Replace V-Belts with Notched or Synchronous Belt Drives

Approximately one-third of the electric motors in the industrial and commercial sectors use belt drives.[1] Belt drives provide flexibility in the positioning of the motor relative to the load. Pulleys (sheaves) of varying diameters allow the speed of the driven equipment to be increased or decreased relative to the motor speed. A properly designed belt power-transmission system offers high efficiency and low noise, requires no lubrication, and presents low maintenance requirements. However, certain types of belts are more efficient than others, offering potential energy cost savings.

The majority of belt drives use V-belts, which use a trapezoidal cross section to create a wedging action on the pulleys to increase friction and improve the belt's power transfer capability. Joined or multiple belts are specified for heavy loads. V-belt drives can have a peak efficiency of 95% or more at the time of installation. Efficiency is dependent on pulley size, pulley wear, V-belt alignment, transmitted torque, under or oversizing belts for load requirements. Efficiency can deteriorate by as much as 5% over time if slippage occurs because the belt is not periodically retensioned.

The most important operational and maintenance issue in a V-belt drive is its tension. If belts are too loose, they tend to vibrate, wear rapidly, and waste energy through slippage. If belts are overtightened, they will show excessive wear. An increased belt load may shorten bearing life through excessive lateral loading and could possibly result in shaft failure. The proper tension of a V-belt is the lowest tension at which the belt will not slip at peak-load conditions. After the break-in period, belt tension should be checked every 3 to 6 months.

A notched belt has grooves or notches that run perpendicular to the belt's length, which reduces the bending resistance of the belt. Notched belts can use the same pulleys as cross-section standard V-belts. They run cooler, last longer, and are about 2% more efficient than standard V-belts.

Synchronous belts (also called cogged, timing, positive-drive, or high-torque drive belts) are toothed and require the installation of mating grooved sprockets. These belts operate with a consistent efficiency of 98% and maintain their efficiency over a wide load range.[2] In contrast, V-belts have a sharp reduction in efficiency at high torque due to increased slippage. Synchronous belts require minimal maintenance and retensioning, operate in wet and oily environments, and run slip-free. However, synchronous belts are noisier than V-belts, less suited for use on shock-loaded applications, and transfer more vibration due to their stiffness.

Example Energy Savings Calculations

A continuously operating, 100-horsepower (hp), supply-air fan operates at an average motor load of 75% while consuming 527,000 kilowatt-hours (kWh) of electrical energy annually. What are the annual energy and dollar savings if a 95% efficient (η_1) V-belt is replaced with a 98% efficient (η_2) synchronous belt? Electricity is priced at $0.08/kWh.

Energy Savings = Annual Energy Use x $(1 - \eta_1/\eta_2)$
= 527,000 kWh/year x (1 – 95/98) = 16,130 kWh/year

Annual Cost Savings = 16,130 kWh x $0.08/kWh = $1,290

Suggested Actions

- Conduct a survey of belt-driven equipment. Gather application and operating-hour data. Then determine the cost effectiveness of replacing existing V-belts with notched belts or synchronous belts and sprockets.
- Consider synchronous belts for all new installations; the price premium is minimal due to the avoidance of conventional pulley costs.
- Consider having a power transmission specialist determine the energy and cost savings potential from retrofitting all V-belt drives with synchronous belts. Synchronous belts rely on tooth grip instead of friction to efficiently transfer power and provide a constant speed ratio.
- Install notched belts where the retrofit of a synchronous belt is not cost effective.

A notched belt, left, runs cooler and has a higher efficiency than a standard V-belt. A synchronous belt, right, can maintain high efficiency over a wide load range and requires minimal maintenance. *Images courtesy of ©Gates Corporation*

Further Considerations

For centrifugal fans and pumps, which exhibit a strong relationship between operating speed and power, synchronous belt sprockets must be selected that take into account the absence of belt slippage. Fluid flow, pressure, and operating costs could actually increase if slippage is reduced and a centrifugal load is driven at a slightly higher operating speed.

Cost effectiveness improves when notched or synchronous belts are installed at the end of V-belt life or when a belt change out is scheduled. When completing a belt retrofit/efficiency upgrade, a properly designed synchronous belt drive should match the *required* rotating equipment speed and not rely on a speed that is calculated based on existing sheave diameters. Application engineers also need to understand application requirements and determine the pulley center-to-center distance, operating equipment speed, speed ratio, shaft sizes, and transmitted horsepower.

Synchronous belts are the most efficient choice. However, notched belts may be a better choice when vibration damping is needed or shock loads cause abrupt torque changes that could shear a synchronous belt's teeth. Noise from synchronous belts might be objectionable in some applications.

References

[1]Mleziva, Brian, Greenheck Fan Corporation, "Ensuring Proper Fan-Belt Tension," *HPAC Engineering,* July 2011.

[2]Gates Rubber Company, "Synchronous Belt Drives Restore Energy Savings," December 1997.

Resources

U.S. Department of Energy (DOE)—For more information on motor and motor-driven system efficiency and to download the MotorMaster+ software tool, visit the Advanced Manufacturing Office (AMO) website at *manufacturing.energy.gov.*

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