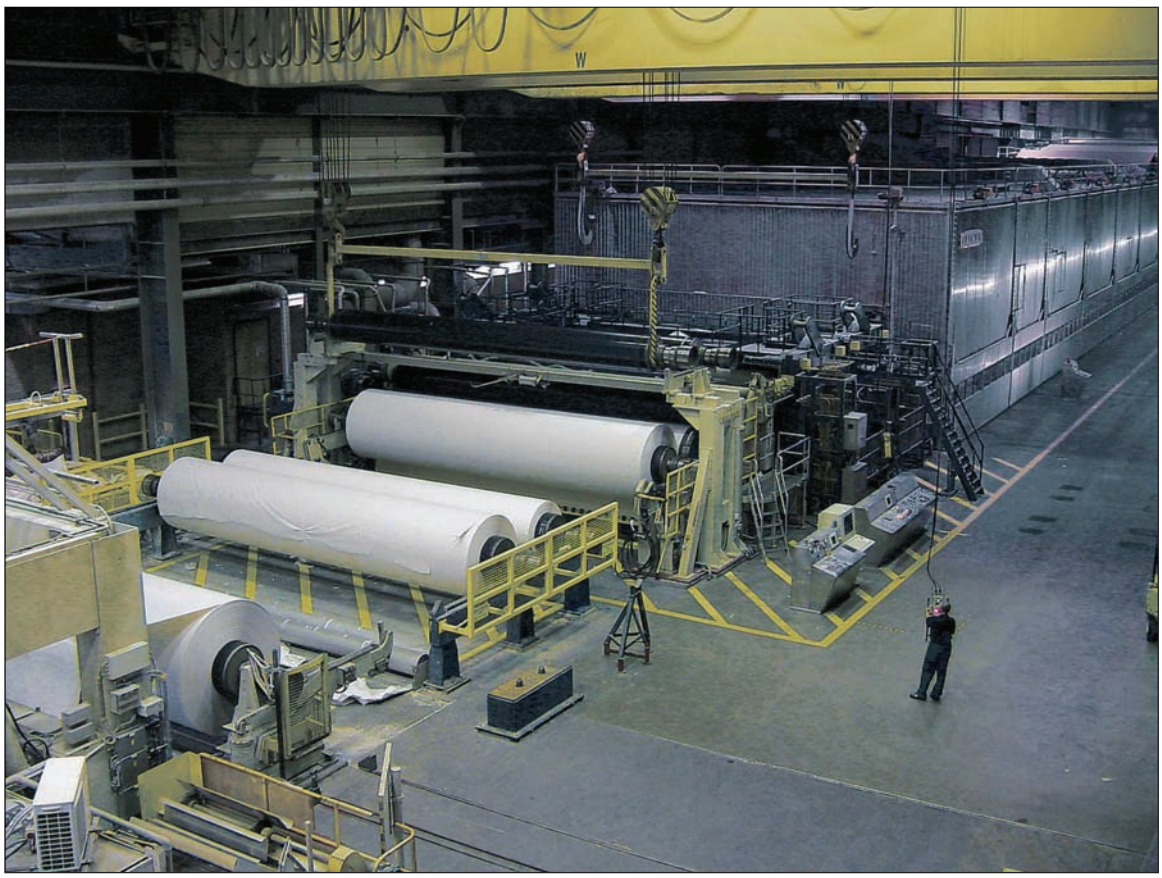
Power with Precision

CAN DIRECT DRIVE TECHNOLOGY IMPROVE YOUR BOTTOM LINE?

Jack McGuinn, Senior Editor



The paper industry was one of the first to use direct drive technology in a big way. (Photo courtesy of ABB.)

Manufacturers relying upon drive systems in their production process have long sought ways to improve gearbox efficiency. While a gearbox-driven system has been the mainstay for manufacturers, it has also been, among other things, the source of frequent breakdowns, expensive line stoppages and increasingly costly maintenance. Gears and bearings wear out and must be replaced; gearboxes leak oil, which must be replenished and scoured from the factory floor; and, they are often bulky and take up much needed real estate in and around the machine being run—a paper machine, for example. Add to that the fact that such issues compromise a machine's precision and controllability, and it is no wonder that manufacturers had come to search for a better way to run their production lines.

Depending on whose history you fol-

low, a "better way" began to appear as far back as the 1950s, according to Jeff Arnold, technology specialist/direct drive, for Danaher Motion.

"In the 1950s, Kollmorgen Inland Motor, in cooperation with MIT, developed the original direct drive torque—or DDR for direct drive rotary—motor for use on stabilized platforms in inertial navigation systems," he says. "This brush DC motor, with its large-diameter, thin-ring design, was ideal for this lightweight, high-torque application."

At ABB Inc., it wasn't until the late 1990s that the technology improved and the company jumped into the electric propulsion industry with the introduction of their Azipod direct torque control (DTC) motor.

"Marine propulsion—outboard motors for cruise ships is what ABB started with," says Chuck Hollis, ABB manager for ACS drives. "They go underneath the ship, and the propellers are directly attached to the shaft of the motor, which is underwater in a pod. It has revolutionized the propulsion of these cruise ships—the new Queen Mary II has got seven of them on her. And we license the technology to a couple of other (companies), so they're not all built by us, but ABB started that technology in 1996-97, and the use of permanent magnet (PM) motors definitely drove it.

"There are all kinds of advantages to it, not least of which is that these cruise ships don't need tugboats anymore."

Indeed, the pm-motor direct drive now provides these ships with far greater precision and controllability as they wend their way through the seaports and harbors of the world.

And at Siemens Energy and Automation/Direct Drives, they, too, entered the direct drive arena in the 1990s.

"As a supplier to machine tool builders, Siemens' initial direct drive motor offering was for applications involving motorized spindles for machining centers, turning centers and grinding machines," says David Plews, project leader/applications engineering. "In 2000, Siemens acquired the direct drive business of Krauss-Maffei, which was integrated into the Siemens Machine Tool organization as Siemens Linear Motor Systems (SLMS). SLMS offers direct drive linear motors as well as direct drive torque motors.

As the three examples above indicate, direct drive can be used in any number of applications where such things as positionability, controllability, accuracy and precision are paramount. Such applications include: handling systems, pick-and-place and sorting applications, circuit manufacturing machines, measuring machines, machines for optical inspections, laser cutting, milling and grinding machines, packaging and labeling machines and machine tools.

At ABB, the bread-and-butter component of their direct drive line is what they call the DriveIT Direct Drive Solution, which consists of a permanent magnet synchronous motor controlled by a low-voltage AC drive, based on its ACS 600 or ACS 800 AC drive, and connected directly to a motor/load without gearboxes or pulse encoders. This is coupled with ABB's direct torque control (DTC) software, which optimizes motor control and eliminates the need for an encoder to provide speed feedback.

Ken Graber, ABB team leader, marketing and communications for low voltage drives, products and systems, breaks it down further regarding the benefits.

"Elimination of the gearbox via these new permanent magnet motors/drive configurations saves space and installation costs, energy and maintenance, and provides more flexibility in production line and facility design. The AC motor also delivers high torque at low speed—a benefit traditionally associated with DC motors—and, in doing so, also eliminates the necessity of a DC motor and associated brush replacement and maintenance.

For an application-specific example, ABB's Hollis talks about the company's entrée into markets other than electric propulsion for cruise ships—specifically, dryer sections of paper machines for the pulp and paper industry. But it was in fact the marine application and ABB's Azipod motor that opened the door to other applications.

"Within ABB, some of the pulp and paper guys said, 'That's (the Azipod) pretty cool; we ought to do something with this,' " Hollis relates. "And they determined that they could eliminate gearboxes if we had low-speed motors. So they decided to eliminate gearboxes primarily on the dryer sections of paper machines. Typically, you've got a big gearbox, and a big, long motor sticking out and, and the motor was in the way. It was an inline thing, and some people said

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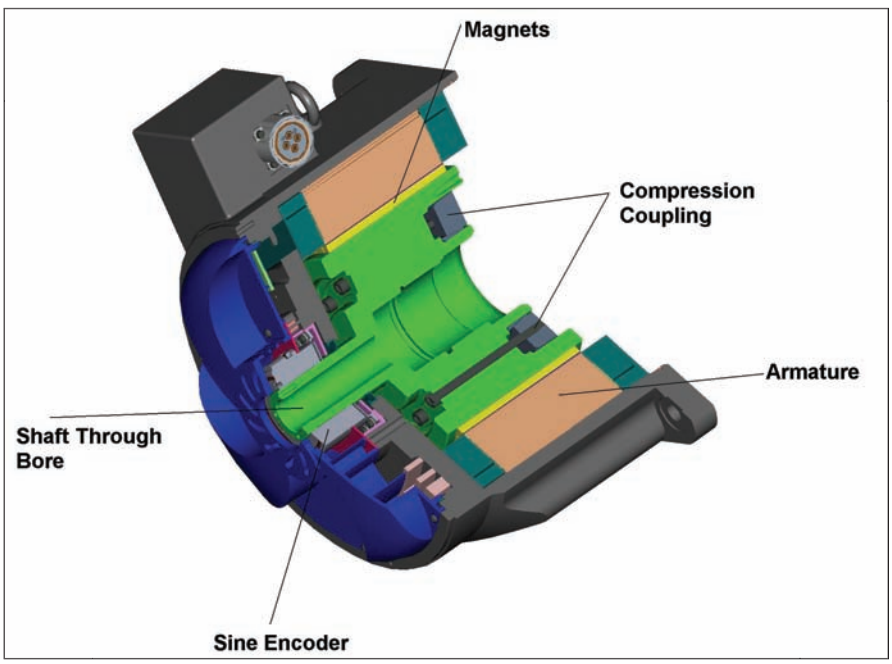


A cutaway view of a Danaher permanent magnet motor. (Illustration courtesy of Danaher.)

'The thing's in the way, we can't move the paper to where we want it,' etc. And they said, 'Why don't we just take the gearbox out and we'll use a low-base-speed motor, and then we won't have this size problem.' And that's what has driven a number of the situations that have been looking at this direct drive technology."

Siemens' Plews lays out some other applications suited for direct drive.

"For servo (positioning) applications, direct drive motors are best suited for those with high-dynamic requirements, low processing forces, a requirement for smooth motion and precise positioning," he says. "An example would be a high-speed machining center designed for cutting aluminum. Machines at the other end of the spectrum would not be optimal applications; e.g., a machining center for cutting steel, which requires lower cutting speeds and higher cutting thrusts than aluminum.

"Direct drives offer advantages in positioning accuracy due to the elimination of lost motion between the motor and the load—i.e., backlash in the gearbox. A typical rotary application might be a roller in a winding operation, where dynamic response and smooth motion are required."

And yet, according to Plews, direct drive does have its limitations, most of them application-driven.

"Gearbox designs offer the ability to adapt the machine to a varied torque and speed requirement by changing the gear ratio. With a direct drive design, this is obviously not possible. Direct drive designs also require a high level of technology to achieve high dynamic performance.

"Also, machine designs which need to be adapted via different ratios based on the final use, are the most notable examples" of where direct drive takes a back seat to the gearbox approach. "Designs using multi-range gearboxes, which allow for a wider, constant power range, are also impractical to convert" to direct drive.

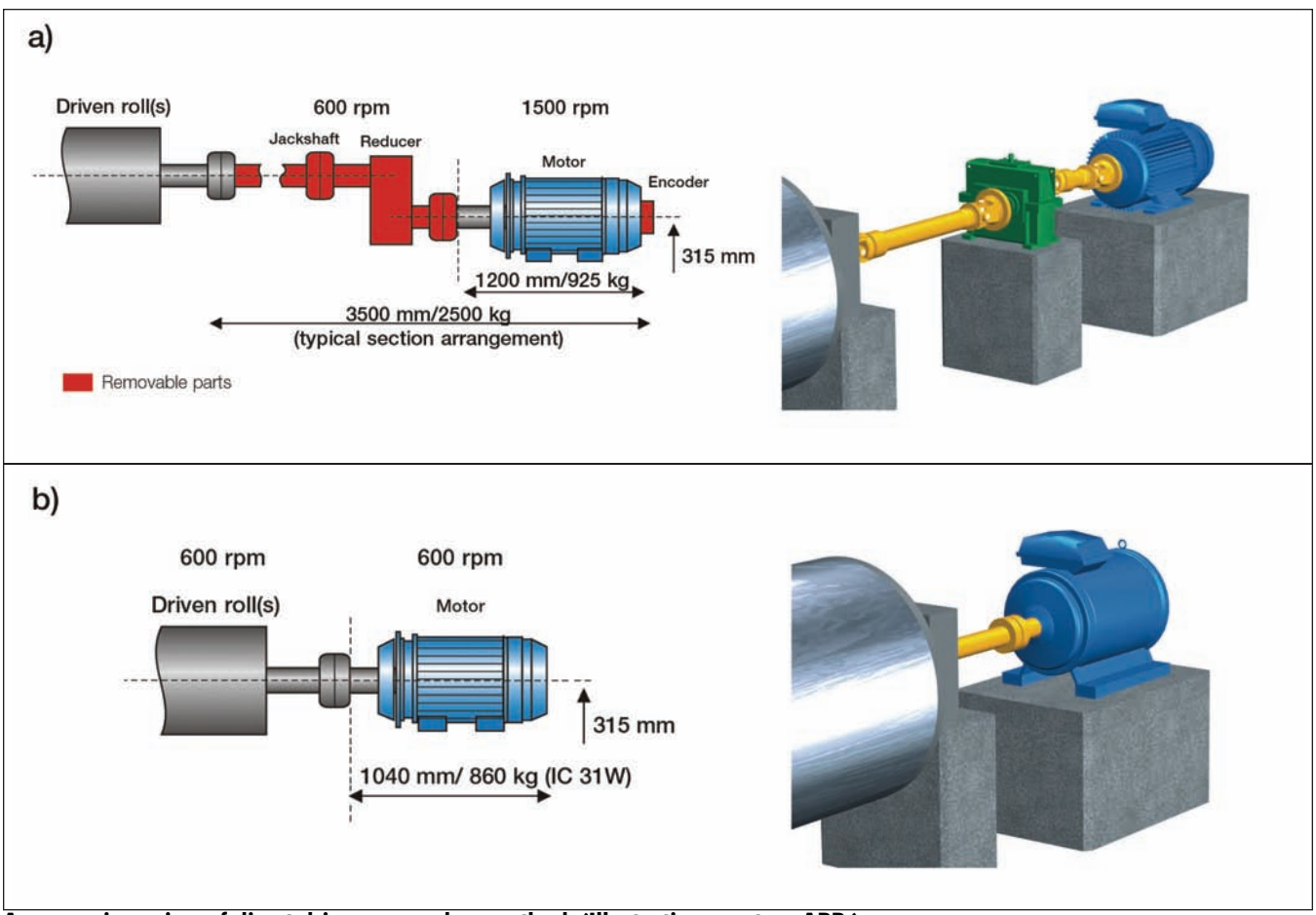
Plews adds that direct drives are often the more expensive option.

"While direct drives have their advantages, the cost advantage of gearboxes in applications where the advantages offered by direct drives are not required ensures that gearbox-based designs will remain in use for years to come."

That aside, Danaher's Arnold extols direct drive's virtues.

"The best applications for DDR (direct drive rotary) motors are industrial process control machines that can benefit from the DDR proposition." According to Arnold, the DDR "proposition" is:

- Improved accuracy (up to 50 times)—improves quality of product being manufactured
- Faster response time—increases machine throughput
- Fewer parts—reduced assembly time, less inventory, compact design
- Zero maintenance and no wear components—unlike mechanical transmissions
- Greater reliability—eliminate



A comparison view of direct drive vs. gearbox method. (Illustration courtesy ABB.)

mechanical transmission parts that can break
- No inertia matching requirement—often allows use of a smaller motor
- Reduced audible noise—up to 20db reduction

Arnold adds that "One application that benefits from the accuracy and response of the DDR motor is a CNC machine that makes precision gears. It takes the performance of a DDR motor to make a really good gear."

ABB's Hollis concurs with that opinion and offers up one of his own.

"Everyone wants to replace a gear ratio of more than 8 to 1," he says. "And these motors are not cheap—they're pretty expensive. So there's just no doubt that it is much cheaper to get torque multiplication in a gearbox than by building a low-base-speed AC motor with lots of torque capability. Direct drive is not a threat to gearboxes, I can tell you that."

As for the expense of direct drive, we put the question to Plews at Siemens of whether the cost of those permanent magnet motors will be coming down anytime soon.

"Yes—as with any emerging technology, the cost of the technology will come down as new approaches are developed," he says. "For example, the Siemens 1FN6 linear motor series features a secondary section free of magnets. For applications with long travels, such as handling systems to load an automated machine tool cell, this has a positive impact on the cost of a direct drive solution."

Bottom line, direct drive technology would appear to be very application-specific. We asked Danaher's Arnold to boil it down for us as to when—and when not—direct drive is the answer.

"In an application where overall size of the package is paramount, a mechanical transmission may allow for a smaller total envelope solution," he says.

On the other hand, "Any machine that can benefit from improved accuracy and response time, improved readability, reduced maintenance, reduced parts count and assembly time should be considered for using direct drive rotary motors."

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A Cartidge DDR motor from Danaher is used in applications like stamping presses and tire balancing machines. (Photo courtesy of Danaher.)