



DESIGNING DRIVES FOR A COMPETITIVE EDGE

GET MORE FROM YOUR INDUSTRIAL BELT DRIVES

A field redesign results in unprecedented performance

INTRODUCTION

If you're an electromechanical engineer who designs power transmission or motion control systems for industrial equipment, you face an ongoing challenge. You must adopt new technologies to remain competitive in the marketplace. You may be wondering, if my drive design is working, why change?

A field redesign can save on costs, improve productivity, and reduce downtime and maintenance. This paper will examine two field retrofits that led to better performing, more competitive drive designs.

Standard designs may call for a roller chain or gear drive. For many engineers, replicating these solutions is standard procedure — but burdensome. Replacing a roller chain or gear drive involves unnecessary risk and expense, and downtime you could avoid by using a different solution.



MARKET IMPACT OF INAPPROPRIATE OR OUTDATED DESIGNS

A poorly performing drive is costly to the user. The equipment may operate inefficiently, consuming too much energy. It may slow the production cycle, or cause damage to other components in the system. Poorly designed drives will increase the user's maintenance expense budget.

Bob is responsible for upkeep and repairs. About once a quarter, he replaces a 190-pound, 14-foot roller chain — a greasy, dirty beast.

He divides the chain into segments and carries each piece up six flights of stairs and a ten-foot ladder to the crow's nest. For the return trip, he carries down the old roller chain segment. He repeats this process again... and again... and again until he has all of the new chain pieces in the crow's nest where he then reassembles.

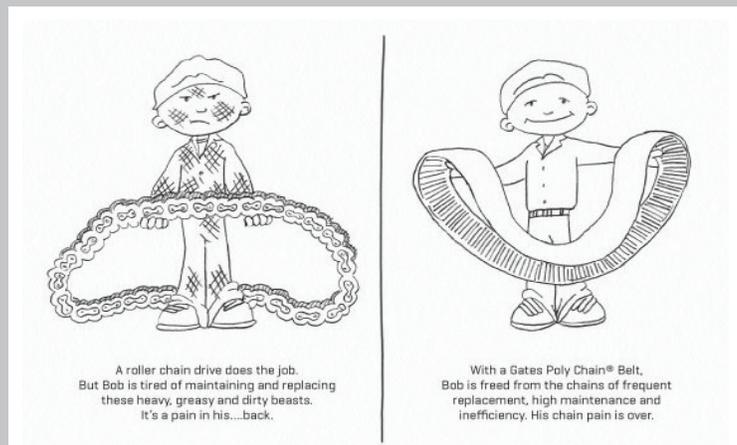
Little does Bob know, there's a better way. Weighing in at just nine pounds, the Gates Poly Chain® belt requires no grease and virtually no maintenance. Not only can Bob replace the Poly Chain belt in just one trip, he only has to do it every couple of years. Talk about reduced replacement costs.

Gates Poly Chain Belts are

- > Lightweight for improved employee safety
- > Grease free, so no lube to attract filth
- > Maintenance free, thanks to no metal-on-metal wear.

Use Gates Design Flex® Pro™ software to redesign your two-point drive.

Visit gates.com/drivedesign.



Watch Bob's Story at info.gates.com/chainpain.

Signs of a Poorly-Performing Drive

How can you tell when a drive is just “wrong” for the equipment? Watch for these signs:

- > Frequent replacement
- > Premature failure
- > Higher than usual maintenance
- > Noise
- > High temperature

Vibration

The drive may have been improperly sized for the application. Or the application may have changed over time, placing requirements such as higher speed or throughput on the equipment not intended in the original design. Whatever the cause, the cure is to reassess the drive and application.

Long-Term Cost

When converting to a different type of drive design, consider not only the component acquisition costs, but also the total cost of ownership and customer satisfaction. A drive system that minimizes maintenance and replacement of components can not only save money in the long run, but also increase uptime and productivity.

DRIVE DESIGN CONSIDERATIONS

Application Criteria

Designing a drive system to deliver rotary and/or linear motion begins with some basic objectives:

- > Cost [initial price, replacement cost, total cost of ownership]
- > Performance [speed, torque, power, acceleration]
- > Efficiency [mechanical and electrical]
- > Size, weight and space limitations
- > Geometry [center distance, layout]
- > Precision and accuracy
- > Noise and vibration
- > Environment [temperature, contaminants, etc.]
- > Reliability and service life
- > Customer satisfaction

Manufacturing Criteria

Consideration must also be given to the economics of the drive sub-system. Some factors include:

- > Cost and accessibility of components
- > Ease of manufacture assembly time
- > Production line output
- > Rework warranty

POPULAR DRIVE DESIGN OPTIONS

Several technologies are available to the designer of power transmission and motion control drive systems. Common ones include:

- > Roller chain
- > Gears and gearboxes
- > Belts

We'll briefly review the pros and cons of each of these systems, and present examples of roller chain and gear drive conversions that led to improved designs.

Roller Chain

One of the oldest forms of power transmission in existence, roller chain is comprised of a series of connected metal links that engage sprocket teeth. It is available in a wide variety of styles and materials.

Advantages: Roller Chain

- > Transmits high power/torque at low speed
- > Relatively low initial cost
- > Uses readily available components
- > Fairly forgiving when misapplied
- > 91% - 94% efficient
- > Simple, readily available
- > Versatile [length, attachments, splicing]
- > Serpentine capability
- > Synchronization ability
- > Low cost of acquisition



Disadvantages: Roller Chain

- > Noisy
- > High maintenance
- > Requires regular lubrication
- > Pins and bushings wear with use
- > Chain stretches over time
- > Needs periodic retensioning
- > Considerable downtime and lost productivity

Gears

Gears are toothed machine parts, such as a wheels or cylinders, which mesh with other toothed parts to transmit motion or to change speed or direction. Gear reducers [also called speed reducers, gearboxes, gearheads] are gear sets that convert input from a motor or other power source into lower RPM and correspondingly higher torque. Gear types commonly used in power transmission and positioning applications include:

- > Spur gears [straight teeth that are parallel to the axis of rotation and can transmit power between parallel shafts]
- > Helical gears [spiral teeth that can transmit power between parallel as well as right-angled axes]

- > Bevel gears
- > Planetary gears
- > Cycloidal gears
- > Spline or harmonic gears
- > Worm gears
- > Rack and pinion gears [convert rotary motion into linear motion]

Advantages: Gears

- > Available in a wide range of sizes and power capabilities
- > Wide speed operating range
- > Compact

Disadvantages: Gears

- > Noisy
- > Require lubrication
- > Wide range of efficiency depending on gear type [worm gears: 60%; cycloidal gears: 97%]
- > May lose torque on large motors



Belts

Belts are designed to transmit power via pulleys, sheaves, or sprockets.

V-belts have a V-shaped cross section that wedges into a corresponding V-shaped groove in the sheave or pulley. Synchronous belts transmit power by engaging the belt's teeth in a pulley or sprocket, not by wedging friction, as in V-belts. Belt teeth mesh with sprocket teeth to provide positive power transmission on high-torque applications at high and low speeds. They are identified by their pitch length, profile type [trapezoidal, curvilinear, modified curvilinear], tooth pitch [distance between adjacent teeth], and top width.

Advantages: V-Belts

- > Wide range of power capability
- > Wide speed operating range
- > 94-97% efficient
- > Low acquisition cost
- > Low cost of ownership
- > Widely available
- > Quiet
- > Clean running
- > Smooth running
- > Clutching ability
- > No lubrication



Trapezoidal, Gilmer



Curvilinear



Modified Curvilinear

Disadvantages: V-Belts

- > Slip
- > Finite length sizes, manufacturer dependent
- > Maintenance required for optimal performance
- > Limited temperature range

Advantages: Synchronous Belts

- > Near 98-99% efficiency
- > Maintenance free [no retensioning]
- > No lubrication required
- > Belts are rust-free in corrosive environments
- > Corrosion-resistant hardware available
- > No contamination caused by lubricants
- > Low cost of ownership
- > Minimal dynamic elongation thanks to high modulus tensile cords
- > No slippage
- > Wide range of power capability
- > High power density
- > Wide speed operating range
- > Accurate positioning
- > Low acquisition cost
- > Widely available



Disadvantages: Synchronous Belts

- > Sensitive to improper alignment; should not be used on systems where misalignment is inherent to the drive operation
- > Slightly higher initial cost compared to roller chain
- > Finite length sizes, manufacturer dependent

Quickly Design Industrial Synchronous and V-Belt Drives

Create and compare multiple belt drive designs that fit your specifications with Gates Design Flex® software.

[Access Design Flex](#)



CASE STUDY

ROLLER CHAIN TO SYNCHRONOUS BELT

Resulting in \$330,000+ Annually

A bottling facility encountered frequent downtime on a series of conveyor lines driven by #60 roller chain to feed bottles into a labeling unit. Differing rates of chain wear, stretch, and elongation on the multi-stage drives caused variations in speed so that one end of the conveying line would begin running faster than the other. As a result, bottles were slammed against each other, shattering and immediately halting production.

When this happened the entire operation had to be shut down to retension the chain drives, which took two hours of maintenance time and stopped all production downstream. Dumpsters of broken bottles were cleaned up and sent to a recycling facility. Additionally, each shift was spending two hours of preventive maintenance time in an attempt to keep the roller chain drives running properly. Regardless, the roller chain had to be entirely replaced every three months. This ongoing problem was solved by improving the original design through conversion to synchronous belt drives, using Gates Poly Chain® GT® Carbon® belt drive systems. The high power rating of these carbon fiber-reinforced belts allowed width-for-width replacement.

Because a synchronous belt doesn't stretch over time like roller chain does, the conveying speed remained consistent across all the lines and throughput increased by 20 percent.

Because a synchronous belt doesn't stretch over time like roller chain does, the conveying speed remained consistent across all the lines, preventing the bottles from piling up and breaking. Throughput increased by 20 percent. Fewer bottles breaking reduced the need and cost of recycling. Synchronous belts don't need lubrication, which eliminated the two hours per shift of preventive maintenance time, freeing maintenance personnel to handle other tasks and eliminating the risk of contamination from the lubricant. And without metal-to-metal contact, the synchronous belts are less subject to wear. Life expectancy for the synchronous belts is two years, compared with three months for the roller chain.

The annual cost savings resulting from this chain to belt conversion was calculated at \$330,000 per year, not including the recovery of lost production time and reduced recycling costs. Payback for this project was less than one year.



Multi-stage roller chain drives on a conveyor wore unevenly, creating synchronization problems.



Retrofitting with synchronous belt drives made line speed consistent and eliminated maintenance downtime.





CASE STUDY

GEARS TO SYNCHRONOUS BELT

The Switch Saved \$48,000 Per Machine

Gear-driven 30-ton stamping presses operate 24/7 in a manufacturing plant. The continuous hammering action wore down and narrowed the gear teeth on the 24" bull gears, creating slack in the system, throwing off the timing of the stroke, and gradually reducing product output. When the speed variation reached ± 35 rpm, the plant engineer knew that the gears were so thoroughly worn it was time to replace them, typically every 3-4 months.

Each stamping press used an electric motor with a set of gears on either side, an \$18,000 replacement cost. It took 48 hours to shut down the machine, replace the gears, and put the stamping press back into operation. That's two days of lost productivity per machine.

The plant engineer was looking for a better solution, such as hardening the gears to make them last longer. But a better solution was a synchronous belt drive. The drive had to be compact and strong and space was limited. The solution was a Gates Poly Chain® GT® Carbon® belt drive system, at about 1/3 the cost of the replacement gears, and an anticipated installation time of half a day.

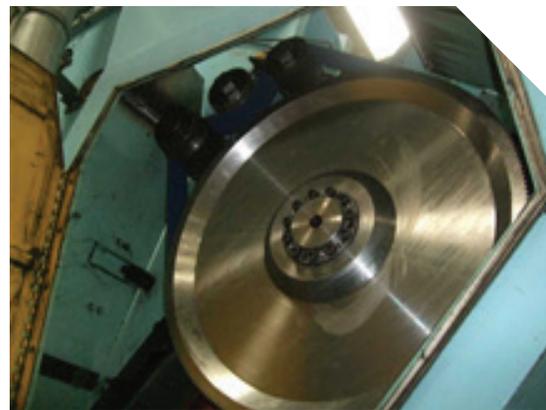
After the conversion the belt drive operated more smoothly and efficiently than the gear drive it replaced. Backlash was eliminated. There was no split-second delay in the hammer stroke with the belt drive. The speed variation was only ± 0.5 rpm. This greater efficiency translated into a gain of three strokes and 15 products per minute. By the end of one week the belt-driven stamping press was producing an extra pallet of products compared to the gear-driven machine. The drive has been in operation for over 10 months with no technical problems.

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As a result of this conversion, the user is asking the stamping press manufacturer for additional machines to be redesigned with belt drives. The redesign is taking \$48,000 out of the cost of each machine.



Bull gears on a stamping press needed replacing every three months due to wear.



A synchronous belt drive [fit into the same limited space] needs no lubrication and has a two-year lifespan.

[View more case studies like these.](#)





CONCLUSION

Field experience is the true test of a drive system. When high maintenance or frequent replacement of drive components becomes the norm, it's time to reassess the drive design. As the examples above demonstrate, synchronous belt drives present a viable alternative to roller chains or gears in many industrial applications. Replacing these older drive technologies with a synchronous belt system offers one way to gain a competitive edge in the market – through superior equipment or machinery.

Perform a Field Redesign for a Competitive Edge

Engineering design assistance with belt drive systems is available from Gates Corporation. Contact a Gates Product Application Engineer, [303] 744-5800, email ptpasupport@gates.com, or visit www.gates.com/drivedesign.