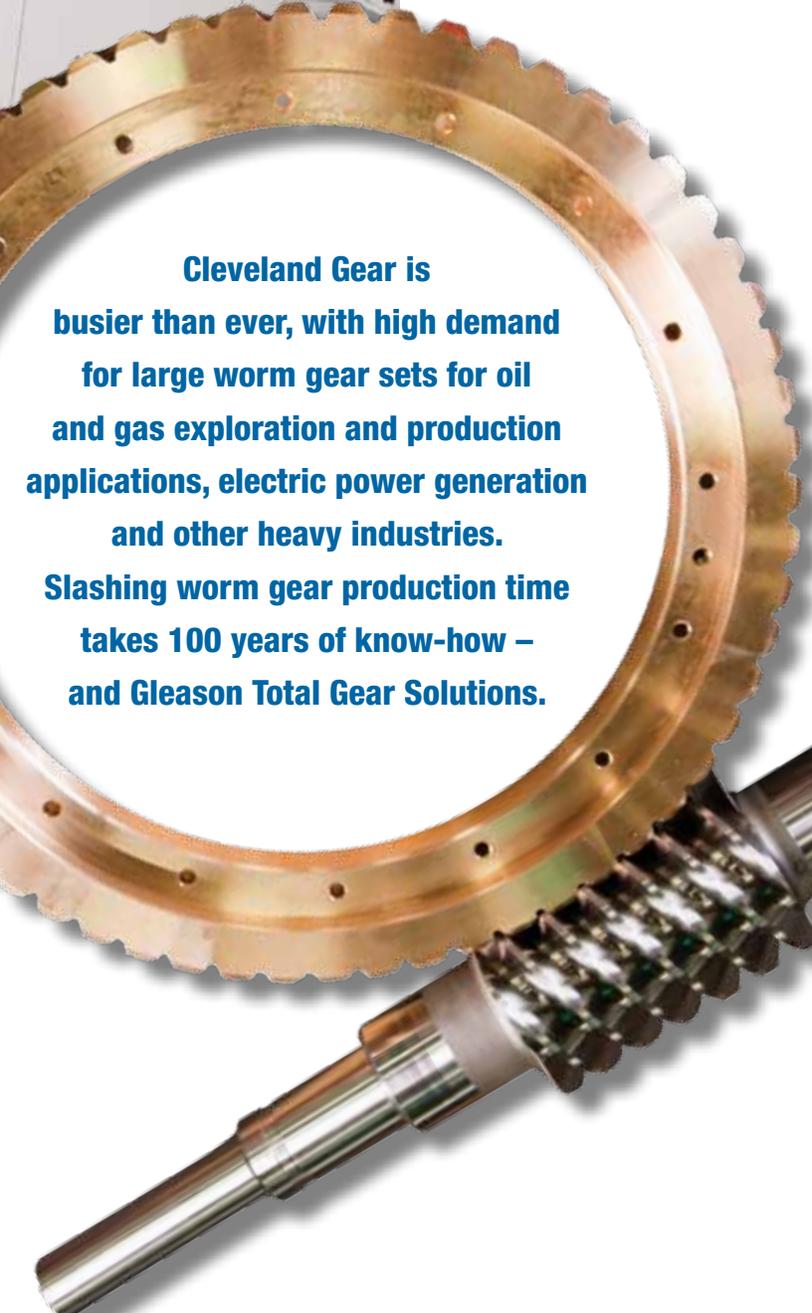
Co., one of America's most successful worm gear and gear reducer manufacturers – and oldest – with the celebration of its 100 year anniversary this year. “Our niche is the ability to more efficiently produce large worm gears having a center distance up to 54”, and usually in lot sizes of just three or less,” says Mr. Hupp. “We’re unique in that we have the master worms, worm form gauges and custom hobs for virtually every gear set ever produced, so we can replicate exactly a gear originally made as far back as the early 1900s. But of equal importance given today’s demand is the investment we’ve made in new Gleason hobbing machines and tooling, which we’ve found to be the most productive solutions available.”

### 50% improved gear production

Standing side by side on Cleveland Gear's worm gear manufacturing floor are two circa 1950s Pfauter 2.5 and 3.0 meter gear hobbing machines, each capable of hobbing complete a typical 41” CD (center distance) worm gear every



Three new Gleason-Pfauter Hobbers are helping Cleveland Gear revolutionize the production of large worm gear sets like the one shown below. (Dominic Rega, president of Gleason's area rep. company and Cleveland Gear Manager, Manufacturing Engineering Bill Hupp are shown standing next to Cleveland Gear's latest acquisition.)



**Cleveland Gear is busier than ever, with high demand for large worm gear sets for oil and gas exploration and production applications, electric power generation and other heavy industries. Slashing worm gear production time takes 100 years of know-how – and Gleason Total Gear Solutions.**

20 hours. Across the aisle from these vintage Pfauters is Cleveland Gear's new Gleason-Pfauter P 2400 Hobber, just installed in June of this year, which Mr. Hupp says can cut the same gear in just half the time. The new P 2400 joins two other Gleason-Pfauter Hobbers, a P 1200/1600 installed in 2009 and a P600/800 that went into service in 2011. These machines have added significant new capacity and productivity to the Cleveland Gear operation, says Mr. Hupp, and opened the door for even greater productivity improvements downstream. "The typical worm gear set consists of a hardened high speed steel worm that meshes with a softer bronze-alloy worm gear, or wheel," explains Mr. Hupp. "The threads on our worms are produced on older thread milling equipment, heat treated and then finished on a thread grinder. We can use the new Gleason-Pfauter machines to gash the threads with the Gleason Opti-Cut® cutter system, resulting in a significant savings in the time needed for these operations. Additionally, we can use the Opti-Cut gashers to rough cut the gear teeth before finish hobbing worm gears made from harder bronze alloys where it's advantageous to gash first and thus greatly reduce hobbing cycle times downstream."

**The perfect 'mesh' of machine and cutting tool technology**

Mr. Hupp attributes some of the productivity and accuracy improvements that are being achieved with the Gleason-Pfauters to their particularly rigid and robust construction, and their ability to handle the very high cutting forces generated. The worktable, for example, is mounted directly in the machine bed, thus ensuring optimal conditions for absorbing cutting forces and transferring them to the base of the machine. The use of hydrostatic table bearings combined with a zero-backlash double worm index drive guarantees precise table travel and maximum face and radial runout accuracies for the worktable. The slideways are wide, hydraulically preloaded guides used in combination with a separate linear guide and backlash-free roller bearing assembly, ensuring highly precise slide movements at any feed rate. And the motorized hobhead is designed to deliver the maximum cutting capacity for indexable carbide insert gear cutters like the Gleason Opti-Cut, as well as the custom-designed hobs produced in-house by Cleveland Gear or developed in conjunction with Gleason Cutting Tools Corporation.

“We can’t grind worm gears, because the teeth are concave with a tooth profile conjugate to the worm, so we have to live with what the hobbers produce,” says Mr. Hupp. “The accuracy of our gears is critical and is measured by the ‘intimacy’ of the contact pattern. Cleveland Gear has used its 100 years of experience to obtain an understanding of what happens when worm gears are loaded up – so we optimize the contact pattern to ensure there’s always room for lubricating oil to enter that mesh. An optimized pattern is absolutely vital to highly efficient power transmission, long term performance and reliability of the gear.”

Ultimately, every worm gear is inspected for profile, lead and contact pattern by meshing them with master worms on a dedicated tester.



While machine design and construction are important considerations, Mr. Hupp says that the special design of the hob doing the cutting is the most decisive factor. For 100 years, Cleveland Gear has designed, developed and manufactured its own hobs. In fact, hobs are numbered in a sequence that dates back to hob #1 made in 1912. Today, on the new Gleason-Pfauter P 2400, hob #1924 is in use – a hob that was developed by Gleason Cutting Tools Corporation.



“Rarely would we buy a hob outside, but with the help of Dominic Rega, president of Gleason’s representative company, Donald R. Nettis Company, we worked through the design and development of hob #692 (X and X1) with Gleason Cutting Tools for use on the P 1200/1600 several years ago, ultimately resulting in a hob that could cut a gear in 42 minutes as compared to eight hours previously,” explains Mr. Hupp. “Furthermore, we’re getting 50 workpieces per sharpening out of the #692 X and X1 vs. just two workpieces per sharpening before.”

The hobs used for worm gear cutting are considerably different from those used for typical parallel-axis gears. Cleveland Gear uses a tangential hobbing process, whereby the hob is fed longitudinally along its axis as it revolves. The hob is designed with a tapered section that progressively roughs the worm gear’s teeth, and then finishes them with a finishing section as the hob advances past the worm gear, in a combined axial and rotary motion. David Fitzpatrick, one of Cleveland Gear’s founders received a U.S. Patent for the tangential feed hob in 1920. In addition to helping to optimize this design, Gleason Cutting Tools was able to produce the #692 and, most recently, the #1924 hob, in their new Coarse Pitch Hob Cell at Gleason Cutting Tools’ Loves Park, IL facility. Glenn Schlarb, Engineering Manager at

Gleason Cutting Tools recalls, “The #1924 hob had some very special characteristics, including an unusually high thread angle, that we were able to produce using our new equipment, including roughing the threads and gashes, and form relieving the teeth, all on just one machine.”

### **Total Gear Solutions – and service**

A key consideration in selecting the Gleason hobbors was the company’s ability to provide turnkey solutions, including workholding, cutting tools and, most significantly, customer support. For example, Gleason’s Manfred Schlienzy, the chief engineer for CNC programming for the Gleason Global Services group, has been, according to Mr. Hupp, irreplaceable in optimizing the tangential hobbing process on the Gleason machines. “Manfred shows up first thing in the morning, stands at the machine and never leaves, doesn’t even eat as far as we can tell,” says Mr. Hupp. “It’s just one example of what Gleason is willing to do, and how far they’ll go. I don’t believe we would have gotten this same level of commitment from any other builder. While not without its challenges, it’s been a fabulous partnership thus far between us, Dominic, and Gleason.”

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**Cleveland Gear’s new Gleason-Pfauter P 2400 Hobber cuts worm gears in half the time required previously, using hob #1924, developed by Gleason Cutting Tools Corporation and manufactured in Gleason Cutting Tools’ new Coarse Pitch Hob Cell. The use of Gleason’s Opti-Cut® gasher by any of the new Gleason machines can greatly reduce worm thread machining time and machining of worm gears made from harder bronze alloys.**