ENERGY SAVINGS FROM SYNCHRONOUS BELT DRIVES

Introduction

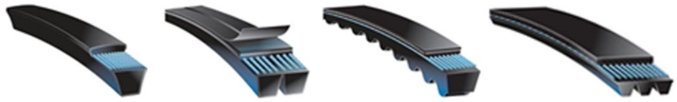
According to the U.S. Department of Energy, manufacturing operations in the U.S. spend $30 billion annually on the electricity powering motor-driven systems. Many of the 40 million electric motors in operation, which consume 70 percent of all electricity used in the plants, are not running at optimum efficiency.

Why does efficiency matter? Efficiency of any power transmission system is a measure of the power loss associated with the motor, the bearings and the drive. Loss of power is a loss of money.

Approximately one-third of the electric motors in the industrial and commercial sectors use belt drives. If the efficiency of these systems were improved by a mere 5%, the plants would see tremendous energy savings. Such savings are not out of reach. Synchronous belt drives operate so efficiently that they enable savings across a variety of industrial applications.

Comparing V-Belts and Synchronous Belts

Most of today's belt drives use standard V-belts, which have a trapezoidal cross section creating a wedging action on the pulleys.



V-belts are manufactured in a wide variety of materials, cross sections, banded multiples, reinforcement styles, and constant and variable speed configurations. Low acquisition costs, wide availability and quiet performance make them a popular power transmission solution.

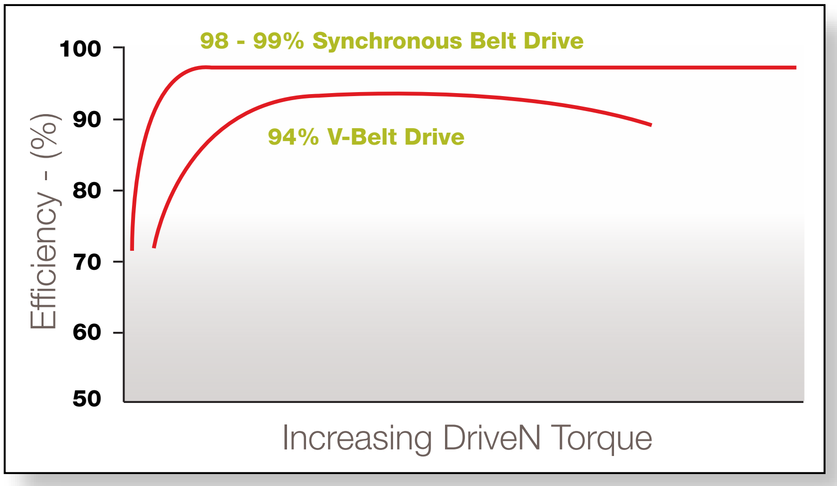
Certain physical characteristics of these V-belts cause energy loss. Energy losses in belt drives are separated into two categories, torque loss and speed loss. One factor impacting torque loss is heat generated due to the friction between the belt sidewall and the groove surface of the metal. V-belts depend on friction as they are part of a wedging mechanical system and therefore have greater energy loss due to heat generation than a synchronous drive, which has positive engagement between the belt tooth and sprocket groove and is generally cooler running. Another form of torque loss comes from the energy required to bend a belt around a sprocket or sheave. The thinner cross section of a synchronous belt requires less energy to bend than the thicker cross section of a V-belt.

Synchronous belt drives are an alternative to V-belt drives and roller chain drives. The synchronous belt's tooth profile has evolved over time from trapezoidal, to the rounded tooth of curvilinear and finally to modified curvilinear, pictured above from left to right.

Speed loss is also a characteristic of V-belt drives. A positive tooth/groove engagement prevents a synchronous belt drive from slipping, while V-belt drives, no matter how well maintained, will exhibit some amount of slip. Slip occurs when the tension is insufficient to transmit the load. V-belts elongate and require retensioning on a regular basis whereas synchronous belts have minimal elongation and require no retensioning if properly installed.

Although properly maintained V-belt drives can run as high as 95-98% efficient at the time of installation, this deteriorates as much as 5% during operation. Poorly maintained V-belt drives may be up to 10% less efficient.

Synchronous belts, such as Gates PowerGrip® GT®2 and Poly Chain® GT® Carbon™ belt drive systems, remain at an energy efficiency of approximately 98%-99% over the life of the belt.



On average, a synchronous belt drive is 5% more efficient than a V-belt drive, eliminating excess energy consumption.

Increased Efficiency Equates to Savings

To determine the kilowatt-hours saved when using synchronous belt drives rather than V-belt drives, the following formula is used:

$$KWh = \frac{(Motor\ HP)(Hrs/Yr)(.746)(.05)}{Motor\ Efficiency}$$

where constant .746 is the conversion factor from hp to KW, and .05 is the 5% energy savings gained by converting.

Maintenance managers can leverage improved energy efficiency by converting v-belt drives to synchronous belt drives in one of two ways:

1. Maintaining current capacity while using less power, or
2. Increasing capacity using the same power.

For example, if the current airflow is satisfactory in an HVAC application, a synchronous belt drive would use less energy to do the job. If the current airflow is insufficient, a synchronous belt drive could increase airflow without increasing use of energy.

Saving Maintenance Expense & Downtime

V-belt drives and synchronous belt drives demand approximately the same amount of time for installation. A key difference between them, in terms of maintenance, is that synchronous belts do not require a run-in procedure or retensioning. It is recommended that a newly installed V-belt is retensioned 24 hours after installation. Time is spent locking out the power, removing the belt guard, retensioning, securing the belt guard and resuming power. Companies that are too busy to do the proper 30-minute run-in process are later burdened by premature belt failure. That means costly belt replacement is needed.

In addition, V-belts should be retensioned based on a scheduled preventive maintenance program for optimum performance. Like run-in, each procedure takes approximately 30 minutes, during which the drive must be shut down and productivity is lost. On critical drives, a synchronous belt, which requires no retensioning, not only improves energy efficiency but also eliminates downtime. More uptime equates to more production, which leads to higher profit.

Quick Facts

- Industrial motor use consumes 25% of total electricity usage in the U.S.
- The majority of belt failures can be traced to environmental factors (debris, temperature, contaminants) and improper belt drive maintenance.

A Short Payback Period

Factoring in energy savings, maintenance savings and reduced downtime, payback from converting to synchronous belt drives is typically much less than one year.

Estimating potential energy savings and the payback period for a synchronous belt drive is simple:

$$\text{Annual Energy Cost (\$)} = \frac{\text{(Motor HP)(Hrs/Yr)(.746)(Cost per KWh)}}{\text{Motor Efficiency}}$$

$$\text{Annual Energy Savings (\$)} = \text{(Energy Cost)(Efficiency Increase)}$$

$$\text{Payback Period} = \frac{\text{New Drive Cost}}{\text{Annual Energy Savings}}$$

For example, if energy costs are $0.10 per KWh, the annual energy cost for a 40-HP motor running at 89% efficiency, 8,736 hours per year, totals $29,290.14. The annual energy savings is $1,464.51. If a new synchronous belt drive costs $342.83, the payback period is .23 years – fewer than three months.

When a V-belt drive is converted to a synchronous belt drive, savings continue to accrue year after year.

CASE STUDY

V-Belt to Synchronous Belt Conversion Yields Dramatic Cost Savings in Plant's HVAC System Operation

Reichhold, Inc. is a global supplier to the composites and coatings industries, with 18 manufacturing facilities in 11 countries. The maintenance technician at the Durham, North Carolina facility approached a representative of Gates Corporation, maker of industrial power transmission belt drive systems, to survey the plant for potential energy savings. During the hot summer months, the plant spent approximately $80k per month in energy costs to operate its equipment.

The Gates representative analyzed 21 HVAC units with 30 hp motors, 44 fume hood exhaust fans with 5-10 hp motors and four cooling tower fan drives with 50 hp motors – all V-belt driven – using the belt drive selection tool Design Flex® Pro™.

HVAC Unit Analysis and Conversion

The HVAC drive units were equipped with 4-strand, Tri-Power® V-belts, which required periodic retensioning and replacement every three months. The V-belt drive was replaced with a 14mm Gates synchronous Poly Chain® GT® Carbon™ belt drive, and performance was tracked.

Amps dropped from 12.5 to 10.4. Annual KWh usage fell into a range between 10,103 and 10,557 KWh/yr, representing a yearly energy cost savings of $505 to $527 per unit. Converting all 21 units represents an energy cost savings of 21 x $505 = $10,608. In addition, the synchronous belt drive will run for years without retensioning or replacement, saving additional downtime and maintenance expense.

Cooling Tower Fan Drive Analysis and Conversion

The Reichhold facility also included two 1,320-ton chillers with matching cooling towers. Each cooling tower had two fan drives fitted with V-belts. When one of the fan drives was converted to a 14mm Gates synchronous Poly Chain GT Carbon belt drive, the difference in performance was substantial. Estimated yearly cost savings for converting all four fans is $12,595, including reduced downtime and maintenance costs.

Exhaust Fan Drive Analysis and Conversion

Although covered, the 44 fume hood exhaust fans on the Reichhold facility rooftop are subject to extreme seasonal temperature changes. Hi-Power® II 2-strand V-belts must be replaced every three months. The immediate result from conversion to an 8mm synchronous Poly Chain GT Carbon belt drive saw a 12.9% reduction in energy consumption. In addition, the annual cost of maintaining each V-belt was $250. Converting all 44 drives represents a maintenance cost savings of $11,000/year, in addition to the lower energy costs.

Before: Cooling tower fan with 5 strand V-belt drive.

After: Same unit with synchronous belt drive.

Conclusion

The maintenance and energy cost savings achieved by converting various V-belt drives to synchronous belt drives at the Reichhold facility totals over $34,000 per year.

Resources

To contact a Gates representative about drive conversions that increase efficiency and reduce energy costs, email gjohnson@gates.com. For more information about energy efficiency, please visit www.gatesprograms.com/efficiency.