# Gearmotors Pulling, Pushing — and Controlling — Their Weight

## Industrial mainstay adapts to remain relevant in a 4.0 world

Jack McGuinn, Senior Editor

As manufacturers wend their way through what is now the increasingly vertical 4.0 world of industry, more of what were once-essential manufacturing components and processes find themselves on the endangered species list.

But not gearmotors. In some industries, they're becoming more relevant than ever. For example, as more hydraulics-driven applications transition to electronic actuators, gearmotors are taking over. In addition national defense and automotive are just two major sectors where geared actuators are specified, especially for custom applications. Indeed, if high force is required, gear or ball screw actuators remain the way to go.

This is not to say that gearmotor makers don't have concerns and conditions to deal with; some very real ones include:

- Growing gearmotor manufacturer and customer cost concerns in light of the escalating China trade war, which will directly affect magnet prices (brush and brushless DC, as well as IPM AC) and commutators (brush DC) — not to mention tariff-related rising steel and aluminum prices.

Looking for more insight, we asked some industry experts for their views on gearmotor usage and continued relevancy.

For instance: what is the relevancy of gearmotors relative to hydraulics used in electronic actuators? Is the needle pointing up or down? What would be their most common industrial application? It depends — as almost always — on the application. Is brute force needed — or motion-controlled finesse?

"Just about every OEM application you can think of is trying to accomplish greater flexibility, precision and efficiency, says John Morehead, principal consultant for Motion Mechatronics. "That's why there's a strong move to replace hydraulic actuators with electric motor-driven actuators. Rather than the brute force of a hydraulic motor driving various linkages, the move today is toward distributed motion with individual smaller, more efficient electric gearmotors. A notable example is agricultural precision planting to increase yields and reduce costs for farmers. Not only can the maintenance of a complex system of jackshafts, sprockets and chains be replaced with individual gearmotors; each one can be controlled individually to maximize yield for each row planted, which is important when the multi-row planter turns corners or follows curves. The elimination of hydraulic fluid leaks and contamination is a bonus.

"A wide range (of relevancy), says George Holling, CTO, Rocky Mountain Technologies and ***Power Transmission Engineering*** motors blogger. "We are working on missile actuators where size, volume and weight are the prime concerns, and gearmotors do well. Gearmotors now start to match the power density of hydraulic systems on an overall system comparison. The distributed system and the independence between actuators vs. a single hydraulic reservoir add a high level of redundancy and potentially also lower overall system and installation cost, as wires are lighter and cheaper to install than hydraulic lines."

This Chinese-made gear motors is a switched reluctance traction motor with internal plastic gear (Photo courtesy Rocky Mountain Technologies).

Looking for more, we asked about the efficacy of gearmotors/actuators in, for example, fly-by-wire and drive-by-wire applications requiring high power densities.

Holling responds that "The total efficiency is the actuator efficiency * gear efficiency. As motor speed increases, the motor efficiency will increase — especially p to 2KRPM-3KRPM at higher speeds it will drop again. Gear efficiency is

approximately 90%; most gear ratios are 3:1 to 6:1."

Morehead believes that "High-power density brushless DC gearmotors, combined with optimized efficiency gearing, is becoming the standard in autonomous warehouse robots. Brushless DC is not only more responsive but also more efficient and compact, with virtually limitless lifetime expectations compared to conventional brush DC gearmotors."

Returning to automotive applications, is it relevant to wonder what, if any, part gearmotors play in electric vehicles? To what extent do potentially deal-breaking things like size, weight and gear cost apply?

"EV motors typically have a fixed reduction gear to reduce the motor size," Holling states. "Increasingly, OEMs are looking to increase the motor speed to 12KRPM or more to save motor cost. There will be an optimal point where the total cost of motor + gear is minimized."

And what of any advances of note in plastic-geared gearmotors/drive systems? Available information is a bit sketchy, but Holling reports that he's "seen a durable, plastic-based gear system out of China: lightweight, low cost and somewhat durable. And we know of at least one Chinese manufacturer that integrated a plastic gear into a traction motor for small 3-wheel delivery trucks. I do not know if this panned out though."

China's mention returns us to the tariffs/trade war issue. Sure, it is all very political and perhaps uniquely Trumpian, but this is a "guns-and-butter," all-hands-on-deck issue for certain manufacturers — like those of gearmotors.

Morehead allows that "Unexpected tariff burdens are a fact of life today, where gearmotors possess content sourced from China and has prompted U.S. gearmotor manufacturers to look toward other low-labor-cost APAC (Asian-Pacific) countries for component or motor sourcing. Of course, the warning signs have been there for years and basic global economics foretell that the advantages of low labor and material costs are fleeting as economies develop. If all you make today is a standard-design gearmotor, you've set yourself up for global commoditization.

"While it's more important today than ever to provide the best application and design engineering support, along with highest quality and shortest lead times, it is becoming evident that customers are looking for more than just a gearmotor. Those gearmotor manufacturers who can also provide motor controls, cabling, brakes, encoders, brackets, shielding, enclosures and anything else customers will find advantageous to purchase as a sub-assembly will be rewarded with a stronger customer relationship and increased insulation from competition."

For Holling, in much the same vein, "These motors are becoming a commodity item with shrinking margins and strong price competition from China and others, which makes them less attractive to U.S. producers," says Holling. "Unless the supplier can offer a value-added which commands better margins, the U.S. is not competitive."

Meanwhile, seemingly, everything is a moving target in today's automated, bot-driven world. And highly sophisticated, software-driven motion *control* is now manufacturing's meat du jour. So where do, say, brushless DC motors fit in?

"Integrating the control required to make the brushless motor turn with the motor only makes sense in terms of eliminating costs of cabling and enclosures, while simultaneously eliminating electrical interference issues," says Morehead. "In addition, the OEM's installation time and cost are reduced and field servicing, which is always a burden, is greatly simplified. The OEM's greatest source of frustration is when a motor-and-drive problem arises and they're faced with finger pointing from two separate sources. Simple speed controls are just the first step and the gearmotor manufacturer's controls capability needs to eventually expand to positioning and networking to ensure being able to offer the highest-value, differentiated gearmotor solutions."

Holling explains that "Integrated controls can simplify the machine design, wiring costs etc. Thus, an integrated controller is a prime example of a value-added service that customers value and pay for. An integrated controller can also reduce design time and cost for equipment. Allow for future upgrades and field replacements (repair with different or generic components), and the reduced wiring and connections can potentially improve reliability."

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## For more information

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# Direct Drive and Hybrid-Servo Motors — with or without Gears

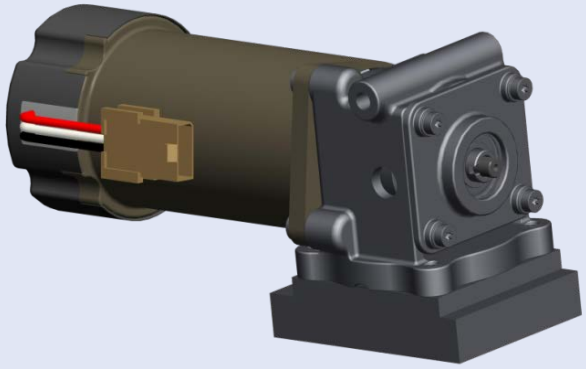
Newer-technology direct drive and hybrid-servo-type motors are enjoying increasingly more pervasive market share. The following is from a company — QuickSilver Controls Inc. (QCI) — focused on making these types of motors. But they do have some users that add gearheads to the motors. They have also worked with customers using harmonic drive gearmotors for certain applications as well. These comments are from Don Labriola, QuickSilver president and founder.

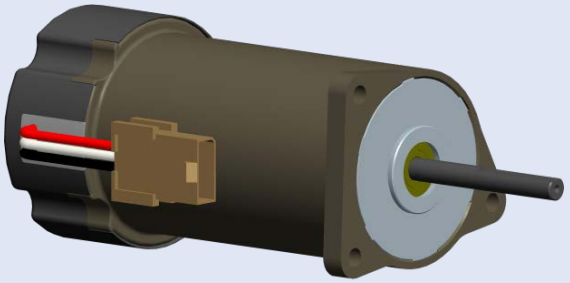
**On relevancy of gearmotors relative to hydraulics used in electronic actuators; most common industrial applications**

- We have seen the replacement of hydraulics with electronic drives in molding applications due to reduced fire risk and reduction of environmental recovery costs associated with spills of hydraulic fluids. In entertainment systems, the high power density of new electronics systems as well as the high efficiency has allowed removal of the hydraulics in many systems, preventing both the environmental cleanup as well as customer exposure to hydraulic vapors which can result from small pinhole leaks. The degree of maintenance and requirement of maintenance knowledge appears to be significantly lower for the electronic actuators, the electronic actuator having longer periods between maintenance.

**On efficacy of gearmotors/actuators in applications requiring high power densities**

- Both high power density and high efficiency are needed in warehouse automation powered by batteries or other storage, as the ratio of operations time to charging time sets the effectiveness of the system. Efficiency either less batteries or longer time between charging, or both. Starting with high torque motors can reduce the number of stages needed, reducing cost, size, and losses. Hybrid servos based on indirect permanent magnet transverse motors can provide wide speed ranges at high efficiency, and minimize energy lost while holding loads while transporting.





**On growing cost concerns in light of tariffs and escalating China trade war**

- We do our design and fabrication — mechanics, cases, electronics assembly, final assembly — in the U.S. Some of our smaller motors are obtained from China, but these are a smaller portion of our total cost, and, at least for the first two rounds, most types have not been affected — though the third proposed round will end up picking up most of the remaining China sourced motors. The hybrid servo motors we generally use consume a much smaller quantity of magnetic material than conventional servo motors, limiting the price effects of these materials.

**On value-added actuator solutions**

- QCI has made (its) business from integrated motion control as well as remoted control boxes. Many of our applications are able to run direct drive due to the high continuous torque ratings produced by hybrid-servo motors and to their high torque constants and high motor quality factors *Kq = Torque/sqrt* (power). Software allows variable torque, variable speed, emulation of particle clutch, as well as many communications options and onboard programming through customer-friendly development environments. When a gearmotor is required, hybrid servos can typically reduce the number of stages due to the high motor torque available, as well as the high inertial mismatch capability of hybrid- servo motors.

**On control integration as a key driver in the growth of brushless DC motors**

- Integrated fault detection, precise motion profiles, gentle starting and four-quadrant control of the motion — simple-to-complex program capability — are all built into the motor package. This significantly reduces the integration effort, cabling volume, and costs. Total system performance is also well parameterized from the data sheets, and integration design is reduced.

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