Direct Drive Technology Improves Flexo Printing Quality and Throughput

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White Paper

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Flexographic printing technology has become increasingly popular because it more easily maintains printing quality and reduces startup time and waste.

But flexo printing quality depends on maintaining extremely accurate synchronization of the anilox roller and plate cylinder used in each print deck module. 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 servomotors 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.

Recent 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). Eliminating the mechanical transmission enables the servo loop gain to be increased, thereby increasing the bandwidth of the servo loop. Speed control and phasing between the anilox and plate cylinder can be closely controlled in the absence of 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 towards DDR systems in flexo presses and consider alternative implementation methods.

The Importance of Synchronizing Anilox Roller and Plate Cylinder

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 consistent 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 than the right amount of ink is transferred to the print cylinder, resulting in a light section in the printed piece. Whenever the print cylinder moves faster than the anilox roller, 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 *(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 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.

With "gearless" printing presses *(Figure 2)* each roller is driven independently by a motor/gearbox combination. Each anilox, plate, and impression cylinder has an independent servo applied. However, a gearbox is

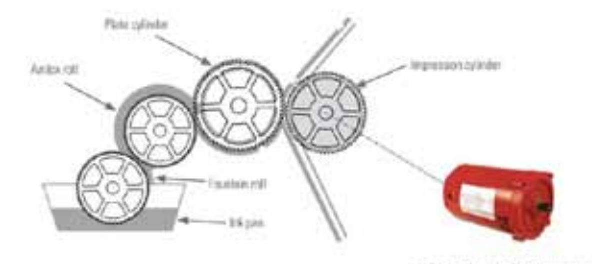

Figure 1 - In a geared press configuration, all rollers are tied together with gears driven by a single motor.

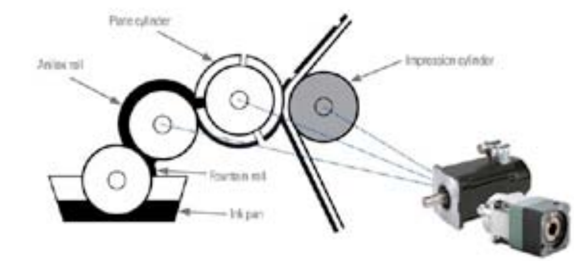

Figure 2 - In a "gearless" press configuration, each roller is driven independently by a motor/gearbox combination.

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installed between the load and the feedback device adding inaccuracies. The result is that positioning accuracy in a "gearless" system typically is between +/- 1 arc minute and +/- 10 arc minutes. The accelerations and decelerations in a geared system are also limited by the gear-train backlash. Increasing accelerations 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

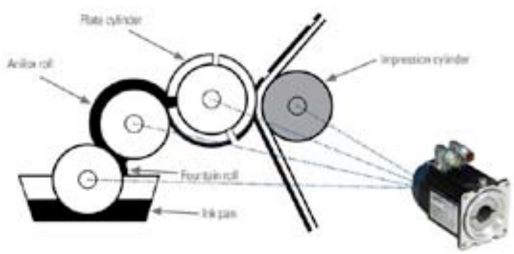

Figure 3 - In a direct drive press configuration, all rollers are driven independently by a direct drive rotary motor, without the need for gears or gearboxes.

by separate DDR motors. A feedback device such as a high resolution sine encoder provides the servomotors 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 servomotor. A motion profile defines the operation of each servomotor 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.

Benefitting from advancements in drive & control technology

Recent advances in drive and control technology provide additional benefits when coupled with Kollmorgen Cartridge DDR® Motor technology.

For example, the latest generation of servo drives provides true plug-and-play operation with standard servomotors, electric cylinders and linear positioners. The person assembling the printing machine simply plugs the motor and feedback device into the drive and the drive adjusts all parameters to match the motor and feedback device. The drives support a variety of feedback devices.

For programming of each print station or deck, modern control and drive systems can provide multi-axis, coordinated motion control for system synchronization.

Programming in IEC 61131-3 languages as well as custom SW for complex cams is available. An entire multi-color machine can be controlled by a single PAC (Programmable Automation Controller) which provides single point access to each motion axis on the machine. Alternatively, each print deck can be controlled as a single motion subset and then tied into a master controller. This includes simple drag and drop configuration of I/O, HMI, and other machine devices.

DDR systems equipped with the latest generation servo drives, which provide up to 27 bit resolution feedback, 64 bit positioning resolution, 125 microsecond position loops, 62.5 microsecond velocity loops and 0.670 msec current control loops, 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.

The servo drive plays an important role in this print performance in that it must maintain low-noise and high gain to achieve the necessary bandwidth of the servo loop. Since there is no mechanical advantage provided by a gearbox, the gains of the servo loop must be higher than standard geared systems. This drives the need for low noise, high gain loops. While the DDR system typically provides a very stiff, single body mechanical assembly, there is still compliance in this system that needs to be accommodated by the use of advanced observers and bi-quad filters to achieve the best bandwidth possible. Servo drives must provide this key link in total system performance to achieve superior print quality.

Improving Press 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. During commissioning of the machine, the operator merely pushes a single button and an auto-tuning feature adjusts all the loops, filters and gains, including observers, for optimum performance in seconds. Auto-tuning provides precise control of all motor types and compensates for load variations.

An easy-to-use Graphical User Interface (GUI) is helpful in providing fast commissioning and troubleshooting. Engineers and technicians can quickly diagnose problems over an Ethernet connection to the drive or controller, including remote diagnostics analyzed by a motion control expert miles away from the actual machine. Other necessary drive software tools for the machine designer are:

- Easy to use multi-channel oscilloscope
- One click auto-tuning
- Multi-function Bode plots
- Capability to share machine performance data quickly over email

These elements, along with the basic servo performance, provide the necessary “engine” to complement DDR technology to provide excellent print quality.

Reducing Bill of Materials, and Maintenance, Requirements

With a direct drive press, the parts count on a typical Bill of Materials is reduced by up to 10 parts per color print deck. This mechanical simplification of the machine translates into faster assembly, less maintenance, and less overhead to purchase parts for the machine. Table 1 compares a typical geared solution with a direct drive system. When considering a 10 color press, over 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 DDR 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 Can Be Used

Since the direct drive motor is directly connected to the machine, inertia matching is not required as it is on a conventional servomotor with gears. Stepper motors are typically sized to match the load in order to have enough torque to overcome disturbances when torque is low due to the nonlinearity caused by torque roll-off or resonance at certain frequencies. However, closed loop servomotors 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 drive, 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 direct drive 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 20 dB lower compared to a geared system since transmission components generate considerable noise levels. So, installing a direct-drive system can help achieve the required audible noise specifications.

Geared Press	Gearless Press	Direct Drive Press
Motor	Servomotors	Direct Drive Rotary Motor
Precision Gears	Gearboxes	
Lubrication System Oil Bath Filter Pump Sealed Housing Shafts	Mounting Brackets for Gearmotors	
	Shaft Couplings	
Bearings		
Frame Members and Supports		
Mounting Hardware		

DDR Motor Alternatives

DDR technology has developed in an evolutionary manner. The original frameless direct drive motors *(Figure 4)* were designed into the machine architecture

Figure 4 - Frameless DDR motor technology is designed into 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 since 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.

Figure 5 - Full frame DDR systems integrate all of the components of a complete motor, including the rotor, stator, bearings and feedback device, within a housing.

The next generation of DDR technology, sometimes referred to as full frame systems *(Figure 5)*, 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.

Figure 6 - Kollmorgen Cartridge DDR ® servomotors are fully housed and ready for mounting to the machine. Over a five-year period, These motors can reduce operating costs up to $10,000 per motion axis compared to conventional geared servo systems.

The most recent approach to direct drive rotary systems, The Kollmorgen Cartridge DDR® servomotor *(Figure 6)*, 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 5 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 Kollmorgen Cartridge DDR® 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 DDR 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 direct drive translates 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.

ABOUT KOLLMORGEN

Kollmorgen is a leading provider of motion systems and components for machine builders around the globe, with over 70 years of motion control design and application expertise.

Through world-class knowledge in motion, industry-leading quality and deep expertise in linking and integrating standard and custom products, Kollmorgen delivers breakthough solutions unmatched in performance, reliability and ease-of-use, giving machine builders an irrefutable marketplace advantage.

For more information visit www.kollmorgen.com, email support@kollmorgen.com or call 1-540-633-3545.