# Plastic: The Not-So-Alternative Technology

William R. Stott

**"We're taking over,"** says Art Milano.

It's a bold statement from the engineering manager of Seitz Corporation, one of the largest manufacturers of injection molded plastic gears, but Milano has reason for his optimism. Plastic gears are big business—probably bigger than most gear industry "insiders" realize.

Although estimates vary, the number of injection molded plastic gears manufactured in the United States **each year** probably numbers in the billions. Some people we talked to even suggested that plastic gears outnumber metal gears.

When you consider that a modern automobile incorporates up to 50 motorized devices—windshield wipers, seat adjusters, automatic windows, etc.—and that most of these devices use plastic gears, it becomes easy to see how the plastic gear industry has grown. When you consider some of the other industries that use a lot of plastic gears—computer printers, VCRs, home appliances, automated teller machines—numbers in the billions seem downright realistic.

So if you still manufacture gears the old-fashioned way—by cutting chips out of metal—should you be worried? Probably not, says Irving P. Laskin, an independent consultant who specializes in plastic and metal gear design. Plastic gears have found a niche in small, low-power gear trains, and while their use has become ubiquitous in certain applications, still others require the ultra high precision, load carrying ability or temperature resistance of machined metal.

In fact, although it's tempting for plastic and metal shops to view each other as competitors, some traditional metal-cutting machine shops have *benefited* from the increase in plastic gear business. Very often, these shops are called upon to make the molds or to make prototype gears out of metal because the turnaround time is generally much faster, says Laskin. Also, most injection molders don't have the knowledge or equipment to make metal parts themselves.

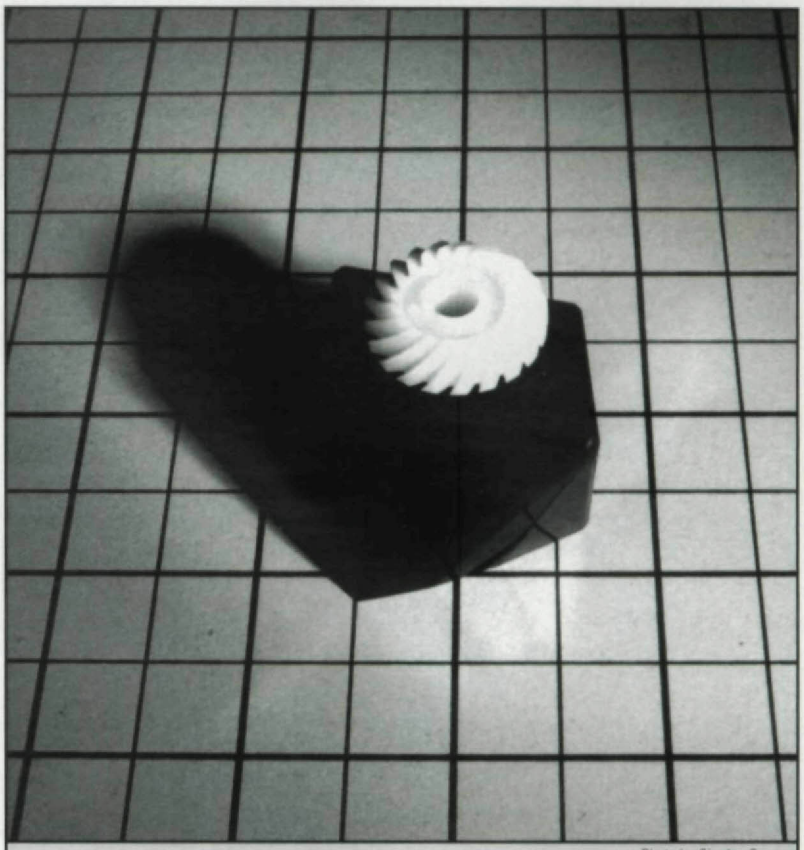


Photo by Charles Cooper

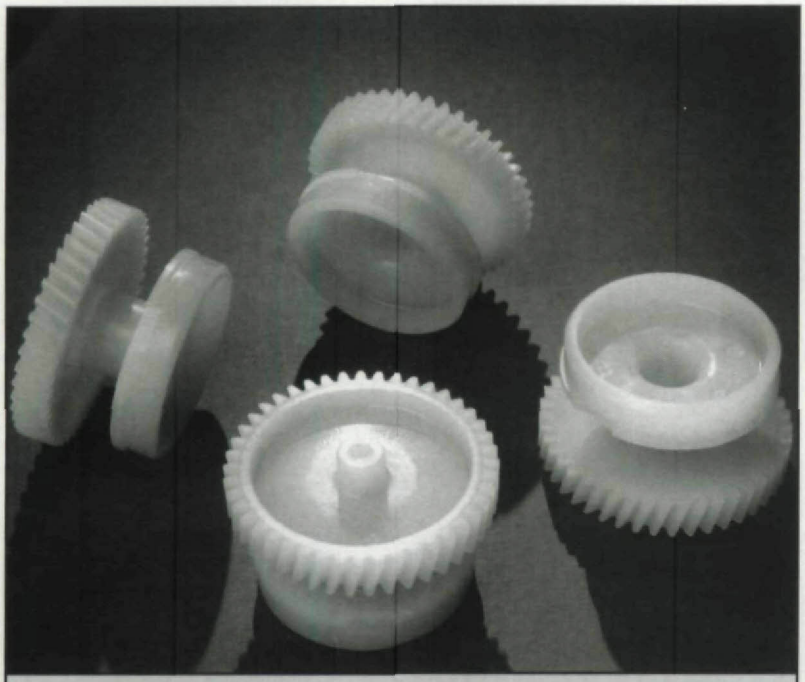
Lexmark implemented several spiral bevel gears in a recent printer drivetrain to increase the contact ratio and improve the smoothness of the gear train. The ever-increasing resolution of printers is demanding more and more accurate gear trains.

**Spiral Bevel Gear**

**Manufactured by: ABA-PGT, Inc., Manchester, CT.**

**Product: Lexmark printers.**

**Material: acetal and polyketone.**



**Laser Printer Gears**

**Manufactured By: GW Plastics, Bethel, VT**

**Product: Toner cartridge for Lexmark Optra line of laser printers**

**Material Used: Carilon® polymers from Shell Chemical**

This 40 mm gear is part of the photoconductor drum assembly used in the toner cartridge for Lexmark's Optra laser printer. The gear meshes with a mating gear in the printer itself. Requirements were toughness, quietness, wear resistance and creep resistance.

"In the past, it would have been unheard of to produce a 1400 dpi printer," says Alan B. Conrad, Industrial and Consumer Business Unit Manager for G.W. Plastics. "Gears are integral to that kind of technology."

This part was formerly manufactured out of lubricated acetal, but the Carilon polymer proved to be more stable (resulting in more consistent quality), more wear resistant and less expensive than the version of acetal previously used for this part.

Typical of injection molded plastic gears, this part enabled the designer to combine the gear with other parts without adding machining operations or assembly.

In addition, there has recently been a lot of cooperation between the traditional gear community and plastic gear manufacturers and material suppliers. One result of this cooperation is *ANSI/AGMA 1006, Tooth Proportions for Plastic Gears*, which was released along with *ANSI/AGMA 1106*, the metric equivalent, in 1997. AGMA's plastic gear committee is now working on an information sheet for plastic materials selection, says consultant Clifford Denny, committee chairman.

On the other hand, plastic gears were once unheard of for anything other than toys. "There was a time a long time ago when small, fine-pitch gears were all machined from metal," says Laskin. "The plastic gear industry hadn't developed yet." But today, plastic gears are in very serious applications such as medical tools, Laskin says.

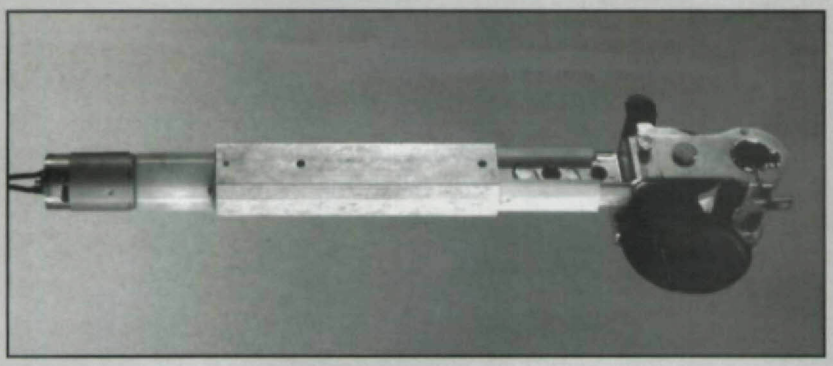
We're beginning to see plastic gears in applications with higher power and load demands. Fractional horsepower gearboxes are now commonly made out of plastic. Plastic gears capable of transmitting up to one 1 hp are achievable using today's technology. But plastic gear engineers now have their sights on 5 hp and greater applications in the not-too-distant future.

Some of the plastic gear manufacturers are currently working on gear trains in the 1-2 hp range, although most of them would not comment on any specifics for this article.

Another area where plastic injection molded gear manufacturers are looking is bigger parts. Injection molders have had difficulty creating parts larger than 2-3" in diameter. With larger spaces to fill, it becomes difficult to get an even flow of material into the mold. Traditionally, larger plastic gears have been machined just like metal gears, says Laskin. But injection molders continue to look at ways to increase their share of the market. "I'm entertaining doing an 8-pitch gear," says Milano.

The big chemical companies have added their considerable resources to the push. Ticona has a dedicated "Gear Team" for educating the industry about designing and implementing plastic gears. Ticona's gear team has developed P-GEAR, an automated gear testing system that collects data on fatigue life, wear, temperature, stiffness and other properties for gears molded with different materials. Similarly, Shell Chemical markets its Carilon and other lines of polymers specifically for gear manufacturing.

Better resins mean stronger gears. "The technology is getting better every year," says Seitz Corp.'s Milano. "We're not calling them actua-

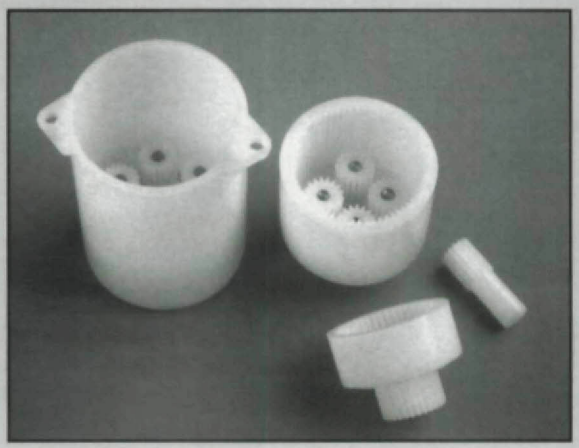


**Seat Belt Adjuster**

**Manufactured By: Epic Components Co., New Boston, MI.**

**Product: AlliedSignal Safety Restraint Systems seat belt height adjuster.**

**Material Used: Celcon® M90 acetal copolymer from Ticona.**

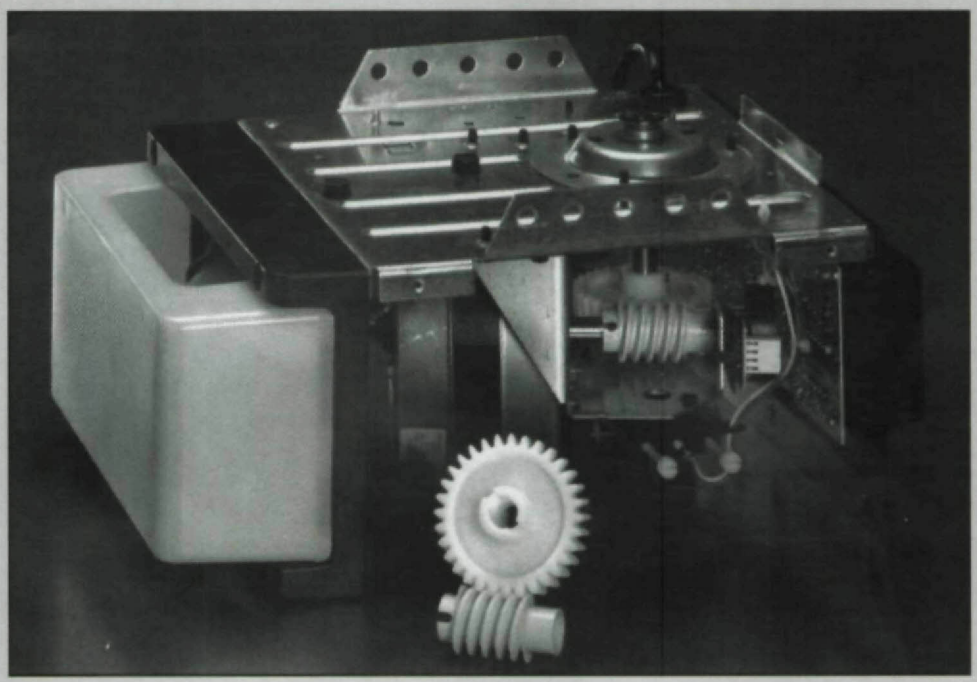


The coupled epicyclic gear system in this transmission is typical of the internal, cluster and split-power arrangements in today's plastic gear drives. Consisting of 14 injection molded acetal gears, the transmission is 1.44 inches in diameter and weighs 1.5 oz. It transmits 12 oz-in. of torque from a dc motor.

"A system of this type employs a number of internally- and externally-toothed gears to split the motion from the motor drive into multiple power paths, enabling the designer to pack a lot of gear ratio into a very small space," says Ticona gear specialist Dr. Zan P. Smith. "To do the job of the SRS transmission with conventional spur gears would require a gear set around five times larger."

The plastic worm for this garage door opener is mounted on a motor shaft and meshes with the gear to turn a vertical shaft that drives a belt or chain to move the garage door's operating arm along a track. The double-lead mesh keeps two sets of teeth in contact at all times to distribute the load and minimize friction and backlash.

The gear set replaces a glass-filled nylon worm and a steel gear from earlier models. The gears cost less than the previous materials, and the double-lead design eliminates the need for a brake.

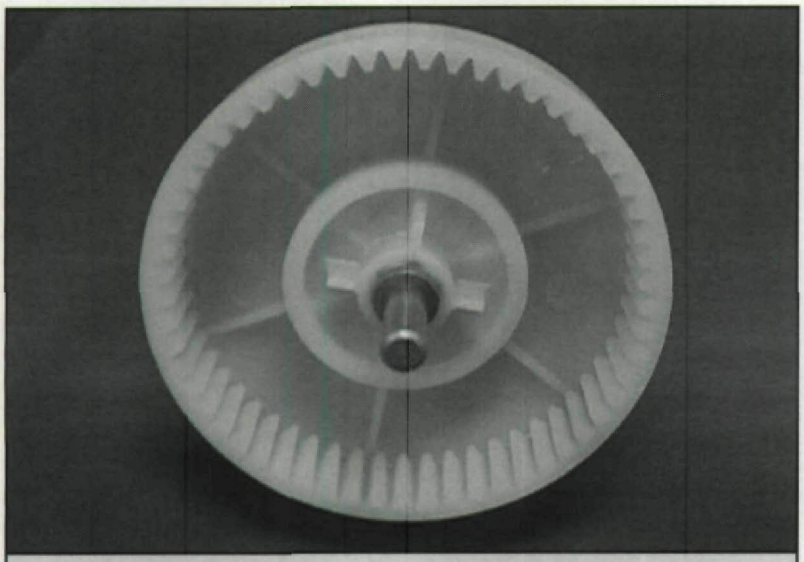


**Garage Door Opener**

**Manufactured By: Chamberlain Group, Elmhurst, IL.**

**Product: Ceiling-mounted garage door opener.**

**Material Used: DuPont Minlon® 10B40 mineral-reinforced nylon (worm) and Delrin® 100 acetal resin (worm gear).**



**Electric Chainsaw Internal Gear**

**Manufactured by: Seitz Corporation, Torrington, CT.**

**Product: Pulan Electric Chainsaw**

This internal spur gear is a good example of the tendency today to use plastic for gears that have typically been made out of metal. It is part of a gear train driven by a 1.068 hp motor at 25,000 rpm. The maximum output torque is 137 in-lbs.

Seitz Corporation developed this gear using the latest AGMA PT-1 standardized tooth profile. However, the part required an extensive development program.

"Our experience told us that this internal spur gear would develop taper during the molding process," says Seitz Corp. engineering manager Art Milano. "A tapered tooth profile generates poor contact ratio, excess noise and most likely a weak gear. We knew we would develop this internal gear in phases to determine and compensate for the amount of taper we would encounter during production."

Seitz's development program includes three phases, Milano says. Phase One involves design, material selection and calculation of safety factors. During Phase Two, the company designs and builds prototypes, adjusting the mold until the parts measure up. Phase Three involves live testing of the gear in its application and making any necessary final adjustments to the mold.

tors any more. We're calling them plastic transmissions now."

But increasing the load and power capabilities of plastic gears are not the only areas where the technology is improving. Advances in resin technology and processing controls have allowed molders to hold tighter and tighter tolerances, says Alan B. Conrad, Industrial and Consumer Business Unit Manager for G.W. Plastics, Inc., Bethel VT. Injection molders today are capable of consistently producing gears as high as AGMA Class 9, Conrad says, and "some are asking for AGMA 10."

As buyers of plastic gears continue to seek better, stronger gears, and as manufacturers continue to aggressively explore new markets for their products, the plastic gear industry will continue growing at a rapid rate.

While most experts agree that we aren't likely to see plastic gears in automotive transmissions or plastic gears driving lift bridges anytime soon, the plastics suppliers, who want to sell more resin, and manufacturers, who want to sell more parts, are working together to push the envelope of plastic gear technology, and at least one advocate is hopeful that even some of these high-power, high-temperature industries might not be too far out of reach.

"I think we're going to see more appliance transmissions, lawnmower transmissions, even vehicles powered by plastic gears," says Milano. ✪

**Tell Us What You Think...**
If you found this article of interest and/or useful, please circle **213.**

If you would like more information about **ABA-PGT, Inc.**, please circle **214.**

If you would like more information about **DuPont Chemical**, please circle **215.**

If you would like more information about **G.W. Plastics**, please circle **216.**

If you would like more information about **Seitz Corporation**, please circle **217.**

If you would like more information about **Shell Chemical Corporation**, please circle **218.**

If you would like more information about **Ticona**, please circle **219.**

**Industry resources are coming together for a workshop titled *TOPTEC: Plastic Gears for Power Applications, Fractional to 5hp*, which is scheduled for August 26–27 in Dayton, Ohio. The event, cosponsored by AGMA and the Society of Automotive Engineers, will feature presentations on plastic gear applications, design, manufacturing and testing.**

**This is the first of what is intended to be an annual event. It will include presentations on innovative design concepts, software, materials selection, inspection and more. There will also be a "Power Gear Symposium" focusing on the future of the industry.**

**For more information, contact the SAE Dayton section at (412) 772-8524.**