

Gears on the Firing Line

High-volume centrifugal compressors push the limits of gear quality and reliability in this case study from Acme Gear, Cooper Turbocompressor and Reishauer

Dennis Richmond

Air compressors are a good example of industrial machinery with components that rotate at very high speeds, up to 80,000 rpm. They are subject to very high rotational forces and often variable loads. Strong, high-precision gears for the power transmission trains that drive the impellers are critical components of machinery operating under such conditions.

Compressors often operate around the clock in these applications. High reliability (up time), energy efficiency and vibration-free operation (typically, gear noise cannot be heard over the gas compression and flow noise) of compressors are important considerations. The results of a gearbox failure can be catastrophic—resulting in plant operation shut down and damage to drive shafts and impellers. Repairs or rebuilds can be costly.

Cooper Turbocompressor in Buffalo, NY, manufactures a wide range of oil-free centrifugal compressors for plant air and process applications. Typically they are the source of compressed air for process machine tool operation, pneumatic tools and even snow-making equipment, with power ratings from 150 to more than 1,200 horsepower. Cooper is also an industry leader for compressors in the air separation industry (suppliers of liquid oxygen, nitrogen and other gases) up to 22,000 hp.

Acme Gear supplies Cooper Turbocompressor with dynamically balanced, single helical bull gears, in sizes up to 32.68 in. pitch diameter, and pinions for their TA2000, TA3000 and C-8



Fig. 1 – Joe Gelles, president of Acme gear, with the modified Reishauer RZ820 used to grind centrifugal compressor gears.

centrifugal compressor lines as well as custom-engineered compressors rated between 2,000 and 7,000 hp. In many instances Acme supplies all of the gearing for a particular compressor. Acme also provides gearing for custom-engineered compressors, some with two separate gearboxes run in series off the same drive motor. Reishauer CNC gear grinding machines are employed for production, including a new Reishauer RZ820 for the larger bull gears.

The gearboxes and drive trains of Cooper's single and multi-stage compressors are an integral part of the entire assembly. A single main drive or bull gear will drive one to three pinions. They must reliably drive compressor impellers to pinion speeds of up to 80,000 rpm, provide vibration-free rotation of all drive shafts and impellers and balance out and absorb varying thrust loads for high-efficiency operation.

Centrifugal compressor gearing is some of the most difficult to produce due



Fig. 2 – Cooper Turbocompressor gear being ground with 5° bevel.



Fig. 3 – Finished bull gear being removed from Reishauer RZ820.

to its complexity and the stringent requirements for material quality and dimensional tolerances. And, consistent, high-precision machining of hard alloy steels is a tough job that places great demands on both operations and the production machinery used to make them.

Acme's compressor gears are manufactured with through-hardened, aircraft-quality alloy steels, which are subjected to both destructive and nondestructive

testing procedures. Tolerances of 1/10,000 (.0001) in. are necessary. Some specific areas require tolerances held to +/- fifty millionths (.00005) in. In the case of ground, hardened steel parts, there is no distortion due to machining stresses. Final tolerances are achieved without subsequent stress relief and grinding or polishing, as might be the case with gears produced by gear hobbing or shaping machines.

The gearing Acme supplies is ground to AGMA 12 and 13+ levels. Cooper also has its own set of proprietary specifications related to the manufacturing of centrifugal compressor quality gearing, and Cooper's operations are ISO 9001 certified.

Cooper Turbocompressor's quality department audits Acme three to four times a year in addition to an annual "Supplier Quality Performance Review," which is a thorough review of products and procedures on both a quantitative and qualitative basis. Cooper also has very formal rejection and disposition procedures as well as cause and corrective action reporting requirements. Acme Gear consistently scores in the highest 10 percent of their supplier base.

Acme consistently meets such stringent requirements through a close relationship based upon mutual benefit and respect both with Cooper and with their own suppliers of materials and production machinery. For Cooper, it is very important that suppliers employ, maintain and upgrade their machinery and processes to the levels necessary to reliably and consistently produce the gearing quality that Cooper and, ultimately, their customers require.

Supplying the High Performance Gears

Originally founded as Marine Boat Engine Company in 1929, Acme Gear of Englewood, NJ, was initially in the business of rebuilding marine engines. In 1955, the company moved from Long Island City to its present site in Englewood and was renamed Acme, "because it represents the highest point,



Fig. 4 - Each turbocompressor gear is quality checked for accuracy and dimensionality of bevels.

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the culmination," states Joe Gelles, Acme president.

In the mid-1960s, the business began to shift. Acme became heavy in the cut gear business. Government contractors such as Grumman, Fairchild and Republic were relocating, cutting back or just closing down. Around 1967, Acme decided to make the shift from cut gears to precision ground gears because of the evolving niche requiring high quality components.

Acme Gear began to produce high speed, precision gears for existing customers like Borg Warner Corporation, Carrier Industries, Bendix and Hillcraft. Demands on the gearing have changed dramatically in the last 30 years. In 1967, "high speed" was around 2,000 rpm. Today, Acme produces precision gears capable of about 120,000 rpm. "It's more than just speed," says Gelles. "In the printing industry, for example, magazine presses have more than seven colors being overlapped while running at tremendous speeds. The precision required to maintain those exacting registrations demands a lot from the gearing."

Acme Gear has recently installed a modified version of a Reishauer RZ820 machine. It enables Acme to produce a 32.68" precision gear for Cooper Cameron as part of a high efficiency refrigeration compressor. Acme worked in conjunction with Reishauer to modify an RZ820 to meet the customer's needs for a larger workpiece from the standard 32" capacity. "Acme had been producing a lot of gearing in the 27" range, which fit wonderfully on the other Reishauer RZ series machines, but when a new, larger design came up at Cooper, we sat down with the Reishauer people and together came up with the perfect solution," says Gelles.

Other new features on the RZ820 machine in addition to the larger capacity included a more powerful grinding motor (5.5 kw), variable speed grinding spindle (1100-2150 rpm) that can be selected for individual passes, manually actuated fine balancing and hydraulic tailstock.

Joe Gelles predicts an increase in the usage of high speed precision gears throughout the industry. The demand for

more efficient performance in compressors, elevators, mining equipment and locomotives. As for the automotive industry, Gelles concludes, "While they're shaving and honing a lot of them still, the consumer will demand transmissions that will last longer, make less noise and operate more efficiently. This will be especially true as the auto industry moves into the era of electric cars. We'll be ready for them when it happens." ☉

Dennis Richmond

is vice president of Reishauer Corporation, Elgin, IL, manufacturers of precision gear grinding machinery.

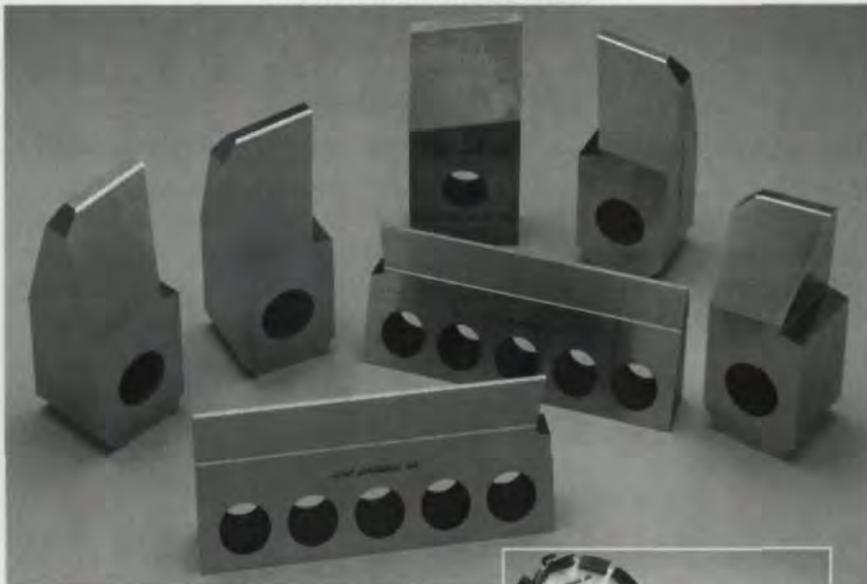
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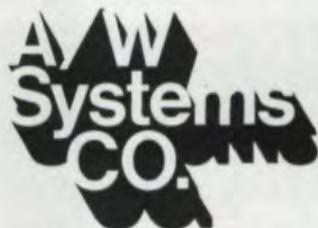
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