THE PLASTIC GEAR PAY-OFF

Eliminating Noise, Weight AND Wear Proves Valuable IN 2012

Matthew Jaster
Associate Editor

The only plastic gear applications mentioned in Darle Dudley's *Handbook of Practical Gear Design*—originally published in 1954—involved items like toy trains, film projectors and cash registers. Thanks to energy efficient manufacturing as well as a desire to cut down on costs, the plastic gear has significantly evolved. Opportunities readily available to plastic gear manufacturers today include automotive, business and printing machines, lawn and garden equipment and medical applications—and business is booming.

"I can't speak about other segments of gear manufacturing, but plastic molded gears still seem to be the focus in the industry for improved performance and cost savings," says Rod Kleiss, president of Kleiss Gears, Inc., located in Grantsburg, Wisconsin. "We are stretched to keep up with demand."

continued

Adds Andrew Ulrich from Thermotech, located in Hopkins, Minnesota, "Though we are not acutely aware of how the machined gear market is doing, we can say the molded gear market is strong and growing."

"Especially from a custom gear/gear tooth perspective," adds Bruce A. Billmeyer, president/owner, Plastic PowerDrive Products, LLC, located in Elk Grove Village, Illinois. "Although a portion of the U.S. molded gear market does come from foreign sources, the innovation still resides here in the United States. This innovation comes in the form of materials, gear combinations with other components and gear assembly techniques."

ABA-PGT, Inc. specializes in both external and internal spur and helical plastic gears in addition to worm, face and bevel. Glenn Ellis, senior gear engineer, ABA-PGT, says, "Plastic gears have a place in the industry just as metal gears do. They both have their own marketplace, this being size, strength, weight and even the quantity required."

There's always a push for reducing cost and weight and that continues to increase the interest in plastic gearing, according to David Sheridan, senior design engineer at Ticona. "Certainly lately, with all the bells and whistles added to automobiles outside of the drivetrain, we're seeing huge gains in automotive applications. Many plastic gear applications were once found only in luxury car models, but these features are now being integrated into standard models as well."

"We're not back to pre-recession numbers but business is good," adds John Winzeler, president of Winzeler Gear in Harwood Heights, Illinois. "Today there are more opportunities for plastic gears, especially where both sound and cost reduction are a factor. More and more, we're getting interest in transmitting power, not just motion."

A Tale of Two Segments

Plastic gears can be cut like their metal counterparts and machined for high precision with close tolerances. Plastic cut gears can also be utilized for the development of prototypes. Injection molded plastic gears are fast, economical and can cost significantly less than machined, stamped or powder metal gears. When determining which type to consider for a specific application, costs, quantity, quality and performance must be considered.

"Historically, molded gear advantages have been considered to be lightweight, quiet, resistant to corrosion, and may be used without external lubrication. While they held these properties, plastic gears were also considered to be less accurate and flimsy. There has been significant progress on many fronts to address these disadvantages," Ulrich at Thermotech says. "First, considerable work developing engineering materials and the understanding of the mechanical properties of these materials has been completed. Secondly, computer programs have been developed along with routine tooth proportion manage-

ment to leverage the ability to build molds without restriction to standard steel gear manufacturing tooling."

"Remember, in molded plastic gears we only cut metal once and then can make millions of copies by injecting liquid into that mold," says Thomas McNamara at Thermotech. "This is the most cost-effective means of producing a high volume of gears."

Adds Kleiss, "Cut plastic gears can replace metal with plastic. This can be a solution to a specific problem if materials replacement is the answer. Molded plastic gears offer a few more opportunities. The gear design can be easily optimized for the specific application. We use a method we call shape forming to fit the needs of the transmission. The molded solution offers unique part characteristics outside of the gear itself that would be difficult—if not impossible— to build into in cut gears."

"High production is much easier on molded gears, which leads to a lower price point. With a quality mold, the repeatability is very high," Ellis says. "Once the mold has been qualified, the future production runs should not have much variation. The potential quality of a cut gear is still higher than the molded gear. One of the things a designer must know is what quality is required for their application. Why request and pay for a quality higher than needed?"

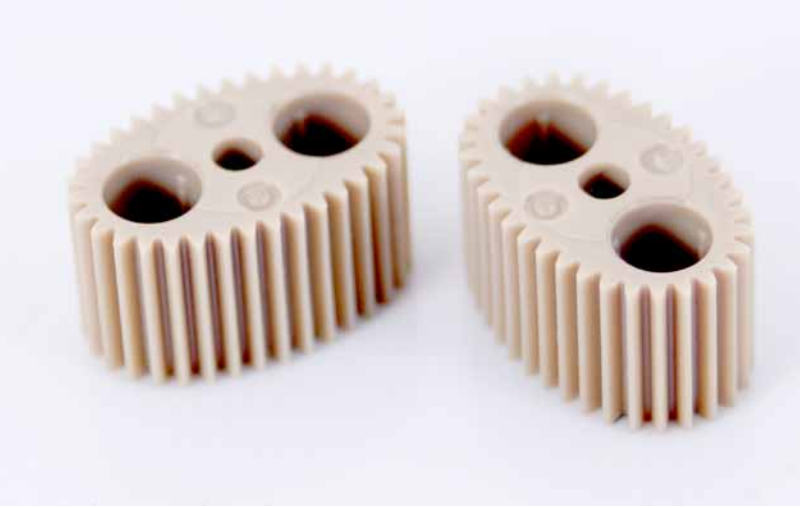
In the end, both methods have advantages and disadvantages and it's up to the customer to determine what plastic gear solution will best fit their specific application.

Making millions of copies of a plastic gear from a mold is a cost-effective way to produce high volume (courtesy of Thermotech).

Overcoming the Limitations of Plastic

The limitations in plastic gearing remain fairly straightforward. "Quite simply, plastic gears are weaker than metal. They can't operate at the same high temperatures. The most precise plastic gear will not be as accurate as the most precise metal gear, unless we start

continued



Kleiss uses their own internal software for the design, inspection and testing of molded gears (courtesy of Kleiss).

talking about micro-gears, which can be much smaller and more accurate than their cut metal counterparts," Kleiss says. "I think a bright spot for plastics is PEEK (polyetheretherketone), and its derivatives are promising much improved performance at high temperatures and high loads. New compositions of nylons are hitting the market now with improved properties. I expect even further material improvements in the coming years."

"The biggest limitation is strength, especially for higher RPM and horsepower requirements," adds Billmeyer. "The future does hold some intriguing solutions with metal plastic hybrids, or over-molded metal frameworks. Some of the new high-temperature combination plastics such as nylon with phenylpolysulfone look promising."

"Strength and temperature are the biggest limitations," Ellis says. "New materials have been gaining ground on both these laminations. With higher temp materials plastic gears are now found commonly under the hood of automobiles."

Load capacity, especially at temperature, is the most significant limitation according to Sheridan. "The automotive transmission is all metal for obvious reasons. There needs to be more done in the future to challenge life expectancy and critical failures. Most plastic gears don't run continuously, but I believe new materials will become available in the future that will address strength, wear and friction modifications."

Plastic Gear Lubrication

How has the lubrication evolved in plastic gearing? Plastic gear manufacturers believe that many factors affect the compatibility between lubricants and plastics.

"Plastic gears can be internally lubricated. Anything from silicone to Teflon can be molded into the material for self-lubrication. Most engineering plastics are inherently low friction. Unfilled nylon is a particularly good example. In addition, external lubricants can be used to good effect in specific applications," Kleiss says.

"Some plastics do not require any lubrication because they are internally lubricated. However even some of these will work better if a break-in grease is used. Some other plastics work best if they are well greased," Ellis says. "Caution must be taken as some plastic will react with certain lubricants."

"External lubrication does not have to be a challenge. Start with the basic soap-based products and escalate from there. Care must be taken to ensure all of the ingredients in the lube are compatible with the molding material," Ulrich at Thermotech says.

"There are cases where this was overlooked and incompatibility was the root cause of failure. Keep in mind that many plastic gear applications can be run dry with the aid of internal lubricants such as PTFE, silicone, molybdenum disulfide and other compounds and blends. This is a huge advantage to end users over externally lubricated transmissions, eliminating the need for replacement or replenishing of the external lube," adds McNamara at Thermotech.

Spreading the Plastic Gospel

The AGMA Plastic Gearing Committee evaluates materials, design, rating, manufacturing, inspection and application of molded or cut-tooth plastics gearing. They recently conducted a meeting in Michigan to discuss the test methods for plastic gears, the inspection of molded plastic gears and the identification of plastic gear failures.

"We focus a great deal of our time on the standards and I think if we made the committee more accessible to the entire plastic industry, it would be beneficial," Sheridan says. "We'd love to have more bodies show up and get involved in the relevant issues that are affecting plastic gearing today."

"AGMA's Plastics Gear Committee works on various documents to assist design engineers with the unique aspects of the design, manufacture and metrology of plastic gears. With the release of these documents, designers and manufacturers will have more uniform knowledge and understanding for the application of plastic materials into the gear industry," McNamara at Thermotech says.

"AGMA is a metal-focused organization," Billmeyer says. "It does not provide anywhere close to the required research or technological information required. What limited software, consultancy, or market research comes from the plastic suppliers such as DuPont or Ticona."

"I am not aware of any real focused effort on the part of AGMA to understand or further develop the potential for molded gears or for truly bracketing the molded accuracy of a plastic gear," Kleiss adds. "This would require a different kind of inspection analysis than has proved successful for cut metal gears. We use our own internal software for everything, from the design to the inspection and testing of molded gears and their transmissions."

Perhaps there are other ways to promote technological solutions in plastics. Education is one area that has proven successful for Winzeler Gear.

"Our Ultra Light Urban Vehicle project, in cooperation with Bradley University, continues to evolve," Winzeler says. "This project has given us knowledge of power transmission in small vehicles and allows us the opportunity to present the benefits of plastic gearing from a weight, friction reduction and sound quality perspective. The project continues to grow, as well as the interest from transmission manufacturers."

If meetings and educational collaborations can't get the job done, Sheridan at Ticona turns to the tried and true initiatives of other areas of gear manufacturing. "Gear Expo is always a great venue to start discussions on the latest in plastic gear technology. We also hold in-house training sessions as well as webinars to provide as much assistance as we can to our customers now and in the future."

An Alternative to the Alternative

For several issues of this magazine, *Gear Technology* has considered plastics to be an alternative form of gear manufacturing along with powder metals and forging. Can the argument be made that plastics are no longer on the outside of gear manufacturing looking in?

"It is actually becoming the other way around these days," Kleiss says. "Metal is sometimes considered as a possible alternative manufacturing method, but only if every possible solution in plastic has been rejected. We promote performance as the key goal. Performance is cost- effective. Cost-effective means dollars saved and a

Winzeler Gear has reaped the benefits of plastic gearing from a weight, friction reduction and sound quality perspective (courtesy of Erich Schrempp, Schrempp Studios).

better product."

"Molded plastic gearing has considerable potential still. With new molding materials continuously entering the market, coupled with the ability to design and build highly accurate mold tooling and injection molding machines capable of producing and maintaining a consistent process shot after shot, injection molded gears are replacing machined gears at a higher rate than ever before. It still remains the most economical method of producing high volumes of gears," Ulrich says.

"We are continually trying to research and develop higher temperature materials that behave more like conventional gear materials," Winzeler says. "The challenge is that we see very little R&D activity outside of advanced product design. Most R&D has a timetable and there's no extra time to experiment. Metal gears have had years of knowledge and once plastic gearing can attain the same levels of research and development, more and more plastic applications will become available to us."

For more information:

ABA-PGT
10 Gear Drive
Manchester, CT 06042-0270
Phone: (860) 649-4591
www.abapgt.com

Kleiss Gears, Inc.
390 Industrial Avenue
Grantsburg, WI 54840
Phone: (715) 598-4492
www.kleissgears.com

Plastic Powerdrive Products, LLC
970 Nicholas Blvd.
Elk Grove Village, IL 60007
Phone: (847) 637-5233
www.plasticpowerdrive.com

Thermotech
1302 South 5th Street
Hopkins, MN 55343-7877
Phone: (800) 735-1888
www.thermotech.com

Ticona
8040 Dixie Highway
Florence, KY 41042
Phone: (800) 833-4882
www.ticona.com

Winzeler Gear
7355 West Wilson Ave.
Harwood Heights, IL 60706
Phone: (708) 867-7971
www.winzelergear.com

Kleiss provides molded plastic gears for a variety of applications (courtesy of Kleiss).