WHITE PAPER

Cost Savings through Energy Efficient Power Transmission Systems

Introduction
By its definition, power transmission is the movement of energy from its place of generation to another point where it is applied to perform useful work. Any loss of power is a loss of money for users. To minimize losses and keep energy consumption in check, power transmission drives must operate at optimum efficiency.

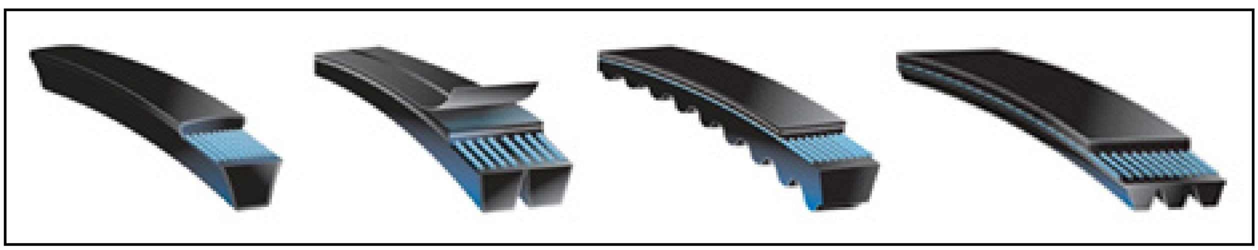
This paper compares the efficiency-related characteristics of two belt drives – V-belt drives and synchronous belt drives – to show the potential for savings.

Energy Efficiency Defined
Efficiency of any power transmission system is a measure of the power loss associated with the motor, the bearings and the belt drive. It is defined by the following formulas:

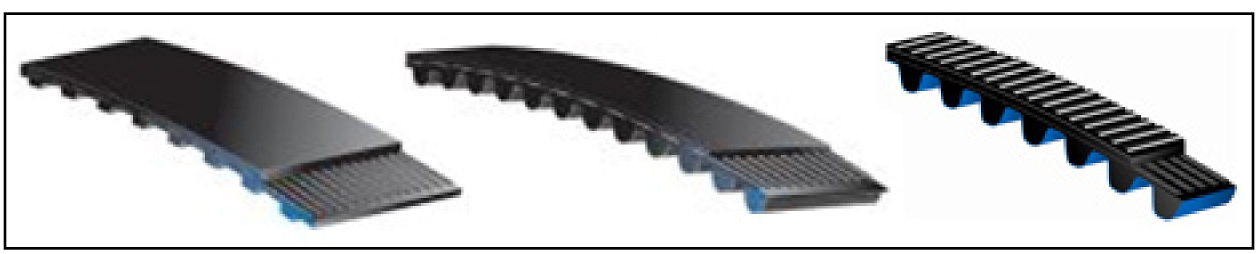
$$Efficiency = HPout/HPin$$

$$Efficiency = (TORQUEout \times RPMout)/(TORQUEin \times RPMin)$$

As these equations show, energy losses in belt drives are separated into two categories: torque loss and speed loss. These losses vary in V-belt and synchronous belt drives as a result of the belts' inherently different physical characteristics.



V-belt drives are a popular power transmission solution because of their low acquisition costs and wide availability.



Synchronous belt drives are an alternative to V-belt drives (and roller chain drives) when plant maintenance managers and design engineers are changing out metal components or designing a new system.

Comparing Synchronous Belt and V-belt Drives for Energy Efficiency

One factor impacting torque loss is that heat is 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.

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 while synchronous belts have minimal elongation.

Given these characteristics, a V-belt drive initially operates at 94-97% efficiency and can deteriorate up to 5% during regular operation. Poorly maintained V-belt drives can become as much as 10% less efficient. In contrast, a synchronous belt drive operates at a constant 98-99% efficiency, and on average, is 5% more efficient than a V-belt drive.[1]

Energy Savings Example

Those designing or making a conversion to a synchronous belt drive may be deterred by higher upfront costs. As evidenced by a calculation of energy savings, the decision to convert often provides a very short payback period and generates significant overall savings. The difference in initial acquisition costs is rapidly repaid by the savings in energy costs. Appendix A provides formulas for determining Annual Energy Cost Savings.

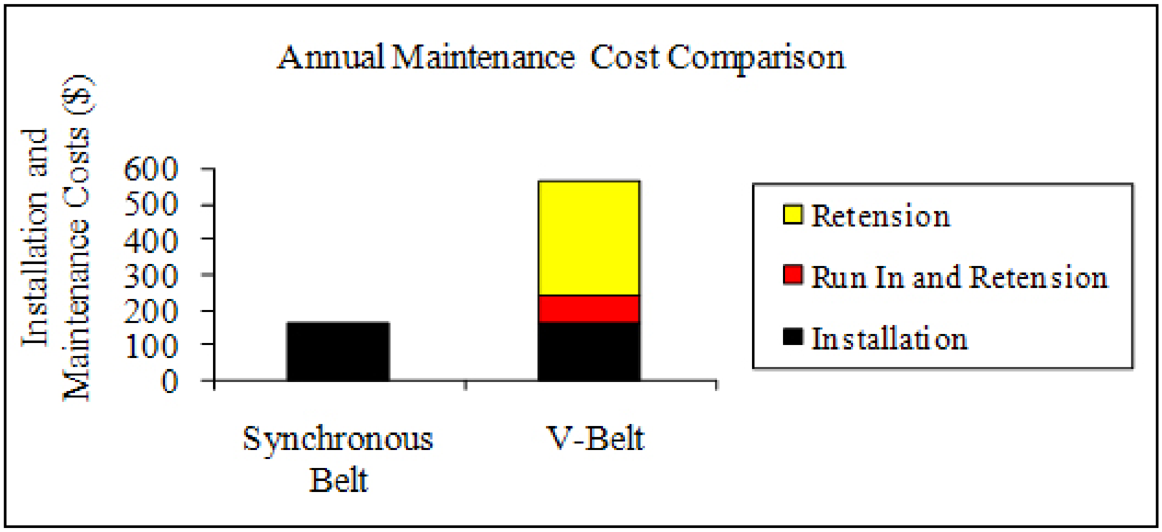
As an example, a 40-HP motor, running at 89% efficiency, 24/7, with energy costs at 10 cents per kilowatt-hour, has an annual energy cost of $29,290. Converting to a synchronous drive improves motor efficiency by 5% for an annual energy savings of $1464. Payback on the drive investment is less than a quarter of a year. When the annual dollar savings amount is multiplied by the number of similar motors in a plant, and added to the savings from motors of all other types, a facility's overall energy savings impact is clear.

The Added Benefit: Maintenance Savings

Synchronous belts eliminate tension maintenance when properly installed, resulting in less attention from maintenance personnel and additional savings in productivity.

Continuing the 40-HP motor example, compare the maintenance costs incurred in a one-year period for a synchronous belt drive and V-belt drive. Installation time does not differ and is $160 ($40 per hour x 2 technicians x 2 hours). The recommended run in procedure for the V-belt drive uses the same two technicians for another hour, so the additional cost is $80. Assuming the drive is well maintained, retensioning occurs four times for $320. Therefore, the V-belt drive's annual maintenance cost is $560, while the synchronous drive's is $160.

Below is a graphical representation of the difference:



[1]For a thorough energy savings evaluation, it is necessary to use equipment that measures all of the components of energy usage – time, current, voltage and power factor – simultaneously. Common handheld instruments (ammeter, voltmeter, etc.) are insufficient by themselves. If an energy savings survey is to be performed on a belt drive application, one must use equipment that has the ability to measure all four components of energy usage.

These maintenance costs assume that both belt drives are replaced once per year. However, depending on maintenance practices, synchronous drives may outperform V-belt drives and require less frequent replacement.

Conclusion

Inefficient drives waste energy. Because energy usage and maintenance costs are a concern for every plant, a synchronous belt drive is the ideal solution. Gates offers top-of-the-line, energy efficient synchronous solutions, including PowerGrip® GT®2 and Poly Chain® GT® Carbon™ belt drive systems.

Resources

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

Annual Energy Cost Savings from Synchronous Drives

Estimated annual energy savings in dollars at different costs per kilowatt-hour (KWH) for motors of various horsepower

Motor hp	Average Motor Efficiency	40 hours/week (2,080 hours/year)		80 hours/week (4,160 hours/year)		24 hours/day (8,760 hours/year)	
		$0.05/KWH	$0.10/KWH	$0.05/KWH	$0.10/KWH	$0.05/KWH	$0.10/KWH
3	79%	$15	$30	$30	$60	$62	$128
5	81%	$24	$48	$48	$96	$101	$202
7.5	83%	$35	$70	$70	$140	$148	$296
10	83%	$47	$94	$94	$188	$197	$394
15	85%	$68	$136	$136	$272	$288	$576
20	86%	$90	$180	$180	$360	$380	$760
25	88%	$110	$220	$220	$440	$464	$928
30	89%	$131	$262	$262	$524	$550	$1,100
40	89%	$174	$348	$348	$696	$734	$1,468
50	90%	$215	$430	$430	$860	$907	$1,814
60	90%	$259	$518	$518	$1,036	$1,089	$2,178
75	91%	$320	$640	$640	$1,280	$1,346	$2,692
100	91%	$426	$852	$852	$1,704	$1,795	$3,590
125	92%	$527	$1,054	$1,054	$2,108	$2,219	$4,438
150	92%	$632	$1,264	$1,264	$2,528	$2,663	$5,326

The above chart gives the estimated annual energy savings in dollars at different costs per kilowatt-hour for various motor horsepowers that result from converting to synchronous belt drives from V-belt drives. Savings have been calculated on the basis of synchronous drive efficiency being 5% higher than an equivalent V-belt drive.

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

$$KWH = \frac{motor\ hp\ x\ hours/year\ x\ .746\ x\ .05}{motor\ efficiency}$$

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

Example: $KWH = \frac{20\ hp\ x\ 2080\ x\ .746\ x\ .05}{.86\ motor\ efficiency} = 1804\ KWH$

At a cost of $0.12 per kilowatt-hour, the dollar saving achieved by using a synchronous drive is:

$$1804\ KWH\ x\ \$0.12 = \$216.48$$

Multiply this amount by the number of similar motors in your plant. Add to this similar savings with all the motors of different horsepower, and you have the estimated total annual energy savings made possible by synchronous drives.

When considering energy savings, air moving drives exhibit the greatest potential. Fan drives, unlike pump drives, have predictable loads, but ambient conditions such as air density or wind velocity can change the loads and thus the electrical reading. Measuring efficiency is quite complex, and the results obtained can be misleading if not accurately analyzed on a sound engineering basis. When properly designed and maintained, V-belt drives can also exhibit high efficiencies, however, improper drive maintenance, perhaps more than any other single factor, affects belt efficiency and therefore energy use.

For more information contact Gates Product Application at 303-744-5800 or email ptpasupport@gates.com.