Direct Drive Technology

Improving Flexo Printing Quality and Throughput

By Tom England

TABLE 1. BILL OF MATERIALS LIST

Geared Press	Gearless Press	Direct-drive Press
Motor	Servo motors	Direct-drive rotary motor
Precision Gears	Gearboxes	
Lubrication System	Mounting brackets for gear motors	
Oil Bath	Shaft couplings	
Filter		
Pump		
Sealed housing		
Shafts		
Bearings		
Frame members and supports		
Mounting hardware		

Flexographic printing technology has become increasingly able to maintain print quality and reduce startup time and waste. Most operators concern themselves with registration and color accuracy and consistency—as they should. But many don't realize the importance that accurate synchronization of the anilox roller and plate cylinder used in each print deck module plays on print quality. Traditionally, this has been accomplished either by gearing the anilox roller and plate cylinder together and driving both with a single AC induction motor or by using separate servo motors to drive each axis through gearboxes. As press speed and printing quality requirements have increased, the inevitable inaccuracies in the gearing system have become a limiting factor on press print quality and speed.

Advancements make it possible to synchronize the anilox roller and plate cylinder to a much higher level of precision without mechanical transmissions by using closed loop control technology and driving both directly with independent, direct-drive rotary (DDR) servo motors. The elimination of the mechanical transmission enables servo loop gain to be increased, and therefore, bandwidth of the servo loop. Speed control and phasing between the anilox and plate cylinder can now be closely controlled in the absence of the gear backlash, thus providing for higher speeds and accuracies for improved print quality. Throughput is also increased because the higher control loop gain enables faster machine operation. This article will examine the trend toward DDR systems in flexo presses and consider alternative implementation methods.

- Speed control and phasing between the anilox and plate cylinder can be closely controlled in the absence of gear backlash.
- The latest generation of servo controllers provide resolution feedback up to 27 bits with 64-bit positioning resolution.
- DDR systems offer accuracy of about +/-25arc seconds--up to 20 times higher than conventional geared systems.

IMPORTANCE OF SYNCHRONIZING

In the flexo printing process, the anilox roller contacts the plate cylinder that carries the plate with a dot pattern that forms the printed image. The dots on the plate act as suction cups and lift the ink out off the anilox roller. Providing constant ink coverage is obviously critical to printing quality and this depends on maintaining consistent motion between the surfaces of the anilox roller and plate cylinder. Whenever the print cylinder moves faster than the anilox roller, less ink is transferred to the print cylinder, resulting in a light section in the printed piece. Whenever the anilox roller moves faster than the print cylinder, more than the normal amount of ink is transferred, resulting in a dark section.

The traditional approach to synchronizing the anilox roller and plate cylinders is to use a bull gear attached to the central impression drum to drive them both as shown in Figure 1. The problem with this approach is that backlash is inevitable in any mechanical transmission system. Even when a geared system is tuned very tightly, within a short period of time the gears will wear and backlash will begin to occur. Backlash

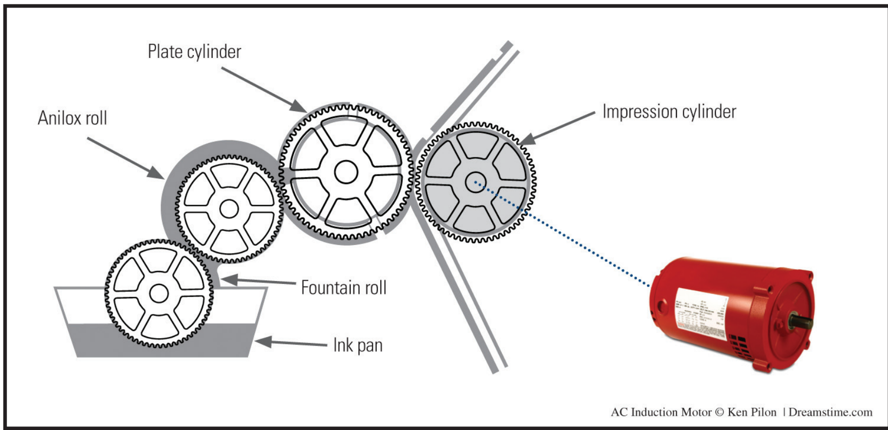

FIGURE 1.
A geared press configuration. All rollers are tied together with gears driven by a single motor.

causes the roller and cylinder to rapidly accelerate and decelerate as the gear teeth bounce back and forth against each other. The result sometimes is the appearance of alternating light and dark horizontal lines on the printed product.

"Gearless" printing presses (Figure 2) refer to those machines that eliminated gearing together off all of the axes running from a single motor. Instead, each anilox, plate, and impression cylinder has an independent servo applied. However, a gearbox is installed between the load and the feedback device, which adds inaccuracies. The result is that positioning accuracy in a "gearless" system typically is between +/- 1 arc minute and +/- 10 arc minutes. The acceleration and decelerations in a geared system are also limited by the gear-train backlash. Increasing acceleration past the safe level will lead to instability or gear damage. Some printing companies address these problems by frequently adjusting the antibacklash control system on the press, sometimes as often as weekly. This can result in a substantial amount of downtime without solving the underlying problem.

ELIMINATING THE MECHANICAL TRANSMISSION

Advancements in control and motor technology over the past decade now make it possible for the motion of the anilox and plate cylinders to be electronically synchronized by a closed loop control system to a much higher level of accuracy by eliminating the mechanical transmission system and creating a totally direct-drive configuration (Figure 3). The basic idea is that the anilox roller and plate cylinder are each driven independently by separate, direct-drive servo motors.

A feedback device such as a high resolution sine encoder provides the servo motors with far more accurate position and velocity information that the controller compares to its programmed motion profile and based on this signal sends velocity command signals to the amplifier that drives the servo motor. A motion profile defines the operation of each servo motor in terms of time position and velocity. In practice, the anilox roller and plate cylinder are synchronized in both speed and phase, ensuring that every point around the surface of the anilox roller is synchronized with the plate cylinder.

The latest generation of servo motor controllers provides resolution feedback up to 27 bits, with 64-bit positioning resolution, and 125msec position loops, 62.5msec velocity loops and 0.670msec current control loops. So DDR systems can deliver much greater accuracy than the best mechanical transmission systems even immediately after adjustment of the antibacklash control system. As a general rule, DDR systems offer accuracy of about +/- 25 arc seconds system accuracy, which can be up to 20 times higher accuracy than conventional geared servo systems. The result is substantial improvements in print quality.

IMPROVING THROUGHPUT

When the load is directly coupled, the settling time is no longer limited by the transmission, so the servo loop gain can be increased. This provides the necessary servo stiffness to achieve excellent speed regulation and phase control between the anilox, plate, and central impression cylinders. Press speeds using direct-drive technology can be increased in many applications because the accuracy of the mechanical transmission system is often the limiting factor.

Switching to direct-drive further improves press throughput by reducing setup and maintenance time. A typical flexo press servo system equipped with gearboxes requires periodic tuning adjustments of the antibacklash control system to compensate for gear wear. DDR systems, on the other hand, since they are directly coupled to the load, require no periodic tuning. There is complete elimination of backlash and the need for antibacklash controls. Years later, the tuning settings are typically the same as the day the machine was installed.

With a direct-drive press, the parts count on a typical Bill of Material (BOM) is reduced by up to 10 parts per color print deck. This mechanical simplification translates into faster assembly, less maintenance, and less overhead to purchase parts. Table 1 shows a comparison of a typical geared solution with a direct-drive system. When

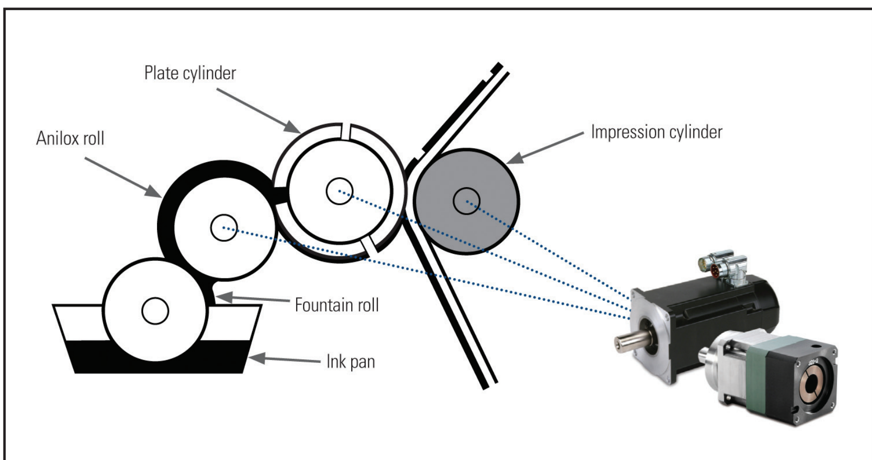

FIGURE 2.
A gearless press configuration. Each roller is driven independently by a motor/gearbox combination.

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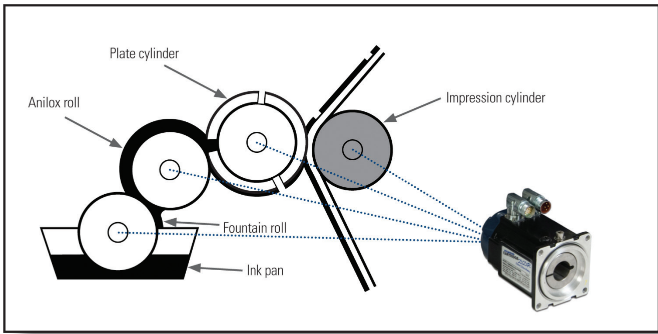

FIGURE 3.
A direct drive press configuration. All rollers are driven independently by a direct-drive rotary motor, without the need for gears or gearboxes.

considering a 10-color press, more than 100 parts can typically be removed from the BOM.

When the anilox roller and plate cylinder are driven by a single motor via a gear system, it is difficult to separate the two axes for maintenance and exchange of printing sleeves or plates. In a direct-drive configuration, the anilox, plate, and CI drum can be moved independently of each other for easy maintenance, cleaning, and change of plate blankets. This can also be viewed as a safety improvement since the rolls can be controlled independently.

Finally, the direct-drive method also eliminates the need for alignment, lubrication and eventual replacement of the mechanical transmission system.

SMALLER MOTORS

Since the direct-drive motor is directly connected to the machine, inertia-matching is not required as it is on a conventional servo motor with gears. Stepper motors are typically sized to match the load in order to have enough torque to overcome disturbances when torque is low, which occurs as a result of nonlinearity caused by the torque roll-off or resonance at certain frequencies. However, closed-loop servo motors with controlled commutation are not prone to the same de-synchronization issues and torque losses. The servo system also maintains a linear and predictable speed torque curve without the need for special commutation sequences or anti-resonance control.

For these reasons, DDR motor size can be based on the peak torque required for achieving the desired acceleration time specifications. With direct drives, inertia mismatch of 250 to 1 is common and mismatch of 800 to 1 has been implemented. In many flexo presses, the size of the motor is dictated by the inertial matching requirements. The result is that a much smaller and more energy-efficient DDR motor can be used in most applications.

Today, many machine specifications, even in the industrial environment, list the maximum allowable audible noise levels. The audible noise level of a direct-drive system can be as much as 20dB lower than a geared system, as transmission components generate considerable noise levels. So, installing a direct-drive system can help achieve the required audible noise specifications.

DDR ALTERNATIVES

Direct-drive rotary technology has developed in an evolutionary manner. The original frameless direct-drive motors were designed into the machine architecture along with a feedback device and became a fully integrated part of the machine. This approach has the advantage of consuming the least amount of space. On the other hand, frameless motors are relatively expensive to fully integrate as they typically require substantial changes to the design of the underlying machine. Frameless motors are also more difficult to service because they are embedded into the machine. While the initial development cost burden is high, the benefits of higher performance, higher quality, and small space requirements justify this technology in some applications.

The next generation of DDR technology, sometimes referred to as full-frame systems, integrates all of the components of a complete motor including the rotor, stator, bearings and feedback device within a housing. The machine shaft slips through the bore in the motor and attaches to the rotor. This approach substantially reduces development costs since the motor no longer needs to be integrated with the printing press. The disadvantage of this approach is that the motor's and the machine's bearings must be precisely aligned, which is a complex and time-consuming task. The bearings in the motor and the load are directly coupled in a linear fashion making it nearly impossible to align the system components properly without causing premature bearing failure due to loading.

The most recent approach to DDR systems, the cartridge DDR servo motor, is fully housed and ready for mounting to the machine. However it has no bearings and uses the host machine to support the motor's rotor. This approach makes it easy to use direct-drive technology on machinery that already has bearings, particularly in applications such as printing where rollers already use heavy-duty, precision bearings. The motor has a hole in the middle which slips over the shaft of the anilox roller, plate cylinder, or central impression roll and the motor housing bolts to the machine frame.

Installation typically takes less than five minutes. The motor slides over the shaft until a motor pilot engages a machine pilot. The housing is secured with bolts. The motor rotor is then secured to the machine roller shaft by means of a compression coupling tightened to a specified torque. The rotor is now rigidly connected to the machine shaft. The encoder alignment is pre-set so that no adjustments need to be made. Cables are connected and the motor is ready to run.

A servo system equipped with a cartridge motor is expected to work for 10 years without any maintenance. Although the initial system cost might be higher compared to a conventional geared system, over a period of several years, eliminating the cost of repairs and periodic maintenance makes the overall cost of purchasing and operating a cartridge system lower. Even with the slightly higher initial cost, over a five-year period, cartridge motors can reduce operating costs up to $10,000 per motion axis compared to conventional geared servo systems.

It's no secret why direct-drive technology is being increasingly used in new printing press designs. For printers, the higher quality and throughput associated with DDR systems translate into higher profitability. For manufacturers of printing presses, direct-drive technology offers a substantial competitive advantage as well as easy integration with current and new machine designs. ■

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